The Technical Control of Dairy Products

THE TECHNICAL CONTROL *of* DAIRY PRODUCTS

A Treatise on the Testing, Analyzing, Standardizing and the Manufacture of Dairy Products

By

TIMOTHY MOJONNIER, M. S.

President Mojonnier Brothers Company
Milk Engineer
Consulting Chemist for Dairy Industries

and

HUGH CHARLES TROY, B.S.A.

Professor of Dairying, in charge of
Testing in the Department of Dairy Industry
Cornell University, Ithaca, New York
Consulting Chemist for
New York State Department of Farms and Markets
Formerly State Chemist, New York

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To all who are interested in the progress of the dairy industry, in its varied branches, this book is dedicated.

Preface

IN THE compilation of this book, the authors have endeavored to systematize and present a large amount of original information and data, in such a way as to make it of the greatest value to teachers, students, plant operators, chemists and dairy control agencies. Some of the material has already appeared in addresses, and technical papers, but the larger part has not heretofore appeared in print. The diagrams and standardizing tables shown in Chapters X to XIV inclusive, have been developed in connection with and used for some time, with Mojonnier standardizing equipment, and in instruction work. They are incorporated in this book with the hope that a larger number may profit by their proven merit and utility. Drawings and tables largely based upon original data are used frequently to make more clear the operation and application of several new methods and appliances for testing and controlling dairy products. The numerous graphs shown have been drawn from tabulated results of carefully planned and executed experiments, some of which have covered a period of several years.

It is realized that there are many milk plant practices upon which opinions differ, but the aim in this book is to present facts and methods that have proven in actual practice to possess the greatest merit. Constructive criticisms or suggestions that readers may be prompted to make will be greatly appreciated.

Acknowledgment of other sources of information as far as possible is made in the text. Special credit is due to Mr. J. A. Cross for conspicuous services as mentioned in several places in the text; to Mr. W. O. Frohring for valuable suggestions in connection with Chapter XVI, as well as for arranging for the loan of numerous valuable graphs and photomicrographs from the Telling-Belle-Vernon Co.; to Mr. O. W. Mojonnier for valuable suggestions in connection with Chapter XIX; to Mr. Roscoe Moon for help and co-operation in the preparation of illustrations and in proof reading;

to the Fred Klein Co., Chicago, Ill., for excellent co-operation in all matters pertaining to the printing of the book, and to Mr. H. J. Liedel for careful aid in many ways. Credit is further due to Mr. J. J. Mojonnier, Miss Lucy Klein, Mr. E. C. Jensen, Mr. Len Fortney, Mr. H. O. Buhrman, and others connected with Mojonnier Bros. Co. Acknowledgment is also made of courtesies extended by Mr. Mark Shanks of the Standard Ice Cream Co., Chicago, and Mr. Mark Goodman, of the Goodman-American Ice Cream Co., Chicago.

THE AUTHORS.

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LIST OF ABBREVIATIONS

c. p.	= Chemically pure
c. c. or cc.	= Cubic centimeter
cm.	= Centimeter
mg.	= Milligram
gm.	= Gram
mm.	= Millimeter
cm.	= Centimeter
b. p.	= Boiling point
F.	= Fahrenheit
C.	= Centigrade
"	= Inches
'	= Feet
Lbs.	= Pounds
T. S.	= Total solids
M. S. N. F.	= Milk solids not fat
S. N. F.	= Solids not fat
T. M. S.	= Total milk solids
T. S. N. F.	= Total solids not fat
B. of H.	= New York Board of Health Lactometer
N.	= Normal solution
N/10 or 0. IN	= Tenth-normal solution
B. T. U.	= British Thermal unit
Sp. H.	= Specific heat
° R.	= Degrees retardation
c.	= Small calorie
C.	= Large calorie
Sq. cm.	= Square centimeter
E. M. F.	= Electro motive force
pH	= Hydrogen ion concentration
C_H	= Hydrogen ion normal acid solution
C_{OH}	= Hydrogen ion normal or normal alkaline solution
A. O. A. C.	= Association of Official Agricultural Chemists
Sp. Gr.	= Specific gravity
B.	= Baume
B.	= Bacillus

Dairy Building, New York State College of Agriculture, Cornell University, Ithaca, New York.

CHAPTER I

THE DAIRY PLANT LABORATORY

The testing laboratory in a dairy plant does not generally receive the consideration that its importance warrants. This is so because it is of recent development, and the proprietors of many dairy plants do not yet fully realize the economical value of the work. As they become more conscious of the fact that the composition of a marketable dairy product has a large influence on fixing its value and that the composition cannot be accurately determined without suitable accommodations and equipment, the laboratory and its work will receive as much consideration as other important operations in the manufacture of milk products. The loose methods in operation during the development of the industry will not prove successful under the present system of keen competition, and just as no business can hope to operate successfully for any length of time without an efficient system of accounting so a dairy manufacturing plant cannot hope to operate successfully without accurately determining the composition of each product received and distributed. The possibility of preventing loss through thorough control methods is of such importance that no reasonable detail should be overlooked in equipping the laboratory.

Location. The laboratory should be a separate room located near the office and where practical, should have direct communication with the manufacturing rooms. It should be used solely for analytical work and the chemist should not be annoyed or distracted by persons passing through it, nor by the conversation of others present. Where these precautions are observed valuable time may be saved, the work will proceed more rapidly, and the liability for mistakes to occur and consequent losses will be reduced to a minimum. The air in most dairy manufacturing plants as a rule is exceedingly moist due to escaping steam, wet

floors, and the large amount of water constantly used for cleaning purposes. Since excessive moisture is injurious to sensitive and delicate apparatus and makes accurate work more difficult, the laboratory should be located in the driest part of the building. Moist walls, escaping steam and wet floors should be avoided as much as possible.

Floor. A smooth floor that does not absorb moisture, and which may be easily and thoroughly cleaned serves best. Water from adjoining rooms should not be allowed to flow into the laboratory. Ample drains should be supplied to carry away wash water. Asphalt on a concrete base is very satisfactory, but any substantial floor will serve. The floor and walls should be solid and free from vibrations as they will have to support chemical balances, and other delicate apparatus that should rest on solid foundations in order to prevent their injury, and give the best service.

Ventilation. The ordinary means of ventilation, where possible, should be supplemented by forced draft. This may be readily supplied and serve a double purpose by placing a flue leading from the hood. Proper ventilation will assist materially in freeing the laboratory of excessive moisture, noxious gases that should not be allowed to enter the manufacturing rooms, and in contributing to the health of the workers.

Temperature. The temperature should be held at all times as near to 68° F. (20° C.) as is convenient. Wide changes in temperature are to be avoided because of the effect upon the apparatus and upon the density of solutions.

Tables and Desks. The laboratory tables should be substantial and covered with material impervious to moisture or chemicals. Where expenses must be kept down wooden tops stained black and treated with acid and alkali proofing substance are commonly used. Sheet lead laid over plank is favored by some and is preferred to wooden tops. Glazed white tile or slabs of vitrolite give good service, and are very neat and attractive. Any finish that cannot be easily and thoroughly cleaned, or which is softened by heat should be avoided. While wooden drawers give good service, metal drawers made from pressed steel are an advantage because they do not swell nor check under varying atmospheric

or moisture conditions. Ample drawer space for storing apparatus should be provided under the benches and tables. The drawers should vary in depth from three to ten inches according to the apparatus they are to contain. The larger enclosed spaces under the benches should be reserved for the taller pieces of apparatus. Narrow shelves for holding reagent bottles should be placed on the walls over the work benches. Cupboards for holding chemicals should also be supplied.

Hood. No laboratory is complete or satisfactory without a roomy well ventilated hood. It should be equipped with sliding sash front to permit observation of operations without opening the hood. Where available the hood as well as the work benches should be supplied with gas and water cocks.

Sinks. The sinks should be large and conveniently located as much work must be done near them. Iron or porcelain sinks are to be preferred, and where they are to be used to carry away mineral acids, they should be lined with sheet lead, and the waste pipes should also be made of lead. Where possible the sinks should be supplied with hot as well as cold water. The plumbing should be so constructed that it may be readily reached when repairs are necessary.

Steam and Electricity. Both steam and electricity can be used in many ways to advantage in the testing laboratory. Where power for operating a large amount of equipment is installed, it will be a comparatively simple detail to supply the laboratory. While it is not always indispensable, electricity is coming more into general use in laboratory methods, and in many analyses it is a real necessity.

Lighting. Good light is a real necessity in laboratory work. A large skylight opening toward the north serves well, and where the location of the room permits, this means of lighting should be adopted. It should be supplemented with side lights where possible. The best light is obtained through north windows, but light from other directions will serve fairly well. The laboratory should also be provided with a good system of artificial light as it will be needed on dark days, and in the morning and late afternoon of the shorter days. White or light colored walls will also assist materially in giving good light.

Apparatus. The larger and more important pieces of apparatus are the Mojonnier tester, balances, polariscope, microscope, viscosimeter, centrifuges, water-still, drying ovens, hot water bath, extraction apparatus, and muffle furnace.

The Microscope. A good microscope is an essential piece of apparatus in every dairy plant laboratory. Where bacteriological work is carried on, it is an absolute necessity, and it will be frequently used in the examinations of milk sediment for distinguishing yeasts and molds and detecting milk sugar crystals in condensed milk and other milk products, and for the study of butter fat globules. For these reasons the chemist should have a good microscope with all accessories immediately available.

The following are the more important of the small, necessary items of equipment for a completely equipped dairy laboratory:

Balance, Harvard trip, or torsion. Sensitive to 1/100 gram.
Balance, specific gravity.
Beakers, glass, 100 c.c., 250 c.c., 500 c.c.
Beakers, aluminum, 150 c.c.
Beaker covers (watch glass). Different sizes.
Bottles, reagent. Glass stoppered, 250 c.c., 500 c.c., 1000 c.c. and 2000 c.c.
Bottles, washing, with rubber stopper and flexible delivery tube.
Bottles, weighing.
Boxes, microscope slide.
Brushes, wooden handles for cleaning cylinders and jars.
Brushes, camel's hair for cleaning scale pans.
Brushes, on tinned iron wire handle for cleaning long tubes.
Burettes with glass stopcock. Capacity 10 c.c. and 50 c.c., graduated to 1/10 c.c.
Burettes, Mohr's. For pinch cock. Capacity 50 c.c., graduated to 1/10 c.c.
Burners, alcohol lamps, glass.
Burners, Bunsen.
Burners, Bunsen's ring form.
Centrifuges, high speed, with accessories.
Clamps, burette Lincoln.
Clamps, Universal for condensers, etc.
Clamp holders. For attaching clamps, extensions, rings, etc.
Clamp test tube.
Clamps, tubing.
Condensers, with bulb condensing tube, used in perpendicular position.
Condenser, with straight condensing tube, used in slanting position.
Connecting bulb tubes, Kjeldahl's.
Corks, best quality, various sizes.

Corks, rubber.
Cork borers of polished brass, 12 in nest.
Cork borer, sharpener.
Cork softener.
Cork screw.
Cotton for plugging test tubes.
Crucibles, glazed porcelain, with covers.
Crucibles, Gooch.
Gooch crucible holder, Bailey's.
Crucible, platinum with cover, capacity 15 c.c.
Crucible tongs.
Cylinders, for use with hydrometers and lactometers.
Cylinder, graduated 10 c.c., 25 c.c., 100 c.c., 1000 c.c.
Desiccators, one large, one small.
Dishes, crystallization, flat bottoms.
Dishes, evaporating, porcelain.
Forceps, fine straight points.
Drying oven, double walled for water.
Extraction apparatus, heaters for.
Files, round (rat tail).
Files, triangular.
Filter paper, various sizes.
Filter paper, ash free.
Filter cover, porcelain.
Filter pump.
Flasks, ordinary form.
Flasks, Erlenmeyer, 125 c.c., 250 c.c., 500 c.c.
Flasks, distilling.
Flasks, for suction filtration.
Flasks, Kjeldahl digestion.
Flasks, sugar, accurately graduated at 100 c.c. and 110 c.c.
Flasks, graduated at 250 c.c., 500 c.c.
Funnels, glass, different sizes.
Funnels, separatory.
Funnel tubes.
Furnace, muffle, for all kinds of muffle work.
Glass rods.
Glass tubing, various diameters.
Hydrometers, specific gravity and Beaume scales.
Lactometer, Quevenne.
Milk sediment tester and accessories.
Mortar, agate or porcelain with pestle.
Pipettes, small with rubber bulb.
Pipettes, volumetric, 5 c.c., 10 c.c., 25 c.c., 50 c.c.
Ring stands, iron.
Rings, support with clamp.
Rubber policemen.

Rubber tubing.
Sand bath, of iron.
Shears, laboratory.
Sieves, mesh, 20, 60, 80, 100, 140, 180.
Spatulas.
Supports, burette, condenser and funnel.
Test tubes, 10 c.c., 25 c.c., 50 c.c.
Test tube racks.
Test tube baskets.
Thermometers.
Tripods.
Triangles, wire, and pipe stem.
Tripods, iron for Bunsen burners.
Tubes, connecting.
Tubes, distilling.
Watch glasses.
Water bath.
Wire gauze.
Wire gauze, iron with asbestos center.

Additional Apparatus for Bacteriological Work.

Autoclave.
Sterilizers.
Dry air sterilizing oven.
Incubator.
One c.c. pipettes, graduated in tenths.
Test tubes, heavy walled.
Erlenmeyer flasks, 1000 c.c.
Petri dishes, 100 x 10 mm.
Reading glass.
Counting plate.
Counter.
Wax pencils.

The following are the more important chemicals required in a completely equipped dairy laboratory:

Acid acetic, glacial 99.0%.
Acid hydrochloric C. P. concentrated 38.0%.
Acid nitric C. P. concentrated 69.0%.
Acid oxalic C. P. crystallized.
Acid rosolic.
Acid sulphuric C. P. concentrated 100%.
Alcohol, amyl.
Alcohol, ethyl, absolute Sp. Gr. .7938, and also 190° proof, 95%.
Alum (potassium aluminum sulphate) crystallized.
Ammonia, concentrated 28%.
Ammonium chloride.
Ammonium molybdate.

Asbestos fibre.
Barium chloride.
Chlorinated lime, crystallized.
Calcium peroxide.
Carbon bisulphide.
Cochineal, indicator.
Copper sulphate, crystallized.
Distilled water.
Ether, moisture and residue free, both ethyl and petroleum.
Ferric chloride.
Formaldehyde, 40%.
Fuchsin, crystallized.
Glycerin, U. S. P.
Potassium iodide.
Lead acetate (crystallized).
Litmus paper and cubes.
Magnesium carbonate.
Mercury.
Methyl orange.
Phenolphthalein.
Potassium carbonate.
Potassium hydrate sticks.
Potassium permanganate.
Pumice stone.
Rochelle salts (crystallized sodium and potassium tartrate).
Silver nitrate, C. P. crystallized.
Sodium carbonate.
Sodium hydrate, sticks.
Starch.
Tumeric, dry powder and paper.
Xylol.
Zinc dust.
Tenth—normal sodium hydroxide.
Tenth—normal hydrochloric acid.
Tenth—normal ammonium hydroxide.
Tenth—normal silver nitrate.
Saturated lime water.

GENERAL PLANS FOR DAIRY LABORATORIES.

No fixed plan can be recommended to suit all plants. The conditions prevailing at each separate plant must be taken into consideration before deciding upon the arrangement and equipment of the laboratory. Fig. 1 shows the suggested floor plan for a plant laboratory where a number of different dairy products are manufactured. Under some conditions it might be desirable

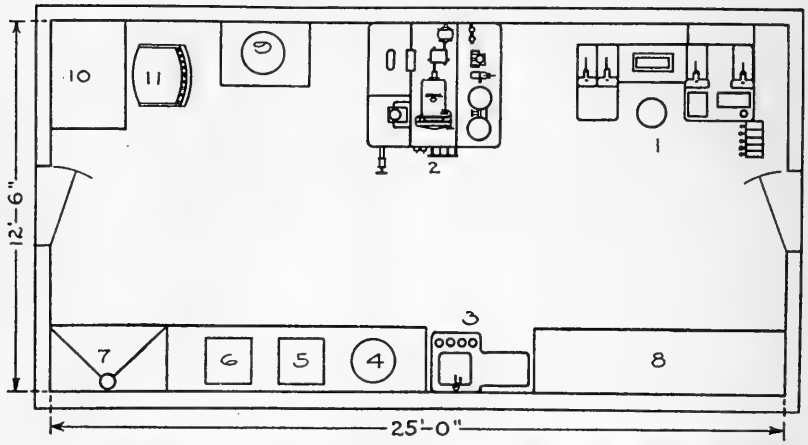


Fig. 1. Suggested floor plan for laboratory in plant manufacturing several different dairy products, including evaporated milk, sweetened condensed milk and ice cream.

1. Mojonnier milk tester. 2. Evaporated milk controller. 3. Washstand. 4. Autoclave. 5. Sterilizer. 6. Incubator. 7. Hood. 8. Work bench. 9. Babcock tester. 10. Desk. 11. Chair.

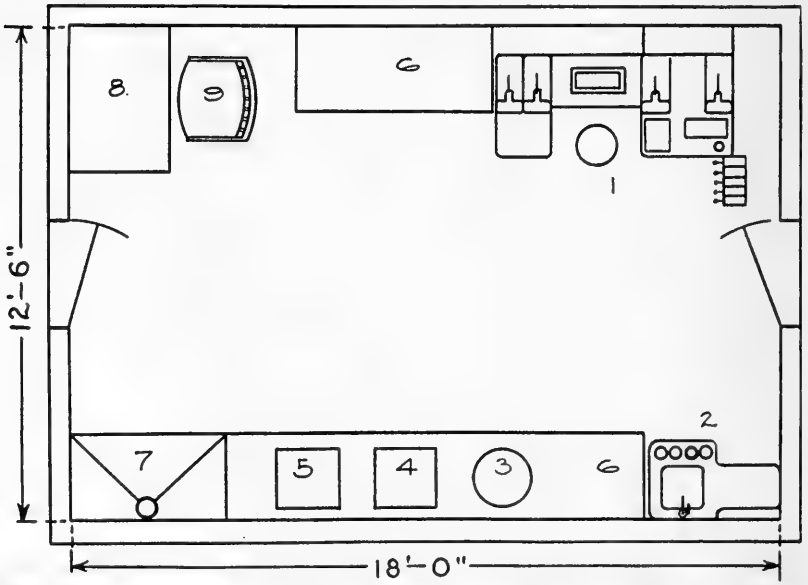


Fig. 2. Suggested floor plan for laboratory in plant manufacturing ice cream.

1. Mojonnier milk tester. 2. Washstand. 3. Autoclave. 4. Sterilizer. 5. Incubator. 6. Work bench. 7. Hood. 8. Desk. 9. Chair.

to divide the work into departments, and to partition the laboratory into separate rooms. The arrangement of the control laboratory where such is maintained will be governed by the work to be done therein, and in many respects can be considerably different, both as regards arrangement and equipment, from the plant laboratory. Fig. 2 shows the suggested floor plan for a small factory laboratory where only ice cream or a limited number of other dairy products are manufactured. The equipment in this case can be reduced to a minimum, being limited to apparatus for controlling fat and total solids and where so desired, for making bacteriological and a few other minor tests.

CHAPTER II

THE CONSTITUENTS OF MILK

General Statement. Milk is the normal secretion of the mammary glands of mammalia during the period of lactation following parturition. The definition of milk, adopted by the Association of American Dairy, Food and Drug Officials, Aug. 3, 1917, was the following: "Milk is the whole, fresh, clean, lacteal secretion obtained by the complete milking of one or more healthy cows, properly fed and kept, excluding that obtained within 15 days before and 5 days after calving, or such longer period as may be necessary to render the milk practically colostrum free."

The milk of a number of different species of mammalia has been used as human food. In parts of the world the milk of the zebu, goat and sheep is of some commercial importance. Goat's milk in some instances has found favor in this country as food for infants of delicate digestion, probably because the casein does not readily mat into a lump when acted upon by acids in the stomach. The casein in that respect behaves more like the casein in human milk. However, the substance commercially known as milk in this country, refers to the milk of the cow, and it is used in this sense in this volume unless otherwise specified.

THE PHYSICAL PROPERTIES OF MILK.

Milk and the products obtained from milk are so universally used that their principal physical properties are a matter of common knowledge. Whole milk consists of an emulsion of light-yellow fat globules in an opaque white serum that usually has a slight bluish tinge. The color of whole milk as well as of other dairy products varies under many different conditions, both of production and manufacture. The practice of standardizing color is a long established one in many industries. Physical properties

TABLE 1.

The Water, Fat and Solids Not Fat Content of Different Dairy Products Derived from a Certain Whole Milk.

Constituents	Whole Milk	Skim-milk	Cream	Butter (un-salted)	Butter-milk	Cheese (Fresh American Cheddar)	Whey	Sweet-ened Con-densed Whole Milk	Plain Bulk Con-densed Skim-milk	Plain Bulk Con-densed Whole Milk	Evap-orated Milk	Ice Cream Mix	Whole Milk Powder	Skim-milk Powder
Water	87.75	91.08	54.62	16.00	90.83	38.00	93.00	26.50 45.50 sugar	74.50	70.00	74.50	66.00 13.50 sugar, gelatin and flavors	5.00	5.00
Fat	3.75	.10	40.00	83.00	.40	30.00	.30	8.00	.29	8.00	7.80	8.00	29.09	1.07
Milk solids not fat	8.50	8.82	5.38	1.00	8.79	32.00	6.40	20.00	25.21	22.00	17.70	12.50	65.91	93.93
Total solids	12.25	8.92	45.38	84.00	9.17	62.00	6.70	73.50	25.50	30.00	25.50	34.00	95.00	95.00
Pounds of finished product obtained from 1000 lbs. whole milk testing as indicated under whole milk. No allowance for losses in manufacture.	1000	909	91	44	47	101	899	425	397	386	481	680	129	85
								3.5 lbs. excess fat to be removed in standardizing				17.0 lbs. fat short to be added in standardizing		

such as flavor, viscosity and appearance that frequently affect the sale of the product also vary under many different conditions. It is not within the province of this chapter to discuss these properties in detail. Further reference will be found in later chapters.

THE COMPOSITION OF MILK.

The constituents of milk and milk products divide themselves into groups both for commercial and scientific considerations. First: Water and total solids (ordinarily at least no attempt is made to account for the gases in milk). Second: The total solids are divided into two parts, one being called fat and the other solids not fat. Both of these later groups form the basis of our leading dairy industries. Third: The solids not fat are again further divided into their several component parts which will be described in later paragraphs.

In Table 1 the composition is given of our most common American dairy products, in terms of water, fat, solids not fat, and total solids. It is assumed that the initial lot of whole milk weighed 1000 pounds, and that it tested 87.75 per cent of water; 3.75 per cent of fat; 8.50 per cent of solids not fat, and 12.25 per cent of total solids. It is further assumed that the entire lot of products mentioned in the table were obtained from a similar quantity and composition of whole milk. The pounds of each kind of product thus obtained is given. Note the remarks in the case of sweetened condensed milk and in ice cream mix. The yield and composition of these products as mentioned could not have been obtained except by removing part of the fat in the case of the sweetened condensed milk, and by adding additional fat in the case of the ice cream mix.

VARIATIONS IN CONTENT OF FAT AND SOLIDS NOT FAT IN WHOLE MILK.

The composition of milk varies considerably, and the percentage of no single constituent is constant between samples taken from different sources or different milkings of the same individual. The range of variation that occurred in the percentage of fat and in the percentage of solids not fat in the milk from 1217 herds is shown in Fig. 3.

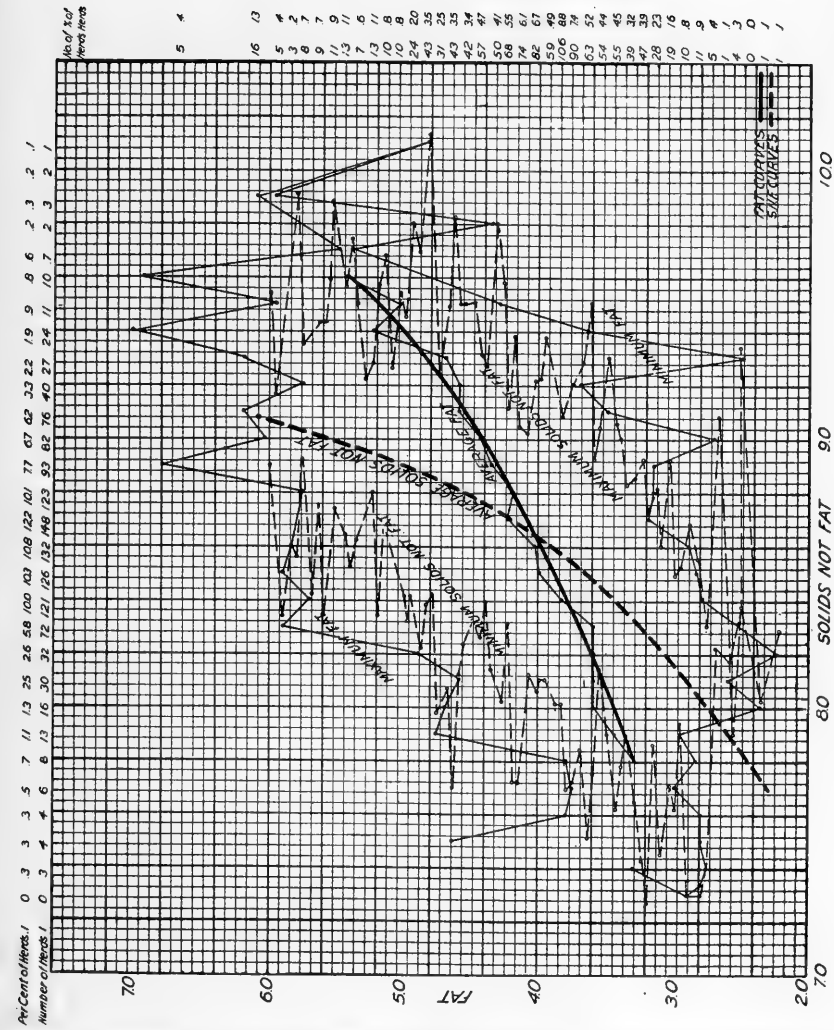


Fig. 3. Variation in fat and solids not fat in milk from 1217 New York Herds Tests made by H. C. Troy and W. B. White.

It also shows the general relation that exists between the percentages of fat and solids not fat. The data represent the composition of single samples of the mixed herd milk from 1217 different herds. They included the different breeds and classes of cows in central and western New York. The number of cows in the different herds is not known, but would probably average about ten. The samples were taken at all seasons of the year from the mixed herd milk by inspectors, experienced in such work, after watching the milking operation and making certain that the samples truly represented the milk produced by the herd at that milking. Several hundred of the samples were analyzed by one of the authors of this book, while he was State Chemist in New York, and the remainder were made by his successor, Mr. W. B. White, State Chemist, Ithaca, New York.

The fat varied between 2.25 per cent in the lowest analysis to 6 per cent in the highest. The solids not fat varied between 7.25 per cent in the lowest analysis to 10.13 per cent in the highest. The percentage of solids not fat increases as the percentage of fat increases, but the ratio of increase is not constant and gradually diminishes as the higher fat percentages are reached.

The percentage of fat was obtained by the Adams extraction method excepting in a few cases where the Babcock method was used. The solids not fat were obtained by drying to constant weight 2.5 to 3.0 grams of milk in a flat bottomed platinum dish in a water-jacketed drying oven containing boiling water, and then subtracting the percentage of fat from the percentage of total solids.

DISTRIBUTION OF CONSTITUENTS OF WHOLE MILK.

Table 2, next page, was prepared to show at a glance the percentage composition of each important class of constituents in whole milk, and likewise of the separate constituents making up the various classes.

The various constituents are discussed both by groups and also individually in the following paragraphs.

Gases. In the majority of dairy products, the material gases contained therein are of no practical or commercial significance. Gases are frequently the product of decomposition in which event they become undesirable constituents, and may cause large com-

mercial losses, principally in the case of butter, cheese and sweetened condensed milk. In other products such as Koumiss, the development of carbon dioxide is of prime importance, and determines the commercial value of the product to a considerable extent. The principal gases found in freshly drawn milk are carbon dioxide, oxygen and residual gases, generally assumed to be nitrogen, but this assumption remains unproved. The total volume amounts to about 7 to 9 per cent. According to Marshall's experiments, the above gases are present in the milk before the same leaves the udder.

TABLE 2.

Distribution of Constituents of Whole Milk.

Milk	Milk fats	Olein	33.95	Glycerides of insoluble and non-volatile acids	3.40%	3.70%
		Palmatin	40.51			
		Stearin	2.95			
		Myristin	10.44			
		Laurin	2.57			
		Butyrin	6.23	Glycerides of soluble and volatile acids	0.30%	
		Caproin	2.32			
		Caprylin	.53			
		Caprinin	.34			
	Milk serum	Casein	2.60	Nitrogen containing substances	3.25%	T. S. 12.35%
		Albumin	.60			
		Globulin	trace			
		Fibrin	trace			
		Lecithin	.05			
		Milk sugar			4.50%	Solids not fat 8.65%
		Citric acid			0.20%	
		Potassium oxide	.175	Ash	0.70%	
		Sodium oxide	.070			
		Calcium oxide	.140			
		Magnesium oxide	.017			
		Iron oxide	.001			
		Sulphur trioxide	.027			
		Phosphorus pentoxide	.170			
		Chlorine	.100			
		Water				87.65%
					Total	100.00%

Water. The water forms about 87% of the milk substance. It is derived directly from the blood and serves as a vehicle for carrying the other constituents of the milk in a fluid condition. The water may be separated from the other substances by distillation. It may then be condensed and collected. After removing traces of volatile gases, it has exactly the same composition and physical properties as pure water from any other source.

Total Solids. The total solids include all of the milk constituents that are not evaporated when a small amount of the milk is spread over a large surface and dried to practically constant weight at a temperature of 100° C. The percentage of total solids may vary between 10.5 and 15.5. In a few exceptional cases it may fall outside of this range, but in the vast majority of analyses it will fall between 11.5% and 13%. The percentage of total solids in milk or other dairy products is of special importance as it is a measure of the food substance contained therein, and also because legal enactments have fixed minimum percentages of total solids for most dairy products.

Solids Not Fat. The solids not fat are made up of casein, sugar, albumin, ash, and a few other less abundant, but nevertheless important constituents. They form the solids in the serum after the fat has been removed. The white, opaque color of milk is largely due to their presence although the fat globules add to this property. In milk of average composition, the solids not fat supply about one-half of the energy producing substances and practically all the muscle building properties. The higher specific gravity of milk over that of water, is also due to these substances; the specific gravity of the solids not fat being about 1.615. They increase the viscosity (sticky quality) of milk, and as some of them are not in complete solution, they assist in holding the fat in an emulsified state, preventing its rapid rise to the surface, and complete separation from the remainder of the fluid under the influence of the force of gravity. Even when force is applied in centrifugal methods of separation, the solids not fat prevent the removal of some of the smaller fat globules so that separator skim-milk rarely contains less than .05% of fat.

Van Slyke and Bosworth[1] state that sugar, citric acid, potassium, sodium and chlorine are wholly in solution, and that the

albumin, inorganic phosphates, calcium and magnesium are partly in solution and partly in suspension. Any of these substances that are in suspension would assist in holding fat in an emulsified condition.

Skim-milk, buttermilk, whey, plain and sweetened condensed skim-milk and skim-milk powder owe their commercial importance to their content of milk solids not fat. The small amount of fat carried in these products also adds to their value. There is everywhere a growing recognition of the food value of milk solids not fat.

Milk Fat. The fat from milk is generally known as it appears in butter. For this reason it is commonly called butter fat. Before it is separated from milk it may be seen, with the aid of a microscope, in the form of minute opalescent globules floating in the milk serum. Different investigators have determined the diameter of the fat globules of milk. While their results are not wholly in accord, it appears that the diameters of the globules vary between 0.01 mm. and 0.0015 mm. (approximately 0.004 and 0.00006 inch). The fact that fat globules of milk do not readily unite, combined with other phenomena, led to the theory at one time supported by some investigators, that the globules are surrounded by a membrane, but there is scarcely evidence sufficient to support this conclusion. The consensus of opinion among investigators is that the fat exists in the milk in the form of a true emulsion.

The appearance of butter fat globules under the microscope varies with the product, and with the treatment which the product has received.

When fat is completely separated from the milk in the form of butter, it is characterized by its yellow color, and by desirable and attractive flavors and aroma. Animal fats may appear somewhat yellow especially when melted to an oil, and by selecting the fats from certain parts of the carcases of cattle of some breeds, tallow may be obtained that has a yellow tint when solid, but the depth of yellow color in butter is not obtained in tallow,

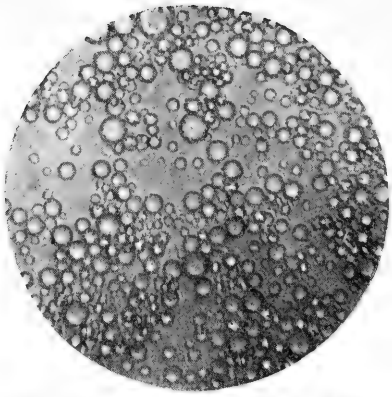


Fig. 4. Fat Globules in Whole Milk. Mag. 500 Dia.
Courtesy Telling-Belle Vernon Company

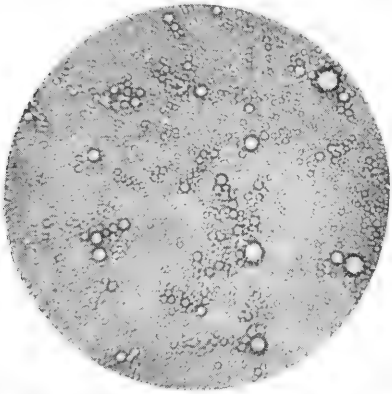


Fig. 5. Fat Globules in Ice Cream Before Homogenizing. Mag. 200 Dia.
Courtesy Telling-Belle Vernon Company

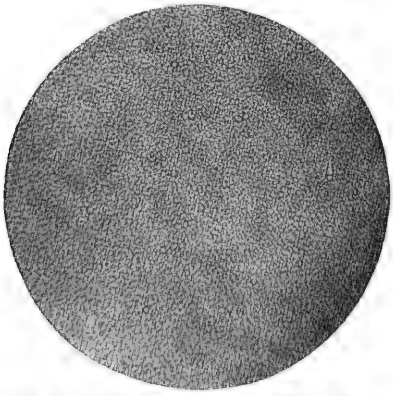


Fig. 6. Fat globules in Ice Cream Mix After Homogenizing. Mag. 200 Dia.
Courtesy Telling-Belle Vernon Company

without the addition of foreign coloring. The yellow color of milk fat may vary according to the individual cow, the breed and the feed. The fat having the more pronounced yellow color is produced in the early summer, when the food is green and succulent, while the palest fat is produced in the winter months when such feed may not be obtained. The color of the fat in the form of butter is somewhat intensified by the addition of salt.

Fig. 4 shows fat globules in whole milk. Fig. 5 shows the fat globules in ice cream mix before homogenizing, and Fig. 6 after homogenizing.

The melting point of milk fat varies between 31° and 36° C. (88° and 96° F.). A number of factors combine to influence the melting point, but the exact effect of each is not known. The specific gravity of milk fat ranges between .93 and .94 at 15° C. (59° F.). The fat expands as the temperature is increased, thus lowering the specific gravity until at a temperature of 60° (140° F.) it is about .90, and at 100° C. (212° F.) it is approximately .864.

Milk fat is composed of 9 different fats. Browne[2] made a study of the percentage of each present and obtained the following results.

Palmatin 40.51%, olein 33.95%, myristin 10.44%, stearin 2.95%, laurin 2.73%, butyrin 6.23%, caproin 2.32%, caprylin 53%, caprinin 34%.

The fats are composed of three elements, carbon, hydrogen and oxygen. The atoms of these elements combine with each other under the force of chemical attraction to form molecules. The substances made up of these molecules possess different properties according to the proportion of each element present, and the manner in which the atoms are combined. Combined in one way and one proportion, they form the well known substance called glycerine; combined in another way and in differing proportion, they form a series of substances called fatty acids. In the elaboration of milk fat in the body of the animal nine distinct fatty acids are formed and combined with glycerine. Each molecule of glycerine holds three fatty acid radicles in combination. The acids present in milk fat are butyric, caproic, caprylic, lauric, myristic, palmitic, oleic and stearic. Combined

with glycerine they form the nine fats named above. It appears that any three of the fatty acids may unite with a glycerine radicle, thus forming a more complex molecule than would be possible if the glycerine molecule were combined with three radicles of a single fatty acid.

The fat molecules may be split up into glycerine and fatty acids. By separating the glycerine and purifying it, the ordinary glycerine of commerce is obtained. When set free from the glycerine the butyric and caproic acids are soluble in water while the other fatty acids from milk fat are not soluble. The fatty acids of milk fat may also be grouped as volatile and non-volatile. When a mixture of fatty acids in water is boiled the butyric, caproic, caprylic, capric and possibly some of the lauric acids are volatilized. By means of a distilling apparatus they may be collected and measured by titration with an alkali.

This is one of the best methods of distinguishing milk fat from all other fats and oils as the percentage of volatile fatty acids in the latter is much lower. It is the presence of the fats from the volatile fatty acids, especially butyric, that gives butter its characteristic flavor. The fat in butter becomes rancid as a result of the splitting up of the fat molecule, as the fatty acids when freed from the glycerine radicle have very characteristic and pungent odors and flavors.

The percentage of the harder fats is lowest during the earlier stages of the lactation period with a corresponding increase in the percentage of the softer fats. This has a practical bearing as the softer butter resulting retains moisture more readily than the harder butter made from fat secreted toward the end of the period of lactation. The manufacturing process must be modified to meet these differing conditions or butter containing a percentage of moisture above the legal limit may result.

Both from a physiological and commercial standpoint, the fat is the most important constituent of all dairy products. This accounts for the exact control required over this constituent.

Casein. Casein is the principal protein of milk, and it is present in the milk of all mammalia. It has been studied by a number of investigators, and different names have been given to the substance as it exists in fresh milk, and to the principal

product derived from it in the natural souring of milk. Van Slyke[3] states that the neutral substance as it is believed to exist in fresh milk is calcium caseimate, consisting of casein in combination with 1.5% of calcium oxide. The true casein consists of the protein that remains after it has been separated from the calcium oxide. The name calcium paracasein is given to the insoluble substance formed by the action of rennet.

The casein forms about 80% of the milk proteins, the albumin about 15%, and small amounts of other proteins make up about 5%. It appears that some of the same influences that affect the percentage of fat in milk, also may cause variations in the percentage of casein.

Casein is present in fresh sweet milk in the form of minute gelatinous particles saturated with the remainder of the serum until the substance is evenly distributed throughout the mass of liquid. Substances that act in this manner are called colloids. The colloidal particles of casein do not pass through animal membrane or unglazed porcelain and may be separated from skim-milk by using these substances as filters. The calcium casein separated from skim-milk by this means, is a gelatinous substance nearly white in color. It is not quite as opaque as the casein precipitated from milk by acids, and is not so readily ground to a white powder when dry.

The casein molecule has a very complex structure being made up of a large number of atoms. The six elements that enter into its composition, and the percentage of each according to Kirchner[4] is carbon 53%, hydrogen 7%, oxygen 22.70%, nitrogen 15.70%, phosphorous .85%, sulphur .75%.

Pure casein may be separated from fat-free milk serum by precipitation with very dilute acid. Special precautions must be taken to prevent other milk constituents from contaminating the casein during the operation, and to wash it free from foreign substances before drying.

In the natural souring of milk, the lactic acid which is developed from the milk sugar, unites with the calcium of the calcium caseinate, forming calcium lactate, setting free the casein and precipitating it, in the form commonly seen in curdled milk. The precipitation of the casein begins when the acidity reaches

about .6% at 70° F. if the acid is developed normally in the milk. If the acid is added to the milk at a temperature of 70° F. a slightly lower percentage will coagulate the casein. The higher the temperature, the lower will be the percentage of acid necessary to cause coagulation. Casein is also coagulated by the salts of a number of metals and by concentrated alkaline solutions; while dilute alkaline solutions and concentrated acid solutions dissolve it. Heat changes the casein compounds in fresh milk under pressure and coagulates the casein at 130 to 140° C. The enzymes, rennin and pepsin also precipitate casein and are used extensively for this purpose in the manufacture of cheese. The specific gravity of casein is between 1.26 and 1.35.

Casein serves primarily as a food as it is found in milk, and the usual milk products. It forms a large part of the substance of nearly all cheese, and gives to cottage cheese practically all of its food value. In some proprietary foods the casein is treated with sodium compounds, and other salts that are also found in milk, and other substances to make it more soluble or to give it special properties. Plasmon, Tila, Nutrose, Eucasein, Sanatogen, Lacto-Somatose and Argonin are trade names given to foods of this nature made from casein.

Galalith and Lactoform are substances made from casein after precipitation with metallic salts, or by other means and then treated with formaldehyde. This substance may then be used for some purposes as a substitute for, or in imitation of bone, horn, ivory, celluloid, porcelain and similar materials. It is used in the manufacture of buttons, door knobs, knife handles, picture frames, tubes, rods, oil flasks, cartridge cases, sink plugs and corks.

It is mixed with medicinal reagents to assist in administering them, and it is used in many massage creams, ointments and soaps. Glues, adhesives, putties, paints, calcimine, photographic materials, glazing materials, dolls and toys are also sometimes made from it. It is also further used in calico printing, in making imitation leather, insulating material, washable oil paper, drawing and writing paper, and in treating cloth and felting, and loading silk and other cloth, to make them heavier.

Milk Sugar. Milk sugar or lactose forms about 38 per cent of the total solids. The percentage present in milk from

different sources, and from different milkings of the same animal does not vary over nearly as wide a range, as does the percentage of fat. It is composed of carbon, hydrogen and oxygen. Three modifications of milk sugar are known to exist, all of which behave differently towards polarized light.

First, the monohydrate or α milk sugar which has the formula $C_{12}H_{22}O_{11} + H_2O$. This is the ordinary crystallized milk sugar of commerce, and the form that crystallizes out from water solutions at room temperature. As the formula shows, it contains one molecule of water of crystallization. This water is retained upon heating to 100° C. in the dry state, or in water in an unsaturated solution. At 130° to 140° C. the molecule of water is given off. At 170° C. it decomposes forming lacto-caramel. It melts at 203.5° C. with further decomposition. Its specific heat is 0.30 and its specific gravity is 1.54.

Second, the anhydrous modification called β anhydrous milk sugar which has the formula $C_{12}H_{22}O_{11}$. Hudson[6] devised a method whereby this modification could be produced in a chemically pure condition. His method is based upon the principle that this form crystallizes out of hot, supersaturated solutions of milk sugar. The specific gravity at 20° C. is 1.59.

Third, another anhydrous modification called α anhydride which is obtained when the monohydrate milk sugar is heated at 125° C. to constant weight. This form is very hygroscopic, and the evidence indicates that, upon dissolving in water, it goes back to the monohydrate form.

The solubility of milk sugar has been studied by Dubrunfaut,[5] C. S. Hudson,[6] E. Soillard,[7] Mack & Liedel,[8] and in the laboratory of Mojonnier Bros. Co. Milk sugar has both an initial and a final solubility. That is, by mixing an excess of milk sugar with water, a certain amount will go immediately into solution, and a further additional amount will also go into solution, after prolonged mixing of milk sugar with water. It is this fact that accounts for the disagreement in results between different investigators. The final solubility at different temperatures is given upon the graph Fig. 7 and in Table 3, page 25.

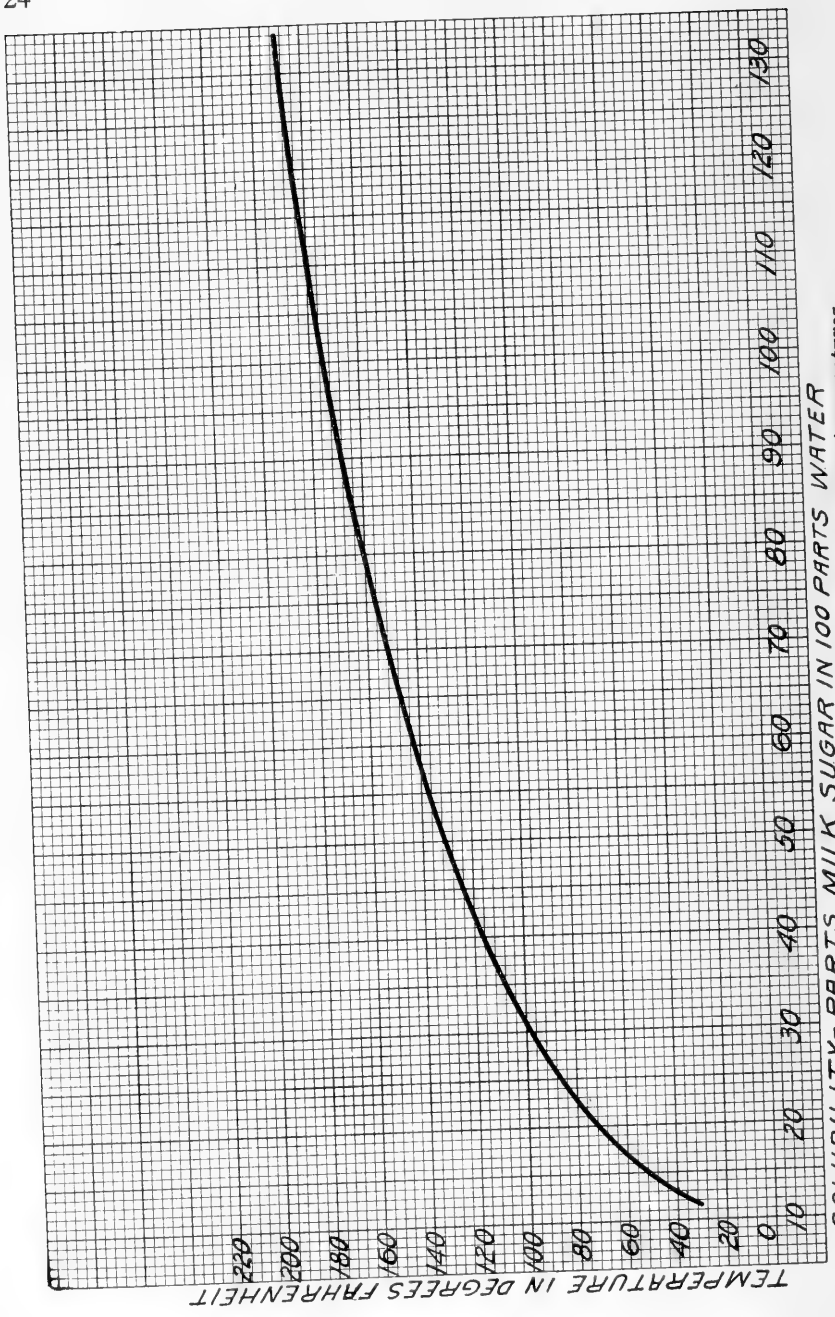


Fig. 7. Solubility of milk sugar in water at various temperatures.

TABLE 3.

The Solubility of Milk Sugar at Different Temperatures.

Temperature degrees F.	Parts milk sugar dissolved in 100 parts water.	Temperature degrees F.	Parts milk sugar dissolved in 100 parts water.
35	11.9	120	43.0
40	13.2	125	46.8
45	14.0	130	51.0
50	14.9	135	59.9
55	15.9	140	64.5
60	17:0	145	65.8
65	18.2	150	69.3
70	19.5	155	74.5
75	21.0	160	80.1
80	22.8	165	86.2
85	24.8	170	93.2
90	27.0	175	101.2
95	29.3	180	110.5
100	31.7	185	121.3
105	34.3	190	133.9
110	36.8	192	139.2
115	39.7		

As indicated by the foregoing results, the solubility decreases with lowering temperatures, or vice versa. The rate of solution increases rapidly with rising temperatures. Between 32° and 35° F. the solubility increases at the rate of .17 parts of milk sugar to 100 parts of water for each degree F. of rise in temperature.

Between 190 and 192° F. the increase is at the rate of 2.65 parts, or 15.6 times greater than at the lower temperature.

The crystalline monohydrate of milk sugar according to Traube[19] belongs to the monoclinic system, and the same has the following constants: a, b, c = 0.3677; 1: 0.2143, B = 109° 47′.

The faces are clinodomes.

A typical crystal is illustrated under Fig. 8. For purpose of comparison, typical crystals of cane sugar are illustrated under Fig. 9. This shows the characteristic difference between the two sugars.

Fig. 10 is a photomicrograph of milk sugar crystals crystallized from a pure lactose solution by evaporation of the water at room temperature.

Milk Sugar, like cane sugar, as pointed out by Browne,[20] crystallizes in a variety of forms. This is proved by examination of the above photomicrographs. This accounts for the lack of agreement upon the subject between authorities.

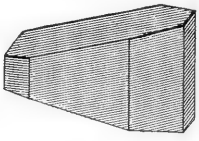
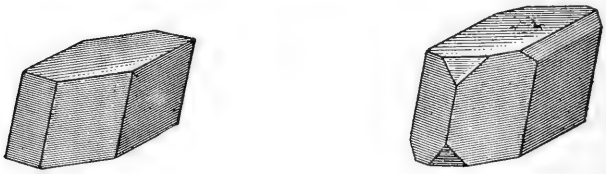


Fig. 8. Typical Monolinic Crystal of Milk Sugar the faces of which are clinodomes.



I II

Fig. 9. Typical Monolinic Crystals of Sucrose, I. Tabular Form, II. Form with Hemihedral Faces.[20]

Decomposition Products of Milk Sugar. Through the action of lactic acid bacteria, milk sugar is converted into lactic acid, one molecule of sugar yielding four molecules of lactic acid, according to the following equation:

$$C_{12}\ H_{22}\ O_{11}+H_2O = 4\ C_3H_6O_3.$$

In actual practice the theoretical amount of lactic acid is not realized, as a part of the sugar is broken down to form other substances, the principal of which are carbon dioxide and water. Only about 70% of the sugar that disappears is found in the form of lactic acid. A part of the acid, thus formed from the

milk sugar, unites with the calcium, setting the casein free. The latter then coagulates and forms the curd of sour milk.

When a little more than .20% of lactic acid has developed in milk its presence may be detected by its odor, and when the percentage reaches .25% to .30% it is noticeable to the taste. When .60% of acid has developed in the milk the casein coagulates at ordinary temperatures, and when about .90% of acid has developed the ordinary variety of lactic acid bacteria becomes inactive and the development of the acid ceases. Special forms of bacteria like those used in the manufacture of Yogurt (Bacterium caucasium) develops acidity as high as 3%.

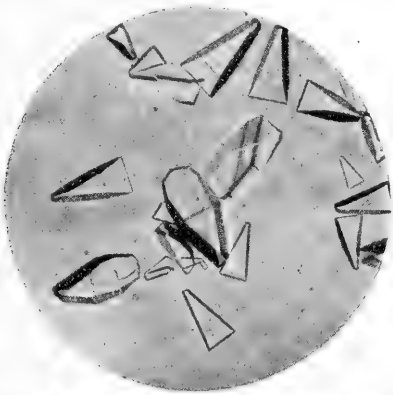


Fig. 10. Milk Sugar Crystals. Mag. 200 Dia.
Courtesy Telling-Belle Vernon Company.

Milk sugar, when fermented by the action of certain special varieties of yeasts, also yields alcohol. With the presence of bacteria, lactic acid may be formed at the same time, and the casein is partly broken down. This form of fermentation is used in the manufacture of koumiss from mare's milk and kephir (or kefir) from the milk of cows, sheep or goats. Koumiss may develop as high as 3% of alcohol and 1.25% of lactic acid while kefir may contain a little more than 1% of alcohol and .9% of lactic acid.

Uses of Milk Sugar. Milk sugar is used to a large extent with cream and water in modifying cow's milk for feeding infants when it is desired to reduce the percentage of protein. It is supposed to have special value in checking undesirable fer-

mentation in the digestive tract. It is sometimes used as a food for consumptives, and in cases of dropsy and wasting diseases. It also finds use in pharmacy as a base for pills, tablets and other similar purposes.

The percentage of milk sugar in concentrated milk products like evaporated milk and condensed milk varies according to the degree of concentration of the milk, and the percentage originally present. The condensing process does not necessarily cause any change in the milk sugar unless it is exposed to high temperatures for a long time, thus partially carmelizing the milk sugar and giving it a darker color. This, in turn, gives a very light brown color to the milk. Where the concentration of milk is carried to a point that does not leave enough water to hold the sugar in solution, it crystallizes out, and the concentrated product has a sandy and gritty feeling on the tongue when tasted. If such product is used in the manufacture of ice cream without pasteurizing and diluting, it sometimes transmits this undesirable property to the frozen product. A large part of the milk sugar in sweetened condensed milk is usually present in the crystallized form. It is not considered objectionable in this substance, especially if the crystals are small enough to remain in suspension.

Milk sugar may readily become the starting point for many defects in dairy products. For this reason its properties and its behavior under varying conditions require close study.

Albumin. Milk contains about .6 per cent of this protein. Because it is not present in milk in such large amounts, and is not of such commercial importance, it has not received as much study by investigators as has been given to casein. It differs from casein in composition, and in several of its properties. It is in solution in milk, and it may be coagulated by heat above 70° C. Acids do not coagulate it at ordinary temperatures and it is not coagulated by rennet nor by magnesium sulphate added almost to saturation. It contains no phosphorus, and about twice as much sulphur as casein. The albumin may be separated by boiling the liquid that remains after precipitating the casein from skim-milk with dilute acids or rennet, and filtering. The coagulated albumin will remain on the filter as a white

amorphous mass which is not as granular as casein that has been coagulated by acids.

Sebelien[9] prepared pure albumin from milk and gives it the following composition: Carbon, 52.19%; hydrogen, 7.18%; nitrogen, 15.77%; sulphur, 1.73%; oxygen, 23.13%.

Albumin contributes about one-sixth of the protein food value of milk and whole milk products that retain all of the milk constituents. The albumin in the whey obtained in the manufacture of cheddar cheese, is sometimes coagulated by heat and skimmed off. It is then made into an Italian form of cheese that is known as Ricotte. In the process of manufacturing milk sugar it is necessary to remove the albumin from the liquid. This is accomplished by heating the liquid to coagulate the albumin, then passing it through filter presses. The albumin collects on the press cloths. When removed from these it is used as chicken feed, or in the manufacture of fertilizer.

Mineral Constituents. Milk yields about .75% of ash when dried and burned in a manner to prevent loss of mineral matter. The ash does not accurately represent the salts in the milk as they are changed in the process of burning, and their exact combination is not definitely known. They are in solution with the exception of a little less than one-half of the phosphorus, and about two-thirds of the calcium which are in suspension according to Soldner.[10]

He estimates that the salts are composed of the following substances in the proportions given here:

	Per Cent
Sodium chloride	10.62
Potassium chloride	9.16
Monopotassium phosphate	12.77
Dipotassium phosphate	9.22
Potassium citrate	5.47
Dimagnesium phosphate	3.71
Magnesium citrate	4.05
Dicalcium phosphate	7.42
Tricalcium phosphate	8.90
Calcium citrate	23.55
Lime combined with casein	5.13
	100.00

In the ash the bases are united with phosphoric, hydrochloric, carbonic and sulphuric acids, and as oxides. It has been thought that the small amount of sulphuric acid present is derived from the sulphur contained in the protein. The mineral matter in milk varies between rather narrow limits. It appears to increase slightly as the percentage of sugar decreases and vice versa. The percentage of ash in naturally rich milk is usually higher than in poor milk. The percentage also increases in milk secreted toward the end of the period of lactation. There are very small amounts of other substances which would slightly affect the salts in solution, but they are relatively not very important, as far as now known.

Lecithin. This substance is found associated especially with milk fat, egg yolk fat and liver fat. It is also found to a limited extent in some other animal and plant cell material. It is sometimes classed as a phosphorized fat and has the formula C_{44} H_{90} O_9 NP. It is a yellowish white solid, soluble in ether and alcohol and may be separated from other food substances by the use of these solvents. When the extracted substance is treated with water, it appears to absorb it, but apparently does not go into complete solution, remaining in the form of an opalescent emulsion. When treated with an alkali it yields fatty acids, phosphoric acid, and other substances.

Experiments by Supplee[11] and by Cusick[12] indicate that the fishy flavor frequently found in butter is due to the tri-methylamine derived from decomposition products of lecithin.

Vitamines. In the past few years, investigators have proved that milk contains certain substances popularly called vitamines which are essential to health and growth. As yet none of these substances has been isolated, nor has their chemical identity been discovered. At the present time authorities are agreed that at least three distinct vitamines exist in milk. This number is known from their functional differences, ascertained largely by the biological method. Largely at the suggestion of McCullom[13] and his associates, these have been named fat soluble A, water soluble B and water soluble C or anti-scorbutic vitamine, respectively.

Fat Soluble A is especially abundant in milk fat, egg yolk fat, and in liver and kidney fat. It is also found in leafy vegetables.

Water Soluble B is found in the non-fatty part of milk. It is also found in the yolk of eggs and in the leaves of plants. Fat Soluble A and Water Soluble B are found in greater abundance in milk and its products than in any other foods known up to this time. This is one of the strongest reasons why milk and its products should constitute a generous part of the diet of human beings from infancy to old age. It has been found by long and careful research that these two vitamines are not affected, reduced, or destroyed by any of the usual manufacturing processes used in the home or in the factory in the handling of milk and its products. Pasteurized milk, evaporated milk, sweetened condensed milk, ice cream, milk powder, butter and cheese all contain the above two vitamines in great abundance.

Water Soluble C or anti-scorbutic vitamine is the least abundant in milk of the three vitamines named above. Even fresh milk just as it comes from the cow is deficient in this vitamine, and in any event its shortage should be supplied through other sources. Fortunately Water Soluble C is quite abundantly distributed in nature. Oranges and tomatoes contain it in relatively large quantities, providing a cheap and abundant supply. The addition to the diet of the juice from these products, either fresh or sterilized, can be practiced to advantage even in early infancy.

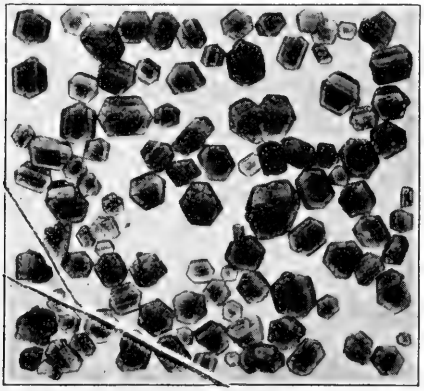


Fig. 11. Citric Acid crystals prepared from cow's milk. About one-half actual size. Prepared by one of the authors.[21]

Citric Acid. This substance (H_3 C_6 H_5 O_7. H_2O) or its salts is a normal constituent of milk. The amount in milk appears to vary but on the average about .20 per cent is probably present. It is a tri-basic acid and the crystallized calcium salt is sometimes found in evaporated milk. Barthel[14] states that by calculating the amount of alkali metals present in milk it is found that they are present in excess of the amount that would be satisfied by the chlorine and phosphoric acid and that investigations by Beau[15] lead to the conclusion that the amount of citric acid in milk is on an average .2 per cent. Crystals of citric acid prepared from cow's milk are illustrated in Fig. 11.

Traces of a number of other substances such as adenine, guanine, silica, urea, iodine and lacto-globulin are known to be present in milk. Babcock and Russell (1897)[16] found an enzyme called galactose that dissolves casein. It was prepared from centrifuge slime and its aqueous extracts possess proteolytic properties to a considerable degree. It is most active in slightly alkaline solutions, and heat of 73° to 75° C. readily destroys it. The presence in milk of one or more proteolytic enzymes is now generally accepted, although little is known of their composition. Fresh milk is sometimes amphoteric to litmus, that is, it changes red litmus paper slightly blue and blue litmus paper red. Therefore that indicator cannot be used in determining the acidity. This behavior of milk toward litmus is believed to be due to the phosphates in milk, as some phosphate compounds in solution act in a similar way. Milk is acid to phenolphthalein, and this indicator is generally used in determining its acidity. The apparent acidity is largely due to salts of phosphorus which undergo a readjustment in the presence of an added alkali.

The apparent acidity of fresh milk normally varies between .10 per cent and .18 per cent, but in exceptional instances has been found as high as .24 per cent, calculated as lactic acid.

Rice[17] investigated the milk of individual cows and found titratable acidities as high as .22%. High percentages of casein and solids not fat usually, but not always, accompany high apparent acidity. Electrical conductivity and hydrogen concentration did not differ from that of normal milk. Titration by the Van Slyke oxalate procedure indicated that phosphates were al-

ways somewhat higher in this class of milk. McInerney[18] determined the amount of phosphates in samples of fresh milk from herds producing milk of high apparent acidity. In each instance the percentage of phosphates was high.

REFERENCES.

[1] Van Slyke, L. L., and Bosworth, A. W.: The Condition of Casein and Salts in Milk. Tech. Bul. No. 39, N. Y. State Agr. Exp. Sta., 1914.

[2] Browne, C. A.: Jour. Am. Chem. Soc., 21, p. 807, 1899.

[3] Van Slyke, L. L., and Bosworth, A. W.: Tech. Bul. No. 39, N. Y. State Agr. Exp. Sta., 1914.

[4] Kirchner, W.: Handbuch der Milchwirtschaft, Berlin, 1898.

[5] Dubrunfaut: Compt. Rend., Vol. 42, p. 228, 1856.

[6] Hudson, C. S.: Journal American Chem. Soc., 1904 and 1908.

[7] Soillard, S.: Chemie et Industrie, Sept. 1919.

[8] Mack & Liedel: Thesis. Ohio State University, 1920.

[9] Sebelien: Zeitschr. f. Physiol. Chemie, 1885, Vol. 9, p. 445.

[10] Soldner: Die Solz der Milch und ihre Beziehungen zu dem Verhalten des Kaseins. Die Landwirtsch. Versuchsstation, 1888, Vol. 35, p. 361.

[11] Supplee, G. C.: The Lecithin Content of Butter and Its Possible Relationship to the Fishy Flavor. Memoir 29, Cornell Univ. Agri. Exp. Sta., Ithaca, N. Y., November, 1919.

[12] Cusick, J. T.: Phosphorus in Butter. Memoir 30, Cornell Univ. Agri., Exp. Sta., Ithaca, N. Y., April, 1920.

[13] McCollum, E. V.: The Newer Knowledge of Nutrition.

[14] Barthel, Chr.: Milk and Dairy Products. Trans. by Goodwin, W. London, 1910.

[15] Beau: Revue General du Lait, Vol. III., 1904, p. 385.

[16] Babcock, S. M., and Russell, H. L.: Unorganized Ferments of Milk, a New Factor in the Ripening of Cheese, 14th, An. Rpt., Univ. Wis. Ag. Exp. Sta., Dec., 1897.

[17] Rice, F. E.: Abst. of paper on apparent acidity of milk, Science, New Series, Vol. L., No. 1296, Oct., 1919.

[18] McInerney, T. J.: Unpubl. Exps., Dept. of Dairy Ind., N. Y. S. Coll. of Agr., Cornell Univ., Ithaca, N. Y.

[19] Traube: Jahrb. V-7, p. 430.

[20] Browne: Reprinted by permission from Brown's "Handbook of Sugar Analysis" published by John Wiley & Sons, Inc.

[21] Mojonnier, T.

CHAPTER III

HISTORY AND PRINCIPLES OF FAT AND TOTAL SOLIDS TESTS

(A) FAT TESTS.

The fat in milk and its products varies so widely, and milk and its products are so easily adulterated that the same are now bought and sold largely on a composition basis. Legislative enactments in many countries fix minimum standards for composition, while the value of dairy cows depends upon the fat percentage in their milk as well as upon the yield. Also difficulty has been experienced in attempting to determine the exact composition of milk. For all of the above reasons, chemists devoted much study and labor to devising methods for accurately determining the percentage of fat in milk and other dairy products. Great impetus was given to the work during the latter half of the 19th century by the rapid growth of the dairy industry, and the introduction of the factory system whereby milk producers pooled their milk for manufacturing purposes. The large number of fat determinations necessary, and the system of manufacture in vogue, required that the method of analysis should be rapid as well as accurate. The increased knowledge of chemistry, and the establishment of many experiment stations with well equipped laboratories in Europe and America, made it possible for a corps of trained chemists to attack the problem. The need for accurate methods was imperative, both upon the part of the investigator and the dealer in dairy products. In the first case, inaccurate results would lead to inaccurate conclusions and to confusion. In the second case inaccurate results would lead to unsatisfactory commercial transactions and financial losses. As a result of these researches, a very large number of tests were developed. While many of the methods possessed considerable merit, a few were so satisfactory that the others did not come

into general use. The tests may be grouped under the following headings:

A. Tests where chemicals are not used.

B. Tests where chemicals are used with or without the assistance of centrifugal force.

A.

1. Cream Gauges.
2. Fjord's Centrifugal cream test.
3. Heeren's pioscope.
4. Feser's lactoscope.
5. The churn test.
6. The oil churn test.

B.

1. Soxhlet's method.
2. Short's method.
3. Parsons' method.
4. Failyer and Willard's method.
5. Cochran's method.
6. Adams' Paper coil method.
7. The Röse-Gottlieb method.
8. Neilson's Kaolin method.
9. Liebermann-Szekely's method.
10. Weibull's desiccation method.
11. Bell's Maceration method.
13. Richmond's Kieselguhr method.
12. The Storch method.
14. The Werner-Schmid method.
15. The Ritthausen method.
16. The Wanklyn method.
17. The De Laval Lactorite.
18. The De Laval Butyrometer.
19. The Leffman and Beam method.
20. The Gerber method.
21. The Russian Babcock method.
22. The Babcock method.
23. Sichler's Sin-Acid Butyrometer test.
24. Lindstom's Butyrometer test.
25. The Mojonnier method.

This bare historical summary indicates the large amount of work which has been done upon this problem. The list as given could be further subdivided, inasmuch as the methods involve several different chemical and physical principles. The principles of all the tests now in use in various parts of the world were discovered during the decade between 1880 and 1890.

The Babcock method, which has attained world wide fame, was first published in 1890. This method is so well known, and so fully described in several excellent books upon the subject, that it needs no further elaboration here.

The Adams method was first published in 1885. This is an English method. It involves the extraction of the sample in a dry form with anhydrous ethyl ether. This method was considerably used, and upon certain dairy products it gives satisfactory results while upon others, particularly skim-milk and concentrated milk products, the results which it yields are sometimes greatly in error. It deserves to be classified as among the very best of the ether extraction methods.

In 1888 Röse[1] published the method with which his name is now associated. Like the Adams method, the principle was based upon the solubility of fats in ether. However, there was this fundamental difference. Adams made a dry extraction while Röse used a wet extraction. The operation was carried out by him as follows:

About 20 grams of the milk are mixed with 2 c. c. of ammonia, then 45 c. c. of alcohol and 120 c. c. of a mixture of equal parts of ether and light petroleum are added. The mixture is shaken in a stoppered burette of 230 c. c. capacity. The volume of the ethereal layer is read off, and 25 c. c. of it is evaporated in a tared flask, the fat being dried by aspirating dried air through the flask for 10 minutes, while heating in a glycerol bath at 90° C. The residue is then cooled and weighed, and the percentage of fat is calculated. An addition of 0.015% should be made for fat remaining in the aqueous layer. The method was modified by Gottlieb and republished in 1892. It then became generally known as the Röse-Gottlieb method.

Schreib, H. (1888),[2] after having considerable experience with the Röse method, and after making special experiments with it on the dry residue, obtained the same amount of fat on the fourth day as on the first, whether the residue was preserved in paper as in Röse's experiments, or in the basins in which the evaporation took place.

Gottlieb (1892)[3] modified the Röse method by reducing the volume of milk to 10 grams and by reducing the volume of the

alcohol to nearly that of the milk. The amount of each ether used was reduced to 25 c. c. and details of the method worked out and explained. He states that the method is trustworthy as shown by the results of many analyses made by the method, and by comparisons with other methods, and that it is easily and quickly carried out. The author made 30 analyses in one day, a number that should not be considered as a maximum. He further states that the cylinder employed for the analyses may also be used for estimating fat in cream, butter and finely powdered cheese.

Lang (1893)[4] compared the results secured with several of the wet extraction methods and states that they agree well.

Weibull (1898)[5] shows that fat tests made by the Röse-Gottlieb method on separated milk and buttermilk check better where the samples are analyzed by different chemists than when other methods are used and Kuhn (1898)[6] agrees with him.

Popp, M. (1903)[7] did considerable work on the Röse-Gottlieb method. He gives the principle of the method and enumerates the precautions to be taken. He with Siegfeld (1903) found that the method worked well with skim-milk and whole milk.

A series of determinations were made on whole milk and skim-milk letting the ether-petroleum milk solution stand ½, 1, 2, 3 and 6 hours. The greatest effect due to time of standing was .02% for skim-milk and .07 per cent for whole milk. Tests were also run using ammonia solutions of varying strengths, but there was no visible effect on the determination.

The revised Röse-Gottlieb method for whole milk, skim-milk and buttermilk is given by Popp[8] as follows: Put 10 c. c. of milk in a 100 c. c. cylinder that is graduated to ½ c. c. Add in order, 1 c. c. of ammonia of proper concentration, 10 c. c. of alcohol, 25 c. c. of ether, 25 c. c. of petroleum ether. Shake after each addition, let stand about an hour, draw off the ether-petroleum ether fat solution till only 1.5 c. c. of it remains in the cylinder.

Using ether, wash the fat left in the pipette into the fat solution, distill off the ether and petroleum ether and dry and weigh the fat as usual. Multiply the weight of fat found by 10 to give direct per cent.

To simplify the method of removing the ether fat solution, Rohrig (1905)[9] devised a graduated stoppered cylinder provided

with a side tube and tap at the 25 c. c. mark. By means of this tap, an aliquot part of the ethereal solution may be drawn off into a weighed flask. The percentage of fat in butter may also be estimated by means of this apparatus.

Thomsen (1905)[10] carried on experiments with the Röse-Gottlieb method to estimate the fat in milk when proteins were peptonized, and the milk dried into a mixture of kaolin and barium carbonate. He secured practically the same results with the method as with the Adams method. The results agree moreover with those obtained by the Röse-Gottlieb method on the unpeptonized milk, but are lower than the results obtained in unpeptonized milk by the Adams method.

In order to determine the saponifying effect of the ammonia on the fat in the Röse-Gottlieb method, Burr (1905)[11] experimented with emulsions of milk fat and water which, when analyzed by this process, yielded the amounts of fat originally weighed out, showing that no loss of fat due to possible saponification by the ammonia had taken place. He states that in the case of milk, the risk of saponification is, moreover, still less, as a considerable portion of the ammonia combines with the casein.

Gordon (1906)[12] used Rohrig's modification of the Röse-Gottlieb method for estimating the fat in eight samples of cream, twelve samples of milk and eight samples of skim-milk, and showed that trustworthy results may be obtained. He states that the proportion of ether to light petroleum ether is of importance and should not differ greatly from that originally recommended. If a mixture of 10 c. c. of ether with 50 c. c. of petroleum ether is employed, the results will be much too low.

Barthel (1910)[13] gives a very thorough review of the best methods for determining the percentage of fat in milk. He divides the methods according to their character and application into main groups: scientific methods and practical methods. He places the Röse-Gottlieb method in the scientific group and reviews the work of a number of other investigators. He states that with whole milk the Röse-Gottlieb, and the extraction methods give results which agree very closely, but with separated milk and buttermilk the former always shows higher values. The differences on an average, are .03 per cent for separated milk, and for buttermilk more, sometimes as much as 0.1 per cent. The rea-

son for this lies simply in the fact that in the latter cases the fat is in a very finely divided state, and so cannot be extracted completely after drying on some porous material.

Kropat (1914)[14] applied the modification to the estimation of the fat in creams, butter and cheese.

Richmond (1910)[15] makes the following statement: "On the whole, the Gottlieb method is the best, though those due to Adams, Storch, Werner-Schmid, and Nell are little, if at all, inferior in accuracy.

Melliere (1914)[16] attempted to devise a method somewhat similar to the Röse-Gottlieb, and Woodman modified the method by reducing the amount of milk taken and the amount of reagents used. He also devised an apparatus for removing the ether fat solution. He states that all of the successful methods for determining the fat by direct extraction from the milk itself involves the complete or partial solution of the casein. In the Röse-Gottlieb method the casein, precipitated from the milk in very finely divided particles by the alcohol, is dissolved by the ammonia. The fat is dissolved by the ethyl ether, and the addition of petroleum ether is to render less soluble the milk sugar or other non-fatty solids which would be dissolved by ethyl ether alone.

Balton[17] gives a description of the Röse-Gottlieb method and states in his description of the Gerber method that "it is very advantageous to read the tubes against some standard method of fat analysis, such a method is the Gottlieb process."

In his excellent work on food analysis, Leach, 1913, after describing his modification of the Babcock method for estimating the fat percentage in sweetened condensed milk, recommends the Röse-Gottlieb method when the accuracy of a gravimetric process is desired. It is the only test that he mentions in his directions for determining the percentage of fat in ice cream.

In the United States probably the first user of the Röse-Gottlieb method was the late Prof. G. E. Patrick, for many years the chief of the Dairy Laboratory, United States Department of Agriculture, at Washington. It was largely through his efforts that the merits of this method were brought to the attention of the American chemists, and that its use became introduced in American laboratories.

Bigelow and Fitzgerald (1915),[18] chemists in the research laboratory of the National Canners' Association, collaborating with Govers, Mojonnier and Grinrod, chemists employed in the laboratories of separate condensed milk companies, made a comparative study of the Babcock and Beimling methods and modifications of them, and of the Röse-Gottlieb method for determining the percentage of fat in evaporated milk. The results of comparative tests in each of the four laboratories are given for a number of samples. In their comments on the Adams method, Bigelow and Fitzgerald state that "the error due to the fat extracted from the coils and thimbles is partly compensated by the fact that the milk fat can never be extracted completely from a sample prepared by drying in this manner. The extraction of the milk fat continues for a number of days, and is practically never complete, and the double method of extraction by the Adams method has no advantage with evaporated milk." They found considerable difficulty in securing correct results with the Babcock method on evaporated milk. The trouble is attributed to a change in the protein as a result of the heat of processing, rendering its solution more difficult, and thus preventing the complete separation of the fat. When used in the plant with evaporated milk that has not been sterilized, the results are better, but still are only approximate.

In the summary of the experiment, it is stated that "the various modifications of the Babcock method are not sufficiently accurate to be depended upon for determining whether the evaporated milk is up to standard. It is strongly advisable that the Röse-Gottlieb method be used for this purpose. If any of the modifications of the Babcock method be employed for evaporated milk, considerable allowance must be made for the inaccuracies of the method. Results obtained by any modification of the Babcock method are totally inaccurate unless the fat column is clear, with the meniscus at the bottom of the column perfect, and not distorted by either char or milky appearance."

In Table 4 there is given the fat percentages that they obtained by different methods from a few samples of evaporated milk.

TABLE 4.

Fat Percentages Obtained by Different Methods.

Sample Number.	Röse-Gottlieb method.	Adams method.	Babcock method.	Beimling method.
707	8.16	7.68	....	8.18
708	8.03	7.50	....	8.03
709	7.67	6.77	....	7.67
710	7.69	7.18	....	7.77
711	7.77	7.16	....	7.69
712	7.89	7.22	....	7.81
713	7.42	6.97	....	7.38
802	8.62	8.30	8.60	8.69
807	7.70	6.77	7.65	7.75
824	8.56	7.68	8.25	8.48
834	8.26	....	8.15	8.07
836	8.41	....	8.35	8.48
830	7.90	....	....	7.78
837	8.07	....	8.05	7.92
840	8.40	....	8.20	8.25

In this experiment the Babcock test was modified by taking nine grams of evaporated milk and adding ten c. c. of water. The test was then completed in the regular way, excepting that the reading was taken from the extreme bottom of the fat column to the bottom of the upper meniscus, multiplying the reading by 2, and adding a constant factor of 0.15.

The Beimling test was carried out in a Babcock milk test bottle. Nine grams of the evaporated milk were taken; 10 c. c. of water added, and thoroughly shaken. The Beimling test was completed in the regular way, and then read from the extreme bottom of the fat column to the bottom of the upper meniscus. The reading was multiplied by 2 and 0.25% deducted.

The Röse-Gottlieb method as used in the experiment was carried out as follows:

"Weigh from 4.5 to 5.0 grams evaporated or condensed milk into a Röse-Gottlieb tube, add water to make about 11 grams and add 1¼ to 1½ c. c. concentrated ammonium hydroxide and thoroughly mix by shaking.

"Add 10 c. c. of 95% alcohol and shake thoroughly. Fill up to the level of the side tube with water, if necessary, and shake. Add

25 c. c. ether and shake well for one minute. Add 25 c. c. petroleum ether (B. P. below 65° C.), and shake well for one minute.

"Allow tube to stand until layers separate well. Draw off ether fat solution as completely as practicable, and run it through a small, quick acting filter into a weighted flask. (Weighted by counterpoising, if not finished the day it is started.)

"Re-extract liquid into tube just as before with 25 c. c. of each ether, shaking after each is added. Before the addition of the ether, a little alcohol may be added, and the contents of the tube mixed by shaking, to bring the layer of ammoniacal liquid close up to the outlet tube, for by repeated extractions, the surface of separation is lowered.

"Run the ether solution from the second extraction through the filter into the flask and wash end of spigot, filter paper, and the lower surface of the funnel, with sulphuric ether; or better, with a mixture of equal parts of sulphuric ether and petroleum ether which has been allowed to stand for separation of water.

"In the examination of cream, a third extraction is necessary, but with evaporated and condensed milk, the third extraction recovers only 0.02 or 0.03% fat and may be omitted.

"Evaporate the ether slowly on a steam bath and dry fat in steam oven until its weight is constant. Weigh after one hour and then at half-hour intervals. As soon as the fat begins to gain in weight, stop drying and take the next previous weight. Increase of weight is due to oxidation after all moisture and alcohol are gone. In all cases the drying should be completed the day it is begun.

"Prove purity of the extracted fat by solution in petroleum ether. If a residue remains, filter the ether into another tared flask and wash flask, filter and funnel with petroleum ether. Evaporate, dry and weigh as before. If the work has been properly done, neither a third extraction nor purification of the fat is necessary. A blank determination should be made unless the reagents are known to be free from residue. This blank is small, being perhaps about 0.01 and 0.02% with proper reagents.

"The petroleum ether and ethyl ether used should be distilled to insure their purity. Petroleum ether employed should boil below 65° C."

Biesterfeld and Evenson in 1917[19] reported results obtained by the Röse-Gottlieb method upon condensed milk and milk powders. By following the extraction in the usual alkaline medium, with an additional extraction in an acid medium, they recovered a trace of fat which they believed could not be recovered by the alkaline extraction alone. Their suggestion has not come into general use partly on account of the extra time required, and partly on account of the small factor of safety which the trace of remaining fat may provide.

The Mojonnier modifications of the Röse-Gottlieb method are based both upon the process and apparatus patents applied for or granted to J. J. Mojonnier. The patents issued to date are as follows:

Process patent April 3, 1917, Sept. 27, 1921; Apparatus patents Feb. 5, 1918, April 9, 1918, June 11, 1918, and Aug. 5, 1919. Numerous claims upon additional patents not yet issued have been allowed.

The improvements have made it possible to shorten the time greatly and also to increase largely the accuracy of the test. Some of the earlier methods of testing dairy products were rapid, but the results were inaccurate. The Röse-Gottlieb method as originally applied, and to a considerable extent several of the earlier methods were accurate but slow. Too much time was required to make a test to make the methods practicable for factory control work. The improvements invented by Mojonnier combine in one apparatus a means for obtaining both accuracy and speed. These two considerations are equally valuable when dealing with dairy products that are at once both valuable and perishable. Fig. 12 shows graphically the saving in time by the Mojonnier modifications, as compared with the Röse-Gottlieb method.

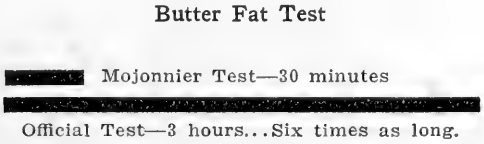


Fig. 12. Saving in Time Upon Fat Test Mojonnier Method.

THE MOJONNIER MILK TESTER.

This is the name applied to the apparatus devised by Mojonnier for applying his modifications of the Röse-Gottlieb method. A novel feature of the Mojonnier Tester is the fact that it combines in one equipment, methods and apparatus for making both fat and moisture (or total solids) tests. This dual feature is not found in any other apparatus upon the market. Inasmuch as the above two tests are the most important tests required in appraising the value of dairy products, the ability to make rapidly both tests simultaneously upon the same product with the certainty of getting accurate results, becomes at once obvious. The development of the total solids test will be treated in other paragraphs of this chapter.

REAGENTS TO BE USED IN THE MOJONNIER MILK TEST AND THEIR FUNCTIONS.

The reagents used in making fat tests upon the Mojonnier Tester are as follows:

(1). Distilled water. This should be free from oil, or any kind of mineral residue, and as nearly chemically pure as possible. It should be stored in glass, enameled steel, or tinned copper containers.

(2). Ammonia. Commercial, chemically pure, testing about 26° Baume, or .8974 specific gravity at 60° F. and containing about 29.40 per cent ammonia gas (NH_3).

(3). Alcohol. 95 per cent, 190° proof, .8164 specific gravity at 60° F. best quality grain or ethyl alcohol. Should not leave any residue upon evaporation.

(4). Ethyl Ether. Best commercial quality. To contain not more than 4 per cent of water. Specific gravity .713 to .716 at 25° C. Boiling point about 35° C. To leave no residue upon evaporation. If there is any doubt as to its purity, it should be re-distilled before using. It should be stored in a cool place. It is both inflammable and explosive, and care must be exercised in its handling. It should be stored in glass, glass enameled, or tinned steel containers.

(5). Petroleum Ether. Best commercial quality. Specific gravity .638 to .660 at 25° C. Boiling point not over 120 to 140° F.

Should distil at not over 140° F., and leave no residue upon evaporation. If there is any doubt as to its purity, it should be re-distilled before using. It should be handled with the same care and in the same manner as ethyl ether.

RUNNING BLANKS UPON REAGENTS.

Too much emphasis cannot be placed upon using reagents of the proper purity. Blank determinations using water instead of milk should be made frequently, as errors which can be avoided may creep into the work.

THE FUNCTION OF THE VARIOUS REAGENTS.

Water. Distilled water is added to concentrated milk products in the flask in order to bring the substances to the fluid condition of whole milk, and to provide a liquid to carry the solids not fat in solution when they are dissolved by the other reagents. Sometimes it is also necessary to add a little water after centrifuging the second extraction in order to bring the dividing line between the ether fat solution and the solids not fat solution up to the desired point which permits all of the ether fat solution to be poured from the flask without removing any of the other substances.

Ammonia. The ammonia is added to dissolve the casein which is not in true solution in milk, but is present in the form of minute gelatinous particles evenly distributed throughout the mass. It also neutralizes the acidity of the product. This reduces the viscosity of the mixture, and permits the solvent which is added later to more readily dissolve the fat. The ammonia would also probably tend to destroy colloidal phosphorous compounds, if any are present, and still further reduce the viscosity.

Alcohol. The alcohol assists in preventing the formation of the characteristic gelatinous mixture which occurs when ether is vigorously shaken with milk. It thus enables the solvent to come in contact with the fat globules during the shaking operation, and also allows the ether fat solution to collect in a layer when all of the fat has been dissolved.

Ethyl Ether. Ethyl ether dissolves the fat and holds it in its own solution. It also dissolves a small amount of the milk sugar

and other solids not fat which, if not corrected, would cause erroneous results.

Petroleum Ether. Petroleum ether is also a good fat solvent, but in this test it assists especially in throwing out from the ethyl ether-fat solution the last traces of water. The water holds milk solids not fat in solution and if any of the water is carried over with the ether-fat solution the other solids would be present with the fat when it is finally dried and weighed, thus causing results that would be too high. It throws out of the ethyl ether solution any solids not fat that may have been dissolved therein.

Phenolphthalein is sometimes added to the extent of a drop or two before pouring off the ether solution. This makes a sharp dividing line between the ether solution and the non-fatty residue, but this practice is not recommended, owing to the slight solubility of phenolphthalein in ether which causes too high results.

EFFECT OF USING EITHER MORE OR LESS THAN THE STANDARD AMOUNT OF THE VARIOUS REAGENTS.

Table 5 gives the results obtained by varying in turn the various reagents used in making the fat tests. The object being to ascertain the effect of such variations, and the limits allowable without affecting the accuracy of the tests. Five sets of experiments were made, varying in turn each of the five reagents. In one case the regular quantity of all reagents was used. In the second case less than the regular amount of any one reagent was used, leaving the others constant. In the third case more than the regular amount was used, leaving the others constant.

TABLE 5—Effect of Using Varying Amounts of Reagents.

Regents and How Used	Method of Varying Reagents	FRESH MILK				CREAM			
		Quantity of Reagents Used		Per Cent Fat	Remarks	Quantity of Reagents Used		Per Cent Fat	Remarks
		1st Ext.	2nd Ext.			1st Ext.	2nd Ext.		
Water varied Other reagents regular	Regular amount	None	None	3.13	NORMAL	6 cc	None	35.99	NORMAL
	Less than regular amount	None	None	3.13	NORMAL	None	None	35.97	Light jelly adding ethyl ether. Line low
	More than regular amount	5 cc	None	3.12	Dividing line too high. Impractical	11 cc	None	35.92	Foaming after adding alcohol. Line high
Ammonia varied Other reagents regular	Regular amount	1.5 cc	None	3.13	NORMAL	1.5 cc	None	35.99	NORMAL
	Less than regular amount	None	None	3.13	Heavy emulsion after adding ethyl ether	None	None	35.93	Milky after adding alcohol and ether
	More than regular amount	6.50cc	None	3.13	Dividing line too high. Impractical	6.5 cc	None	35.95	NORMAL
Alcohol varied Other reagents regular	Regular amount	10 cc	5 cc	3.13	NORMAL	10 cc	5 cc	35.99	NORMAL
	Less than regular amount	5 cc	None	1.92	Heavy jelly after adding ethyl ether extraction incomplete	5 cc	None	33.74	Jelly after adding ethyl ether extraction incomplete
	More than regular amount	20 cc	5 cc	3.13	Line too high Impractical	20 cc	5 cc	35.90	NORMAL
Ethyl ether varied Other reagents regular	Regular amount	25 cc	15 cc	3.13	NORMAL	25 cc	25 cc	35.99	NORMAL
	Less than regular amount	10 cc	10 cc	3.07	Light jelly after adding ethyl ether	15 cc	15 cc	35.86	Light jelly
	More than regular amount	35 cc	25 cc	3.12	No advantage	35 cc	25 cc	35.93	Low line
Petroleum ether varied Other reagents regular	Regular amount	25 cc	15 cc	3.13	NORMAL	25 cc	25 cc	35.99	NORMAL
	Less than regular amount	10 cc	10 cc	3.13	NORMAL	15 cc	15 cc	35.90	Extraction incomplete
	More than regular amount	35 cc	25 cc	3.13	No advantage	35 cc	25 cc	35.89	NORMAL No advantage

TABLE 5—Effect of Using Varying Amounts of Reagents (Continued).

Reagents and How Used	Method of Varying Reagents	EVAPORATED MILK				SWEETENED CONDENSED MILK				ICE CREAM MIX			
		Quantity of Reagents Used		Per Cent Fat	Remarks	Quantity of Reagents Used		Per Cent Fat	Remarks	Quantity of Reagents Used		Per Cent Fat	Remarks
		1st Ext.	2nd Ext.			1st Ext.	2nd Ext.			1st Ext.	2nd Ext.		
Water varied	Regular amount	4 cc	None	8.09	NORMAL	8 cc	None	8.76	NORMAL	6 cc	None	13.53	NORMAL
	Less than regular amount	None	None	8.04	Jelly after adding ethyl ether	None	None	6.62	Heavy jelly after adding alcohol	None	None	13.57	Heavy jelly after adding ethyl ether
Other reagents regular	More than regular amount	9 cc	None	8.09	Line high	13 cc	None	8.69	Line high extraction incomplete	11 cc	None	13.53	Light jelly Line high
Ammonia Varied	Regular amount	1.5 cc	None	8.09	NORMAL	1.5 cc	None	8.76	NORMAL	1.5 cc	None	13.53	NORMAL
	Less than regular amount	None	None	8.13	Jelly after adding ethyl ether	None	None	8.77	Milky Line high	None	None	13.60	Jelly after adding ethyl ether. Milky.
Other reagents regular	More than regular amount	6.5 cc	None	8.09	NORMAL	6.5 cc	None	8.82	Line high Results high	6.5 cc	None	13.54	Line high
Alcohol varied	Regular amount	10 cc	5 cc	8.09	NORMAL	10 cc	5 cc	8.76	NORMAL	10 cc	5 cc	13.53	NORMAL
	Less than regular amount	5 cc	None	5.61	Very milky extraction incomplete	5 cc	0 cc	3.42	Extraction incomplete	5 cc	None	5.36	Heavy jelly extraction incomplete
Other reagents regular	More than regular amount	20 cc	5 cc	8.11	Line high Light emulsion	20 cc	5 cc	8.93	Line high. Results high.	20 cc	5 cc	13.65	Line high. Some alcohol carried over.
Ethyl ether varied	Regular amount	25 cc	25 cc	8.09	NORMAL	25 cc	25 cc	8.76	NORMAL	25 cc	25 cc	13.53	NORMAL
	Less than regular amount	15 cc	15 cc	8.07	Extraction incomplete	15 cc	15 cc	8.75	Line a little high	15 cc	15 cc	13.50	Extraction incomplete
Other reagents regular	More than regular amount	30 cc	30 cc	8.09	No advantage	30 cc	30 cc	8.76	No advantage	30 cc	30 cc	13.53	No advantage
Petroleum ether varied	Regular amount	25 cc	25 cc	8.09	NORMAL	25 cc	25 cc	8.76	NORMAL	25 cc	25 cc	13.53	NORMAL
	Less than regular amount	15 cc	15 cc	8.07	Extraction incomplete	15 cc	15 cc	8.75	Extraction slightly incomplete	15 cc	15 cc	13.46	Extraction incomplete
Other reagents regular	More than regdlar amount	30 cc	30 cc	8.09	No advantage	30 cc	30 cc	8.77	No advantage	30 cc	30 cc	13.53	No advantage

A study of the results given in the preceding table proves the importance of using the various reagents in the right proportion, one to the other, and in the proportions that have been found by experience to give the correct results upon the various dairy products. The quantity of both water and alcohol used have the largest influence upon the accuracy of the results. Using too little water causes a gelatinous precipitate when the ethyl ether is added, and in turn this causes low results. Using too much water raises the dividing line in the extraction flask, and makes it impossible to pour off completely the ether solution containing the fat, from the remainder of the reagents. Using too little alcohol causes particularly a heavy jelly upon adding ethyl ether, and in turn causes results that are greatly in error. This emphasizes the importance of using only the best quality of ethyl alcohol, conforming to the specifications given. Using too much alcohol frequently causes too high results, due to raising the dividing line too much. Using too little of either ethyl or petroleum ethers causes too low results on account of the extraction of the fat being incomplete, while using too much causes a waste of reagents without increasing the accuracy of the test. Variation in the quantity of ammonia used causes less disturbance than variation in the quantity of the other reagents.

RESULTS OF COMPARATIVE FAT TESTS BY MOJONNIER METHOD AND OTHER METHODS.

Comparison of results by Mojonnier and Babcock methods upon whole milk.

A careful experiment was made to determine the relative efficiency of the Babcock method as applied to fresh milk with the Mojonnier method. The tests using the Babcock method were made in two different Chicago laboratories. The tests using the Mojonnier method were made by F. M. Bundy. The results of the experiments are given in Fig. 13, next page.

The horizontal line, which may be called the standard line, represents the values obtained using the Mojonnier method. The spots and stars represent the amount overread or underread by the Babcock method.

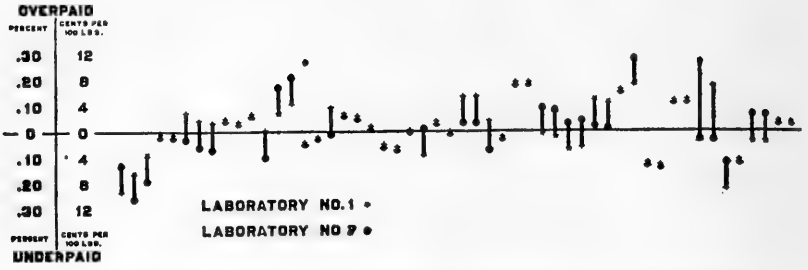


Fig. 13. Results by Mojonnier and Babcock Methods Upon Whole Milk.

Only the difference between the two methods is shown. All values above the standard line show overreading. All under the standard line show underreading. The stars give the values obtained by one laboratory, and the round spots those obtained by the second laboratory upon the same sample. The amounts that would have been overpaid or underpaid had the tests been obtained in a plant that buys its milk upon the butter fat basis are given both in per cents and in cents per 100 pounds, at the left of the table. Each one-tenth per cent is assumed to have a value of four cents. The differences, if any upon the same sample as reported by the two respective laboratories, are represented by the vertical bands connecting the stars and the round spots.

The results of the experiments show plainly the wide variation in tests obtained by the same operator, and also between two different operators. Out of a total of 52 samples tested, laboratory No. 1 reported 30 samples that tested more than .05% either over or under the standard line, and laboratory No. 2 upon the same number of tests, reported 27 samples that tested likewise. Out of 104 tests, irrespective of the operator, 51.9% of the tests were overread and 43.3% were underread.

A COMPARISON OF THE FAT PERCENTAGES OBTAINED IN SEVERAL MILK PRODUCTS BY DIFFERENT METHODS OF TESTING.

Under the direction of one of the authors[30] in the dairy testing laboratory at Cornell University determinations were made

by various methods of the fat content of different dairy products. The results are given in the tables immediately following.

TABLE 6.

Fat Content of Whole Milk as Found by Three Methods; upon 14 Different Samples.

Sample Number.	Mojonnier.	Adams.	Babcock.	Sample Number.	Mojonnier.	Adams.	Babcock.
1	4.22	4.17	4.30	8	5.16	5.11	5.00
2	3.67	3.62	3.60	9	4.40	4.44	4.30
3	3.98	3.91	4.10	10	3.40	3.34	3.40
4	4.76	4.77	4.80	11	4.23	4.25	4.30
5	3.64	3.61	3.60	12	3.32	3.30	3.40
6	4.71	4.62	4.80	13	4.78	4.71	4.80
7	3.87	3.86	3.90	14	4.85	4.82	5.00

The results in the above table show a close agreement between the Mojonnier and the Adams methods, when applied to fresh milk. There is a considerable disagreement in results between the Babcock and the other two methods. The difference is not constant in one direction, as in other comparative tests reported in this chapter.

TABLE 7.

Fat Content One Sample Cream Tested Seven Times by Two Methods, and One Sample Evaporated Milk Tested Eight Times by Three Methods.

Cream.		Evaporated Milk.		
Mojonnier method. Per cent.	Babcock method. Per cent.	Mojonnier method. Per cent.	Adams method. Per cent.	Babcock method. Per cent.
36.68	37.00	8.07	7.92	7.90
36.75	37.50	8.05	7.97	8.00
36.68	37.50	8.05	8.08	7.90
36.69	37.25	8.11	7.93	8.20
36.70	36.50	8.08	7.96	8.20
36.74	37.00	8.07	8.06	8.00
36.70	36.50	8.08	8.03	8.40
....	....	8.07	8.00	8.20

The above results show the close agreement by the Mojonnier method upon both products, and the considerable disagreement in results by other methods, both within themselves, and by comparison with the Mojonnier method.

TABLE 8.

Fat Content of Skim-Milk as Found by the Mojonnier and the Babcock Methods. Tests Made by Prof. T. J. McInerney, Cornell Univ.

Sample.	Mojonnier method. Duplicate.	Babcock test. Duplicate.	Difference. Duplicate.
1	.10 — .10	.05 — .05	.05 — .05
2	.10 — .10	.06 — .06	.04 — .04
3	.11 — .11	.03 — .03	.08 — .08
4	.07 — .09	.05 — .05	.02 — .04
5	.29 — .30	.26 — .26	.03 — .04
6	.07 — .07	.01 — .02	.06 — .05
7	.074— .074	.04 — .04	.034— .034
8	.08 — .08	.03 — .04	.05 — .04
9	.24 — .27	.14 — .14	.10 — .13
Average	.126— .132	.074— .076	.051— .056

The above results prove that the Babcock method gives too low results when applied to skim-milk. The shortage in this experiment was found to range from .02 to .13%, or upon the average about .06%.

COMPARISON OF RESULTS UPON SAME PRODUCT BY DIFFERENT OPERATORS, USING MOJONNIER METHOD.

One sample of sweetened condensed milk was tested by six different operators using the Mojonnier method. The results obtained are given in the following table.

TABLE 9.

Fat Content Same Sample Sweetened Condensed Milk by Mojonnier Method, as Found by Six Different Operators, Compared with Results by Official Method.[20]

Operator No.	Where tests were made.	Per cent fat found.
1	Pecatonica, Ill.	8.38
2	Grayslake, Ill.	8.44
3	Burlington, Wis.	8.38
4	Burlington, Wis.	8.38
5	Valders, Wis.	8.37
6	Valders, Wis.	8.36
	Burlington, Wis.	8.36[21]

The above results indicate the close agreement possible to obtain between different operators, being one of the best possible proofs of the accuracy of the method.

TABLE 10.

Fat Content of Buttermilk by the Mojonnier and Babcock Methods

	Mojonnier Method.		Babcock Method, Regular Procedure. 17.6 cc. buttermilk. 17.6 cc. acid, 16″ disk. Centrifuged at 1000 R.P.M. for 5, 2 and 1 mins.		Babcock Method, Modified Procedure. 17.6 cc. buttermilk. 23.0 cc. acid, 16″ disk. Centrifuged at 1500 R.P.M. for 10, 2 and 1 mins.	
	Per cent fat.		Per cent fat.		Per cent fat.	
	Original.	Duplicate.	Original.	Duplicate.	Original.	Duplicate.
1	.528	.523	....	....	.44	.46
2	.693	.710	.12	.12	.41	.46
3	.661	.667	.16	.14	.37	.31
4	.333	.332	.04	.04	.06	.07
5	.356	.350	.05	.04	.09	.07
6	.299	.295	....	....	.18	.18
7	.328	.320	.05	.05	.21	.22
8	.325	.322	.03	.03	.09	.13
9	.431	.390	.08	.08	.20	.20
10	.480	.440	.17	.17	.27	.27
11	.597	.586	.26	.25	.34	.37
12	.431	.449	.07	.07	.30	.30
13	.432	.434	.12	.12	.20	.20
14	.472	.475	.11	.11	.25	.25
15	.447	.451	.10	.10	.25	.25
16	.386	.382	.05	.06	.18	.20
17	.649	.646	.27	.27	....	....

The above results indicate that the present method of applying the Babcock test to the determination of fat in buttermilk is useless, as it is misleading, and it may lead to considerable loss.

COMPARISON OF RESULTS BY MOJONNIER AND BABCOCK METHODS UPON ICE CREAM MIX.

A number of compartive tests upon the different qualities of ice cream mix are given in the following table.[22]

TABLE 11.

Comparison of Results by Mojonnier and Babcock Methods Upon Ice Cream Mix.

Wholesale grade. All ingredients in mix. Ready for freezing.					Philadelphia grade. All ingredients in mix. Ready for freezing.				
Per cent fat.					Per cent fat.				
Sample No.	Mojonnier	Babcock	Over reading	Under reading	Sample No.	Mojonnier	Babcock	Over reading	Under reading
			By Babcock method.					By Babcock method.	
1	9.85	8.50	...	1.35	22	14.39	14.00	...	.39
2	10.62	8.60	...	2.02	23	14.89	15.00	.11	....
3	10.09	8.40	...	1.69	24	16.70	15.50	...	1.25
4	9.61	8.35	...	1.26	25	14.64	14.40	...	.24
5	9.65	8.40	...	1.25	26	15.15	15.40	.25	....
6	10.36	9.20	...	1.16	27	14.77	14.80	.03	....
7	9.55	8.40	...	1.15	28	15.81	15.40	...	.41
8	10.00	9.60	...	.40	29	15.33	15.00	...	.33
9	10.18	9.60	...	.58	Special mix. No cane sugar added.				
10	9.72	9.60	...	.12					
11	9.61	9.00	...	.61	30	11.09	8.00	...	3.09
12	9.83	9.60	...	.23	31	11.80	10.00	...	1.80
13	10.12	9.20	...	.92	32	12.58	9.80	...	2.78
14	10.35	8.80	...	1.55	33	11.92	9.60	...	2.32
15	10.03	9.00	...	1.03	34	11.82	9.20	...	2.62
16	10.02	8.80	...	1.22	35	11.60	8.50	...	3.10
17	10.43	9.60	...	.83	36	11.20	8.65	...	2.55
18	10.36	9.20	...	1.16	37	12.04	9.10	...	2.94
19	10.72	10.40	...	.32	38	11.78	9.30	...	2.48
20	9.44	9.60	.16	...					
21	10.09	9.80	...	.29					

In the above mixes the milk S. N. F. was as follows:

Philadelphia grade	6.50% milk S. N. F.
Wholesale grade	10.00% milk S. N. F.
Special mix	18.00% milk S. N. F.

Inasmuch as the mix containing the lowest amount of milk S. N. F. shows the closest agreement, and that containing the most, the greatest disagreement in results by the two methods,

W. O. Frohring,[22] concludes that this factor largely controls the difference. Other factors causing errors by the Babcock method enter into the testing of ice cream mix, as well as in the case of other dairy products. The results given in the table indicate the possibilities for serious errors when the Babcock method is used to test ice cream mix.

The results reported by the Babcock method included only those in which the fat column was entirely clear. Nine grams of the ice cream mix were placed in eight per cent milk bottles. To this was added 9 c. c. of acetic acid, and the usual amount of sulphuric acid. All readings were made from a water bath at 140° F.

PROOFS OF ACCURACY OF FAT DETERMINATIONS MADE BY THE MOJONNIER METHOD.

In a careful experiment[23] the fat obtained from a large number of milk fat extractions on the Mojonnier Tester was itself tested for purity by the Mojonnier method. The fat was weighed into the extraction flask, 10 c. c. of water added and the determination completed in the usual way. The results were as follows:

Weight of fat in the sample taken.....	.4004
Weight of fat recovered.....	.4003
Per cent of fat in the fat extracted from milk products	99.98
Per cent of moisture in the fat extracted from milk products.....	0.02

These results prove that the substance extracted from milk products by the Mojonnier method is practically chemically pure milk fat.

In another experiment an accurately weighed amount of pure fat was placed in an extraction flask and extracted according to the procedure described above. With two extractions 99.90 per cent of the fat was recovered. With three extractions 99.97 per cent was recovered. When pure fat was added to skim-milk, in which the fat had been previously determined for the purpose of making the necessary corrections, the total recovery of the pure fat amounted to 99.96 per cent with two extractions.

These results show that pure fat under the conditions given can be practically completely recovered when the determination is made by the Mojonnier method.

For the purpose of comparison, in another experiment, two large samples of the product recovered from the fat column in Babcock test bottles were tested for fat, moisture, and total solids with the results given in Table 12.

TABLE 12.

Composition of Fat Column in Babcock Test Bottles

Sample.	Per cent of moisture.	Per cent of Solids not fat.	Per cent of fat.
No. 1[24]	3.01	6.29	90.70
No. 2[25]	.85	3.99	95.16

These results show that the fat column in the Babcock test is not composed of pure fat. The amount of substances not fat present are probably offset to some extent by the fat not collected in the fat column, but no doubt variations in the amount of these substances in the fat column are responsible for some of the inaccuracies of the test.

(B) TOTAL SOLIDS AND MOISTURE TESTS.

The total solids test of many dairy products ranks closely in importance with the fat test. Among the principal reasons being that the percentage of total solids in pure milk varies between quite wide limits; the minimum percentages for total solids have been fixed in many cases by legislative enactments, and by municipal and state regulations, and in the manufacture of concentrated milk products. The percentage of total solids affects both the process and the quality of the product and the cost thereof.

As in the case of butter fat, a large amount of work has been done in the past in devising satisfactory methods for estimating total solids in milk and its products. The efforts have been directed principally in two directions, namely (1) by formulas based upon the butter fat test and the specific gravity, and (2) by various modifications of gravimetric methods.

Babcock,[26] Richmond[27] and Fleischman,[28] all published formulas for calculating total solids in dairy products. These formulas

are all based upon knowing the specific gravity of the milk, and the percentage of fat present, so that these determinations have to be made before the percentage of total solids can be calculated.

If the method is used in practical work, the Quevenne lactometer reading is taken, and this reading is used in the formula. The fat is determined by the Babcock or similar method. Working in this way the calculations can be depended upon to give only a rough approximation of the true percentage of total solids present, particularly in the case of condensed milk products. The Babcock formula is favored in this country over other formulas. It is as follows:

$$\text{Total solids} = \frac{L}{4} + 1.2 \times F$$

L = Quevenne lactometer reading
F = Per cent of fat

Problem: The Quevenne lactometer reading of a milk sample is 31 and the per cent of fat is 3.60.

$$\text{Total solids} = \frac{31}{4} + 1.2 \times 3.6 = 12.07$$

Another formula that gives results as dependable as the above especially when used on rich milk is the following:

$$\text{Solids not fat} = \frac{L + F}{4}$$

Problem: The Quevenne lactometer reading of a milk sample is 32 and the per cent of fat is 3.80.

$$\text{Solids not fat} = \frac{32 + 3.80}{4} = 8.95\%$$

$8.95\% + 3.80 = 12.75$, % of total solids

This subject is discussed at length by numerous authorities to which the reader is referred for further information.

In the gravimetric methods the underlying principle in all cases is the same, but they differ from one another in many particulars. In all cases a weighed quantity of milk is dried to constant weight at about the temperature of boiling water, either with or without the use of any absorbent materials. Among the best known of the gravimetric methods are the Babcock asbestos method, the method of the Society of Public Analysts of England, the Adams paper coil method and Mojonnier method.

Bigelow and Fitzgerald[29] in their able research made a thorough investigation of methods for determining total solids in evaporated milk. They found "that the addition of sand to milk in drying constitutes a danger rather than a safeguard, and needlessly complicates the method."

The gravimetric method recommended by them for determining total solids in evaporated milk was as follows:

"Weigh two grams of sample into a three-inch lead bottle cap; add about 5 c. c. of water to dissolve the milk and distribute it over the bottom of the dish; heat in the water jacketed oven under atmospheric pressure until the sample is evaporated to apparent dryness. Continue heating for four hours and weigh. Return to the oven and heat again for two hours and weigh. If the two weights show a loss of more than 0.05 per cent, the heating is continued, with weighings at two hour intervals until the last two weighings do not differ by more than 0.05 per cent."

They made a comparative study of results obtained by the above gravimetric method, and by formula based upon the butter fat test and the specific gravity of the sample. The formula recommended by them to be used with both raw and evaporated milk was as follows:

Per cent total solids = 1.2 x fat + (specific gravity — 1.000) 0.25.

They found "that with sterilized evaporated milk more accurate results were obtained on the original samples than after dilution. Before sterilization the product is of course, more fluid and the specific gravity can be determined more readily, and the results are somewhat more accurate than in the processed milk. Even in that case, however, the method of calculation from the specific gravity is not as accurate as the determination by drying, and the latter is strongly recommended."

The results reported are given in Table 13.

J. J. Mojonnier introduced the method now known as the Mojonnier method in 1915. The principles underlying this method are covered by process patents dated April 3, 1917. It differs in several particulars from all other methods previously employed.

TABLE 13.

Total Solids Found by Formula and by Gravimetric Method. Bigelow and Fitzgerald.

Sample No.	Per cent total solids.				
	Calculated from specific gravity.				
	Specific gravity bottle, undiluted.	Specific gravity bottle, diluted 1—1.	Westphal balance, diluted 1—1.	Specific gravity spindle, undiluted.	By drying.
802	26.64	26.29	26.44	26.83	26.68
807	26.46	....	26.28	....	26.54
824	26.87	26.28	26.84	26.83	26.81
834	26.76	26.27	26.47	26.56	26.50
836	24.77	24.49	24.89	24.71	25.05
837	26.88	26.60	26.84	27.29	27.13
840	28.70	28.32	28.68	28.89	28.59

The patented apparatus designed to carry out the method is all embodied in the Mojonnier Tester, already described. The two main advantages of the Mojonnier method are the great saving in time possible to effect, and the increased accuracy of the results obtained. The saving in time over the official method is illustrated by Fig. 14.

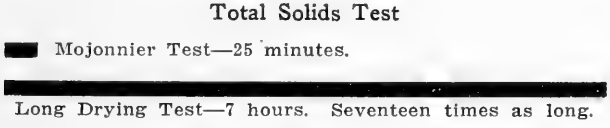


Fig. 14. Saving in Time Upon Total Solids Test.

PROOF OF ACCURACY OF THE MOJONNIER TOTAL SOLIDS TEST.

A series of ten total solids determinations upon the same sample of evaporated milk were made by J. J. Mojonnier upon April 7, 1915, with the following results: 25.95, 25.91, 25.95, 25.97, 25.93, 25.91, 25.97, 25.92, 25.93 and 25.99.

These results show marked agreement in the entire series.

Through the courtesy of the National Dairy Co., Toledo, Ohio, we report the results given in Table 14, being the tests obtained

upon samples of milk from the same batches by their operators of the Mojonnier Tester, and by the operator in the central laboratory at Chicago, also using the Mojonnier Tester.

TABLE 14.
Total Solids Test Upon Evaporated Milk by Two Operators.

Where tests were made.	Sample No. 25	Sample No. 36	Sample No. 59	Sample No. 82
National Dairy Co., Morenci, Mich....	26.66	26.19	26.30	26.41
Mojonnier Bros. Co., Chicago, Ill.; Miss Lucy Klein.....	26.57	26.24	26.29	26.40

The ability of different operators to obtain practically duplicate results upon the same samples of evaporated milk is one of the best proofs of the accuracy of the method.

We are also indebted to the Wisconsin Condensed Milk Co. for comparative tests upon sweetened condensed milk samples all from the same batch, tested by different operators using the Mojonnier Tester, in comparison with test by the official method. The results are reported in Table 15.

TABLE 15.
Total Solids Tests Upon Sweetened Condensed Milk by Several Operators.

Operator No.	Where tests were made.	Per cent total solids found sweetened condensed milk.
1	Pecatonica, Ill.....	73.27
2	Grayslake, Ill.....	73.41
3	Burlington, Wis.....	73.41
4	Burlington, Wis.....	73.50
5	Valders, Wis.....	73.50
6	Valders, Wis.....	73.31
Mr. Titus' official test.	Burlington, Wis.....	73.53

Considering that sweetened condensed milk is probably the most difficult dairy product to test successfully for total solids, the results reported show a close agreement with those obtained by the long official methods.

REFERENCES.

[1] Rose, Bruno: Analysis of Milk: Fat Determinations. Zeitschrift für Angewandte Chemie. Abst. in Jour. Chem. Soci., Vol. 54, p. 1135, 1888.

[2] Schreib, H.: Determination of Fat in Milk. Zeit. Angewandte Chem., Vol. 1, p. 135, 1888. Abst. in Jour. Chem. Soci., Vol. 54, p. 1135, 1888.

[3] Gottlieb, E.: Estimation of Fat in Milk. Milkerei Zeitung, 1892, II. Landw. Versuchs.-Stat., Vol. 40, p. 1-27. Abstract in Jour. Chem. Soci., Vol. 62, p. 549-550, 1893. Patrick, U. S. Dept. Agric., Bur. of Chem., Circ. 66; A. O. A. C. Methods.

[4] Lang: Pharm-Zeitg., 38, 219. Chem. Centr., 1, 960, 1893.

[5] Weibull: Milk Ztg., Vol. 27, p. 406, 1898. Chem. Ztg., No. 63, 1898.

[6] Kuhn: Milk Ztg., Vol. 27, p. 772, 1898.

[7] Popp, M.: Zeitschrift für Untersuchung der Nahrungs- und Genussmit., Vol. 7, p. 772, 1.

[8] Popp, M.: Milch.-Ztg., 1904, No. 20.

[9] Rohrig: Amir. Zeit. Nahr. Genussm., Vol. 9, p. 531-538, 1905.

[10] Thomsen: Th. Sv. Landw. Versuchsstat., Vol. 62, p. 387-399, 1905.

[11] Burr, A.: Milchw. Zentr., 1, 248-250. Abstract Jour. Chem. Soc., 88, 2, 559-560, 1905.

[12] Gordon, P.: Milchw. Zentr., 2, 224-227, 1906. Jour. Chem. Soci., 90, 2, 501, 502, 1906.

[13] Barthel, Dr. Chr.: "Milk and Dairy Products." Translated by Goodwin, W., Ph. D., MacMillan & Co., N. Y. p. 52-55, 1910.

[14] Kropat, K.: Arch. der Pharmacie, Vol. 252, p. 76-82, 1914. Jour. Soci., 106, 2, p. 591, 1914.

[15] Richmond, H. D.: Dairy Chemistry. Second Ed. Revised, p. 118-119, 1914.

[16] Melliere, G. J.: Pharm. et Chim. (7) 9, p. 489-493, 559-563, 1914. Jour. Chem. Soc., 106, 2, p. 590, 1914.

[17] Balton, E. R., and Revis, C.: Fatty Foods, Their Practical Examination. London, 19, p. 347-349.

[18] Bigelow, W. D., and Fitzgerald: The Examination of Evaporated Milk. Bull. No. 5, Jan., 1915. Research Lab. Nat. Canners Assn., Washington, D. C.

[19] Biesterfeld & Evenson: Jour. Ind. & Eng. Chem., 1917.

[20] Courtesy Wisconsin Condensed Milk Co.

[21] Test made by Mr. Titus, Burlington, Wis., using official Röse-Gottlieb Method.

[22] Courtesy Telling-Belle Vernon Co., Cleveland, Ohio. Results reported by W. O. Frohring, Director of Laboratories.

[23] Miss Lucy Klein: Mojonnier Bros. Co., Chicago, Ill.

[24] Sample from Dairy Testing Laboratory, N. Y. State College of Agriculture. Analyst, Miss Lucy Klein, Chicago, Ill.

[25] Analyst, F. M. Bundy, Chicago, Ill.

[26] Babcock: Univ. of Wis. Agr. Exp. Sta., 1895, 12th, Rep't., p. 120.

[27] Richmond: "Dairy Chemistry," 1914, p. 68.

[28] Fleischmann: Lehrbuch der Milchwirtschaft.

[29] Bigelow & Fitzgerald: The Examination of Evaporated Milk, 1915. Bull. No. 5. Research Lab., Nat. Canners Assn., Washington, D. C.

[30] H. C. Troy.

CHAPTER IV

ASSEMBLING THE MOJONNIER MILK TESTER

The Mojonnier Milk Tester is a machine invented especially for the purpose of quickly determining, with the greatest chemical accuracy, the percentages of fat and solids in all dairy products.

The Mojonnier Milk Tester is supplied in three models. Model A is electrically operated with rheostatic heat control throughout. Model D is electrically operated, with rheostatic heat control upon the two outside hot plates, and with thermostatic heat control upon the two ovens. This insures uniform temperature upon both ovens, regardless of any fluctuations in the voltage. Model G is steam operated. The three models are illustrated under Figures 15, 16 and 17, respectively.

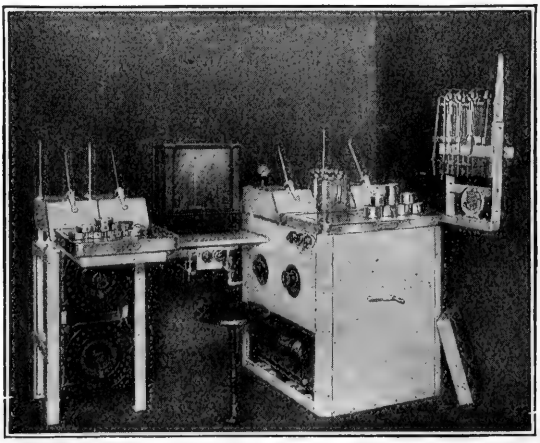


Fig. 15. Model A Mojonnier Milk Tester. Electrically operated. Rheostatic heat control.

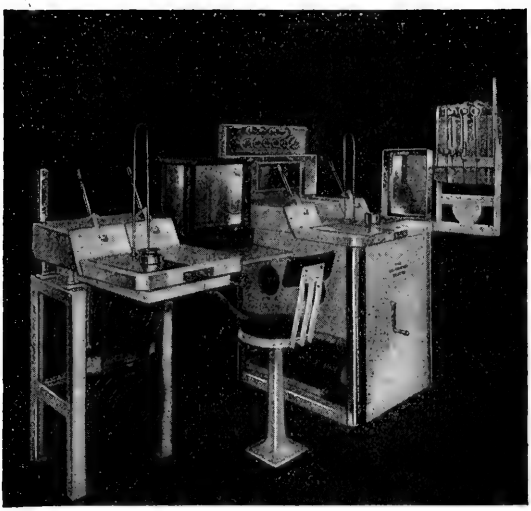


Fig. 16 Model D Mojonnier Milk Tester. Electrically operated. Thermostatic heat control upon the two ovens.

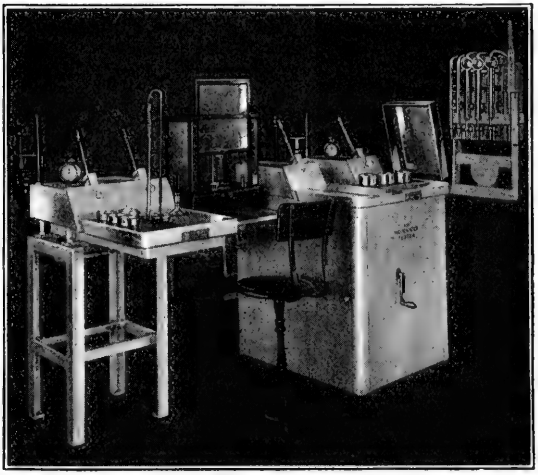


Fig. 17. Model G Mojonnier Milk Tester. Steam operated throughout.

SETTING UP THE MOJONNIER MILK TESTER.

In assembling and locating the Mojonnier Milk Tester in the plant, follow instructions closely. The illustration Fig. 18 will assist in properly setting up the Tester. The tester must be placed in a room with a good solid floor, in order to prevent vibration of the chemical balance. Choose a corner space preferably, or a straight wall. The air in the room should be fairly dry and the temperature between day and night should not vary widely.

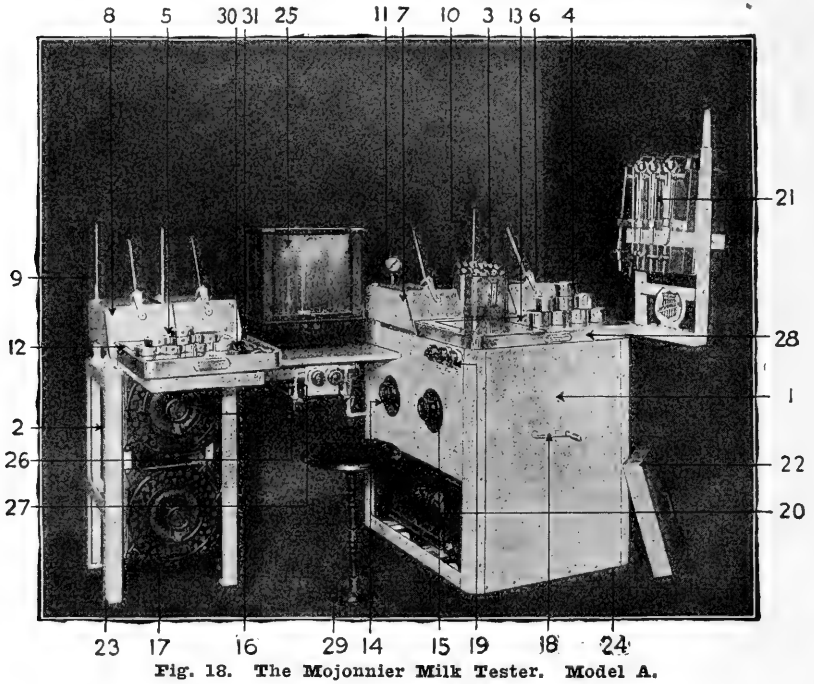


Fig. 18. The Mojonnier Milk Tester. Model A.

(1.) All tests for fat are made upon this side, which is called the fat side.

(2.) All tests for total solids are made upon this side, which is called the solids side.

(3.) Butter fat extraction flasks in centrifuge baskets.

(4.) Eight $3\frac{1}{2}$" diameter aluminum dishes for fat tests. These are the larger dishes furnished with the Tester. The one tall counterpoise counterbalances each dish. Fat dishes have no covers.

(5.) Eight 3″ aluminum dishes for solids tests. These are the smaller dishes furnished with the Tester. The one short counterpoise counterbalances each dish. Cover prevents absorption of moisture from the air during weighing. Counterpoise balances both dish and cover.

(6.) Fat vacuum oven. The temperature in this oven is maintained at 135 deg. C. Thermometer (10) extends into vacuum oven and sets in the mercury well, which in turn rests upon the hot plate. About once a month the mercury well should be refilled with mercury. Be careful to see that the well always forms good contact with hot plate. Regulate temperature by rheostat (15).

(7.) Cooling chamber. Water at room temperature from the tank in bottom part of the fat side is pumped by means of circulating pump in power unit (20) through the flat hollow sheet brass plate inside the cooling chambers, and from there into pipe back of the Tester, then back into tank. Operator must watch outlet on cooling chamber, and see that water is flowing at all times while the motor is running. If water is not running, you may know that the water in the storage tank is low, or that the water circulating pump is out of repair. Keep the tank filled at all times. In winter to prevent freezing, put one gallon of denatured alcohol into the tank. Also when filling tank, put in one-half gallon soluble oil furnished with the Tester. This will assist greatly in keeping the circulating pump in repair.

(8.) Solids oven. Maintained at 100° C. Regulate temperature by means of the rheostat (16). Follow instructions in (6) above closely for method of placing thermometer. Keep joints at door clean, and grease the sliding surfaces with vaseline. This prevents rusting of the ground surfaces, and insures a more perfect vacuum.

(9 and 10.) These are the 250° C. thermometers furnished for the solids and fat ovens respectively. Two sizes of gum tubing are furnished, for fastening the thermometers to the ovens. No other quality of tubing should be used, and if necessary, the tubing should be wired to the thermometer and to the oven connection.

(11.) The vacuum gauge is on the main suction line from the vacuum pump. This registers the vacuum upon either oven, or upon both ovens simultaneously.

(12.) Outside solids plate. Maintained at 180° C. The thermometer can be placed in the nickel plated mercury well that rests directly upon the heating plate. See that this side is level, so that the solids may dry evenly upon the bottom of the dish.

(13.) Outside fat plate. Maintained at 135° C. During the evaporation of ether from the dishes, the temperature falls. The temperature may be kept at 150° C. at the start, and the dishes placed only half way upon the plate. As the plate cools, the dishes may be pushed over until they are entirely upon the hot plate.

(14.) Rheostat for outside fat plate. Turning rheostat handle forward increases the temperature. Turning handle backward decreases the temperature. It is important to see that the lever on handle makes good contact with the separate buttons, and not with two buttons at a time. As soon as the right button has been found that maintains a constant temperature, mark this point upon the white plate. When starting up the Tester, the handle may be turned on full, and then when the temperature is up to within ten degrees of the right point, the handle may be turned back to the previously marked button. The same instructions apply for all rheostats.

(15.) Rheostats for the fat oven.

(16.) Rheostats for the solids oven.

(17.) Rheostat for the outside solids plate.

(18.) Handle for the centrifuge.

(19.) In case the operator forgets the temperature and time for treating the samples at the various points, the same may be noted below each snap switch for each hot plate.

(20.) The power unit consists of a high vacuum pump, a water circulating pump, and a suction fan, all driven by a single motor. The vacuum pump must be submerged in oil furnished with the Tester. The pump chamber should be filled with oil up to mark upon the air cock.

(21.) Automatic burettes. The cans holding the water, ammonia, alcohol, ethyl ether and petroleum ether are placed in this

order. This is the order in which these reagents are added to the flasks containing the weighed sample of milk. The water and ammonia bottles are graduated to .50 c.c. divisions. The alcohol, ethyl ether and petroleum ether burettes are graduated to 5.0 c.c. divisions.

(22.) Place this hood over the fat dishes when evaporating off the ether, so that the suction fan may draw ether fumes outside of the building.

(23.) Fasten these legs to the floor with lag screws.

(24.) This side need not be fastened to floor. In case it is necessary to take out power unit, it is necessary only to disconnect connections in the rear of the machine, and move this part of the machine forward.

(25.) The balance is the heart of the machine. Operator must keep it level, clean and handle it carefully. Raising and lowering knife edges must be done gradually and with care. Make it a habit to clean the balance daily. The weights must be kept clean, and as soon as you notice that some of the smaller weights are wearing out, order new ones.

(26.) This cock releases the vacuum upon the oven when cock (27) is closed. It must be kept closed when the vacuum is being maintained in the oven.

(27.) This cock connects the vacuum oven upon the solids side with the main vacuum line leading to the vacuum pump. The set of cocks at the left is for the control of the vacuum to the fat oven.

(28.) In top of fat plate holder there is a hole communicating with the suction fan upon the power unit. When the exhaust pipe connecting with the suction fan is run out of the laboratory, and the hood is over the dishes, all fumes of ether will be exhausted from the room.

(29.) Screw stool to floor.

(30.) A wash stand for washing all glassware should be provided. This should be properly designed and conveniently located, and supplied with both hot and cold water.

In Fig. 19 is given a phantom view of the fat side of the Mojonnier Milk Tester which aids in a further understanding of the function and the arrangement of the various parts. The power

unit, water tank, centrifuge with head, baskets and extraction flasks, and the device for exhausting the ether vapors are especially pointed out.

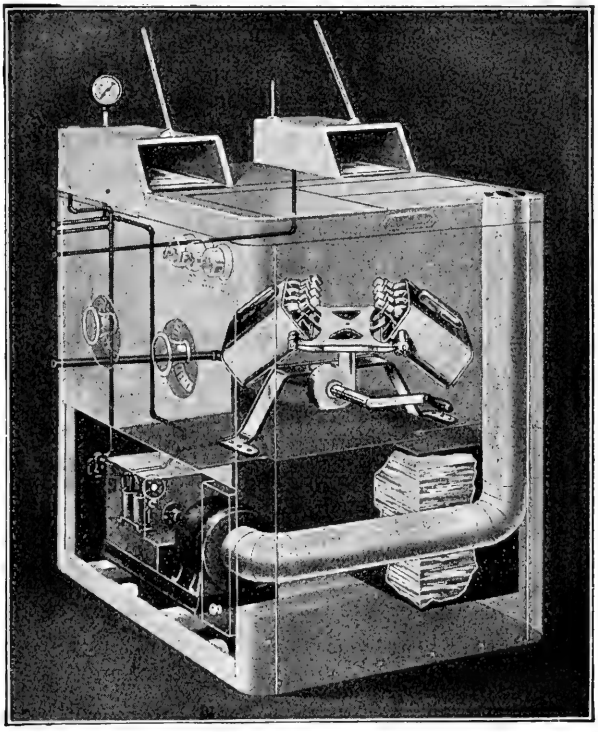
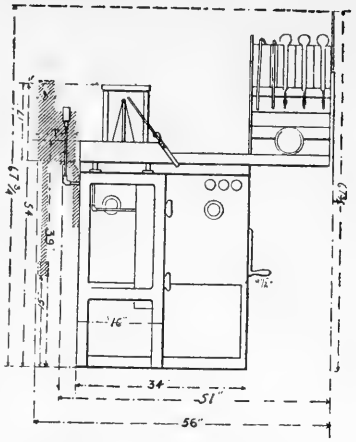


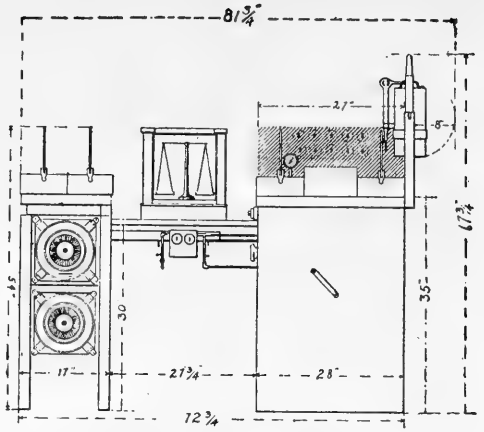
Fig. 19. Phantom view fat side Mojonnier Milk Tester.

Table 16. Dimensions and other engineering specifications covering the Mojonnier Milk Tester.

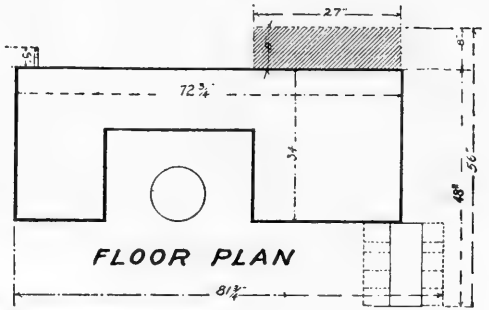
Type	Floor Space	Height Table Top	Height Over all	Shipping Weight	H. P. Consumed		Size of Wire Required
					Min.	Max.	
Model D—For both fat and solids with thermostatic control.....	56 x 82 in.	35 in.	68 in.	1,500 lbs.	1½	3	12
Model A—For fat and solids with rheostatic control	48 x 82 in.	35 in.	68 in.	1,300 lbs.	1½	3	12
Model G—For fat and solids with steam control...	66 x 82 in.	35 in.	68 in.	1,400 lbs.	1½	3	Pipe Inlet ½ in.



SIDE ELEVATION



FRONT ELEVATION



FLOOR PLAN

MOJONNIER MILK TESTER
MODELS "A" AND "D"

Showing dimensions and floor space required.

Shaded portions show position and dimensions of thermostatic control on Model D

Current consumed—Average 1½ h.p.

Current consumed—Maximum 3 h.p.

Shipping weight 1100 pounds.

Fig. 20. Dimensions of Mojonnier Milk Tester.
(Dimensions indicated in inches.)

CHAPTER V

THE OPERATION OF THE MOJONNIER MILK TESTER

In the Mojonnier Milk Tester, there are several operations that remain the same regardless of the product that is being tested. The operator should become familiar with every detail covering the construction, care and use of the machine.

General Care of the Tester. Keep the Tester clean and free from the accumulation of unnecessary materials at all times. It is impossible to do accurate work if the apparatus is not in the best of condition. All japanned parts can be cleaned either with engine oil, applied by a clean cloth, or by washing with good soap and water.

THE POWER UNIT AND THE WATER CIRCULATING UNIT.

Keep the water tank well filled with water. Add about one quart light machine oil to the water in the tank to keep the water pump well lubricated. If the Tester is located in a cold room in winter, add one gallon denatured alcohol to the tank to prevent freezing.

Keep the vacuum pump chamber properly filled with the right kind of oil. The oil should just about reach the top of the pistons, as indicated by the gauge glass upon the side, or cock upon the end, in the earlier models.

Give the motor proper care. It should receive the same attention as is required by any motor, that is, it is to be kept cleaned, and well lubricated.

Should any knocks develop upon the power unit, remedy the same immediately. The construction is very simple, and with a little study the care and operation of the power unit can be readily learned.

THE VACUUM OVENS AND COOLERS.

Keep sufficient mercury in the mercury well to insure good contact between the thermometer and the mercury well. The mercury well should rest directly upon the hot plate, otherwise incorrect temperature will be indicated by the thermometer. If mercury is spilled upon the hot plates, remove it at once. Do not permit mercury to come in contact with aluminum dishes as this may spoil the test. Keep the ground joint between the lid and the oven thoroughly cleaned. In case that it is difficult to get the proper amount of vacuum, look first to this place for trouble. Sometimes it may be necessary to use a small amount of vaseline, but as a rule the best results are obtained by keeping the ground joints thoroughly clean, using just enough vaseline to provide the proper lubrication and to prevent rusting. Be sure that the thermometer opening, and the openings upon the bottom of the oven are thoroughly sealed. It may be necessary to replace the rubber tubing at these points in case that leakage develops. Be sure to see that the cooling dessicators are kept from freezing temperatures. If the water in the cooling plates should freeze, it would ruin the plates. Watch the water coming out of the coolers, in order to be sure that the circulation is correct.

Turning on the Current and Adjusting Temperatures. It is important that the wires connecting with the Tester should be of size specified; namely, No. 12 copper wire. The Tester is provided with a main control switch. Turn on the current to heat the outside hot plates and the vacuum oven plates, by means of the snap switches. These are properly marked for the guidance of the operator. This should be done far enough in advance so that the plates and ovens will be heated to the proper temperature, when they are needed. The temperatures upon the outside plates in all electrically operated models, and in the vacuum ovens upon Model A, may be closely regulated by means of the rheostats. If the voltage is constant, the temperature will remain very near to the point desired for a long period of time after the rheostats have been properly adjusted. Ascertain by the tests just where it is necessary to hold the lever upon the rheostat in order to get the required temperature. After this point is once ascertained, the

lever can be set at the point required, and the temperature allowed to come up automatically when starting in the morning.

In the case of Model D the temperature in the two vacuum ovens is controlled by thermostats. The method of wiring recommended is indicated upon Fig. 21. The mercury thermostat resting in the mercury well is calibrated at the required temperature, and it must be properly connected.

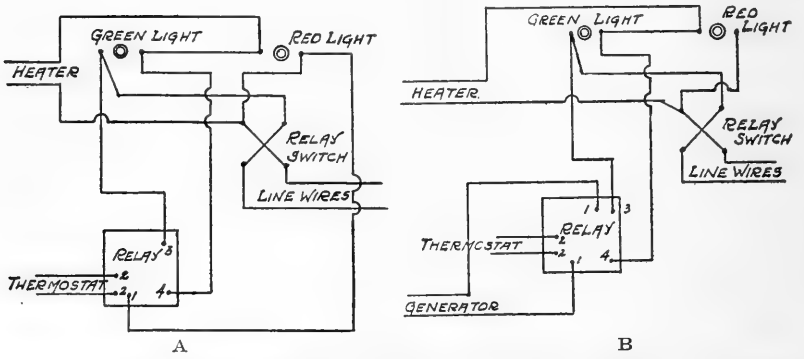


Fig. 21. Wiring Diagrams for Thermostatic Control Model D Mojonnier Tester. A For Direct Current. B For Alternating Current.

Care and Use of the Balance. Keep all parts of the balance and case free from dust. A cover placed over the balance at night serves a very useful purpose. Dust the balance including the pans and weights, using a camel's hair brush for this purpose. Level and adjust the balance so that the pointer will oscillate an equal number of divisions upon each side of zero upon the pointer scale. If the pointer swings too far to the right, turn the adjusting screw upon the beam to the right. If it swings too far to the left, turn the adjusting screw to the left.

Two types of balances are in principal use: namely, the old type with graduated beam and rider, as illustrated under Fig. 22, and the new type called "Chainomatic" with the chain and vernier, as illustrated under Fig. 23. The care to give to either type

of balance is the same. The difference is in the method of balancing the object to be weighed, and of reading the weight. These points will be discussed separately.

A balance is a delicate instrument, and care needs to be exercised in its use at all times. The weights likewise require careful handling. Lack of care in the weighing operations may lead to entirely erroneous results, and thus defeat the object aimed at: namely, the accuracy of the tests.

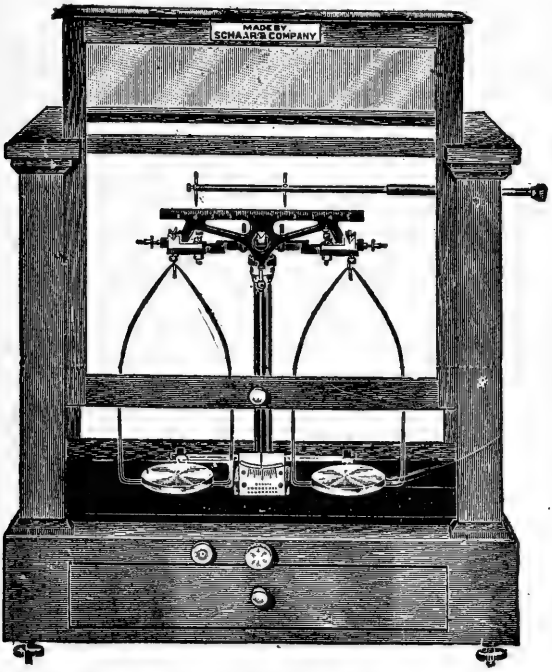


Fig. 22. Analytical Balance.
Courtesy of Schaar & Co.

The balance is enclosed in a glass case to shield it from dust, air currents and moisture. Perhaps the largest factor affecting accuracy in weighing, granting other conditions to be right, is temperature. If the vessel or object to be weighed is of a lower temperature than the balance case, it will weigh apparently **more** than its actual weight. If of a higher temperature than the bal-

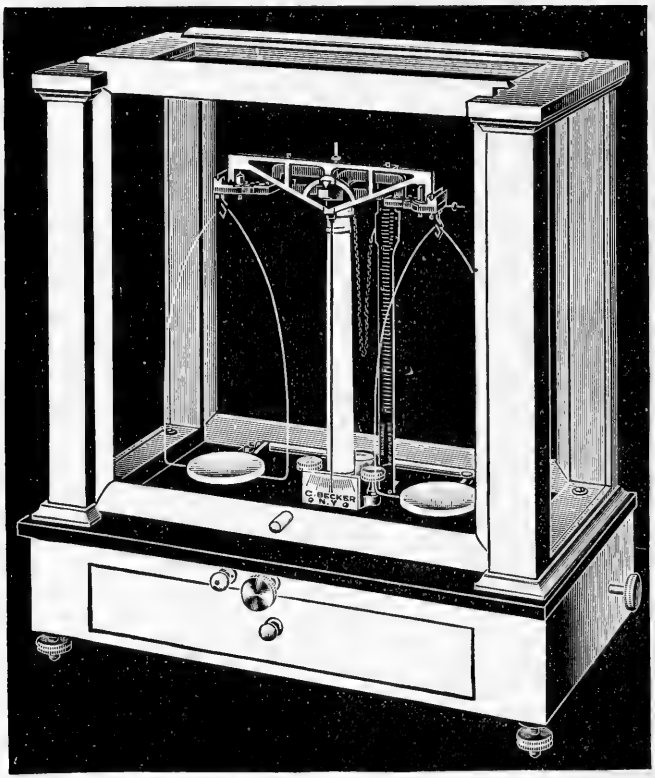


Fig. 23. Analytical Chainomatic Balance.
(Courtesy of Christian Becker Co.)

ance case, it will weigh apparently less than its actual weight. The object should, therefore, be as closely as possible of the same temperature as that of the air in the balance case. The water cooled desiccator used upon the Mojonnier Tester has been designed primarily to facilitate the equalizing of the temperature between the dishes to be weighed and the balance case. See, therefore, that the temperature of the water in the circulating system is as nearly as possible the same as the temperature in the balance case.

The weights should be kept clean, and checked frequently either against each other, or against other standard weights. Promptly replace any weights that may be off the standard, or apply the necessary correction.

When necessary to clean the chain, carefully detach it from the balance. Lay it out straight on a piece of velvet and brush it with a camel's hair brush. Then return it to its proper place on the balance. A small beaker partly filled with sulphuric acid should be kept in one corner of the balance case. Replace the sulphuric acid when it becomes saturated with moisture, and be very careful never to allow the beaker to overflow.

Protect the balance against vibration, and see that it is in exact level. The air bubble in the spirit level should be in the exact center. This can be readily accomplished by means of the leveling screws under the balance case.

The balance should be in exact equilibrium at all times. That is, the pointer should oscillate an equal number of divisions upon each side of zero upon the pointer scale. If the pointer swings too far to the right, turn the adjusting screw upon the beam to the right. If it swings too far to the left, turn the adjusting screw to the left.

Place object to be weighed upon the left hand pan, and the weights or counterpoises upon the right hand pan. Handle the weights with the forceps only, using the right hand. Use the left hand to release the beam from the support, and to raise or lower the balance door. The weights should be placed upon the pan in a systematic order, beginning with a weight that is judged to be somewhat too heavy. Lower weights are then tried in succession in a systematic order until equilibrium results.

Upon the old style balance, adjustments under 5 and 10 milligrams (depending upon the construction of the balance) are made by means of the rider. Keep the balance door closed while the final adjustment is being made. Determine the relation between the divisions upon the rider beam, and the pointer scale. This relation varies with different balances, but when once ascertained upon a given balance, it remains a constant value, and if applied in making a weighing, a great deal of time can be saved. For example, if the pointer oscillates six divisions to the right of zero, and four divisions to the left, with a balance having a relation of .0002 gram to one division upon the pointer scale, the rider is moved .0004 gram to the right to bring the balance into equilibrium.

Upon the Chainomatic Balance, adjustments under .0500 gram are made by means of the screw and vernier. Determine the relation between the divisions upon the vernier, and the pointer scale. If the pointer swings too far to the right, lower the slide,—if too far to the left, raise the slide. About .0003 gram upon the vernier usually equals one division upon the pointer scale.

Exercise great care in recording the weights. A double check should be made by reading both the weights upon the balance pan, and the weights that are missing from the set. The weights should be placed upon a paper near the front of the balance case, with the values of the weights marked upon the place where the respective weights are kept. Remember that one misread weight will spoil an entire test. Upon the Chainomatic Balance read weights as follows:

(a.) Sum of all grams weights equals whole number.

(b.) Sum of 100 or multiple of 100 milligrams equals first decimal.

(c.) Sum of 10 or multiple of 10 milligrams equals second decimal. Out of a possible total of 100 milligrams, 50 milligrams are obtained from the fractional weight, and 50 milligrams from the vernier beam.

(d.) The third decimal is obtained from the vernier beam. Read the value of the line just above the small 0 upon the slide.

(e.) The fourth decimal is the value upon the slide that is in the exact line with any given line upon the vernier beam.

THE IMPORTANCE OF SHORT BALANCE SWINGS.

Much time can be saved by following the proper practice at each step of the weighing operation. Long balance swings consume more time; cannot be read so accurately, and the final result is usually not as dependable as when short swings are used. H. L. Wells[1] made a careful study of the relative merits of long and short swings, and concludes in favor of the short swings. The best practice is to permit the pointer to swing between 4 and 6 points upon either side of the zero line. If the swings are much shorter than this, the error due to the width of the pointer may become considerable. Two complete oscillations only are necessary—the second being a check upon the first one. Every precau-

tion should be taken to speed up the weighing in order that this may not affect the accuracy of the results.

THE INFLUENCE OF TEMPERATURE UPON THE WEIGHING RESULTS.

The temperature factor is too often disregarded. J. J. Mojonnier weighed three aluminum dishes, size about 3″ in diameter by 1″ high at various temperatures. The results obtained are given in the following table:

TABLE 17.

Influence of Temperature Upon the Weight of Aluminum Dishes.

Dish Number.	Balance Temperature	Wt. Dish at 32° F.	Wt. Dish at 63° F.	Wt. Dish at 68° F.	Wt. Dish at 92° F.
4	68	10.0200	10.0126	10.0108	10.0000
3	68	10.0110	10.0043	10.0028	9.9915
2	68	10.0128	10.0029	10.0012	9.9900

This subject was further carefully studied by one of the authors at Cornell University.[2]

The results of the experiments performed are given in Table 18.

TABLE 18.

Influence of Temperature Upon Analytical Weights of Various Objects.

	300 c. c. Aluminum dish	100 c. c. Aluminum dish	300 c. c. Erlenmeyer flask	300 c. c. beaker	50 c. c. platinum dish	7 aluminum discs clamped together	145 c. c. separatory funnel cocks opened	145 c. c. separatory funnel cocks closed	145 c. c. separatory funnel after opening cocks
Wt. temperature 21.5° C.....	54.8882	13.5906	46.7769	49.2125	18.6343	57.7225	56.3290	56.2754	56.3222
Wt. temperature 80° C.....	54.8295	13.5700	46.7430	49.1624	18.6243	57.7168	56.2728	56.2658	56.2754
Decrease in weight due to increased temperature.....	.0587	.0206	.0339	.0501	.0100	.0057	.0462	.0096	.0468

The results given in both of the preceding tables prove the importance of maintaining uniform temperatures between container and balance when weighing both the empty container and in turn the container, after the substance to be weighed has been added to it. The colder the object being weighed, the greater

will be the weight thereof, and vice versa, the warmer the object, the smaller the weight thereof if the balance temperature remains constant. These facts, if not properly reckoned with, may cause large errors in results. With care, the same can be kept under close control.

The principal causes of the above variations are: (a) The influence of air currents set in motion because of the higher temperature of the object being weighed. (b) The displacement of air in the container, due to its expansion at the higher temperatures. In the experiment with the separatory funnel the loss in weight from this cause was about 4.6 times greater than the loss due to the air currents. (c) Other possible causes include the recording of incorrect weights; slight differences in the length of the scale beam; changes in barometric pressure; changes in the temperature of the air in the balance between the weighings, and invisible moisture films upon the surface of the container.

How to Heat the Fat and Solids Dishes Before Weighing. Give to the fat and solids dishes the same treatment before weighing them empty, that is given them before the final weighing in completing a determination when they contain the extracted fat or the solids from the test. Place the clean fat dishes in the vacuum oven at a temperature of 135° C. Turn on the vacuum and leave them in the vacuum oven for 5 minutes. Transfer them to the cooling desiccator, and with the pump still running, leave them therein for 7 minutes before weighing. Be certain that the water is circulating through the plate in the cooling desiccator. Place the clean solids dishes in the solids ovens at 100° C. Turn on the vacuum, and leave them in the vacuum oven with the vacuum on for 5 minutes. Transfer them to, and hold them in the cooling desiccator for 5 minutes while the water circulating pump is running.

Do not weigh either the fat nor the solids dishes far in advance of the time that the same may be required. The principle to keep in mind is the necessity of maintaining the same temperature in the balance case at the time of the two weighings.

How to Weigh the Fat and Solids Dishes. After the dishes have remained in the respective cooling desiccator for the proper time, they should be promptly transferred to the balance pan and weighed accurately to .0001 gram, using the proper counterpoise.

Record the weight and number of each dish in its respective place on the laboratory report sheet. Use cover upon solids dish. No cover is to be used with the fat dish. Return the dishes to the cooling chamber, until needed for the test.

How to Clean the Dishes and the Glassware. The solids dishes should be soaked in water after the test has been completed, and the solids then removed by hand, or by means of a brush suited to the purpose. They should then be thoroughly washed and dried, and placed in the vacuum oven until required for further use. Avoid the use of washing powders and alkalies for cleaning aluminum. The fat dishes should be treated with steam or very hot water until all traces of fat are removed, or they should be treated with a small quantity of gasoline until the fat is all dissolved, and this treatment repeated for a second time. Finally, the dishes are to be cleaned with a dry cloth, and placed in the vacuum oven until needed.

All glassware should be washed either immediately after being used, or it should be placed in water until washed. Extraction flasks should be thoroughly washed with tap water, and then washed out with distilled water. If flasks become dirty, wash with washing powder and shot, or use washing powder with a brush specially designed for this flask. Clean pipettes with brush and water. Use washing powder, if necessary. Rinse successively with water, alcohol and ether, and then dry by holding at exhaust cock leading to the vacuum oven, or place upon the pipette holder between fat oven and cooler.

REFERENCES.

[1] Wells, H. L., Analytical Weighing, Jour. Am. Chem. Soci., Vol. 42, p. 411.

[2] H. C. Troy.

CHAPTER VI

SAMPLING DAIRY PRODUCTS

When samples of milk, or any of its products, are taken for the purpose of examination or analysis, great care must be exercised in order to have the samples truly represent the average composition of the substance. In ordinary liquid dairy products, the fat globules rise toward the surface and form a layer of cream whenever the substances remain at rest. Other small particles of undissolved substance settle to the bottom. Many of the bacteria may be carried in either direction. For these reasons the product must be mixed until the different constituents are evenly distributed throughout the entire mass. Then the sample must be taken immediately.

ACCESSORIES REQUIRED FOR SAMPLING DAIRY PRODUCTS.

To insure proper sampling it is necessary to use the proper tools. The following figures illustrate the apparatus recommended for properly sampling various dairy products.

Fig. 24.

Fig. 24. Mojonnier Composite Sample Bottle, recommended for collecting and holding either composite samples, or any other samples to be tested. The advantages of this bottle are as follows:

1. The pure Para rubber stopper fits the mouth of the bottle tightly and prevents evaporation, and in consequence overreading of butter fat content.
2. No danger of dropping, misplacing or breaking stopper.
3. The non-rust chain and copper ring always keep the stopper accessible for quick restoppering.
4. Can be quickly opened with thumb of hand holding bottle, leaving other hand free for pouring in sample of milk.
5. Sample can be thoroughly shaken and mixed in the bottle without danger of loss.

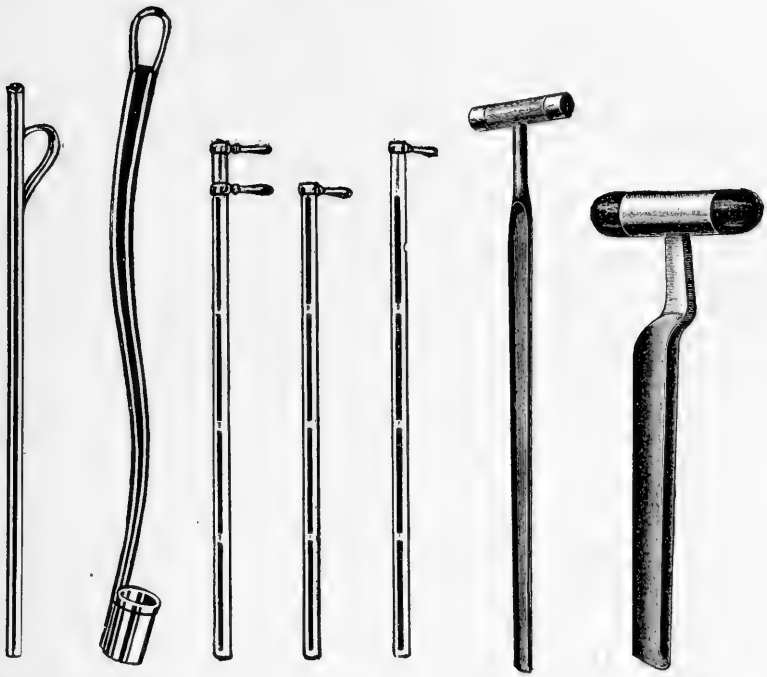


Fig. 25. Fig. 26. Fig. 27. Fig. 28. Fig. 29.

Fig. 25 illustrates milk thief. This is recommended only for sampling fluid milk, principally at the weigh can. If properly used it makes it possible to obtain composite samples that are representative of the entire lot of milk from which the samples were taken.

Fig. 26 illustrates a small milk dipper, such as is frequently used for taking samples at the weigh can. Inasmuch as it holds a constant volume, it will not give representative composite samples unless the lots of milk are all of uniform weight.

Fig. 27 illustrates the Scoville and McKay Samplers. These are extensively used for sampling both fluid milk and cream.

Fig. 28 illustrates a common type of sampler for butter.

Fig. 29 illustrates a satisfactory sampler for cheese.

SAMPLING FLUID MILK.

Fresh milk or milk only a few hours old may be readily mixed by pouring it from one vessel to another a few times or by stirring it with a dipper or similar instrument having a handle sufficiently long to reach down to the bottom of the container. When the cream on the milk has dried until it is flaky or lumpy and part of it has become attached to the sides of the container, it may be softened by warming it to 95° F. or 100° F. before mixing. Frozen milk must be thawed to permit proper mixing before sampling. When the fat has separated so that it floats in small granules or in lumps on the surface of milk, it cannot be restored to its original finely divided condition without warming the milk and passing it through a homogenizer or viscolizer. The fat that separates is lost in ordinary methods of sampling, but it rarely separates in cold milk that is free from acid. Therefore, it is to the advantage of milk producers selling on the fat test to keep their milk in good condition so that no fat will separate before the milk is tested.

When sampling milk or its products for the purposes of standardization, the method to use in collecting the composite sample must be determined by the conditions prevailing at each separate plant. In many cases, it may not be necessary to know the exact test of the milk, as the batch very frequently may be handled upon the basis of the results of the previous day, or by working with the finished product only, in which cases the composite sample can be dispensed with. Three methods of sampling for the purpose of standardizing whole milk are available, as follows:

(1.) At the weigh can. By taking out with a "milk thief" or other similar sampler, a proportional part of the milk from each weighing, just before letting out the milk. This method is likely to be very inaccurate whenever the milk is partly churned or partly frozen, or whenever the milk is improperly mixed in the weigh can. It has the further objection that it requires, as a rule, an extra man to collect the samples, which, of course, increases the operating expense to that extent.

(2.) In the holding tank, after the milk has been thoroughly stirred. This is the ideal method, but it is seldom possible for a

plant to collect all the milk in one tank before starting the several standardizing operations.

(3.) By means of a drip sample. The sample to be collected from the pipe leading out of the weigh can, or at some suitable place upon the pipe line. When possible to apply this method, it is probably the simplest and best method of all. However, care must be taken to see that the drip operates properly, and that it does not get clogged up. Also the sample must be properly protected against evaporation and spoilage, since the sample may be collecting over a considerable period of time. A suggested method for collecting a drip sample is illustrated under Fig. 30.

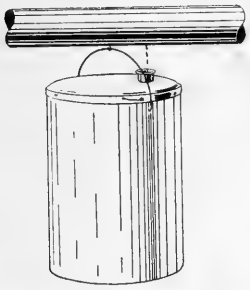


Fig. 30. Method of obtaining drip sample from milk line.

SAMPLING CREAM.

The methods employed in sampling cream are similar in principle to those used in sampling milk. As cream is more viscous and flows less freely than milk, even more effort and care must be taken to insure correct sampling. When cream is sampled immediately after separating, the fat may be evenly distributed by thorough mixing and by pouring it a few times from one vessel to another. When the cream is coagulated or lumpy it should be passed through a wire sieve or strainer. In some cases it may be necessary to warm the cream enough to soften the fat before mixing in order to secure a homogeneous product. The sample may be taken from the container with a dipper or with a sampling tube. When the sample taken is to form part of a composite sample, the amount taken from each delivery should always bear the same proportion to the mass sampled. Neglecting to do this may be the source of large errors.

COMPOSITE SAMPLES DEFINED.

As applied to creamery work, a composite sample is made up of several portions of milk or cream from a single source, usually taken from different days' deliveries, and placed in a bottle with a preservative. In condenseries, ice cream plants and commercial milk plants where different dairy products are to be mixed together, or where all of the products received from different

sources are to be thus mixed, the term "composite sample" may refer to a mixture of aliquots (proportionate amounts) from each of the masses of substances that are to be united and standardized to a definite composition.

It is seldom necessary to test composite fluid milk samples oftener than once a week. Usually they are tested once in two weeks. Where possible to preserve them properly the ideal method is to test them once a month. This reduces the amount of testing to a minimum, saves unnecessary labor and increases accuracy.

PRESERVATIVES FOR COMPOSITE SAMPLES.

The principal preservatives used for keeping composite samples in good condition are mercuric chloride (corrosive sublimate), formaldehyde, and potassium bichromate. The use of mercuric chloride has generally given good results. It can be purchased in tablet form combined with substances that color the milk pink or blue to warn people against drinking it as this preservative is a deadly poison. Two or three of the tablets serve to preserve six or eight ounces of milk for a period of two weeks.

Formaldehyde is also successfully used for preserving composite samples where other preservatives do not completely check growth of moulds. It is not such a deadly poison as mercuric chloride, but milk samples containing it should be marked "poisonous." Five or six drops of a 40% solution of formaldehyde will preserve six or eight ounces of milk over a period of two weeks. "Composite test liquid" is a form of formaldehyde specially prepared and colored, for keeping composite samples. It is the most economical and the most satisfactory preservative now in use.

Potassium bichromate is not as effective a preservative as the others named, but it serves well for holding samples for short periods. It is poisonous but not so severe as mercuric chloride. For preserving milk samples enough of the bichromate is added to give the milk a lemon-yellow color.

CARE OF COMPOSITE SAMPLES.

The samples should be kept in trays or on shelves in a cool cupboard near the weighing can. Each bottle and its location on the shelf should be plainly and correspondingly numbered.

When milk is added the bottle should be shaken with a rotary motion to soften and to reincorporate, without churning, any cream that has risen, and to bring the freshly added milk in contact with the preservative in solution. The cupboard should be closed and locked when sampling is completed for the day.

PREPARING COMPOSITE SAMPLES FOR TESTING.

Even with the best care, some cream will become attached to the sides of composite sample bottles. Therefore, it is always advisable to place the bottles in warm water to soften the cream so that it may be quickly removed from the side of the bottle. When necessary a suitable brush, or spatula, having a piece of rubber tubing drawn over the lower end, can be used to loosen the cream from the sides of the bottle. The cream can then be readily reincorporated. The contents of the bottle should not be heated above 100° F., or part of the fat will separate as an oil, and make it extremely difficult to secure an accurate test sample. By bringing the water in the warming vessel to a temperature of about 100° F. and then placing the bottles in the water, there will be little danger of overheating. Figure 31 illustrates a water bath especially designed to heat composite sample bottles before testing. It is provided with a steam spray pipe, and an overflow so that exact control can be maintained over this operation.

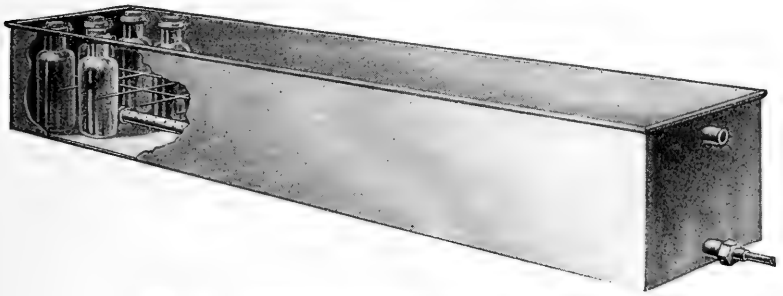


Fig. 31. Composite Sample Bottle Water Bath.

To properly mix the cream with the milk and obtain representative samples, the addition of a small quantity of shot to the bottle before heating and shaking will insure a satisfactory emulsion.

COMPOSITE CREAM SAMPLES.

The practice of taking composite samples of cream has nearly ceased in recent years, as more accurate results are secured by

testing each sample the day it is taken. With such a valuable product as cream, the higher degree of accuracy secured by the daily test offsets the additional expenses. When composite samples of cream are taken, the directions given above for composite milk samples will apply in every detail.

SAMPLING SKIM-MILK.

Skim-milk should be mixed before sampling in the same manner as whole milk. Samples taken from a separator spout at a single instance usually will not show the average composition of the total quantity separated. After separation is completed, proportionate amounts should be taken from each container and mixed together. The test secured on such a mixture will be the average of the entire mass. The same should be kept in air tight sample jars in a cool place until they are tested.

SAMPLING WHOLE MILK FOR MAKING EVAPORATED MILK, OR SWEETENED CONDENSED MILK.

In addition to the directions given on pages 82-83 for sampling whole milk, the following will be of assistance in sampling when testing, in evaporated or condensed milk plants. Secure samples from the holding tanks after the milk has been thoroughly stirred. This is the ideal method, but it is seldom possible for a plant to collect in one tank all the milk required to make up one batch. In some cases, more than one holding tank is available, and the same can be filled alternately with the whole milk. Samples are taken out of the alternate tanks in the proportion of 1 c.c. to each one hundred pounds of milk in the tank. For example, a tank holding eight thousand pounds of milk will require an 80 c. c. sample. Samples from the different tanks that go to make up the entire holdover batch can be mixed together before testing the same for fat and total solids. The objection to this method is that it is seldom possible to allow the milk to accumulate in the tanks in any fixed quantity since it is usually necessary to pump it into the hot wells as soon as it starts accumulating in the holding tanks.

At the hot wells: If the samples are taken at the hot wells, care must be taken that no milk remains in the wells from the previous batch. Also care must be taken that the milk be well stirred be-

fore the sample is taken, and that the sample taken be proportional to the entire weight of milk in the different hot wells. This is a good method, provided the milk in the hot wells can be properly stirred, but it cannot be used in the case of sweetened condensed milk, on account of the sugar remaining in the hot wells.

SAMPLING EVAPORATED MILK AND SWEETENED CONDENSED MILK.

Evaporated milk requires to be sampled and tested both before and after sterilizing. Samples taken from a pan batch should be collected in a well-stoppered bottle as illustrated under Fig. 24. The sample should be promptly cooled to about room temperature and well mixed before testing.

Where the holdover system is used, great care must be taken to secure proper mixing of the entire lot of milk in the holdover tank. The method of agitation used should be proved by testing samples taken from different parts of the holdover batch.

Samples after sterilizing should be properly mixed in the can. Samples in which the butter fat has separated or has become churned require special attention, and it frequently becomes impossible to make an accurate test on account of the mechanical condition of the sample.

Skimmed or whole unsweetened condensed milk are usually sampled in a manner similar to evaporated milk.

Sweetened condensed milk in its several varieties is a product that requires very particular care in sampling. A sample from a pan batch should be collected in a well-stoppered bottle and promptly cooled. A sample from a large holdover batch should be taken only when the agitation is complete. Samples taken from cans, or from barrels, require particular attention on account of the possibility of the milk sugar settling upon the bottom of the containers. Unless the milk sugar is thoroughly reincorporated, it becomes impossible to obtain a test that is representative of the original milk.

SAMPLING FOR ICE CREAM MIX.

Methods for sampling cream and other materials to be used in compounding the ice cream mix will be found under the directions for sampling the respective products. The methods of sampling the mix to determine its composition will vary according to the

conditions peculiar to each plant. Where a homogenizer is used, some operators prefer to take the sample from the cooling coils a few minutes after the homogenizer has started. The mix is then in excellent condition for sampling. Other operators may prefer to take the sample from the pasteurizer before homogenizing. In the latter case, care should be exercised to make certain that the mixture is homogeneous throughout. When neither pasteurizer nor homogenizer is used, dependence must be placed upon ordinary methods of mixing to prepare the batch for sampling. Three ounce or four ounce samples of the mix should be taken with a sampling tube or dipper and placed in air-tight, glass sample bottles until tested.

SAMPLING THE FROZEN PRODUCT.

There is some tendency for the heavier substances to descend, and for the fat percentages to increase in the upper layers of ice cream held in storage. Therefore, care must be exercised in order to secure representative samples. Where the mass is large the sample may be taken with an instrument like a butter trier, drawing a column of the ice cream extending from the top to the bottom of the container. Bricks of ice cream may be sampled by drawing plugs with a trier or preferably by taking the whole of a slice about half an inch in thickness across the brick, and at least an inch from the end. Frozen samples should be melted gradually before testing.

SAMPLING BUTTER.

The sampling of butter is one of the most important and difficult operations in the process of determining its composition. This is so because the water and salt are not evenly distributed throughout the fat. The moisture content of the butter in one end of a churn will be different from the content in the other end. The fat percentage near the surface of a tub of butter, or the surface of a pound print, will be higher than it is at the bottom of the tub or at the center of the pound print. For these reasons, care and judgment must be used in taking the sample. The method of sampling varies according to the condition and location of the butter. When sampling butter in the churn, take with a spatula or butter knife ten or twelve one-fourth ounce portions from different parts of the churning and place them to-

gether in a glass sample jar that has an air-tight stopper. If the butter is in tubs, the sample may be taken with a butter trier. It is best to take drawings—one from near the edge, one halfway between the edge and the middle, and one from the middle. The different drawings are placed together in a sample bottle. Sometimes after the cover is removed the tub is turned upside down and lifted off the butter. A one-half pound wedge-shaped piece of the butter is then taken from one side about half-way between the bottom and the top. Prints may be sampled by taking two or three drawings with a trier or by taking a three-ounce slice across the print about an inch from one end.

SAMPLING BUTTERMILK.

In sampling buttermilk, use the same methods and precautions that are given for sampling whole milk and skim-milk on pages 82-85.

SAMPLING CHEESE.

The percentage of moisture in cheddar and other hard cheese is highest near the center, while the percentage of fat and other solids is highest near the outside. For these reasons considerable care and skill is required to take a truly representative sample without destroying the cheese. The moisture determination given in Table 19 was compiled by one of the authors. It gives the distribution of moisture in a cheddar cheese at intervals over a period of twenty-one days after the cheese was taken from the press and while it was on the shelves in a fairly cool curing room. The cheese was not coated with paraffine.

TABLE 19.

The Distribution of Water in a Cheddar Cheese and the Loss of Water by Evaporation. Results Obtained by Prof. H. C. Troy.

Age of cheese.	Inner third of the plug.	Middle third of the plug.	Outer third of the plug.	Average.
1 day	37.57	36.78	35.69	36.65
3 "	36.90	36.43	35.08	36.13
7 "	36.81	36.59	34.95	36.11
9 "	36.50	36.62	35.00	36.04
11 "	36.56	36.55	34.50	35.87
14 "	36.54	36.49	34.45	35.82
17 "	36.30	36.39	34.41	35.66
21 "	36.47	36.44	34.10	35.67

The simplest and best method to take a sample of a cheddar cheese is to cut out a wedge-shaped piece reaching from the circumference to the center. The sample should be placed immediately in a sample jar having an air-tight stopper.

When it is necessary to take samples without destroying the cheese, draw from the upper side with a cheese trier,—three plugs, one about one inch from the outer rim, one at the center and one half-way between the other two. The plug should extend half-way through the cheese. After drawing the plugs, break off a piece of each plug at the outer end, and close the openings with them. The remainder of the plugs will serve as the sample, and they should be placed in the sample jars, and the jars closed at once.

Disc-shaped soft cheese may be sampled by taking a wedge-shape piece extending from the rim to the center. Square-shaped soft cheese are sampled by taking a slice across the cheese some distance in from one end.

Samples of hard cheese like cheddar are prepared for testing by passing them through a meat chopper or by cutting the cheese into particles about the size of kernels of wheat. This may be done in the sample bottle by using the end of a table knife that has been squared and sharpened. Before taking the final test portion, the contents of the bottle should be well mixed. The soft cheese sample is prepared for testing by mixing it in the sample bottle, using a spatula or knife blade for this purpose. Excellent results are obtained by grinding the sample in a close-grained mortar with a pestle. This must be done rapidly so that there may be no loss of moisture from this operation.

SAMPLING WHEY.

Whey should be well mixed before sampling. The absence of large amounts of casein permits the fat in whey to rise quickly. It is practically impossible to reincorporate all of the fat that rises to the surface, and for this reason fat tests of whey usually show less rather than more fat than the whey contains. Also the particles of casein settle to the bottom quickly and carry down with them any incorporated fat. The manufacturing processes of

numerous varieties of cheese are influenced by the percentage of acids in the whey. For this reason alone the whey has to be sampled and tested for acidity frequently during the advancement of the manufacturing process. In the process of manufacturing cheddar cheese, the whey is sampled immediately before heating the curd, previous to removing the whey, and while the curd is piled, before being milled, and finally also before salting.

As test samples of whey are usually taken by volume, the most satisfactory way is to take them with a graduated pipette from the mass to be sampled immediately after it is mixed. It may then be transferred directly to the vessel in which the test is to be completed. If a sample bottle is used much of the fat may be lost by becoming attached to the sides of the bottle.

SAMPLING OTHER CONCENTRATED DAIRY PRODUCTS.

When exposed to the air, milk powder absorbs moisture rapidly. This makes thorough mixing of the sample especially necessary when the powder is not kept in moisture proof containers. When it is kept in cans it should be well mixed, and if lumps are present it should be put through a sieve before mixing. Sometimes the powder is mixed, then divided into four approximately equal parts. Portions from each quarter are then mixed together and the sample taken, or the quartering process may be carried further.

Sampling Whole Milk Powder. Whole milk powder is sampled in the same manner as skim-milk powder.

Sampling Malted Milk. Malted milk is sampled by the method given for sampling skim-milk powder.

Sampling Milk Chocolate. Milk chocolate cannot be ground to a powder as it will soften into a paste in the process. Therefore it must be shaved or grated into fine particles to permit thorough mixing before taking a test sample.

Frequently the chocolate can be pounded to a smooth, homogeneous mass, in a mortar, with a pestle.

Sampling Cocoa. Since cocoa is usually held in the form of a powder, it may be sampled by the methods given for sampling milk powder.

CHAPTER VII

DIRECTIONS FOR MAKING FAT TESTS, USING THE MOJONNIER TESTER

OUTLINE OF METHOD.

The method for making fat tests upon the Mojonnier Tester is a comparatively simple one. It is modified for various dairy products, but the principles and the general operations remain unchanged. In the case of fresh milk the method in brief is as follows:

Measure 10 grams of milk into the extraction flask illustrated under Fig. 32. Add 1.5 c. c. of ammonia and mix in small bulb of flask. Add 10 c. c. of 95 per cent alcohol, insert cork and shake thoroughly. Add 25 c. c. of ethyl ether, and shake for 20 seconds. Then add 25 c. c. petroleum ether and shake for 20 seconds. Place the extraction flask in the holder of the centrifuge and turn the handle 30 turns, taking about one-half minute. This will give a speed of 600 revolutions per minute. The centrifuge with the holder is illustrated in Fig. 19, Chapter IV. Pour off the ether solution from the remainder of the liquid into the fat dish. Evaporate the ether from the dish, illustrated under Fig. 33.

Fig. 32. Fat Extraction Flask.

Fig. 33. Fat Dish.

Repeat the extraction, adding in turn with thorough shaking after each addition, 5 c. c. of alcohol, 15 c. c. of ethyl, and 15 c. c. of petroleum ether. Centrifuge as before. Add water if necessary to raise the dividing line between the ether solution, and the remaining liquid residue. Pour off the ether solution into the

same dish as was used for the first extraction. Evaporate the ether from the dish. Dry the fat in the vacuum oven. Cool and weigh the dish. Calculate the percentage of fat in the sample.

The necessary modifications of the above method for the various dairy products will be discussed further in this chapter. The successive steps involved will also be discussed in careful detail.

HOW TO WEIGH THE SAMPLES FOR THE FAT TEST.

Several methods are in use for weighing the samples for the fat test, depending upon the product that is being tested. The weighing cross with the short pipettes can be used successfully upon a number of dairy products. Numerous advantages are gained by using the cross, provided the product to be tested permits of its use. Five different samples can be weighed with only six weighings, and if care is taken, great accuracy is obtainable. The following cuts illustrate just how the weighing pipettes and the weighing cross are used.

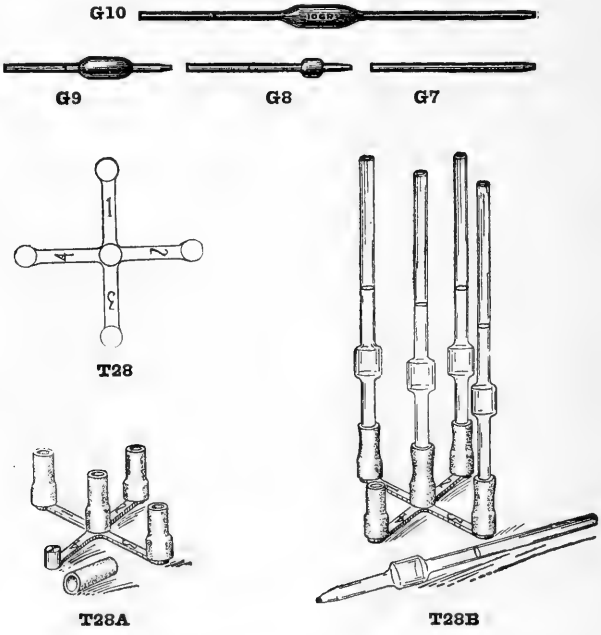


Fig. 34, Weighing Cross with Rubbers and Pipettes. Also 10-gram Pipette

G 7, G 8 and G 9 illustrate 1, 2 and 5 gram pipettes, respectively. G 10 is a pipette graduated to deliver 10 grams of whole milk, and it is never used in connection with the weighing cross. T 28 illustrates the cross itself, with the arms all properly numbered, in order to distinguish between the samples. T 28A shows the cross with the rubber tubes inserted over the knobs, thus forming an air-tight seal. T 28B shows the pipettes inserted in the tubes.

Another very satisfactory method of weighing certain dairy products is by means of Weighing Pipettes. These are illustrated under Fig. 35.

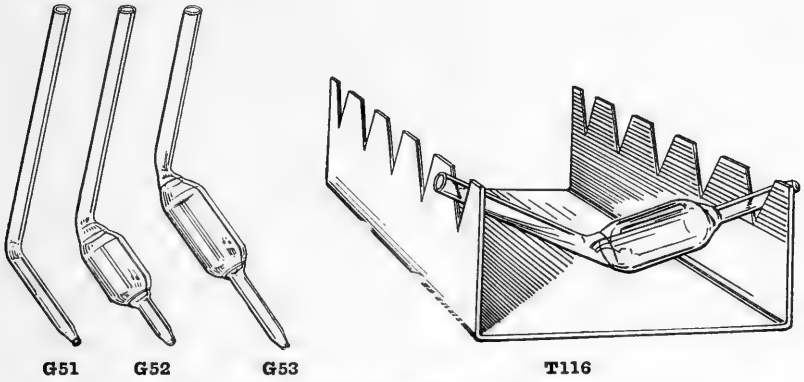


Fig. 35. Weighing Pipettes with Holder.

G 51, G 52 and G 53 illustrate 1, 2 and 5 gram pipettes, respectively. T 116 illustrates the holder that is to be placed upon the balance pan with the pipettes. With this method also, five samples can be weighed with only six weighings.

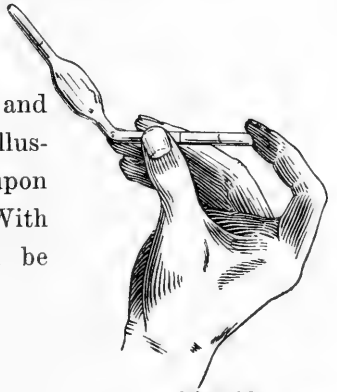
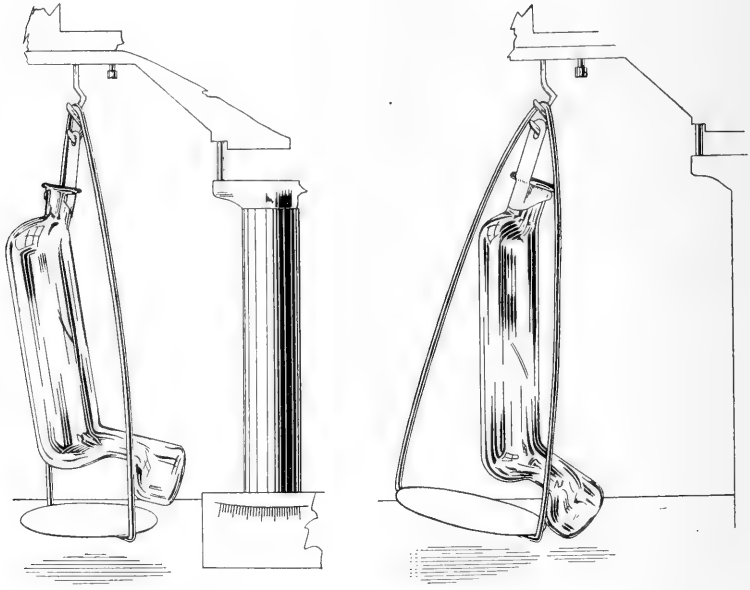


Fig. 36.
Position of Weighing Pipette Before Placing in Holder.

Products that are not homogeneous or that separate rapidly, are weighed most accurately when placed directly into the extraction flask, while the latter is suspended to the arm of the balance. This is illustrated under Fig. 37.



Right Way Wrong Way

Fig. 37.—Flask Hanger with Flask Suspended to Balance Arm.

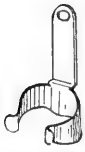


Fig. 38. Flask Hanger.

Fig. 38 is a hanger, one end of which is fastened to the hook upon the balance arm and the other holds the flask around its neck.

To insure absolutely accurate results, the extraction flask at the time of weighing must have the same temperature as that of the balance case, and the weighings of the empty flask and the flask when it contains the sample must be made quickly and closely together. In order not to expand the air inside the flask between the weighings, the flask should not be held in the hands nor allowed to change temperature by any other means.

Butter, and all other products that are not hygroscopic, are weighed with great accuracy in the butter boat illustrated under Fig. 39.

Fig. 39. Butter Boat.

The butter boat is weighed empty, the sample is then placed in it, and the weight obtained by difference.

Several products can be pipetted out, taking ten grams and where possible, this is a very accurate method. The pipettes are graduated to discharge ten grams of whole milk at 60° F., allowing 15 seconds for draining the pipette after the milk has all run out, and then blowing out the last drop of milk in the pipette.

WEIGHT OF SAMPLES TO TAKE FOR THE FAT TEST.

The size of sample to use varies, depending upon the product being tested, and it ranges from one gram in the case of butter to ten grams in the case of raw milk. See instructions following each product, and also Table 21 at the end of this chapter.

HOW TO ADD THE REAGENTS.

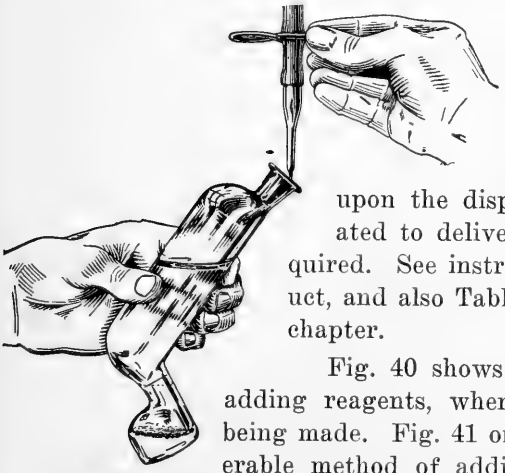


Fig. 40. Adding Reagents

The reagents should be added in the following order: Water, ammonia, alcohol, ethyl ether, and petroleum ether, The burettes upon the dispensing cans are graduated to deliver the proper charge required. See instruction under each product, and also Table 21 at the close of this chapter.

Fig. 40 shows position of flask when adding reagents, when one or two tests are being made. Fig. 41 on next page shows preferable method of adding reagents when several samples are to be tested.

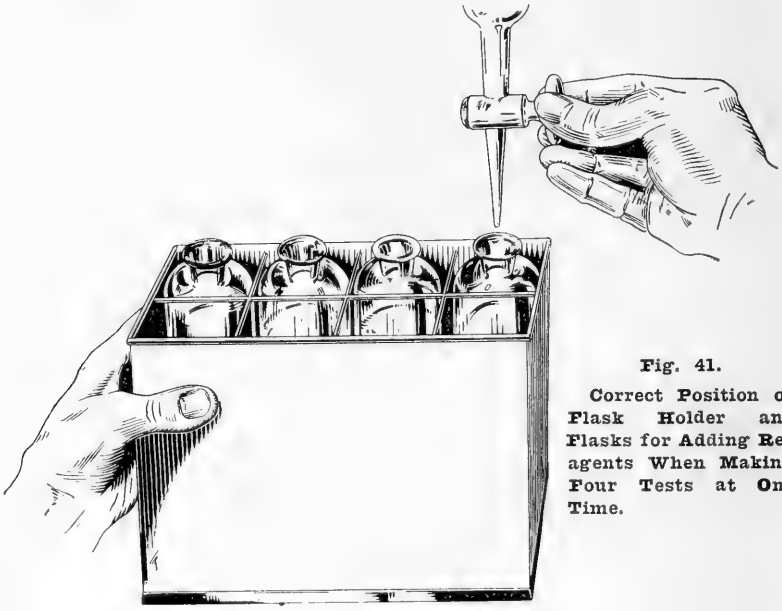


Fig. 41.

Correct Position of Flask Holder and Flasks for Adding Reagents When Making Four Tests at One Time.

HOW TO SHAKE THE FLASK.

If only one sample is being tested, it can be shaken by hand. As many as four samples can be shaken at one time in the holders which are furnished with the equipment. The flask should be held with large bulb down (see Fig. 42), and the small bulb extending upward. In this position they are shaken vigorously lengthwise of flask. After shaking 5 or 6 times, allow liquid in small bulb to run back into large bulb. Repeat this operation at least four times. There is no danger in shaking the samples too much. The only danger is in not shaking the samples enough so that this is a very impor-

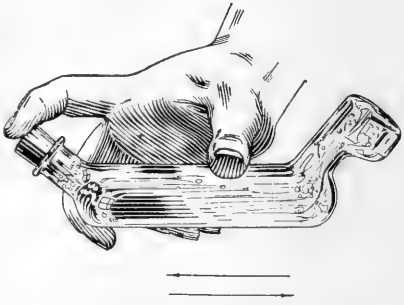


Fig. 42. Correct Position of Flask When Shaking.

tant part of the operation. Fig. 43 illustrates the extraction flask holder by means of which four samples can be shaken at one time.

The flasks should be kept in the position indicated while shaking and the liquid allowed to flow alternately from the large to the small bulb.

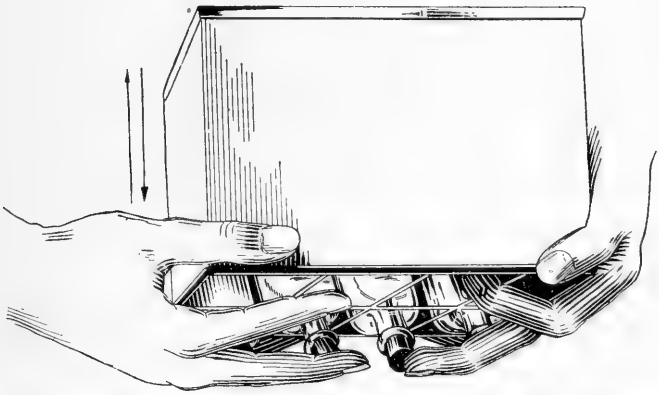


Fig. 43. Illustrates the Position in Which to Hold the Four Flasks That Are Being Shaken at One Time.

HOW TO CENTRIFUGE THE FLASK.

If only one sample is being centrifuged at a time, place a counterpoise upon the opposite side of the centrifuge in order to balance the head. Always see that there is about the same weight upon both sides of the centrifuge. The centrifuge with the head, holder and flask is illustrated under Fig. 19, Chapter IV.

HOW TO POUR OFF THE ETHER SOLUTIONS.

Remove the cork by twisting it carefully from the flask. Pour off the ether solution as completely as possible, taking care not to allow any of the liquid under the ether to flow out of the flask. This can be avoided if the dividing line between the ether solution and the remaining solution is carefully watched, while pouring off. In the first extraction, a larger amount of the ether solution can remain in the flask than in the second extraction. The

correct procedure in pouring off is illustrated under Fig. 44. The fat dish should be placed upon the tester top, and the operator should look down upon the ether solution as it is being poured off, observing the point where all the ether has been removed. By following this method, all but one or two drops of the ether solution should be removed, provided the dividing line was in the right place before pouring out.

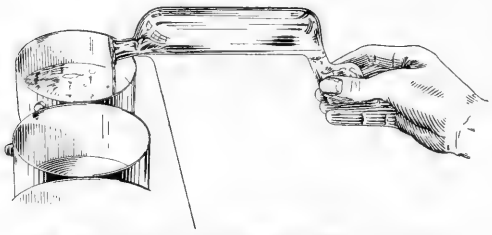


Fig. 44. Correct Procedure When Pouring Ether Solution Into Dish.

HOW TO BRING UP THE DIVIDING LINE

Inability to pour off the ether solution closely is due to the fact that the dividing line between the ether solution, and the remaining solution is too low in the lower bulb of the flask. At the end of the first extraction, the dividing line can remain without change, taking care to pour off the ether solution as closely as possible, regardless of the position of the dividing line. At the end of the second extraction, remove the stopper from the flask, and drop sufficient distilled water from the burette into the extraction flask to raise the dividing line to the desired point. This should be done just before pouring off the ether. If this procedure is followed, it becomes possible to remove the ether almost to the last drop. Fig. 45 shows the position of the dividing line both before and after water is added.

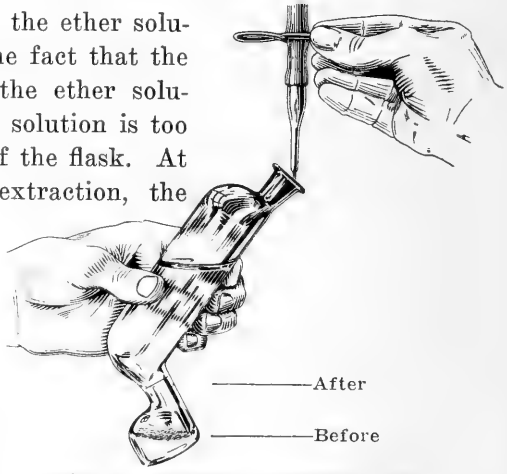


Fig. 45. Position of Dividing Line Before and After Raising.

HOW TO EVAPORATE THE ETHER FROM THE DISH.

It is important to maintain the proper temperature upon the outside hot plate. If the temperature is allowed to go below 135° C., it takes too long to evaporate the ether solution. Upon the other hand, if it rises much above 135° C., there is danger of the ether boiling out over the top of the dish, and also slight danger of oxidation of the fat. If the plate is too hot, it is best to place only part of the dish in contact with the plate. It is recommended that the hood be placed over the dishes, and that the ether fumes be blown out of the room by means of the blower. It is dangerous to allow the ether fumes to evaporate into the working room, and besides it makes it very unpleasant for the operator to work in contact with these vapors. This method is illustrated under Fig. 46.

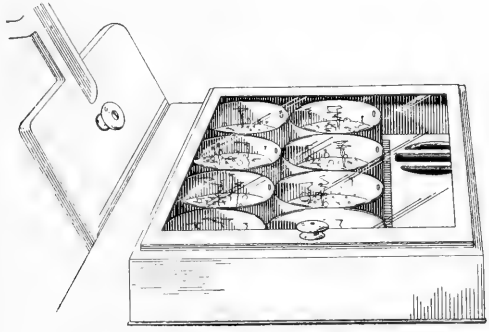


Fig. 46. Evaporating the Ether.

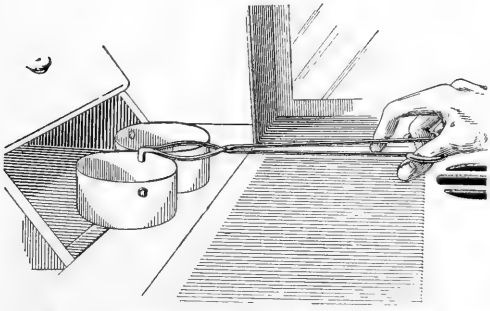


Fig. 47. Transferring Dishes to Vacuum Oven.

HOW TO HEAT THE FAT DISH IN THE OVEN.

Do not transfer the fat dish from the outside hot plate to the vacuum oven until all of the ether has been evaporated. If this is not done, the contents of the dish are quite likely to spatter in the oven. It is very important to maintain proper temperature conditions, namely 135° C., and also the proper vacuum upon the fat dishes, while the same are being heated in the oven. If for any reason, there should be difficulty in attaining either the proper heat, or the proper vacuum, the trouble should be immediately investigated and its cause removed.

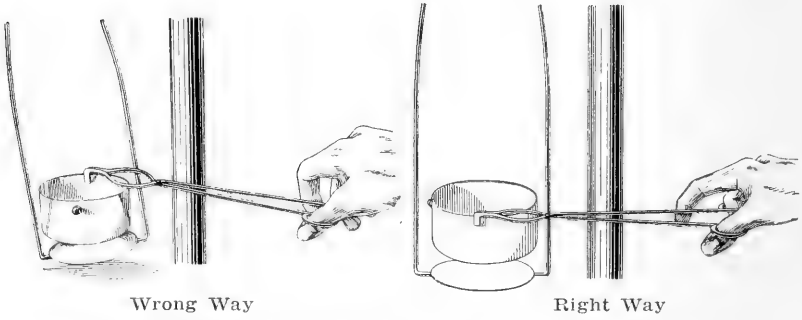


Fig. 48. Method of Placing Dish Upon the Balance Pan.

HOW TO WEIGH THE FAT DISH.

The fat dishes are to be transferred from the vacuum oven to the cooling desiccator in which they are to remain for seven minutes before being weighed. The weighing should be done as promptly as possible after cooling. Allow as little time as possible to elapse between the weighing of the empty dish, and of the dish with the fat in it. The air in the cooling desiccator should be at the same temperature as the air in the balance case. Therefore the two should be located closely together.

DIRECTIONS FOR OPERATING LEVERS CONTROLLING THE VACUUM OVENS.

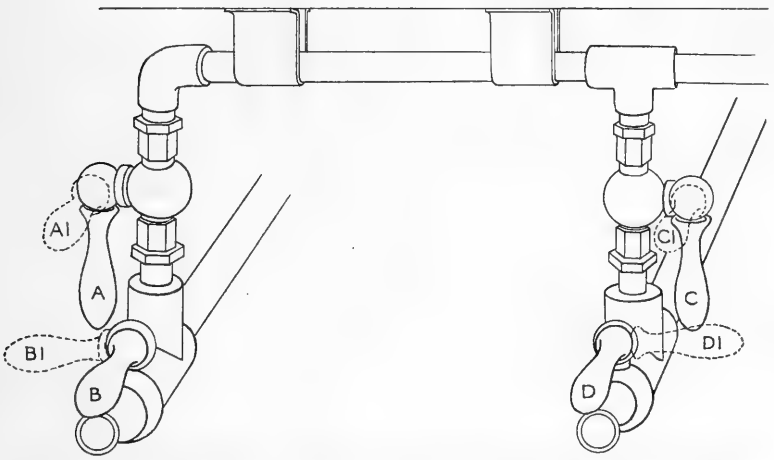


Fig. 49. Valve Handles Controlling Vacuums in Fat and Solids Ovens

Move valve handles in positions corresponding to lettering in above diagram as follows:

For no vacuum in either oven....A, B and C, D

For vacuum in fat oven.....A^1, B and C, D^1

For vacuum in Solids oven.....A, B^1 and C^1, D

For vacuum in both ovens.....A, B^1 and C, D^1

IMPORTANT HINTS TO OPERATORS OF THE MOJONNIER MILK TESTER.

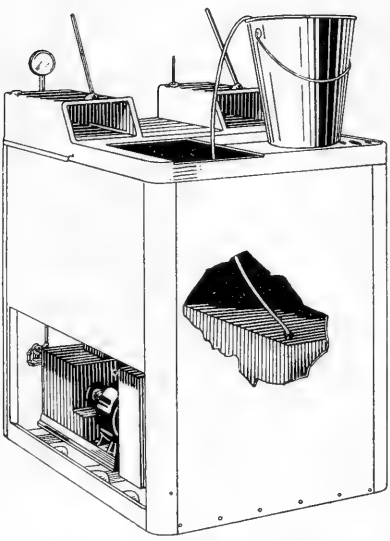


Fig. 50.

When Filling Water Tank Use Rubber Tube and Siphon Water as Illustrated. A Little Water Soluble Oil Placed in the Water Will Prolong Life of Gears in Water Circulating Pump.

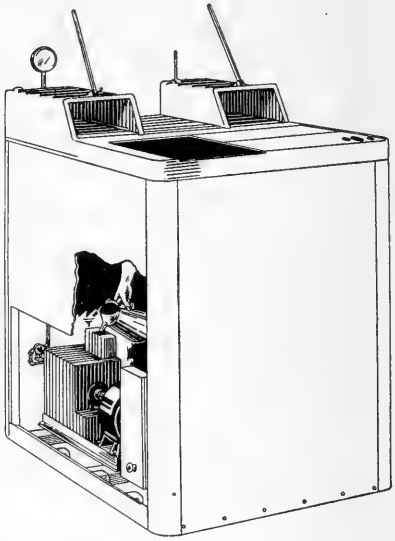


Fig. 51.

When Filling Vacuum Pump Reservoir Fill Spouted Dipper Furnished with Tester and Pour as Illustrated Until Proper Level of Oil is Indicated in Oil Gauge.

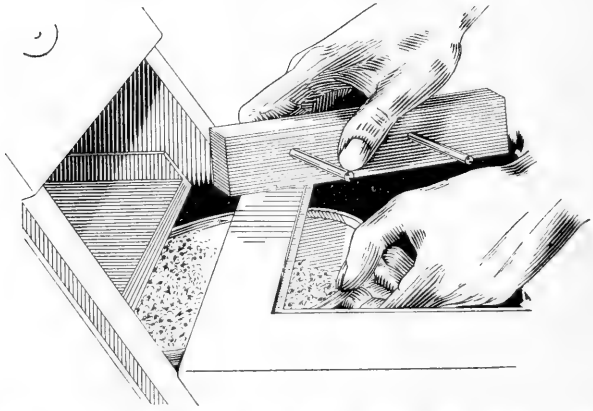
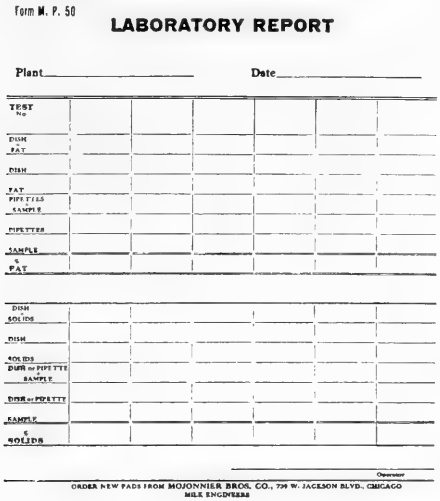


Fig. 52. Place the Calcium Chloride Pan Under the Plate in the Cooling Desiccator, as Illustrated.

HOW TO RECORD THE RESULTS AND TO CALCULATE THE PERCENTAGE OF FAT.

A systematic method should be adopted for recording all data covering the fat tests. Fig. 53 shows a form of laboratory report suitable for recording both fat and total solids tests.


Form M. P. 50

LABORATORY REPORT

Plant_____ Date_____

TEST No.						
DISH						
FAT						
DISH						
FAT						
PIPETTES SAMPLE						
PIPETTES						
SAMPLE						
% FAT						
DISH						
SOLIDS						
DISH						
SOLIDS						
DISH or PIPETTE SAMPLE						
DISH or PIPETTE						
SAMPLE						
% SOLIDS						

Operator

ORDER NEW PADS FROM MOJONNIER BROS. CO., 729 W. JACKSON BLVD., CHICAGO MILK ENGINEERS

Fig. 53. Laboratory Report Blank.

TABLE 20.

Laboratory Report. Test No. 1.

September 1, 1920.

	Evaporated milk.		Evaporated milk.
Dish plus Fat	.4287	Dish plus Solids	.2550
Dish	.0163	Dish	.0124
Fat	.4124	Solids	.2426
Pipettes plus Sample	32.8200	Dish or Pipette, plus sample	.9401
Pipettes	27.6650	Dish or Pipette	.0124
Sample	5.1550	Sample	.9277
Percentage of Fat	8.0000	Percentage of Solids	26.1500

In order to obtain the per cent of fat in the sample, divide the weight of the fat in the dish by the weight of the sample taken. Multiply the result thus obtained by 100 or move the decimal point

two places to the right. Example: Weight of fat found equals .4124 gram. Weight of sample taken equals 5.1550 grams. .4124 divided by 5.1550 equals .0800. .0800 multiplied by 100 equals 8.00 or the percentage of fat in the sample.

HOW TO RUN BLANKS UPON REAGENTS.

It is of the utmost importance to use pure reagents, or to make the proper corrections when using reagents that contain impurities.

To prove the purity of the reagents, blank determinations should be made at frequent intervals. Measure 50 c. c. each of ethyl and petroleum ether in separate fat dishes. Evaporate, heat, cool and weigh the dishes in exactly the same manner as when making a fat test. The residue should not exceed .0005 gram, which is equal to an error of .01 per cent upon a five gram sample. In a second method measure 10 c. c. of water in a fat extraction flask, and add all the reagents and complete the test just as in the case of a fat test upon whole milk. The residue in this case also should not exceed .0005 gram. If the residue exceeds the above limits, trace the trouble to the particular reagent that is responsible for the residue present, and take immediate steps to correct the trouble. Refer to Chapter III.

HOW TO TEST FRESH MILK, SKIM-MILK, WHEY AND BUTTERMILK FOR FAT.

Mix the samples very thoroughly. Measure samples for the test, taking 10-gram sample and using the 10-gram pipette. Drain the pipette 15 seconds, counting from the time the milk has all run out. Then gently blow out the last drop. If it is preferred, the samples can be weighed, although this constitutes an unnecessary operation.

Add no water to the samples.

For the first extraction, add 1.5 c. c. of ammonia; 10 c. c. of alcohol; 25 c. c. of ethyl ether, and 25 c. c. of petroleum ether. Shake thoroughly after the addition of the ammonia, half a minute after the addition of the alcohol, and one minute after the addition of each of the two ethers.

Centrifuge 30 turns, taking one-half minute.

For the second extraction, add neither water nor ammonia,

Add 5 c. c. of alcohol; 15 c. c. each of ethyl and petroleum ethers, and shake 20 seconds after the addition of each reagent.

Centrifuge 30 turns, taking one-half minute.

If necessary to raise the dividing line between the two ether solutions, add the necessary distilled water just before pouring off.

After evaporating off the ether, heat the dishes with the fat, in the vacuum oven at 135° C. for five minutes with not less than 20″ of vacuum. Cool in cooling desiccator to room temperature for seven minutes.

Weigh rapidly. Record results and calculate the percentage of fat.

HOW TO TEST EVAPORATED MILK, CONDENSED BUTTERMILK AND ALL UNSWEETENED CONDENSED MILKS FOR FAT.

Unsweetened condensed milk or evaporated milk, whether unsterilized or sterilized is all tested for fat in very much the same manner. Superheated plain bulk condensed is difficult to sample properly, so that great care must be exercised in getting representative samples. Evaporated milk sterilized in the can, especially after standing for a considerable time sometimes contains the fat, either separated in the form of cream or in the form of churned fat. Samples in this condition are difficult to test, and the proper allowance should always be made in cases of this kind.

To weigh the sample use either the weighing cross, or the weighing pipettes, and in some cases it may be desirable to weigh the sample directly into the flask suspended from the balance arm. The last method would apply where the samples are not homogeneous. Use about 5-gram sample, excepting in the case of condensed buttermilk and of extra heavy superheated milk, when only 3 grams should be used.

For the first extraction, add 4 c. c. of water (except in the case of condensed buttermilk and of extra heavy superheated milk when 6 c. c. of water should be used). 1.5 c. c. of ammonia, 10 c. c. of alcohol, and 25 c. c. each of ethyl and petroleum ethers. Shake thoroughly after the addition of water; again after adding the ammonia; half a minute after the addition of the alcohol and 20 seconds after the addition of each of the two ethers.

Centrifuge 30 turns, taking one-half minute.

For the second extraction, add neither water nor ammonia. Add 5 c. c. of alcohol, 25 c. c. each of ethyl and petroleum ethers, and shake 20 seconds after the addition of each reagent. (In the case of plain condensed skim-milk, and condensed buttermilk, use only 15 c. c. of each ethers in the second extraction.)

Centrifuge 30 turns, taking one-half minute.

If necessary to raise the dividing line, add the necessary distilled water just before pouring off the ether solution in the second extraction.

After evaporating off the ether, heat the dish with the fat in the vacuum oven at 135° C. for 5 minutes with not less than 20 inches of vacuum. Cool in the cooling desiccator to room temperature for 7 minutes.

Weigh rapidly. Record results, and calculate the percentage of fat.

HOW TO TEST SWEETENED CONDENSED MILK FOR FAT.

Proceed without diluting the sample, but be sure to obtain a representative sample, and to make sure that the sample is properly and thoroughly mixed. Sweetened condensed milk is very difficult to sample properly on account of the tendency for the milk sugar to settle out.

To weigh the sample, use either the weighing cross, or the weighing pipette. Use about five grams sample.

For the first extraction, add 8 c. c. of hot water; 1.5 c. c. of ammonia; 10 c. c. of alcohol, and 25 c. c. each of ethyl and petroleum ethers. Shake very thoroughly after adding the water, and again after adding the ammonia, and one minute each after adding the alcohol, and the two ethers.

Centrifuge 60 turns, taking one minute.

For the second extraction, add neither water nor ammonia. Add 5 c. c. of alcohol, 25 c. c. each of ethyl and petroleum ethers, and shake 20 seconds after the addition of each of the reagents. Centrifuge 60 turns, taking one minute.

If necessary to raise the dividing line, add the necessary distilled water just before pouring off.

After evaporating off the ether, heat the dish with the fat, in the vacuum oven at 135° C. for 5 minutes, with not less than 20 inches of vacuum. Cool in the cooling desiccator for 7 minutes.

Weigh rapidly. Record results and calculate the percentage of fat.

HOW TO TEST ICE CREAM MIX FOR FAT.

Mix the sample very thoroughly, and if necessary heat the same slightly in order to melt the butterfat. If the sample is not homogeneous, great care must be exercised in weighing out the same, otherwise the accuracy of the results will be affected. Weigh the sample, using either the weighing cross or the weighing pipettes, and in case that the sample is not homogeneous, weigh the sample directly into the extraction flask suspended from the balance arm. Use about five grams sample.

For the first extraction, add 5 c. c. of water, 1.5 c. c. of ammonia, 10 c. c. of alcohol, and 25 c. c. each of ethyl and petroleum ethers. Shake thoroughly after adding water, and again after adding the ammonia, and one-half minute each after adding the alcohol and the two ethers.

Centrifuge 30 turns, taking one-half minute.

For the second extraction, add neither water nor ammonia. Add 5 c. c. of alcohol, 25 c. c. each of ethyl and petroleum ethers, and shake 20 seconds after the addition of each reagent.

Centrifuge 30 turns, taking one-half minute.

If necessary to raise the dividing line, add the necessary distilled water just before pouring off the ether solution.

After evaporating off the ether, heat the dish with the fat, in the vacuum oven at 135° C. for 5 minutes with not less than 20 inches of vacuum. Cool in the cooling desiccator at room temperature for 7 minutes.

Weigh rapidly. Record results and calculate the percentage of fat.

HOW TO TEST CREAM FOR FAT.

Mix the sample very thoroughly, and heat it slightly, if this should be necessary, in order to melt the fat. To weigh the sample, use either the weighing cross or the weighing pipettes, and if the sample is not homogeneous, use either the butter boat or weigh the sample directly into the extraction flask suspended on the balance arm. In the case of cream testing less than 25 per cent of fat, use two grams sample, and in the case of cream testing more than 25 per cent of fat, use one gram sample.

For the first extraction, add 5 cc. of water, in the case of cream testing less than 25 per cent. Add 6 c. c. of water, in the case of cream testing more than 25 per cent of fat. Shake thoroughly after the addition of the water.

Use also 1.5 c. c. of ammonia, 10 c. c. of alcohol, and 25 c. c. each of ethyl and petroleum ethers. Shake thoroughly after the addition of the ammonia; one-half minute after the addition of the alcohol, and 20 seconds after the addition of each of the two ethers. Centrifuge 30 turns, taking one-half minute.

For the second extraction, add neither water nor ammonia. Add 5 c. c. of alcohol, 25 c. c. each of ethyl and petroleum ether, and shake 20 seconds after the addition of each reagent.

Centrifuge 30 turns, taking one-half minute.

If necessary to raise the dividing line, add the necessary distilled water just before pouring off the ether solution in the second extraction. After pouring off, heat the dish with the fat in the vacuum oven at 135° C. for five minutes with not less than 20 inches of vacuum.

Cool in the cooling desiccator to room temperature for seven minutes.

Weigh rapidly. Record results, and calculate the percentage of fat.

HOW TO TEST MALTED MILK, MILK CHOCOLATE, COCOA, CHEESE AND BUTTER FOR FAT.

Follow the method of sampling recommended under each of these products in turn under Chapter VI. To weigh the samples in all cases, use either the butter boat or weigh directly into the extraction flask suspended from the balance arm.

In the case of malted milk, chocolate and cocoa, use .5 gram sample. In the case of cheese and butter, use 1.0 gram sample.

For the first extraction, add 8 c .c. of hot water, 1.5 c. c. of ammonia (3 c. c. in case of cheese), 10 c. c. of alcohol, and 25 c. c. of each ethyl and petroleum ethers. Shake thoroughly after the addition of the water and the ammonia; one-half minute after the addition of the alcohol, and 20 seconds after the addition of each of the two ethers.

Centrifuge 30 turns, taking one-half minute.

For the second extraction, add neither water nor ammonia. Add 5 c. c. of alcohol, 25 c. c. each of ethyl and petroleum ether and shake 20 seconds after the addition of each reagent.

Centrifuge 30 turns, taking one-half minute.

If necessary to raise the dividing line, add the necessary distilled water just before pouring off the ether solution in the second extraction.

After evaporating off the ether, heat the dish with the fat in the vacuum oven at 135° C. for five minutes with not less than 20 inches of vacuum. Cool in the cooling desiccator for seven minutes.

Weigh rapidly. Record results and calculate the percentage of fat.

HOW TO TEST SKIM-MILK POWDER, BUTTERMILK POWDER, AND WHOLE MILK POWDER FOR FAT.

Follow the method of sampling recommended under these products in Chapter VI. To weigh the sample, use either the butter boat or weigh directly into the extraction flask suspended from the balance arm. Use about 1 gram sample.

For the first extraction, add 8.5 c. c. of hot water, 1.5 c. c. of ammonia (3 c. c. in case of buttermilk), 10 c. c. of alcohol, and 25 c. c. each of ethyl and petroleum ether. Shake thoroughly after adding water, again after adding ammonia, one-half minute after the addition of the alcohol, and 20 seconds after the addition of each of the two ethers.

Centrifuge 30 turns, taking one-half minute.

For the second extraction, add neither water nor ammonia. Add 5 c. c. of alcohol, and shake for 20 seconds. In the case of skim-milk powder, and buttermilk powder, add 15 c. c. each of ethyl and petroleum ether. In the case of whole milk powder add 25 c. c. each of ethyl and petroleum ether.

Centrifuge 30 turns, taking one-half minute.

If necessary to raise the dividing line, add the necessary distilled water just before pouring off the ether solution, in the second extraction.

After evaporating off the ether, heat the dish with the fat in the vacuum oven for five minutes with not less than 20 inches of

vacuum. Cool in the cooling desiccator at room temperature for seven minutes.

Weigh rapidly. Record results and calculate the percentage of fat.

ORDER OF OPERATIONS IN TESTING EVAPORATED MILK FOR BUTTERFAT AND TOTAL SOLIDS WITH THE MOJONNIER TESTER.

In the following outline, the procedure described is that used in the case of evaporated milk. The procedure used in the case of other products is much the same, but as mentioned both in Chapter VI and elsewhere in this chapter, differences may occur in the methods of sampling the products; of weighing the samples; the size of the samples to use; the quantity of water or other reagent to add; the method of shaking, and the method of centrifuging. The outline presumes that only one operator is doing the work. When speed is required, a helper to the operator can materially shorten the time required. In that case, the order of operations will need to be slightly modified.

1. Place the respective dishes in the vacuum ovens and keep them therein for at least five minutes, while the ovens are heated, with the vacuum on.

2. Transfer the respective dishes to the cooling desiccators; turn on the pump, and set the bell for five minutes for solids, and seven minutes for fat.

3. Weigh the solids dish first, being careful to put the cover upon the dish, and record the weight and the number, upon the laboratory report. Put the dish back into the cooling desiccator.

4. Weigh the fat dish without the cover. Record the weight and the number upon the laboratory report, and put the fat dish into the cooling oven.

5. Fill one 5 gram and one 1 gram pipette with milk, and place them upon the weighing cross, or weighing rack, or preferably, weigh the solids sample directly into the solids dish.

6. Weigh the above and record the weight upon the laboratory report upon the line entitled "pipettes plus sample."

7. Transfer the milk in the 5 grams pipette to the extraction flask, and return the empty pipette to the weighing cross, or to the weighing rack.

8. Weigh again, and record the weight in the fat column upon the line entitled "pipettes."

9. Also record the above weight in the solids column of the laboratory report, upon the line entitled "dish or pipettes plus sample." This operation may be omitted if the solids sample is weighed directly into the solids dish.

10. Transfer the milk from the one gram pipette to the weighed solids dish, and return the pipette to the weighing cross, or to the weighing rack, or preferably, obtain the weight of the solids sample by weighing it directly into the solids dish.

11. Place the weighing cross or the weighing rack upon the balance; weigh, and record the weight upon the line entitled "dish or pipette." This operation may be omitted if the solids sample is weighed directly into the solids dish.

12. Add sufficient distilled water to the milk in the dish to make a total volume of 2 c. c. of liquid. Mix and distribute evenly, and place the dish upon the solids hot plate.

13. When evaporation has taken place, transfer the dish to the solids oven.

14. Turn on the vacuum, and set the bell for ten minutes.

15. At this point take the extraction flasks with the milk in the same, and make the first extraction. Centrifuge, and pour the ether into the fat dish.

16. Make the second extraction, same as under 15.

17. During the above period, the solids bell will ring, and the solids dish should be transferred to the cooling desiccator, and the bell set for five minutes.

18. As soon as the ether has evaporated, place the dish in the fat oven; turn on the vacuum, and set the bell for five minutes.

19. When the bell for the solids side rings, weigh the dish, and record the weight.

20. When the test bell for the fat side rings, transfer the dish to the cooling desiccator, and set the bell again for seven minutes.

21. Complete the subtractions upon the laboratory report.

22. Weigh the fat dish; turn off the motor, and finish the calculations.

23. From the tests obtained, determine what material to add to standardize the batch.

LIST OF PRECAUTIONS TO OBSERVE IN MAKING FAT TESTS UPON THE MOJONNIER TESTER.

(1.) Before the reagents are put into the cans, the cans should be throughly cleansed by washing all parts, first with warm water, then with alcohol and finally with ether. **Every third or fourth time that the cans are filled, empty out the last portion of the reagents, and use the same for cleaning purposes,** unless tests prove the same to be of proper quality.

(2.) The bottom of all dishes should be kept as flat as possible. Any bulging should be worked out by resting the dishes upon the marble plate, in front of the balance, and rubbing the entire surface with the thumbs. The operator should observe this every time that the dishes are cleaned. This is very important.

(3.) The calcium chloride in the cooling desiccators should be changed every three or four weeks. The same calcium chloride may be used over and over, by drying the moist calcium chloride in the tin dishes by placing the same upon the hot plate held at 135° C. for at least five hours. However, the better method is to use a fresh supply, as soon as the supply in the desiccators becomes saturated.

(4.) The bottles should be whirled in the centrifuge until the ether extraction is perfectly clear. About 30 turns in half a minute is recommended. For sweetened condensed milk this time must be doubled.

(5.) Be sure to keep the extraction flasks perfectly clean. Wash often with sulphuric acid and washing powder, if necessary. If particles cling to the sides, put in small shot, washing powder and hot water, and shake thoroughly.

(6.) Keep the temperature regulated as near to standard temperature as possible.

(7.) Never pour off the ether solution into a hot dish. Remove the dish from the plate before the second extraction is run into the dish.

(8.) Be careful to pour off the ether into the dishes slowly at first, and gradually increase the stream.

(9.) In using the weighing pipettes, make sure that the neck of the flask is free from water when the pipette is inserted.

(10.) **Always use clean and dried pipettes.**

POSSIBLE CAUSES FOR HIGH FAT TESTS.

If the results upon fat are high as compared with the check results, the cause may be one or more of the following:

(1.) Not keeping the bottom of the dishes flat.

(2.) Improper shaking and centrifuging shown by non-fatty residue in the dish.

(3.) Impure reagents. (If in doubt, run test upon reagents substituting water for milk.)

(4.) Temperature in fat oven too low.

(5.) Dirt has gotten into the dish after the ether was poured into it.

(6.) Improper reading or posting of weights. Weights have lost weight from use.

(7.) Weighing the dish containing the fat at a lower temperature than prevailed when the dish was weighed empty.

POSSIBLE CAUSES FOR LOW FAT TESTS.

If the results on fat are low as compared with check results, the cause may be one or more of the following:

(1.) Leaky corks. Use best corks obtainable.

(2.) Insufficient shaking.

(3.) Adding too much water, or too little alcohol.

(4.) Having dividing line too low, so that too much ether is left behind. If such is the case, add more water to bring the line to the proper height, before pouring off, or make a third extraction.

Table 21.

Product to be tested	METHODS FOR MAKING FAT TESTS Keep sample in oven 5 min. at 135° C., and 7 min. in cooling desiccator								How long to centrifuge	Reagents to add, and how to shake—Second Extraction. Add neither water nor ammonia			How long to centrifuge	METHODS FOR MAKING TOTAL SOLIDS OR MOISTURE TESTS Summary of operations—Weigh directly into dish upon balance		
	How to prepare representative samples	How to weigh fat samples	Size of sample to take for fat test in grams	Reagents to add, and how to shake First extraction						Alcohol	Ethyl Ether	Pet'l'm Ether		Approximate size of sample to take for solids or moisture test in grams	Amount of water to add to sample in dish in cc	How long to keep sample in oven and cooling desiccator
				Water	Ammonia	Alcohol	Ethyl Ether	Petroleum Ether								
Fresh Milk	Mix thoroughly	Measure with 10 gram pipette. Drain 15 seconds	10	No water	1.5 cc Mix thoroughly	10 cc Shake half minute	25 cc Shake 20 seconds	25 cc Shake 20 seconds	30 turns	5 cc Shake 20 seconds	15 cc Shake 20 seconds	15 cc Shake 20 seconds	30 turns	2	None	10 min. in oven at 100°C. 5 min. in cooling desiccator at room temp.
Skim Milk	"	"	10	"	"	"	"	"	"	"	"	"	"	2	"	"
Whey	"	"	10	"	1.5 cc 3 cc if whey is acid mix thoroughly	"	"	"	"	"	"	"	2	"	"	"
Buttermilk	"	"	10	"	"	"	"	"	"	"	"	"	"	2	"	"
Cream testing less than 25% B. F.	Mix thoroughly Heat slightly if churned to melt fat	Weigh directly into flask. If necessary use butter boat	About 2	5 cc Mix thoroughly	"	"	"	"	"	"	"	"	"	1	1	"
Cream testing more than 25% B. F.	"	"	About 1	6 cc Mix thoroughly	"	"	"	"	"	"	25 cc Shake 20 seconds	25 cc Shake 20 seconds	"	1	1	"
Ice Cream Mix	"	Use weighing pipette or weigh directly into flask	About 5	5 cc Mix thoroughly	1.5 cc Mix thoroughly	"	"	"	"	"	"	"	"	1	1	"

Evaporated Milk	Shake in can or mix in bulk very thoroughly	"	About 5	4 cc Mix thoroughly	"	"	"	"	"	"	"	"	"	1	1	"
Bulk Unsweetened Condensed Milk	Mix very thoroughly	"	About 5	6 cc Mix thoroughly	"	"	"	"	"	"	"	"	"	1	1	"
Bulk extra heavy Unsweetened Condensed Milk	"	"	About 3	6 cc Mix thoroughly	"	10 cc Shake one minute	"	"	"	"	"	"	"	0.5	2	"
Sweetened Condensed Milk	Proceed without diluting. Mix very thoroughly	"	About 5	8 cc hot water. Mix until thoroughly dissolved	"	"	"	"	60 turns	"	"	"	60 turns	0.25	2	90 min. in oven at 100°C or 20 min. and deduct 0.30% from total. 5 min. in cooling desiccator at room temp.
Condensed Milk with Sugar and Chocolate	"	"	About 5	"	"	"	"	"	"	"	"	"	"	0.5	2	10 min. in oven at 100° C.5 min. in cooling desiccator at room temp.
Condensed Butter Milk (semi-solid)	"	If fluid use weighing pipette otherwise use butter boat	About 3	6 cc hot water. Mix thoroughly	3 cc Mix thoroughly	10 cc Shake half minute	"	"	30 turns	"	15 cc Shake 20 seconds	15 cc Shake 20 seconds	30 turns	0.5	2	"
Skimmed Milk Powder	Pulverize in close grained mortar. Transfer to sealed jar	Use butter boat	About 1	8 cc hot water. Mix thoroughly	1.5 cc Mix thoroughly	"	"	"	"	"	"	"	"	0.3	2	"
Whole Milk Powder	"	"	About 1	"	"	"	"	"	"	"	25 cc Shake 20 seconds	25 cc Shake 20 seconds	"	0.3	2	"
Butter Milk Powder	"	"	About 1	"	3 cc Mix thoroughly	"	"	"	"	"	15 cc Shake 20 seconds	15 cc Shake 20 seconds	"	0.3	2	"

Table 21 (Continued)

Product to be tested	METHODS FOR MAKING FAT TESTS Keep sample in oven 5 min. at 135° C., and 7 min. in cooling desiccator													METHODS FOR MAKING TOTAL SOLIDS OR MOISTURE TESTS Summary of Operations—Weigh directly into dish upon balance		
	How to prepare representative samples	How to weigh fat samples	Size of sample to take for fat test in grams	Reagents to add, and how to shake First extraction					How long to centrifuge	Reagents to add, and how to shake—Second Extraction. Add neither water nor ammonia			How long to centrifuge	Approximate size of sample to take for solids or moisture test in grams	Amount of water to add to sample in dish in cc	How long to keep sample in oven and cooling desiccator.
				Water	Ammonia	Alcohol	Ethyl Ether	Petroleum Ether		Alcohol	Ethyl Ether	Pet'l'm Ether				
Malted Milk	"	"	About 0.5	"	1.5 cc Mix thoroughly	"	"	"	"	"	25 cc Shake 20 seconds	25 cc Shake 20 seconds	"	0.3	2	20 min. in oven at 100° C. 5 min. in cooling desiccator at room temp.
Cocoa	"	"	About 0.5	"	"	"	"	"	"	"	"	"	"	0.3	2	"
Milk Chocolate	"	"	About 0.5	"	"	"	"	"	"	"	"	"	"	0.3	2	"
Cheese	"	"	About 1	"	3 cc Mix thoroughly	10 cc Shake one minute	"	"	"	"	"	"	"	0.5	2	"
Butter	"	"	About 1	"	1.5 cc Mix thoroughly	10 cc Shake half minute	"		"	"	"	"	"	1	None	10 min. in oven at 100° C. 5 min. in cooling desiccator at room temp.

(5.) Too high temperature in the vacuum oven.

(6.) Insufficient water circulating through the cooling desiccator. The water tank must be kept filled, and the circulating pump must be kept in good working order.

(7.) Improper reading or posting of weights.

(8.) Spattering of the fat in the oven due to transferring the dish to the oven before the ether solution had all evaporated, or if too high heat is carried in the vacuum oven.

(9.) Weighing the dish at a higher temperature than prevailed when the dish was weighed empty.

The following summary contains all the essential facts necessary for making both fat tests and total solids tests when using the Mojonnier Tester. This is arranged so the operator can tell at a glance just how to proceed when testing any given dairy product.

For the convenience of the operator the table gives information regarding total solids tests which are covered in Chapter VIII, to which the reader is referred.

CHAPTER VIII

DIRECTIONS FOR MAKING TOTAL SOLIDS TESTS USING THE MOJONNIER MILK TESTER

OUTLINE OF METHOD.

The method for making total solids tests taking fresh milk as a typical example is in brief as follows:

Weigh about 2 grams of milk in the flat bottomed three inch diameter by one inch high aluminum dish, as illustrated under Fig. 54. Spread the milk in a thin film over the entire bottom of the dish. Place the dish in direct contact with the outside hot plate, having a temperature of as near 180° C. as possible. Hold the dish upon the plate until the first trace of brown begins to appear. Now transfer the dish to the vacuum oven having a temperature of 100° C. Keep the dish in the oven for 10 minutes under a vacuum of not less than 20 inches. Transfer to the cooling desiccator, and hold it there for five minutes, with the water circulating pump operating continuously. Weigh rapidly. Record the weights and calculate the percentage of total solids.

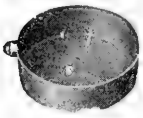


Fig. 54. Solids Dish.

Such modifications of the above method, as may be necessary in the case of various dairy products will be discussed further in this chapter.

The successive steps involved in the entire method will now be discussed in careful detail.

HOW TO WEIGH THE SAMPLES FOR THE SOLIDS TEST.

The samples for the solids test can be weighed by means of the weighing cross, or the weighing pipette, as described under Chapter VII. In many cases it is best to weigh the samples directly into the solids dish, as illustrated under Fig. 55 on next page. The method of weighing that has been found by experience to give the best results, is recommended under each separate product.

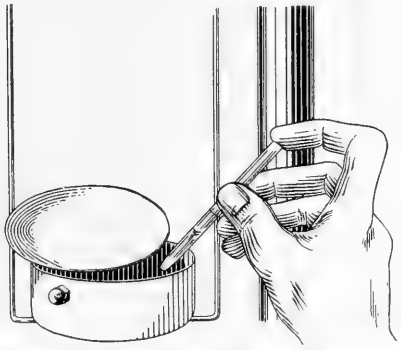


Fig. 55. Weighing the Solids Sample.

WEIGHT OF SAMPLE TO TAKE FOR SOLIDS TEST.

The weight of sample required varies from .25 gram in the case of sweetened condensed milk, to 2.00 grams in the case of whole milk. It is very important to adhere as closely as possible to the size of sample recommended in the case of each separate product. The use of too large a sample will very likely cause high results. Too small a sample may introduce inaccuracies, and may cause either too high or too low results.

HOW TO HANDLE THE DISHES AFTER THE SAMPLES HAVE BEEN WEIGHED IN THE SAME.

The dishes with the samples after weighing, if not convenient to treat immediately upon the outside hot plate, should be placed either upon the marble plate which supports the balance, or they should be transferred to the cooling desiccator. In no case should they be kept upon the outside hot plate support, as that causes evaporation, and makes it subsequently difficult to mix properly with water. Water should be added to the samples, where necessary, as soon as possible after weighing, and the test carried through without stopping between the various operations.

HOW TO ADD WATER TO THE SAMPLES IN THE SOLIDS DISH.

When necessary to add water, always use the best distilled water. It is well to run a blank upon the water to determine if it is free from solid matter. Reject any water that may contain any solid matter. Add sufficient water to make up a total volume that

should not exceed 2 c. c., in the case of the great majority of products. Mix the sample with the water in the dish, so that the contents will be distributed uniformly over the bottom of the dish. In the case of several of the dairy products, this important operation requires considerable skill and care. The necessary precautions will be found in the paragraphs describing the method of testing the various products.

HOW TO TREAT THE SAMPLE UPON THE OUTSIDE SOLIDS HOT PLATE.

It is very important to have the outside hot plate as near 180° C. as possible. If a temperature of more than 180° C. is used, there is great danger of the sample spattering out of the dish. If a temperature of less than 180° C. is used, the operation will be retarded, and the substance dries in the form of a smooth crust from which it is difficult to remove the last remaining traces of water. Heat the sample in the dish until it just begins to turn brown. This is one of the most important steps in the entire operation, and unless properly watched an error may be introduced at this point. Insufficient heating may give high results, and over-heating may give low results. Use the dish contact maker illustrated under Fig. 56, to press the bottom of the dish upon the hot plate. The dish should be so manipulated that vigorous boiling takes place upon the entire surface of the bottom of the dish.

Fig. 56. Dish Contact Maker. Used to Press the Dish Against the Hot Plate.

TEMPERATURE AND VACUUM TO MAINTAIN IN THE SOLIDS OVEN.

Keep the solids oven at a temperature as near 100° C. as possible. This applies to all products to be tested. Also see that there are at least 20 inches of vacuum upon the vacuum oven. If the Tester is properly operated, it should be possible to maintain 25 inches of vacuum at all times.

If for any reason, such for example as breakdown of the motor, it should be impossible to operate the power unit, the test can be completed in one and one-half hours without vacuum. If a

vacuum of less than 20 inches only is obtainable, the time of holding the sample in the oven should be proportionately increased. As a general rule, the recommendation is as follows, in the case of products where the standard is 10 minutes:

Vacuum upon solids oven in inches.	How long to keep dishes in oven under corresponding vacuum.
20 to 25	10 minutes
15 to 20	20 "
10 to 15	30 "
5 to 10	40 "
no vacuum	90 "

HOW LONG TO RETAIN THE DISH IN THE SOLIDS OVEN.

This varies with the product to be tested. The minimum time is 10 minutes, and in the case of sweetened condensed milk, in order to get absolute results, it is best to dry the samples one and one-half hours.

HOW TO COOL THE SOLIDS DISH.

Promptly transfer the dish from the oven to the cooling desiccator, and keep it therein for five minutes, with the water circulating during this time.

HOW TO WEIGH THE SOLIDS DISH.

Always weigh the solids dish with the dish cover upon the dish. Make the weighings as rapidly as possible, as otherwise the sample is quite likely to absorb moisture from the atmosphere. As in the case of the fat tests, a systematic method should be adopted for recording all data pertaining to the solids tests. A satisfactory blank report is illustrated under Fig. 53, Chapter VII.

HOW TO CALCULATE THE PERCENTAGE OF TOTAL SOLIDS.

Divide the weight of the total solids by the weight of the sample taken, and multiply the result by 100, or move the decimal point two places to the right, which will give the percentage of total solids in the sample. Example. Weight of solids found equals .2426 gram. Weight of sample taken equals 2.0216 grams.

$.2426 \div 2.0216 = .1200$

$.1200 \times 100 = 12.00$, or the per cent of total solids in the sample.

HOW TO TEST FRESH MILK, SKIM-MILK, WHEY AND BUTTERMILK FOR TOTAL SOLIDS.

Follow the directions of sampling given in Chapter VI. To weigh the sample, use either the weighing cross, or the weighing pipette, using the 2 grams pipettes, or weigh the sample directly into the dish upon the balance pan. Use about 2 grams sample. Add no water. Spread the milk in a thin film over the entire bottom of the dish. Now place the dish in direct contact, upon the outside hot plate, which should have a temperature of 180° C., and heat the dish until the first traces of brown begin to appear in the residue. Transfer the dish to the vacuum oven at a temperature of 100° C. Keep in the vacuum oven for 10 minutes under not less than 20 inches of vacuum. Transfer to the cooling desiccator, and hold it there for 5 minutes with the water circulating, pump operating continuously. Weigh rapidly. Record weights, and calculate the percentage of total solids.

HOW TO TEST EVAPORATED MILK AND ALL UNSWEETENED CONDENSED MILKS, INCLUDING CONDENSED BUTTERMILK FOR TOTAL SOLIDS.

Follow the directions of sampling given in Chapter VI. To weigh the sample, use either the weighing cross, or the weighing pipettes, using the one gram pipettes, or weigh the sample directly into the dish upon the balance pan. Use one gram sample in all cases, except in the cases of extra heavy superheated plain bulk condensed milk and condensed buttermilk, in which cases .50 gram sample should be taken. Add one c. c. of water to the sample in the dish in all cases, excepting in those of extra heavy superheated plain bulk condensed milk and condensed buttermilk, in which cases 2 c. c. of water should be added. Mix the milk and added water and spread in a thin film over the entire bottom of the dish. Now place the dish in direct contact upon the outside hot plate at a temperature of 180° C., and heat the dish until the first traces of brown begin to appear in the residue. Transfer the dish to the vacuum oven at a temperature of 100° C. Keep in the vacuum oven for 10 minutes under not less than 20 inches of vacuum. Transfer to the cooling desiccator, and hold it there for five minutes with the water circulating pump operating continuously.

Weigh rapidly. Record weights, and calculate the percentage of total solids.

HOW TO TEST SWEETENED CONDENSED MILK FOR TOTAL SOLIDS.

Follow the directions of sampling given in Chapter VI. To weigh the sample use either the weighing cross or the weighing pipette, taking one gram pipette, or weigh the sample directly into the dish upon the balance pan. It is usually most convenient to use the same pipette that was used for weighing out the sample for the fat test. When this is done, it becomes unnecessary to use an additional pipette for handling the solids sample. Use about .25 gram sample. This amounts to about four to five small drops. These drops should be placed in different parts of the dish so that the milk can be more readily dissolved by the water which is to be added later. Add 2 c. c. of hot water. Sweetened condensed milk is comparatively slow in dissolving. It is very important to make a good mixture of the milk with the water, and to spread the milk in a thin film over the entire bottom of the dish. When this is done, the dish should be placed in direct contact with the hot plate, having a temperature of 180° C. Heat the dish until the first traces of brown begin to appear in the residue. Transfer the dish to the vacuum oven at a temperature of 100° C. Keep in the vacuum oven for 20 minutes under not less than 20 inches of vacuum. This method, however, does not effect complete drying, and it is necessary to deduct .30 per cent from the total solids obtained. For example: If the total solids are found to be 73.86 per cent when the sample was dried for 20 minutes, the .30 should be deducted which will give a net content of 73.56 per cent total solids. The results obtained with this method are almost identical with the results obtained when the sample is kept in the vacuum oven for 90 minutes under not less than 20 inches of vacuum, and without making any deductions from the results obtained by drying for 90 minutes. This method is recommended particularly for factory control work where the element of time is so important, while the second method is recommended where the element of time is of no consequence. In either method, transfer the dishes to the cooling desiccator at the end of the drying period, and hold it in the desiccator for five minutes with the water pump operat-

ing continuously. Weigh rapidly. Record weights and calculate the percentage of total solids. On account of the small sample taken, and the general difficulties in the way of sampling and testing sweetened condensed milk, every possible precaution must be exercised in the testing of this product.

HOW TO TEST ICE CREAM MIX FOR TOTAL SOLIDS.

Follow the directions of sampling given in Chapter VI. To weigh the sample use either the weighing cross or the weighing pipette, or weigh the sample directly into the dish upon the balance pan. In any case, use about one gram sample. Add 1 c. c. of water. Spread the ice cream mix with the added water in a thin film over the entire bottom of the dish. Now place the dish in direct contact upon the outside hot plate having a temperature of 180° C., and heat the dish until the first traces of brown begin to appear in the residue. Transfer the dish to the vacuum oven at a temperature of 100° C. Keep in the vacuum oven for 10 minutes under not less than 20 inches of vacuum. Transfer to the cooling desiccator, and hold it there for five minutes with the water circulating pump operating continuously. Weigh rapidly. Record weights, and calculate the percentage of total solids.

HOW TO TEST CREAM FOR TOTAL SOLIDS.

Follow the directions of sampling given in Chapter VI. To weigh the sample, use either the weighing cross, or the weighing pipette, using the two grams pipette. It is frequently necessary to weigh the sample directly into the dish upon the balance pan, or to weigh it in the butter boat. The method of weighing selected is to be governed by the mechanical condition of the sample to be tested. In the case of cream testing less than 25 per cent of butterfat, use one gram sample. In the case of cream testing more than 25 per cent of butterfat, use .50 gram sample. In the case of cream testing less than 25 per cent of fat, add 1 c. c. of water to the sample in the dish. In the case of cream testing more than 25 per cent of fat, add 1.5 c. c. of water. Spread the milk with the added water in a thin film over the entire bottom of the dish. Now place the dish in direct contact upon the outside hot plate having a temperature of 180° C. and heat the dish until the first traces of brown begin to appear in the residue. Place

in the vacuum oven for 10 minutes under not less than 20 inches of vacuum. Transfer to the cooling desiccator, and hold it there for five minutes with the water circulating pump operating continuously. Weigh rapidly. Record weights, and calculate the percentage of total solids.

HOW TO TEST MALTED MILK, MILK CHOCOLATE AND COCOA FOR TOTAL SOLIDS.

Follow the directions of sampling given in Chapter VI. Weigh the sample directly into the dish upon the balance pan. Use about .30 gram sample. Add 2 c. c. of hot water. Spread the sample with the added water in a thin film over the entire bottom of the dish. Now place the dish in direct contact upon the outside hot plate having a temperature of 180° C. and heat the dish until the first traces of brown begin to appear in the residue. Transfer the dish to the vacuum oven having a temperature of 100° C. Keep in the vacuum oven for 20 minutes under not less than 20 inches of vacuum. Transfer to the cooling desiccator, and hold it there for five minutes with the water circulating pump operating continuously. Weigh rapidly. Record weights, and calculate the percentage of total solids.

HOW TO TEST CHEESE FOR TOTAL SOLIDS.

Follow the directions of sampling given in Chapter VI. Weigh the sample directly into the dish upon the balance pan. Weigh with the dish and the sample, a blunt pointed glass rod that can be used to break up any possible lumps of cheese that may later appear in the dish. Use about .50 gram sample. Add 1.5 c. c. of hot water. Spread the cheese with the added water in a thin film over the entire bottom of the dish. Use the glass rod to break up any lumps. Now place the dish in direct contact upon the outside hot plate having a temperature of as nearly 180° C. as possible, and heat the dish until the first traces of brown begin to appear in the residue. Transfer the dish to the vacuum oven having a temperature of 100° C. Keep in the vacuum oven for 20 minutes under not less than 20 inches of vacuum. Transfer in the cooling desiccator, and hold it there for five minutes with the water circulating pump operating continuously. Weigh rapidly. Record results, and calculate the percentage of total solids.

HOW TO TEST BUTTER FOR TOTAL SOLIDS.

Follow the method of sampling recommended in Chapter VI. Weigh the sample directly into the dish upon the balance pan. Use about one gram sample. Add no water. Heat the dish in direct contact upon the outside hot plate, having a temperature of 180° C. until spattering ceases, or until the first traces of brown begin to appear in the residue. Transfer the dish to the vacuum oven having a temperature of 100° C. Keep in the vacuum oven for 10 minutes under not less than 20 inches of vacuum. Transfer to the cooling desiccator and hold it there for 5 minutes with the water circulating pump operating continuously. Weigh rapidly. Record results and calculate the percentage of total solids.

HOW TO TEST SKIM-MILK, WHOLE MILK POWDER AND BUTTERMILK POWDER FOR TOTAL SOLIDS.

Follow the directions of sampling as given in Chapter VI. Weigh the sample directly into the dish upon the balance pan. Use about .3 gram sample. Add 2 c. c. of hot water and spread the sample with the water in a thin film over the entire bottom of the dish. Now place the dish in direct contact upon the outside hot plate having a temperature of 180° C., and heat the dish until the first trace of brown begins to appear in the residue. Transfer the dish to the vacuum oven having a temperature of 100° C. Keep in the vacuum oven for 10 minutes under not less than 20 inches of vacuum. Transfer to the cooling desiccator, and hold it there for 5 minutes with the water circulating pump operating continuously. Weigh rapidly, record results, and calculate the percentage of total solids.

POSSIBLE CAUSES FOR TOO HIGH SOLIDS TESTS.

(1). Bottoms of dishes were not kept flat.

(2). Evaporation upon the outside solids hot plate had not been carried far enough, or it had been done at an improper temperature. Do not remove dish until all visible moisture is off, or until the first trace of brown coloration appears.

(3). Improper reading or recording of weights. Weights have lost weight from use.

(4). Dirt had fallen into dish after sample had been weighed into it.

(5). Temperature in the vacuum oven was too low.

(6). Vacuum was not up to standard.

(7). Too large a sample was taken, rendering it impossible to remove all the water under the conditions recommended.

(8). Weighing the dish with the solids in the same at a lower temperature than prevailed when the dish was weighed empty.

POSSIBLE CAUSES FOR TOO LOW TOTAL SOLIDS TESTS.

(1). Sample was browned too much upon the outside hot plate, due either to too long exposure or to the use of too high temperature upon the hot plate.

(2). Temperature in the vacuum oven was above 100° C.

(3). Milk spattered from the dish. This will not happen if the temperature is kept at 180° C.

(4). Improper reading or recording of the weights.

(5). Water was not running through the cooler.

(6). Weighing the dish with the solids in the same at a higher temperature than prevailed when the dish was weighed empty.

SUMMARY OF METHODS RECOMMENDED FOR TESTING ALL DAIRY PRODUCTS FOR TOTAL SOLIDS.

For this summary the reader is referred to Table 21 at the close of Chapter VII. This gives in a condensed form all the important information required, covering the making of total solids tests when using the Mojonnier Tester.

CHAPTER IX

GENERAL INFORMATION REGARDING THE STANDARDIZING OF DAIRY PRODUCTS

STANDARDIZATION DEFINED.

Standardizing is defined as "comparing with a standard, or rendering standard." As applied to the dairy industry, it has a very broad application, inasmuch as it is used with reference to methods of plant operation; the processing of various dairy products and the physical, chemical and bacteriological limits permissible under a wide variety of products and conditions.

In this book the emphasis is placed upon the standardization of the chemical constituents with especial reference to the fat and the solids not fat content of dairy products. These are the most important constituents of all dairy products both from a chemical and a commercial standpoint, inasmuch as they affect both the quality and the cost of the finished products.

Consideration will also be given to the standardization of products added in the manufacture of certain dairy products, such as the addition of sugar when manufacturing sweetened condensed milk, or of sugar and gelatin when making ice cream.

Standardization is usually understood to mean either the raising or the lowering of either or of both the fat or solids not fat content of all dairy products to a certain fixed standard.

In practice it is possible to standardize either the fat or the solids not fat alone, or the two constituents together in the same product. Where the two constituents are standardized, the same will be present in the finished product in a constant ratio, one to the other. Methods will be given for standardizing various dairy products under the two conditions named.

SUCCESSIVE STEPS INVOLVED IN STANDARDIZING.

(a). **When standardizing for one constituent only.**

The steps involved when standardizing a single constituent are as follows:

(1). Obtaining a representative composite sample of the entire lot of product which makes up the batch, and likewise of the skim-milk or cream which might be used in standardizing.

(2). Testing all of the above products for fat or total solids, depending upon the constituent to be standardized. Where accurate results are desired, these tests should be made upon the Mojonnier Tester.

(3). Calculating the weight of each product to be used, by methods which will follow, and mixing the products together in the proper proportions.

(b). **When standardizing for both fat and total solids.**

The steps involved in standardizing dairy products for both fat and S. N. F. are as follows:

(1). Obtaining a representative composite sample of the entire lot of milk which goes to make up the batch, and likewise of skim-milk and the cream which might be used in standardizing.

(2). Testing of all of the above products involved, for both fat and S. N. F. or T. S. by means of the Mojonnier Tester, excepting that in the case of cream the S. N. F. can be obtained by referring to Table 22 found in this chapter, instead of by actual test.

(3). Calculating the weight of each product to be used by methods which will follow, in order to bring the fat and S. N. F. to the same ratio that they are to have in the standardized product that it is desired to make. If the resulting product should be over the desired standard, the necessary water is to be added to bring it back to the required test.

METHOD OF OBTAINING COMPOSITE SAMPLES.

The reader is referred to Chapter VI for methods recommended for obtaining representative samples of all the various dairy products. It must be kept constantly in mind that accuracy of final results is impossible unless the samples taken be representative of the entire batch.

METHOD OF GETTING WEIGHTS OF THE PRODUCTS.

The man who does the standardizing should be sure that the pounds of whole milk, likewise the pounds of cream and skim-milk used as well as the pounds of all other products involved are correctly reported, and properly checked. If this part of the work is not properly done, large errors may be introduced in the work. In many plants it is impossible to weigh all the products accurately. In such cases the pounds should be obtained by multiplying the volume by the specific gravity or by means of a graduated indicator upon the basis of definite weights of the product placed in the tank under the same temperature as obtain in practice.

METHOD OF TESTING RECOMMENDED.

Where accurate results are desired, the Mojonnier Tester should be used for making both fat and total solids tests. Only approximate results can be obtained if other methods are used for making these determinations.

METHOD OF CALCULATION TO USE.

In subsequent chapters methods of calculation are given, covering the entire range of important dairy products, under a wide variety of conditions. The reader is referred to these chapters for all details. For the sake of clarity, solutions are given by formula, by rule and by example, using simple arithmetic only.

THE USE OF TABLES IN SHORTENING CALCULATIONS.

Much time in making the calculations can be saved by using tables, the following of which are especially recommended:

(1.) Table showing the percentage of S. N. F. and percentage of total solids corresponding to any given percentage of fat in cream.

(2.) Table showing percentage of S. N. F. in various dairy products corresponding to any given percentage of fat. Tables of this kind can be prepared to cover all different dairy products. To prepare such tables, it is necessary to know the final composition of the product desired. Several tables of this nature will be found in subsequent chapters, and the reader will find the proper explanation for their use in connection therewith.

Table 22 gives the corresponding percentage of fat, solids not fat and total solids in cream starting with a cream having a total solids content of 23.00 per cent and ending with a cream having a total solids content of 60 per cent.

The values given were derived from the formula:

$F = 1.102 \times T.\ S. - 10.2$

F = the percentage of fat

T. S. = the percentage of total solids.

The formula is based upon the assumption that on the average there are 100 parts of water for 10.2 parts of milk solids not fat. An example taking an actual test of cream for both fat and total solids using the Mojonnier Tester will serve to illustrate how the above formula is derived. The sample tested 45.20 per cent total solids and 39.61 per cent fat.

$100 - 45.20 = 54.80$, per cent water in sample.

$45.20 - 39.61 = 5.59$, per cent solids not fat in sample.

To find parts or units of solids not fat for 100 parts of water, we have the ratio:

$54.80 : 100 = 5.59 : X$

$X = 10.20$, the parts of solids not fat contained in 100 parts of water in cream of the above test.

In some cases the actual test as found by means of the Mojonnier Tester may be either a little higher or a little lower than the values given in the table. Inasmuch as the total pounds of cream used in standardizing, as a rule are not large, an error as above mentioned would not appreciably affect the final results.

TABLE 22.

Per Cent S. N. F. and T. S. in Cream Corresponding to Any Given Percentage of Fat.

Fat.	S. N. F.	T. S.	Fat.	S. N. F.	T. S.	Fat.	S. N. F.	T. S.
15.15	7.85	23.00	17.41	7.64	25.05	19.66	7.44	27.10
15.20	7.85	23.05	17.46	7.64	25.10	19.72	7.43	27.15
15.25	7.84	23.10	17.52	7.63	25.15	19.77	7.43	27.20
15.31	7.84	23.15	17.57	7.63	25.20	19.83	7.42	27.25
15.37	7.83	23.20	17.63	7.62	25.25	19.88	7.42	27.30
15.42	7.83	23.25	17.68	7.62	25.30	19.94	7.41	27.35
15.48	7.82	23.30	17.74	7.61	25.35	19.99	7.41	27.40
15.53	7.82	23.35	17.79	7.61	25.40	20.05	7.40	27.45
15.59	7.81	23.40	17.85	7.60	25.45	20.11	7.39	27.50
15.64	7.81	23.45	17.90	7.60	25.50	20.16	7.39	27.55
15.70	7.80	23.50	17.96	7.59	25.55	20.22	7.38	27.60
15.75	7.80	23.55	18.01	7.59	25.60	20.27	7.38	27.65
15.81	7.79	23.60	18.07	7.58	25.65	20.32	7.37	27.70
15.86	7.79	23.65	18.12	7.58	25.70	20.38	7.37	27.75
15.92	7.78	23.70	18.18	7.57	25.75	20.44	7.36	27.80
15.97	7.78	23.75	18.23	7.57	25.80	20.49	7.36	27.85
16.03	7.77	23.80	18.29	7.56	25.85	20.55	7.35	27.90
16.08	7.77	23.85	18.34	7.56	25.90	20.60	7.35	27.95
16.14	7.76	23.90	18.40	7.55	25.95	20.68	7.34	28.00
16.19	7.76	23.95	18.45	7.55	26.00	20.71	7.34	28.05
16.25	7.75	24.00	18.51	7.54	26.05	20.77	7.33	28.10
16.30	7.75	24.05	18.56	7.54	26.10	20.82	7.33	28.15
16.36	7.74	24.10	18.62	7.53	26.15	20.88	7.33	28.20
16.41	7.74	24.15	18.67	7.53	26.20	20.93	7.32	28.25
16.47	7.73	24.20	18.73	7.52	26.25	20.99	7.31	28.30
16.52	7.73	24.25	18.78	7.52	26.30	21.04	7.31	28.35
16.58	7.72	24.30	18.84	7.51	26.35	21.10	7.30	28.40
16.63	7.72	24.35	18.89	7.51	26.40	21.15	7.30	28.45
16.69	7.71	24.40	18.95	7.50	26.45	21.21	7.29	28.50
16.74	7.71	24.45	19.00	7.50	26.50	21.26	7.29	28.55
18.80	7.70	24.50	19.06	7.49	26.55	21.32	7.28	28.60
16.85	7.70	24.55	19.11	7.49	26.60	21.37	7.28	28.65
16.91	7.69	24.60	19.17	7.48	26.65	21.43	7.27	28.70
16.96	7.69	24.65	19.22	7.48	26.70	21.48	7.27	28.75
17.02	7.68	24.70	19.28	7.47	26.75	21.54	7.26	28.80
17.07	7.68	24.75	19.33	7.47	26.80	21.59	7.26	28.85
17.13	7.67	24.80	19.39	7.46	26.85	21.65	7.25	28.90
17.18	7.67	24.85	19.44	7.46	29.90	21.70	8.25	28.95
17.24	7.66	24.90	19.50	7.45	26.95	21.76	7.24	29.00
17.29	7.66	24.95	19.55	7.45	27.00	21.81	7.24	29.05
17.35	7.65	25.00	19.61	7.44	27.05	21.87	7.23	29.10

TABLE 22 (Continued).

Fat.	S. N. F.	T. S.	Fat.	S. N. F.	T. S.	Fat.	S. N. F.	T. S.
21.92	7.23	29.15	24.18	7.02	31.20	26.44	6.81	33.25
21.98	7.22	29.20	24.24	7.01	31.25	26.50	6.80	33.30
22.03	7.22	29.25	24.29	7.01	31.30	26.55	6.80	33.35
22.09	7.21	29.30	24.35	7.00	31.35	26.61	6.79	33.40
22.14	7.21	29.35	24.40	7.00	31.40	26.66	6.79	33.45
22.20	7.20	29.40	24.46	6.99	31.45	26.72	6.78	33.50
22.25	7.20	29.45	24.51	6.99	31.50	26.77	6.78	33.55
22.31	7.19	29.50	24.57	6.98	31.55	26.83	6.77	33.60
22.36	7.19	29.55	24.62	6.98	31.60	26.88	6.77	33.65
22.42	7.18	29.60	24.68	6.97	31.65	26.94	6.76	33.70
22.47	7.18	29.65	24.73	6.97	31.70	26.98	6.76	33.75
22.53	7.17	29.70	24.79	6.96	31.75	27.05	6.75	33.80
22.58	7.17	29.75	24.84	6.96	31.80	27.10	6.75	33.85
22.64	7.16	29.80	24.90	6.95	31.85	27.16	6.74	33.90
22.69	7.16	29.85	24.95	6.95	31.90	27.21	6.74	33.95
22.75	7.15	29.90	25.01	6.94	31.95	27.27	6.73	34.00
22.80	7.15	29.95	25.06	6.94	32.00	27.32	6.73	34.05
22.86	7.14	30.00	25.12	6.93	32.05	27.38	6.72	34.10
22.91	7.14	30.05	25.17	6.93	32.10	27.43	6.72	34.15
22.97	7.13	30.10	25.23	6.92	32.15	27.49	6.71	34.20
23.03	7.12	30.15	25.28	6.92	32.20	27.54	6.71	34.25
23.08	7.12	30.20	25.34	6.91	32.25	27.60	6.70	34.30
23.14	7.11	30.25	25.39	6.91	32.30	27.65	6.70	34.35
23.19	7.11	30.30	25.45	6.90	32.35	27.71	6.69	34.40
23.25	7.10	30.35	25.50	6.90	32.40	27.76	6.69	34.45
23.30	7.10	30.40	25.56	6.89	32.45	27.82	6.68	34.50
23.36	7.09	30.45	25.62	6.88	32.50	27.87	6.68	34.55
23.41	7.09	30.50	25.67	6.88	32.55	27.93	6.67	34.60
23.47	7.08	30.55	25.73	6.87	32.60	27.98	6.67	34.65
23.52	7.08	30.60	25.78	6.87	32.65	28.04	6.66	34.70
23.58	7.07	30.65	25.84	6.86	32.70	28.09	6.66	34.75
23.63	7.07	30.70	25.89	6.86	32.75	28.15	6.65	34.80
23.69	7.06	30.75	25.95	6.86	32.80	28.20	6.65	34.85
23.74	7.06	30.80	26.00	6.85	32.85	28.26	6.64	34.90
23.80	7.05	30.85	26.06	6.84	32.90	28.31	6.64	34.95
23.85	7.05	30.90	26.11	6.84	32.95	28.37	6.63	35.00
23.91	7.04	30.95	26.17	6.83	33.00	28.43	6.62	35.05
23.96	7.04	31.00	26.22	6.83	33.05	28.48	6.62	35.10
24.02	7.03	31.05	26.28	6.82	33.10	28.54	6.61	35.15
24.07	7.03	31.10	26.33	6.82	33.15	28.59	6.61	35.20
24.13	7.02	31.15	26.39	6.81	33.20	28.65	6.60	35.25

TABLE 22 (Continued).

Fat.	S. N. F.	T. S.	Fat.	S. N. F.	T. S.	Fat.	S. N. F.	T. S.
28.70	6.60	35.30	30.96	6.39	37.35	33.22	6.18	39.40
28.76	6.59	35.35	31.01	6.39	37.40	33.27	6.18	39.45
28.81	6.59	35.40	31.07	6.38	37.45	33.33	6.17	39.50
28.87	6.58	35.45	31.13	6.37	37.50	33.38	6.17	39.55
28.92	6.58	35.50	31.18	6.37	37.55	33.44	6.16	39.60
28.98	6.57	35.55	31.24	6.36	37.60	33.49	6.16	39.65
29.03	6.57	35.60	31.29	6.36	37.65	33.55	6.15	39.70
29.09	6.56	35.65	31.35	6.35	37.70	33.60	6.15	39.75
29.14	6.56	35.70	31.40	6.35	37.75	33.66	6.14	39.80
29.20	6.55	35.75	31.46	6.34	37.80	33.71	6.13	39.85
29.25	6.55	35.80	31.51	6.34	37.85	33.77	6.13	39.90
29.31	6.54	35.85	31.57	6.33	37.90	33.82	6.13	39.95
29.36	6.54	35.90	31.62	6.33	37.95	33.88	6.12	40.00
29.42	6.53	35.95	31.68	6.32	38.00	33.94	6.11	40.05
29.47	6.53	36.00	31.73	6.32	38.05	33.99	6.11	40.10
29.53	6.52	36.05	31.79	6.31	38.10	34.05	6.10	40.15
29.58	6.52	36.10	31.84	6.31	38.15	34.10	6.10	40.20
29.64	6.51	36.15	31.90	6.30	38.20	34.16	6.09	40.25
29.69	6.51	36.20	31.95	6.30	38.25	34.21	6.09	40.30
29.75	6.50	36.25	32.01	6.29	38.30	34.27	6.08	40.35
29.80	6.50	36.30	32.06	6.29	38.35	34.32	6.08	40.40
29.86	6.49	36.35	32.12	6.28	38.40	34.38	6.07	40.45
29.91	6.49	36.40	32.17	6.28	38.45	34.43	6.07	40.50
29.97	6.48	36.45	32.23	6.27	38.50	34.49	6.06	40.55
30.02	6.48	36.50	32.28	6.27	38.55	34.54	6.06	40.60
30.08	6.47	36.55	32.34	6.26	38.60	34.60	6.05	40.65
30.13	6.47	36.60	32.39	6.26	38.65	34.65	6.05	40.70
30.19	6.46	36.65	32.45	6.25	38.70	34.71	6.04	40.75
30.24	6.46	36.70	32.50	6.25	38.75	34.76	6.04	40.80
30.30	6.45	36.75	32.56	6.24	38.80	34.82	6.03	40.85
30.35	6.45	36.80	32.61	6.24	38.85	34.87	6.03	40.90
30.41	6.44	36.85	32.67	6.23	38.90	34.93	6.02	40.95
30.46	6.44	36.90	32.72	6.23	38.95	34.98	6.02	41.00
30.52	6.43	36.95	32.78	6.22	39.00	35.04	6.01	41.05
30.57	6.43	37.00	32.83	6.22	39.05	35.09	6 01	41.10
30.63	6.42	37.05	32.89	6.21	39.10	35.15	6.00	41.15
30.68	6.42	37.10	32.94	6.21	39.15	35.20	6.00	41.20
30.74	6.41	37.15	33.00	6.20	39.20	35.26	5.99	41.25
30.79	6.41	37.20	33.05	6.20	39.25	35.31	5.99	41.30
30.85	6.40	37.25	33.11	6.19	39.30	35.37	5.98	41.35
30.90	6.40	37.30	33.16	6.19	39.35	35.42	5.98	41.40

TABLE 22 (Continued).

Fat.	S. N. F.	T. S.	Fat.	S. N. F.	T. S.	Fat.	S. N. F.	T. S.
35.48	5.97	41.45	37.74	5.76	43.50	40.00	5.55	45.55
35.53	5.97	41.50	37.79	5.76	43.55	40.05	5.55	45.60
35.59	5.96	41.55	37.85	5.75	43.60	40.11	5.54	45.65
35.64	5.96	41.60	37.90	5.75	43.65	40.16	5.54	45.70
35.70	5.95	41.65	37.96	5.74	43.70	40.22	5.53	45.75
35.75	5.95	41.70	38.01	5.74	43.75	40.27	5.53	45.80
35.81	5.94	41.75	38.07	5.73	43.80	40.33	5.52	45.85
35.86	5.94	41.80	38.12	5.73	43.85	40.38	5.52	45.90
35.92	5.93	41.85	38.18	5.72	43.90	40.44	5.51	45.95
35.97	5.93	41.90	38.23	5.72	43.95	40.49	5.51	46.00
36.03	5.92	41.95	38.29	5.71	44.00	40.55	5.50	46.05
36.08	5.92	42.00	38.34	5 71	44.05	40.60	5.50	46.10
36.14	5.91	42.05	38.40	5.70	44.10	40.66	5.49	46.15
36.19	5.91	42.10	38.45	5.70	44.15	40.71	5.49	46.20
36.25	5.90	42.15	38.51	5.69	44.20	40.77	5.48	46.25
36.30	5.90	42.20	38.56	5.69	44.25	40.82	5.48	46.30
36.36	5.89	42.25	38.62	5.68	44.30	40.88	5.47	46.35
36.41	5.89	42.30	38.67	5 68	44.35	40.93	5.47	46.40
36.47	5.88	42.35	38.73	5.67	44.40	40.99	5.46	46.45
36.52	5.88	42.40	38.78	5.67	44.45	41.04	5.46	46.50
36.58	5.87	42.45	38.84	5.66	44.50	41.10	5.45	46.55
36.64	5.86	42.50	38.89	5.66	44.55	41.15	5.45	46.60
36.69	5.86	42.55	38.95	5.65	44.60	41.21	5.44	46.65
36.75	5.85	42.60	39.00	5.65	44.65	41.26	5.44	46.70
36.80	5.85	42.65	39.06	5.64	44.70	41.32	5.43	46.75
36.86	5.84	42.70	39.11	5.64	44.75	41.37	5.43	46.80
36.91	5.84	42.75	39.17	5.63	44.80	41.43	5.42	46.85
36.97	5.83	42.80	39.22	5.63	44.85	41.48	5.42	46.90
37.02	5.83	42.85	39.28	5.62	44.90	41.54	5.41	46.95
37.08	5.82	42.90	39.33	5.62	44.95	41.59	5.41	47.00
37.13	5.82	42.95	39.39	5.61	45.00	41.65	5.40	47.05
37.19	5.81	43.00	39.45	5.60	45.05	41.70	5.40	47.10
37.24	5.81	43.05	39.50	5.60	45.10	41.76	5.39	47.15
37.30	5.80	43.10	39.56	5.59	45.15	41.81	5.39	47.20
37.35	5.80	43.15	39.61	5.59	45.20	41.87	5.38	47.25
37.41	5.79	43.20	39.67	5.58	45.25	41.92	5.38	47.30
37.46	5.79	43.25	39.72	5.58	45.30	41.98	5.37	47.35
37.52	5.78	43.30	39.78	5.57	45.35	42.03	5.37	47.40
37.57	5.78	43.35	39.83	5.57	45.40	42.09	5.36	47.45
37.63	5.77	43.40	39.89	5.56	45.45	42.15	5.35	47.50
37.68	5.77	43.45	39.94	5.56	45.50	42.20	5.35	47.55

TABLE 22 (Continued).

Fat.	S. N. F.	T. S.	Fat.	S. N. F.	T. S.	Fat.	S. N. F.	T. S.
42.26	5.34	47.60	44.51	5.14	49.65	46.77	4.93	51.70
42.31	5.34	47.65	44.57	5.13	49.70	46.83	4.92	51.75
42.37	5.33	47.70	44.62	5.13	49.75	46.88	4.92	51.80
42.42	5.33	47.75	44.68	5.12	49.80	46.94	4.91	51.85
42.48	5.32	47.80	44.73	5.12	49.85	46.99	4.91	51.90
42.53	5.32	47.85	44.79	5.11	49.90	47.05	4.90	51.95
42.59	5.31	47.90	44.84	5.11	49.95	47.10	4.90	52.00
42.64	5.31	47.95	44.90	5.10	50.00	47.16	4.89	52.05
42.70	5.30	48.00	44.96	5.09	50.05	47.21	4.89	52.10
42.75	5.30	48.05	45.01	5.09	50.10	47.27	4.88	52.15
42.81	5.29	48.10	45.07	5.08	50.15	47.32	4.88	52.20
42.86	5.29	48.15	45.12	5.08	50.20	47.38	4.87	52.25
42.92	5.28	48.20	45.18	5.07	50.25	47.43	4.87	52.30
42.97	5.28	45.25	45.23	5.07	50.30	47.49	4.86	52.35
43.03	5.27	48.30	45.29	5.06	50.35	47.54	4.86	52.40
43.08	5.27	48.35	45.34	5.06	50.40	47.60	4.85	52.45
43.14	5.26	48.40	45.40	5.05	50.45	47.66	4.84	52.50
43.19	5.26	48.45	45.45	5.05	50.50	47.71	4.84	52.55
43.25	5.25	46.50	45.51	5.04	50.55	47.77	4.83	52.60
43.30	5.25	48.55	45.56	5.04	50.60	47.82	4.83	52.65
43.36	5.24	48.60	45.62	5.03	50.65	47.88	4.82	52.70
43.41	5.24	48.65	45.67	5.03	50.70	47.93	4.82	52.75
43.47	5.23	48.70	45.73	5.02	50.75	47.99	4.81	52.80
43.52	5.23	48.75	45.78	5.02	50.80	48.04	4.81	52.85
43.58	5.22	48.80	45.84	5.01	50.85	48.10	4.80	52.90
43.63	5.22	48.85	45.89	5.01	50.90	48.15	4.80	52.95
43.69	5.21	48.90	45.95	5.00	50.95	48.21	4.79	53.00
43.74	5.21	48.95	46.00	5.00	51.00	48.26	4.79	53.05
43.80	5.20	49.00	46.06	4.99	51.05	48.32	4.78	53.10
43.85	5.20	49.05	46.11	4.99	51.10	48.37	4.78	53.15
43.91	5.19	49.10	46.17	4.98	51.15	48.43	4.77	53.20
43.96	5.19	49.15	46.22	4.98	51.20	48.48	4.77	53.25
44.02	5.18	49.20	46.28	4.97	51.25	48.54	4.76	53.30
44.07	5.18	49.25	46.33	4.97	51.30	48.59	4.76	53.35
44.13	5.17	49.30	46.39	4.96	51.35	48.65	4.75	53.40
44.18	5.17	49.35	46.44	4.96	51.40	48.70	4.75	53.45
44.24	5.16	49.40	46.50	4.95	51.45	48.76	4.74	53.50
44.29	5.16	49.45	46.55	4.95	51.50	48.81	4.74	53.55
44.35	5.15	49.50	46.61	4.94	51.55	48.87	4.73	53.60
44.40	5.15	49.55	46.66	4.94	51.60	48.92	4.73	53.65
44.46	5.14	49.60	46.72	4.93	51.65	48.98	4.72	53.70

TABLE 22 (Concluded)

Fat.	S. N. F.	T. S.	Fat.	S. N. F.	T. S.	Fat.	S. N. F.	T. S.
49.03	4.72	53.75	51.35	4.50	55.85	53.66	4.29	57.95
49.09	4.71	53.80	51.40	4.50	55.90	53.72	4.28	58.00
49.14	4.71	53.85	51.46	4.49	55.95	53.77	4.28	58.05
49.20	4.70	53.90	51.51	4.49	56.00	53.83	4.27	58.10
49.25	4.70	53.95	51.57	4.48	56.05	53.88	4.27	58.15
49.31	4.69	54.00	51.62	4.48	56.10	53.94	4.26	58.20
49.36	4.69	54.05	51.68	4.47	56.15	53.99	4.26	58.25
49.42	4.68	54.10	51.73	4.47	56.20	54.05	4.25	58.30
49.47	4.68	54.15	51.79	4.46	56.25	54.10	4.25	58.35
49.53	4.67	54.20	51.84	4.46	56.30	54.16	4.24	58.40
49.58	4.67	54.25	51.90	4.45	56.35	54.21	4.24	58.45
49.64	4.66	54.30	51.95	4.45	56.40	54.27	4.23	58.50
49.69	4.66	54.35	52.01	4.44	56.45	54.32	4.23	58.55
49.75	4.65	54.40	52.06	4.44	56.50	54.38	4.22	58.60
49.80	4.65	54.45	52.12	4.43	56.55	54.43	4.22	58.65
49.86	4.64	54.50	52.17	4.43	56.60	54.49	4.21	58.70
49.91	4.64	54.55	52.23	4.42	56.65	54.54	4.21	58.75
49.97	4.63	54.60	52.28	4.42	56.70	54.60	4.20	58.80
50.02	4.63	54.65	52.34	4.41	56.75	54.65	4.20	58.85
50.08	4.62	54.70	52.39	4.41	56.80	54.71	4.19	58.90
50.13	4.62	54.75	52.45	4.40	56.85	54.76	4.19	58.95
50.19	4.61	54.80	52.50	4.40	56.90	54.82	4.18	59.00
50.24	4.61	54.85	52.56	4.39	56.95	54.87	4.18	59.05
50.30	4.60	54.90	52.61	4.39	57.00	54.93	4.17	59.10
50.35	4.60	54.95	52.67	4.38	57.05	54.98	4.17	59.15
50.41	4.59	55.00	52.72	4.38	57.10	55.04	4.16	59.20
50.47	4.58	55.05	52.78	4.37	57.15	55.08	4.16	59.25
50.52	4.58	55.10	52.83	4.37	57.20	55.15	4.15	59.30
50.58	4.57	55.15	52.89	4.36	57.25	55.20	4.15	59.35
50.63	4.57	55.20	52.94	4.36	57.30	55.26	4.14	59.40
50.69	4.56	55.25	53.00	4.35	57.35	55.31	4.14	59.45
50.74	4.56	55.30	53.05	4.35	57.40	55.37	4.13	59.50
50.80	4.55	55.35	53.11	4.35	57.45	55.42	4.13	59.55
50.85	4.55	55.40	53.17	4.33	57.50	55.48	4.12	59.60
50.91	4.54	55.45	53.22	4.33	57.55	55.53	4.12	59.65
50.96	4.54	55.50	53.28	4.32	57.60	55.59	4.11	59.70
51.02	4.53	55.55	53.33	4.32	57.65	55.64	4.11	59.75
51.07	4.53	55.60	53.39	4.31	57.70	55.70	4.10	59.80
51.13	4.52	55.65	53.44	4.31	57.75	55.75	4.10	59.85
51.18	4.52	55.70	53.50	4.30	57.80	55.81	4.09	59.90
51.24	4.51	55.75	53.55	4.30	57.85	55.86	4.09	59.95
51.29	4.51	55.80	53.61	4.29	57.90	55.92	4.08	60.00

ORDER OF OPERATIONS IN STANDARDIZING DAIRY PRODUCTS.

The following order of operations is typical of that recommended in standardizing the majority of dairy products.

The order as given will have to be departed from in some cases, but where possible to follow it can be the means of saving considerable time. Owing to the perishable nature of dairy products it becomes necessary to study the various operations with the view of saving time where possible.

(1.) Test as far in advance as possible all products that may be required when standardizing. Tests to include both fat and total solids where standardization might require both values to be known.

(2.) About half an hour before the composite whole milk sample is ready, do everything necessary to begin making fat and total solids tests of the whole milk. Duplicate tests are recommended. If the operator is very careful in his work, a single determination may suffice.

(3.) Keep the fat and total solids dishes in the respective ovens for five minutes under the proper heat and with the vacuum on.

(4.) Transfer the dishes from the ovens to the cooling desiccators. Keep water circulating. Weigh the total solids dish with the cover on at the end of five minutes, and the fat dish alone at the end of seven minutes. Record weights and numbers upon the laboratory report. Replace dishes in the cooling desiccators.

(5.) As soon as the composite whole milk sample reaches the laboratory, mix the same thoroughly by pouring back and forth at least six times into two vessels.

(6.) Fill two gram pipette to the mark, and transfer the milk to the previously weighed dish and weigh the dish with the milk immediately. Or if preferred, the sample in the two gram pipette can be weighed from the weigh cross, or the weighing pipette.

(7.) While one operator is weighing the sample as directed under (6) the second operator pipettes out 10 grams of whole milk into the fat extraction flask.

(8.) One operator now prepares the total solids sample for the total solids oven and the second operator the fat sample for the fat oven. Dishes are heated in ovens, cooled in cooling desiccators and weighed in accordance with the directions.

(9.) Calculate the percentage of fat and the percentage of total solids and transfer the result to the proper report blank.

(10.) Calculate the average pounds of material to add, using the proper method of calculation.

(11.) Calculate the average fat and total solids test after having added the required pounds of skim-milk or cream.

(12.) Calculate the pounds of water required, if any is necessary. Make retest for fat and total solids after adding water.

PRINCIPLES OF METHOD OF CALCULATION WHEN STANDARDIZING FOR BOTH FAT AND SOLIDS NOT FAT.

In standardizing for both fat and solids not fat, the exact percentage of these two constituents desired in the finished product must be known. A definite ratio between the two then exists as soon as the composition has been established. This ratio forms the basis for the entire calculation, inasmuch as the problem then resolves itself into calculating the pounds of fat and solids not fat required in any desired mixture of dairy products so that these may be in the same ratio one to the other as in the case of the product desired.

For example, evaporated milk, testing 8.00 per cent fat, 18.15 per cent solids not fat and 26.15 per cent total solids contains fat and solids not fat in the following ratio:

$8.00 : 18.15 = 1 : X$

$X = 2.2687$, the pounds solids not fat that a standardized batch should contain for every pound of fat present.

The ratio can be calculated in several ways, which will be explained in subsequent chapters.

CHAPTER X

CALCULATIONS WHEN STANDARDIZING WHOLE MILK AND CREAM

In standardizing milk for its fat content without regard to its percentage of solids not fat, the usual practice is to add cream when it is necessary to raise the percentage of fat; and to add skim-milk when it is necessary to lower it. However, in the case of certain whole milk products it is frequently necessary to standardize upon the double basis of fat and solids not fat.

In standardizing cream it is seldom necessary, or desirable, to standardize upon any basis other than the fat alone. This is owing to the greater value of the fat as compared with the solids not fat, and also to the fact that the solids not fat in cream are always lower than in whole milk, and the same vary greatly with the content of the fat in the cream.

In this chapter there are given methods of calculation covering the standardization of whole milk and cream upon the basis of the fat alone, and upon the double basis of the fat and solids not fat in the case of whole milk.

A. HOW TO CALCULATE WHEN STANDARDIZING FOR FAT ALONE.

The best method for standardizing for fat alone is the classic method devised by Prof. Pearson,[1] or modifications of the Pearson method. This method is applicable to two different types of problems as follows: (1) When it is desired to make a product of definite fat test regardless of the resulting total weight; and (2) when it is desired to make a definite weight of product of a definite fat test. This method and its modification can be applied to milk, cream and several other dairy products.

PROBLEM 1: HOW TO CALCULATE WHEN IT IS DESIRED TO MAKE A PRODUCT OF DEFINITE FAT TEST REGARDLESS OF THE RESULTING TOTAL WEIGHT.

A rectangle is drawn and the desired percentage of fat is placed in the center of it. The percentage of fat in each of the materials to be mixed together is placed at the left hand corners. The smaller number on the left hand corner is then subtracted from the number in the center, and the difference is placed in the diagonally opposite right hand corner. The number in the center is subtracted from the larger number at the left hand corner and the difference is placed in the diagonally opposite right hand corner. The two numbers at the right hand corners represent the number of pounds of each material to bring together in order to make a mixture containing the fat percentage indicated in the center of the rectangle. The number on the right hand corner refers to the substance represented by the number on the left hand corner directly opposite.

PROBLEM 1: HOW TO CALCULATE WHEN MIXING TOGETHER WHOLE MILK AND CREAM.

Standardizing for Fat Only.

Problem 1, Example 1: How many pounds of 30 per cent cream must be mixed with 900 pounds of 3.2 per cent milk to make a mixture testing 3.6 per cent of fat?

The smaller figure at the left is subtracted from the figure at the center, leaving a difference of .4. The figure at the center is subtracted from the larger figure at the left, leaving a difference of 26.4. This shows that .4 of a pound of 30 per cent cream must be mixed with 26.4 pounds of 3.2 per cent milk to form a mixture

containing 3.6 per cent of fat. A calculation by simple proportion will give the total pounds of cream required as follows:

.4 : 26.4 = X : 900

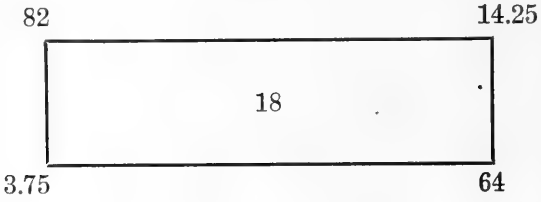
X = 13.64 or the pounds of cream required.

Proof:

900× .032= 28.80, lbs. fat in whole milk.
13.64× .30 = 4.09, lbs. fat in cream.
28.80+ 4.09 = 32.89, lbs. fat in mixture.
900+ 13.64 =913.64, lbs. in total mixture.
32.89÷913.64 = 0.036, lbs. fat for one lb. of milk.
0.036×100 = 3.60, per cent fat desired.

PROBLEM 1. EXAMPLE 2: HOW TO CALCULATE WHEN MIXING TOGETHER WHOLE MILK AND BUTTER TO MAKE CREAM.

Problem 1, Example 2: How many pounds of butter testing 82.00 per cent fat must be mixed with 1,000 pounds of whole milk testing 3.75 per cent fat to make cream testing 18.00 per cent fat?



As in the case of Example 1, the pounds of butter required are found by a calculation in simple proportion as follows:

14.25 : 64 = X : 1000

X=222.6, the pounds of butter to use.

Proof:

1000 + 222.60=1222.6, or the pounds in total mixture.
1000 × .0375=37.50, lbs. fat in whole milk.
222.66 × .82=182.58, lbs. fat in butter.
37.50 + 182.58=220.08, lbs. fat in mixture.
220.08 ÷ 1222.60=0.18, lb. fat in one lb. cream.
0.18 × 100=18.0, per cent of fat desired.

PROBLEM 2: HOW TO CALCULATE WHEN IT IS DESIRED TO MAKE A DEFINITE WEIGHT OF PRODUCT OF A DEFINITE FAT TEST.

This problem is solved most readily by a modification of the Pearson method devised by J. A. Cross. By the Pearson method, the solution of this problem requires two subtractions, two additions, two divisions and two multiplications. By the Cross modification three subtractions, one division and one multiplication only are required.

Solution Problem 2, based upon Rule 1:

Subtract the low test from the high test. Call remainder A. Subtract the low test from the standard desired. Call the difference B. Divide B by A and multiply the result by the pounds of mixture desired. Call answer C, or the pounds of high testing material required. Subtract C from the total pounds required. The remainder will be the pounds of low testing material needed.

Problem 2, Example 3:

How many pounds of milk containing 4.20 per cent of fat and skim-milk containing .1 per cent of fat must be mixed together to make 1000 pounds of milk testing 3.60 per cent fat?

Solution Problem 2, Example 3, based upon Rule 1:

$\frac{3.60 - .10}{4.20 - .10} \times 1000 = 853.65$, lbs. of 4.20 per cent milk required.

1000—853.65=146.34, lbs. of skim-milk required.

Proof Problem 2, Example 3:

853.65 × .042 = 35.85, pounds of fat in the whole milk.
146.34 × .001 = .15, pound of fat in the skim-milk.
35.85 + .15 = 36.00, pounds of fat in the mixture.
36.00 ÷ 1000 = 0.036, lb. fat for one lb. milk.
0.036 × 100 = 3.60, per cent of fat in the standardized milk.

THE CROSS DIAGRAM METHOD

J. A. Cross has developed another excellent improvement of the above method, all based upon the principle of allegation. This method can be used whenever it is desired to mix together two products of different tests with the object of obtaining a definite weight of a third product of a definite test, or also an indefinite weight of a third product of a definite test.

PRINCIPLE OF THE CROSS DIAGRAM METHOD.

Let A and B be the weights of two ingredients to be mixed to produce a weight (A + B) of mixture. Let a and b be the percentages in the two ingredients of some component common to both of them; and let m be the percentage of the same component in the final mixture.

Then the total weight of the component in the mixture is the sum of the weights of that compound in the two ingredients. Formulated algebraically this is

$$aA + bB = m\ (A + B)$$

The above equation may readily be transformed into the following:

$$A : B :: (m - b) : (a - m)$$

Designating a, b and m as composition percentages we can state the above equation in what is called the Principle of Allegation:—

"The weights of two ingredients needed to prepare a given mixture are inversely proportional to the differences between the composition percentages of these ingredients and that of the mixture itself."

Dr. Pearson's method presents the above principle graphically. His method of subtraction insures giving the values of (m — b) and (a — m), and his diagram also automatically shows that these values are in inverse proportion to A : B.

The mixture diagrams illustrated under Figs. 57 and 58 carry this principle a little farther by automatically getting the values of (m — b) and (a — m), and by taking advantage of a simple geometric principle these values are made to add always to 100 and can be considered as percentages.

APPLICATION OF THE CROSS DIAGRAM METHOD.

This method can be applied to the standardization of either milk or cream. The results are accurate within one-half of one per cent or less. The diagram under Fig. 57, applies to cream, and that under Fig. 58 applies to skim-milk and whole milk.

PROBLEM 2, EXAMPLE 3A: MATERIALS ON HAND, 30.00 PER CENT CREAM AND 10.00 PER CENT CREAM. WANTED 100 POUNDS OF 22.00 PER CENT CREAM.

Solution Problem 2, Example 3A, based upon Cross Diagram Method:

Lay a ruler across the diagram in such a way that it cuts 30 per cent on the left and 10 per cent on the right hand vertical scales. Then where the ruler cuts the diagonal scale marked 22 per cent, the pounds of 30 per cent cream can be read directly, namely, 60 pounds. The pounds of 10 per cent cream is then, of course, 40.

In the same position, the ruler shows that 50 pounds of 30 per cent and 50 pounds of 10 per cent will produce 100 pounds of 20 per cent cream. Also that 40 pounds of 30 per cent and 60 pounds of 10 per cent will produce 100 pounds of 18 per cent cream.

The correct proportions of materials of any other percentages can also be found in the same way.

Other problems may also be solved by this method.

Example 3B.

On hand 865 pounds of 26 per cent cream. How much 3.5 per cent milk is necessary to reduce the percentage to 22 per cent?

Solution Example 3B, based upon Cross Diagram Method:

Mixture diagram shows that 82 parts cream and 18 parts milk are necessary. Therefore,

$\frac{865}{.82}$—865=189, pounds 3.5 per cent milk necessary.

Example 3C.

On hand 625 pounds of 17.5 per cent cream. How much 40 per cent cream must be added to raise the percentage to 22 per cent?

Solution Example 3C, based upon Cross Diagram Method:

Mixture diagram shows that the proportion is 20 parts 40 per cent to 80 parts 17.5 per cent, therefore

$$\frac{625}{.80}-625=157, \text{ pounds of 40 per cent cream necessary.}$$

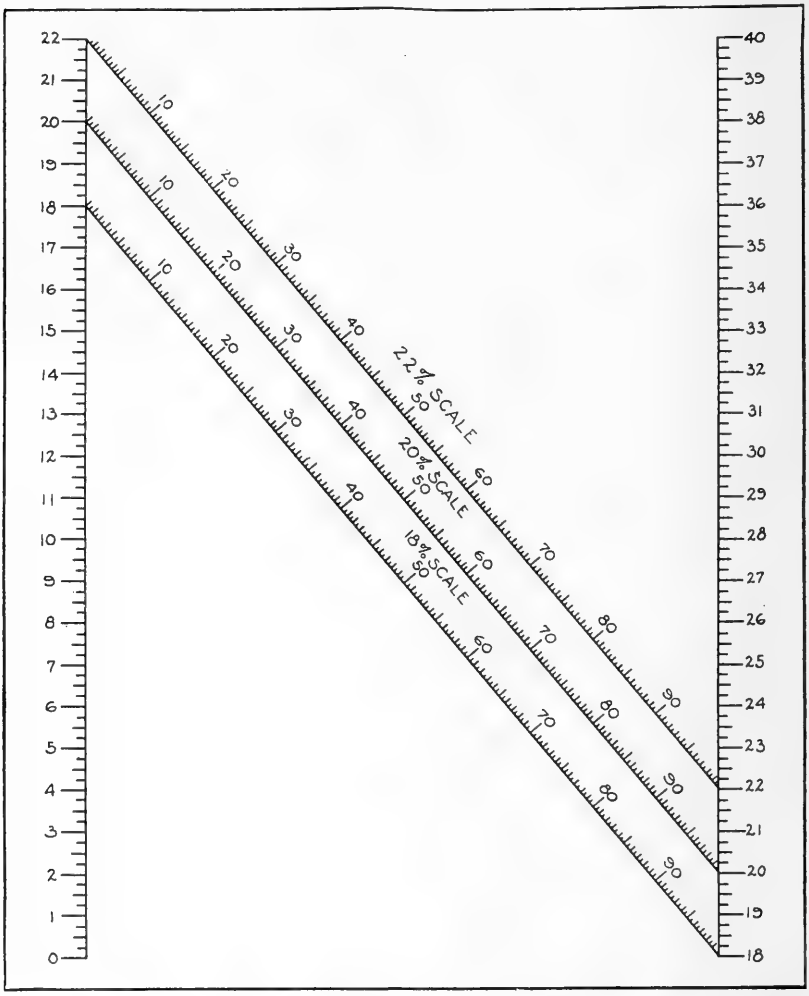


Fig. 57. Cross Diagram Method for Standardizing Cream. High Testing Materials Vertical Right Hand Column. Low Testing Materials Vertical Left Hand Column Test of Product Desired, also Percentage of High Testing Materials Required Upon Diagonal Scale.

Either of the other scales (20 per cent or 18 per cent) will work in exactly the same way, or any desired scale can be sketched in. It would be very easily possible to make a universal mixture diagram which would show the exact proportions of any two materials necessary to produce any desired percentage of another, and to arrange it in such a way that the proportions would add to 100.

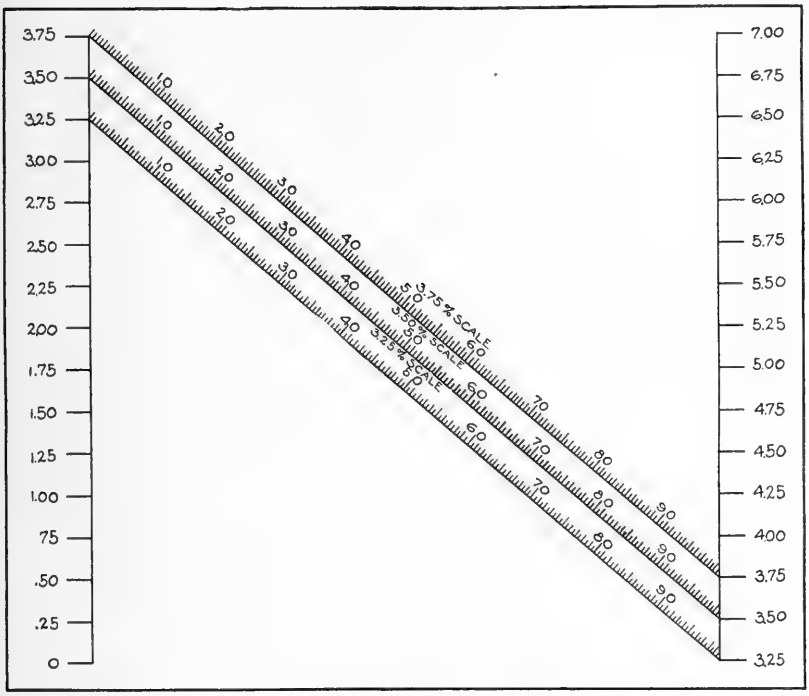


Fig. 58. Cross Diagram Method for Standardizing Milk. High Testing Materials Vertical Right Hand Column. Low Testing Materials Vertical Left Hand Column. Test of Product Desired, also Percentage of High Testing Materials Required Upon Diagonal Scale.

ERF'S METHOD FOR SINGLE STANDARDIZATION.

Another very excellent method for single standardization is that published by Prof. Erf.[2] The method is based upon the making of suitable tables, and when these are once prepared the solution desired is found by reference to the tables. Table 23 applies to the standardization of whole milk.

TABLE 23.

Quantity of skim-milk to be added to, or subtracted from, 100 pounds of milk to make milk of a desired percentage of fat.

Per Cent Fat in Milk on Hand	Desired Percentage of Fat in Standardized Milk.							
	3.25	3.50	3.75	4.0	4.25	4.50	4.75	5.0
3.	− 7.693	−14.285	−20.000	−25.00	−29.412	−33.333	−36.842	−40.000
3.1	− 4.616	−11.428	−17.333	−22.50	−27.059	−31.111	−34.737	−38.000
3.2	− 1.539	− 8.571	−14.666	−20.00	−24.706	−28.888	−32.632	−36.000
3.3	+ 1.539	− 8.714	−12.000	−17.50	−22.353	−26.666	−30.527	−34.000
3.4	+ 4.616	− 2.857	− 9.333	−15.00	−20.000	−44.444	−28.422	−32.000
3.5	+ 7.693	− 0.000	− 6.666	−12.50	−17.647	−22.222	−26.317	−30.000
3.6	+10.760	+ 2.857	− 4.300	−10.00	−15.294	−20.000	−24.212	−28.000
3.7	+13.837	+ 5.714	− 1.333	− 7.50	−12.941	−17.777	−22.107	−26.000
3.8	+16.914	+ 8.571	+ 1.333	− 5.00	−10.588	−15.555	−20.000	−24.000
3.9	+19.991	+11.428	+ 4.000	− 2.50	− 8.235	−13.333	−17.897	−22.000
4.0	+23.068	+14.285	+ 6.666	− 0.00	− 5.882	−11.111	−15.792	−20.000
4.1	+26.145	+17.142	+ 9.333	+ 2.50	− 2.429	− 8.888	−13.687	−18.000
4.2	+29.222	+19.999	+12.000	+ 5.00	− 0.076	− 6.666	−11.582	−16.000
4.3	+32.299	+22.856	+14.666	+ 7.50	+ 0.076	− 4.444	− 9.477	−14.000
4.4	+35.476	+25.713	+17.333	+10.00	+ 2.429	− 2.222	− 7.372	−12.000
4.5	+38.453	+28.57	+20.000	+12.50	+ 5.882	− 0.000	− 5.267	−10.000
4.6	+41.530	+31.427	+22.666	+15.00	+ 8.235	+ 2.222	− 3.162	− 8.000
4.7	+44.607	+34.284	+25.333	+17.50	+10.588	+ 4.444	− 1.057	− 6.000
4.8	+47.684	+37.141	+28.000	+20.00	+12.941	+ 6.666	+ 1.057	− 4.000
4.9	+50.761	+39.998	+30.666	+22.50	+17.647	+ 8.888	+ 3.162	− 2.000
5.0	+53.828	+42.855	+33.333	+25.00	+20.000	+11.111	+ 5.267	− 0.000

To find the pounds of skim-milk to be added or removed, trace the vertical column of the desired per cent of fat to where the horizontal column presenting the percentage of fat in the milk on hand intersects; the result will be the number of pounds of skim-milk to be added to or removed from 100 lbs. of milk, as indicated by a plus or minus sign before the figure.

TABLE 24.

Standardization of Fat Only in Cream.

Percentage quantity of cream of a desired fat content made from cream of a certain fat content by diluting with milk containing 4 per cent of butter fat.

Per Cent Fat in Cream on Hand	Desired Percentage of Fat in Standardized Cream					
	17	20	22	25	27	30
18	92.857	.....	.....	.....	.....	.....
19	86.666	.....	.....	.....	.....	.....
20	81.250	100	.....	.....	.....	.....
21	76.4706	94.706	.....	.....	.....	.....
22	72.2222	88.8888	100	.....	.....	.....
23	68.4222	84.2222	94.2125	.....	.....	.....
24	65.0000	80.0000	90.0000	.....	.....	.....
25	61.905	76.1905	85.7143	100	.....	.....
26	59.0909	72.7272	81.8181	95.4545	.....	.....
27	56.5217	69.5651	78.2608	91.3044	100	.....
28	54.1666	66.6666	75.0000	87.5000	95.8333	.....
29	52.0000	64.0000	72.0000	84.0000	92.0000	.....
30	50.0000	61.5385	69.2308	80.3461	88.4615	100.00

If cream is to be standardized with 4 per cent milk, the result found by the intersecting columns represents the pounds per hundred, or the percentage of the quantity which is cream on hand containing the percentage of fat as indicated.

Example: If cream containing 20 per cent of butterfat is desired and cream containing 26 per cent of fat is on hand, then 72.7 per cent of the quantity desired must be cream containing 26 per cent of fat and 27.3 per cent of the quantity must be 4 per cent milk.

B. HOW TO CALCULATE WHEN STANDARDIZING WHOLE MILK OR CREAM FOR BOTH FAT AND SOLIDS NOT FAT.

Key to Formulas for Standardizing Whole Milk.

The following key gives the information required for substituting values for letters in the formulas found in this chapter:

A = The percentage of fat desired in the standardized product.

D = The pounds of skim-milk required for standardizing.
F = The percentage of fat in the whole milk.
G = The percentage of fat in the cream.
H = The percentage of fat in the butter.
J = The percentage of S. N. F. in the cream.
K = The percentage of fat in the skim-milk.
L = The percentage of fat in the skim-milk powder.
N = The percentage of S. N. F. in the skim-milk.
M = The percentage of S. N. F. in the skim-milk powder.
M′= The pounds of butter required or on hand.
O = The pounds of cream required for standardizing.
O′= The pounds of skim-milk powder required.
P = The pounds of whole milk in the batch.
Q = The pounds of cream desired.
R = The ratio of S. N. F. to fat in the desired product.
S = The percentage of S. N. F. in the whole milk.
S′= The average percentage of fat in the mixed batch.
W= The pounds of water to be added.

METHOD OF HANDLING PRODUCTS.

Cream and skim-milk are the products used in the process of standardizing whole milk. They are usually secured by separating some of the batch of whole milk on hand.

It is best to remove a little more than the theoretical amount, since a small amount of fat remains in the skim-milk. The skim-milk is cooled and run into a separate tank, and after thoroughly mixing a sample is collected for the fat and total solids test. The cream is likewise promptly cooled, mixed and tested for fat. Where it is desired to make a homogenized product, the fresh milk, cream and skim-milk are to be properly homogenized before testing. All products should be carefully weighed, as otherwise inaccuracies will result. Where impracticable to weigh, convert gallons into pounds.

When skim-milk is separated in excess of the amount required to standardize the whole milk, the excess may be standardized back to the composition of whole milk by adding the proper amount of cream. The aim in plant management should be to use each day all the by-products to the best advantage. When a product must be held over until the next day, there is usually

less liability of loss if it is held in the form of cream. After learning the average fat and total solids test by means of the Mojonnier Tester, and the pounds of whole milk in the batch, the pounds necessary to separate to secure the cream, and the skim-milk for use in standardizing may be calculated as follows:

PROBLEM 3: HOW TO CALCULATE POUNDS OF WHOLE MILK TO SEPARATE, TO OBTAIN CREAM AND SKIM-MILK NECESSARY TO STANDARDIZE BATCH.

Solution Problem 3 by Formula 1.

Formula 1: $\left[\frac{(F - A)}{F}\right] P$ = pounds of milk to remove to separate.

Problem 3, Example 4:

Lbs. of whole milk in batch = 10,000.

Test of whole milk = 4.00 per cent fat, 8.60 per cent S. N. F. and 12.60 per cent T. S.

Standardized product to test 3.25 per cent fat, 8.50 per cent S. N. F. and 11.75 per cent T. S.

Solution of Example 4, Based Upon Formula 1:

4.00 — 3.25 = .75, per cent of fat in excess.
10,000 × .0075 = 75, pounds of fat in excess.
75 ÷ .04=1875, pounds of milk to be skimmed.
10,000 — 1875 = 8125, pounds milk containing enough fat to make 10,000 pounds of milk testing 3.25 per cent of fat.

Separate 1875 lbs. of whole milk into cream and skim-milk to be used for standardizing purposes.

PROBLEM 4: HOW TO CALCULATE THE AMOUNT OF SKIM-MILK TO ADD TO WHOLE MILK.

When it is necessary to add skim-milk the ratio between the per cent S. N. F. and fat in the whole milk must be more than the required ratio.

Solution of Problem 4 by Rule 2:

(1.) Divide the percentage of fat in the skim-milk by the ratio between the S. N. F. and the fat in the product desired. Subtract the answer from the S. N. F. in the skim-milk. Call the remainder A, or the percentage of S. N. F. in the skim-milk available for standardizing.

(2.) Divide the percentage of fat in the whole milk by the ratio between the S. N. F. and the fat in the product desired. Call the result B. Subtract from B the percentage of S. N. F. present in the whole milk. Multiply the remainder by the pounds of whole milk in the batch. Call result C.

(3.) Divide C by A. The answer will be the number of pounds of skim-milk necessary to standardize the batch to the required ratio.

(4.) Add together the pounds of whole and skim-milk in the mixed batch. Multiply the pounds of whole and skim-milk by their respective percentages of fat; add together the two results, and divide the sum by the total pounds milk products in the mixed batch. Call the answer D, or the percentage of fat in the mixed batch.

(5.) Subtract from D the percentage of fat desired. Multiply the pounds in the mixed batch by the remainder and divide the answer by the percentage of fat desired. The result will be the pounds of water necessary to add.

Solution Problem 4 by Formula 2:

(1.) **To calculate the pounds of skim-milk required.**

$$D = \frac{P\left[\left(\frac{F}{R}\right) - S\right]}{N - \left(\frac{K}{R}\right)}$$

(2.) **To calculate the average fat test of the mixed batch.**

$$S^1 = \frac{DK + PF}{DP}$$

(3.) **To calculate the pounds of water required.**

$$W = \frac{(S^1 - A)\ (P + D)}{A}$$

Problem 4, Example 5:

Products	Pounds	Per Cents		
		Fat	S. N. F.	T. S.
Whole Milk	10,000	3.77	8.58	12.55
Skim-milk		.16	8.55	8.71
Composition of product desired		3.25	8.50	11.75

Ratio S. N. F. to fat desired is 1 to .3824.

Solution of Example 5, based upon Rule 2:

(1.) **To calculate the percentage of available S. N. F. in the skim-milk.**

.16 ÷ .3824 = .42, per cent of S. N. F. required to equalize the fat in the skim-milk.

8.55 — .42 = 8.13, per cent of S. N. F. available for standardizing.

(2.) **To calculate the pounds of S. N. F. short.**

3.77 ÷ .3824 = 9.86, per cent of S. N. F. required.

9.86 — 8.58 = 1.28, per cent of S. N. F. short.

10,000 × .0128 = 128, pounds of S. N. F. short.

(3.) **To calculate the pounds of skim-milk required.**

128 ÷ .0813 = 1574, pounds of skim-milk required.

(4.) **To calculate the average fat test of the mixed batch.**

10,000+1574=11574, total pounds of milk products in mixed batch.

10,000×.0377=377, pounds of fat in whole milk.

1574×.0016=2.52, pounds of fat in skim-milk.

377 + 2.52 = 379.52, total pounds of fat in mixed batch.

379.52 ÷ 11574 = 3.28, per cent of fat in mixed batch.

(5.) **To calculate pounds of water required.**

3.28 — 3.25 = .03, per cent of fat in excess.

11574 × .0003 = 3.47, pounds of fat in excess.

3.47 ÷ .0325 = 107, pounds of water to add.

Solution of Example 5, based upon Rule 2:

(1.) **To calculate the pounds of skim-milk required.**

$$D = \frac{10000 \left[\left(\frac{.0377}{.3824}\right) - .0858\right]}{.0855 - \left(\frac{.0016}{.3824}\right)} = 1574$$

(2.) **To calculate the average fat test of the mixed batch.**

$$S' = \frac{(1574 \times .0016) + (10000 \times .0377)}{10{,}000 + 1574} = 3.28$$

(3.) **To calculate the pounds of water required.**

$$W = \frac{(.0328 - .0325) \times (10000 + 1574)}{.0325} = 107$$

In the above example no factor of safety was allowed.

Proof for Problem 4, Example 5:

Products in Batch After Standardizing	Pounds	Fat		Solids Not Fat	
		Per Cent	Pounds	Per Cent	Pounds
Whole milk.....	10000	3.77	377.00	8.58	858.00
Skim-milk.....	1574	.16	2.52	8.55	134.58
Water.....	107	.....	.....	.....	.....
Total pounds and average test of mixed batch...	11681	3.25	379.52	8.50	992.58

PROBLEM 5: HOW TO CALCULATE THE POUNDS OF CREAM TO ADD TO WHOLE MILK.

When it is necessary to add cream, the ratio between the percentage of S. N. F. and fat in the whole milk must be less than the required ratio.

Solution of Problem 5 by Rule 3:

(1.) Multiply the percentage of S. N. F. in the cream by the ratio between the S. N. F. and the fat in the product desired. Subtract the result from the percentage of fat in the cream. Call the remainder A, or the percentage of fat in the cream available for standardizing.

(2.) Multiply the percentage of S. N. F. in the whole milk by the ratio between the S. N. F. and the fat in the product desired. Call the result B, or the percentage of fat required. Subtract from B the percentage of fat present in the whole milk. Multiply the remainder by the pounds of whole milk in the batch. Call the result C, or the pounds of fat short.

(3.) Divide C by A. The answer will be the pounds of cream required to standardize the batch to the desired ratio.

(4.) Add together the pounds of whole milk and cream in the batch. Multiply the pounds of whole milk and cream by their

respective percentages of fat; add together the two results and divide the sum by the total pounds of milk products in the mixed batch. Call the answer D or the percentage of fat in the mixed batch.

(5.) Subtract from D the per cent of fat desired. Multiply the pounds in the mixed batch by the remainder and divide the answer by the per cent of fat desired. The result will be the pounds of water necessary to add.

Solution of Problem 5 by Formula 3:

(1.) **To calculate the pounds of cream required.**

$$O = \frac{RS - PF}{G - (JR)}$$

(2.) **To calculate the average fat test of the mixed batch.**

$$S^1 = \frac{OG + PF}{O + P}$$

(3.) **To calculate the pounds of water required.**

$$W = \frac{(S^1 - A)\ (O + P)}{A}$$

Problem 5, Example 6:

Products	Pounds	Per Cents		
		Fat	S. N. F.	T. S.
Whole milk	10,000	3.05	8.60	11.65
Cream	.....	22.05	6.50	28.55
Composition of product desired	.....	3.25	8.50	11.75

Ratio of S. N. F. to fat desired is 1.0 to .3824.

Solution of Example 6, based upon Rule 3:

(1.) **To calculate the percentage of available fat in the cream.**

$6.50 \times .3824 = 2.49$, per cent of fat required to equalize the S. N. F. in the cream.

$22.05 - 2.49 = 19.56$, per cent of fat in the cream available for standardizing.

(2.) **To calculate the pounds of fat short.**

$8.60 \times .3824 = 3.29$, per cent fat required.

$3.29 - 3.05 = .24$, per cent of fat short.

$10{,}000 \times .0024 = 24$, pounds of fat short.

(3.) **To calculate the pounds of cream required.**

$24 \div .1956 = 123$, pounds of cream required.

(4.) **To calculate the average fat test of the mixed batch.**

$10{,}000 \times .0305 = 305$, pounds of fat in the whole milk.

$123 \times .2205 = 27$, pounds of fat in the cream.

$305 + 27 = 332$, pounds of fat in the mixed batch.

$10{,}000 + 123 = 10123$, pounds of milk products in mixed batch.

$332 \div 10123 = 3.28$, per cent of fat in mixed batch.

(5.) **To calculate the pounds of water required.**

$3.28 - 3.25 = .03$, per cent of fat in excess.

$10123 \times .0003 = 3.03$, pounds of fat in excess.

$3.03 \div .0325 = 93$, pounds of water to add.

Solution of Example 6, based upon Formula 3:

(1.) **To calculate the pounds of cream required.**

$$O = \frac{[\ (.3824 \times .0860) - (10{,}000 \times .0305)\ ]}{.2205 - (.0650 \times .3824)} = 123$$

(2.) **To calculate the average fat test of the mixed batch.**

$$S = \frac{(123 \times .2205) + (10{,}000 \times .0305)}{123 + 10{,}000} = 3.28$$

(3.) **To calculate the pounds of water required.**

$$W = \frac{(.0328 - .0325) \times (10{,}000 + 123)}{.0325} = 93$$

In the above example no factor of safety is allowed.

Proof for Example 6:

Products in Batch After Standardizing	Pounds	Fat		Solids Not Fat	
		Per Cent	Pounds	Per Cent	Pounds
Whole milk.....	10000	3.05	305	8.60	860.
Cream.....	123	22.05	27	6.50	8
Water.....	93	.....	.....	.....	.....
Total pounds and average test of mixed batch...	10216	3.25	332	8.50	868.

PROBLEM 6: HOW TO CALCULATE WHEN MIXING BUTTER AND SKIM-MILK POWDER TO MAKE WHOLE MILK OR CREAM.

Two variations of this problem are encountered in plant practice.

(a) When the two products are mixed together with the view of obtaining a product of definite fat test regardless of the resulting total weight, and (b) when it is desired to make a definite weight of product of a definite fat test. Examples covering the two kinds of problems will be given. The same method of calculation under the above two variations can be followed when it is desired to make either whole milk or cream. Solution of these problems by means of formula only are given herewith.

Solution of Problem 6, Variation A based upon Formula 4:

(1.) **To calculate the pounds of skim-milk powder required.**

$$O^1 = \frac{Q\,J}{M}$$

(2.) **To calculate the pounds of butter required.**

$$M^1 = \frac{QA - O^1L}{H}$$

(3.) **To calculate the pounds of water required.**

$$W = Q - (M^1 + O^1)$$

Problem 6, Variation A, Example 7:

Wanted to make 1,000 pounds of cream testing 18.00 per cent of fat and 7.59 per cent of S. N. F. when using butter testing

82.00 per cent of fat and skim-milk powder testing 1.00 per cent of fat and 94.00 per cent of S. N. F.

Solution of Example 7, based upon Formula 4:

(1.) **To calculate the pounds of skim-milk powder required.**

$$O^1 = \frac{1000 \times .0759}{.94} = 80.7$$

(2.) **To calculate the pounds of butter required.**

$$M^1 = \frac{(1000 \times .18) - (80.7 \times .01)}{.82} = 218.5$$

(3.) **To calculate the pounds of water required.**

$$W = 1000 - (218.5 + 80.7) = 700.8$$

In the above example no factor of safety was allowed. The small amount of S. N. F. in the butter was disregarded.

Proof of Problem 6, Example 7:

Products in Batch After Standardizing	Pounds	Fat		Solids Not Fat	
		Per Cent	Pounds	Per Cent	Pounds
Skim-milk powder..	80.7	1.00	.8	94.00	75.9
Butter.....	218.5	82.00	179.2	.....	.....
Water.....	700.8	.....	.....	.....	.....
Total pounds and average test of mixed batch...	1000.0	18.00	180.	7.59	75.9

Solution of Problem 6, Variation B, based upon Formula 5:

(1.) **To calculate the pounds of whole milk possible to make.**

$$P = \frac{M^1\ H}{A}$$

(2.) **To calculate the pounds of skim-milk powder required.**

$$O^1 = \frac{P\ F}{M}$$

(3.) **To calculate the pounds of water required.**

$$W = P - (M^1 + O^1)$$

Problem 6, Variation B, Example 8:

Wanted to make as much whole milk as possible testing 3.75 per cent of fat, and 8.50 per cent of S. N. F. from 50 pounds of butter testing 82.00 per cent of fat, and skim-milk powder testing 1.00 per cent of fat and 94.00 per cent of S. N. F.

Solution of Example 8, based upon Formula 5:

(1.) **To calculate the pounds of whole milk possible to make.**

$$P = \frac{50 \times .82}{.0375} = 1093$$

(2.) **To calculate the pounds of skim-milk powder required.**

$$O^1 = \frac{1093 \times .085}{.94} = 98.8$$

(3.) **To calculate the pounds of water required.**

$$W = 1093 - (50 + 98.8) = 944.2$$

In the above example the fat in the skim-milk powder and the S. N. F. in the butter were disregarded, as the amount of these constituents is too small to affect appreciably the results.

Proof of Problem 6, Example 8:

Products in Batch After Standardizing	Pounds	Fat		Solids Not Fat	
		Per Cent	Pounds	Per Cent	Pounds
Skim-milk Powder..	98.8	1.00	Disregard'd	94.0	92.9
Butter.....	50.0	82.00	41.0	1.00	Disregard'd
Water.....	944.2	.....	.....	.....	.....
Total pounds and average test of mixed batch...	1093.0	3.75	41.0	8.50	92.9

[1]Pearson, R. A., Cornell Farmers Reading Course, Bul. 22, 1904.
[2]Erf, Oscar, Ill. Sta. Bul. No. 75.

CHAPTER XI

STANDARDIZING EVAPORATED MILK

The principle underlying the entire practice of standardizing evaporated milk is based upon mixing together milk and the products obtained from milk in the proper proportions to make a product that contains the fat and the S. N. F. in the same ratio that they are to have in the standard product which it is desired to manufacture. These ratios can be obtained by referring to Table 25, page 165. They are derived by dividing the percentage of one constituent into the percentage of another constituent of the standard product. For example, standard domestic evaporated milk which tests 8.00 per cent fat, 18.15 per cent of S. N. F. and 26.15 per cent of T. S. gives a ratio between the S. N. F. and fat of 18.15 to 8.0, or 1 to .4407.

Evaporated milk may also be standardized upon the basis of the fat only, or of the S. N. F. only. In such cases the unstandardized constituent will be, in the majority of cases, in excess of the standard requirements.

Two general methods of standardizing evaporated milk are possible, namely before condensing and after condensing. In standardizing before condensing, the fat and the S. N. F. are placed in the proper proportion one to the other in the initial product, so that, after condensing, the product obtained can be either of exactly the standard required, or if overcondensed, it can be diluted back to the proper standard with water only. This chapter contains methods with examples that accompany the same, covering every known condition that may be encountered in plant practice, where evaporated milk is standardized both for fat and S. N. F. both before and after condensing.

It is frequently impossible to standardize the initial products before condensing. This is particularly true when the multibatch system is used, as in that case there is scarcely time to make the required tests upon the fresh milk. However, this usually can

be so arranged by careful planning, and when possible the initial product should be standardized, as in that case all that is necessary is to add sufficient water after condensing to bring the evaporated product back to the desired standard.

Where the condensed product is standardized, this can be accomplished in several ways. In such cases, it is best for the product to come from the pan overcondensed, rather than undercondensed, as it is possible to add more accurately the materials required for standardizing when the batch is overcondensed rather than when the opposite is the case. Standardizing after condensing can be accomplished by one or more of the following methods:

(1.) By the addition of water alone. This is the simplest standardization of all.

(2.) By the addition of homogenized, pasteurized cream alone.

(3.) By the addition of homogenized, condensed skim-milk. (If very low in fat, the homogenization can be omitted.)

(4.) By the addition of water and homogenized, pasteurized cream.

(5.) By the addition of water and homogenized, condensed skim-milk.

(6.) By the addition of water, homogenized cream and homogenized condensed whole milk.

SUCCESSIVE STEPS IN STANDARDIZING EVAPORATED MILK BEFORE CONDENSING

The steps involved in standardizing evaporated milk are as follows:

(1.) Obtaining a representative composite sample of the entire lot of whole milk which goes to make up the batch; likewise of the skim-milk, cream, butter or other products which might be used in standardizing.

(2.) Testing of all of the above products involved, for both fat and S. N. F. or T. S. by means of the Mojonnier Tester. In the case of the S. N. F. in cream, it usually suffices to obtain the S. N. F. from Table 22. In the case of unsalted butter, the amount of S. N. F. is so small as to be disregarded.

(3.) Calculating the weight of each product to be used, by methods which follow, in order to make the fat and the S. N. F.

in the initial product of the same ratio as these are to occur in the finished product.

(4.) When the initial product has been standardized so that the fat and the S. N. F. are in the required ratio, the same is to be condensed down to the desired specific gravity to yield a finished product of the test required. In practice it is well to condense the batch to a little higher concentration than desired, as it then becomes possible to bring it back to the desired point by the mere addition of water. If the concentration of the batch should be less than the required concentration it becomes necessary either to recondense part of the batch or condense another batch to add to it, which makes it a very much more difficult and involved problem than when it is necessary to add water only. Or if the plant should have concentrated pasteurized and homogenized cream, or condensed, homogenized whole milk available, these might be added, as the case might require. When the final product obtained from the pan contains an excess of fat over the S. N. F. the error may be corrected by adding condensed skim-milk if this is possible or practicable. Likewise if it contains an excess of S. N. F. over fat the error can be corrected by adding concentrated pasteurized and homogenized cream if this is available.

METHOD OF COLLECTING COMPOSITE MILK SAMPLES.

No fixed method of sampling is recommended that can be applied to meet all the varying conditions of different plants. This important matter will need careful study at each plant, in order to determine the procedure that will give the most accurate samples. The reader is referred to Chapter VI for complete information upon this point.

METHOD OF TESTING

Use the Mojonnier Tester for making all fat and T. S. determinations, upon all products used in standardizing. The skim-milk and cream should be tested before the composite sample of the whole milk reaches the laboratory. The S. N. F. in the cream can be ascertained from Table 22, as the total amount of the same is usually small. As it is necessary to complete the fat and T. S. tests of the whole milk while the last forewarmer is being heated and drawn into the pan, these tests should be made as rapidly as

possible. A short time before the sample is ready the temperature of the hot plates and ovens should be regulated; a fat and T. S. dish cooled and weighed; clean glassware and a weigh cross prepared for use and everything put into readiness for making the test. By systematizing the successive steps, the time for completing the fat and T. S. tests, including the total time for making the calculations, should not exceed twenty-five or thirty minutes, counting from the time the sample reaches the laboratory. Under some conditions it may be desirable to give the operator a helper while making the tests, as this would greatly expedite the operations.

CONSTANTS FOR EVAPORATED MILK

The following table gives the constants for evaporated milk, both domestic and export. This is based upon standards now in force in this country and in Canada, and upon the standards called for in the European requirements. Domestic evaporated milk is given upon the double basis of 7.80 per cent of fat and 25.50 per cent of T. S. and 8.00 per cent of fat and 26.15 per cent of T. S.

TABLE 25.
Constants for Evaporated Milk.

Constants	Export Evaporated Milk	Domestic Evaporated Milk (A)	Domestic Evaporated Milk (B)
Per cent fat	9.25	7.80	8.00
Per cent S. N. F	16.75	17.70	18.15
Per cent total solids	26.00	25.50	26.15
Ratio per cent fat to per cent total solids	2.811	3.2692	3.2687
Ratio per cent fat to per cent S. N. F	1.811	2.2692	2.2687
Ratio per cent S. N. F. to per cent fat	.5522	.4407	.4408
Ratio per cent S. N. F. to per cent total solids	1.5522	1.4407	1.4408
Ratio per cent total solids to per cent fat	.3558	.3059	.3059
Net weight per can, ozs. Baby size	6.0	6.0	6.00
Net weight per can, ozs. Family size	12.0	12.0	12.00
Net weight per can, ozs. Tall size	16.0	16.0	16.00
Net weight per can, ozs. Hotel size	32.0	32.0	32.00
Net weight per can, ozs. Gallon size	136.0	136.0	136.00
Net weight per case, pounds. Baby size	27.0	27.0	27.00
Net weight per case, pounds. Family size	36.0	36.0	36.00
Net weight per case, pounds. Tall size	48.0	48.0	48.00
Net weight per case, pounds. Hotel size	48.0	48.0	48.00
Net weight per case, pounds. Gallon size	51.0	51.0	51.00

METHOD OF GETTING WEIGHTS.

The one who does the standardizing should be sure that the pounds of whole milk, and likewise the pounds of cream or skim-milk used are correctly reported and properly checked.

ORDER OF OPERATIONS IN STANDARDIZING EVAPORATED MILK BEFORE CONDENSING, USING MOJONNIER TESTER.

(1.) Test, as far in advance as possible, the cream sample for fat. Obtain the S. N. F. test of the cream from Table 22, or, if necessary, test the skim-milk or the bulk condensed milk, for both fat and T. S.

(2.) About half an hour before the composite whole milk sample is ready, do everything necessary to begin making fat and T. S. tests of the whole milk. It is recommended that the tests be made in duplicate. If the operator is very careful in his work, a single determination may suffice.

(3.) Keep the fat and the T. S. dishes in the respective ovens for five minutes, under proper heat, and with the vacuum on.

(4.) Transfer dishes from the ovens to cooling desiccators. Keep water circulating through the cooling desiccators. Weigh the T. S. dish with the cover on at the end of five minutes, and the fat dish alone, at the end of seven minutes. Record the weights and numbers upon the laboratory report, Fig. 59. Replace dishes in the cooling desiccators.

(5.) As soon as the composite whole milk sample reaches the laboratory, mix the same thoroughly by pouring back and forth at least six times using two vessels.

(6.) Fill a two gram pipette to the mark, and transfer the milk to the previously weighed dish, and immediately weigh the dish with the milk. Or, if preferred, the sample in the two gram pipette can be weighed from the weigh cross.

(7.) While one operator is weighing the sample as under (6) the second operator pipettes out 10 grams into the fat extraction flask.

(8.) One operator now prepares the T. S. sample for the T. S. oven and the second operator the fat sample for the fat oven.

Dishes are heated in ovens; cooled in cooling desiccators and weighed in accordance with directions.

(9.) Calculate the percentage of fat, and the percentage of T. S. and transfer the results to the evaporated milk report blank.

(10.) Calculate the pounds of material to add, using the method that may apply, selecting the proper one, beginning with Rule 4, and ending with Rule 15.

(11.) Test the finished product for fat and T. S. and enter the results upon the evaporated milk report, Fig. 60.

(12.) Divide the percentage of fat by the percentage of T. S. to get the ratio of T. S. to fat in the finished product.

(13.) If the condensation is not otherwise obtained, divide the percentage of T. S. in the finished product by the percentage of T. S. in the initial product.

(14.) Divide the total weight of raw products used by the condensation to obtain the pounds in the batch after condensing.

(15.) Add water, if necessary, using either Rule 10 or 11. Make a retest for fat and T. S. after adding water.

(16.) Calculate the weight of milk from the cans filled, and figure loss in handling due to overfilling.

ORDER AND OPERATIONS IN STANDARDIZING EVAPORATED MILK AFTER CONDENSING, USING THE MOJONNIER TESTER.

(1.) Test, as far in advance as possible, the cream sample for fat. Obtain the S. N. F. test of the cream from Table 22, or, if necessary, test the condensed skim-milk or the condensed whole milk for both fat and T. S.

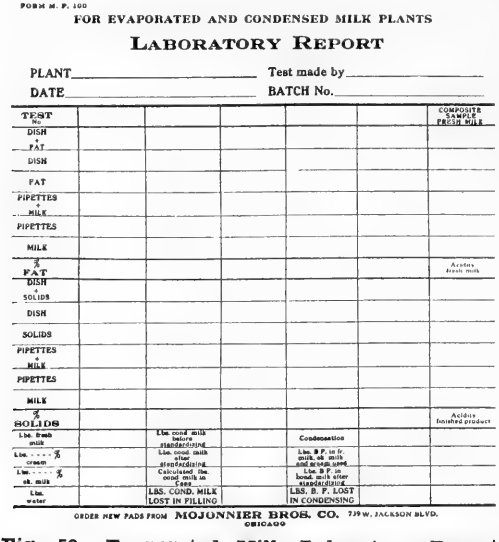
(2.) About half an hour before the condensed batch is all completed, do everything necessary to begin making the fat and the T. S. tests.

(3.) Keep the fat and the T. S. dishes in the respective ovens for five minutes, under proper heat, and with the vacuum on.

(4.) Transfer the dishes from the ovens to the cooling desiccators. Keep the water circulating. Weigh the T. S. dish with cover at the end of five minutes, and the fat dish alone at the end of seven minutes. Record the weights and numbers upon the

laboratory report, Fig.. 59. Replace the dishes in the cooling desiccators.

(5.) Mix the sample from the condensed batch very thoroughly.



FORM M. P. 100

FOR EVAPORATED AND CONDENSED MILK PLANTS

LABORATORY REPORT

PLANT_____ Test made by_____

DATE_____ BATCH No._____

TEST No.						COMPOSITE SAMPLE FRESH MILK
DISH + FAT						
DISH						
FAT						
PIPETTES + MILK						
PIPETTES						
MILK						
% FAT						Acidity fresh milk
DISH + SOLIDS						
DISH						
SOLIDS						
PIPETTES + MILK						
PIPETTES						
MILK						
% SOLIDS						Acidity finished product
Lbs. fresh milk		Lbs. cond. milk before standardizing		Condensation		
Lbs. - - - - % cream		Lbs. cond. milk after standardizing		Lbs. S. P. in fr. milk, at .35% and scalding		
Lbs. - - - - % sk. milk		Calculated lbs. cond. milk to take		Lbs. S. P. in cond. milk after standardizing		
Lbs. water		LBS. COND. MILK LOST IN FILLING		LBS. S. P. LOST IN CONDENSING		

ORDER NEW PADS FROM MOJONNIER BROS. CO. 739 W. JACKSON BLVD. CHICAGO

Fig. 59. Evaporated Milk Laboratory Report.

(6.) Fill the one gram pipette to the mark, and transfer the milk to the previously weighed dish, and immediately weigh the dish with milk. Or, if preferred, the sample in the one gram pipette can be weighed from the weigh cross. Fill the five grams pipette to the mark, and by means of the weighing cross, weigh about five grams into the fat extraction flask.

(7.) One operator now prepares the T. S. sample for the T. S. oven and the second operator the fat sample for the fat oven. Dishes are heated in ovens, cooled in cooling desiccators, and weighed in accordance with directions.

(8.) Calculate the percentage of fat and the percentage of T. S. and transfer results to evaporated milk report, Fig. 60.

(9.) Calculate the pounds of material necessary to add, selecting and using the rule that may apply.

(10.) Mix the batch very thoroughly, after adding the material for standardizing.

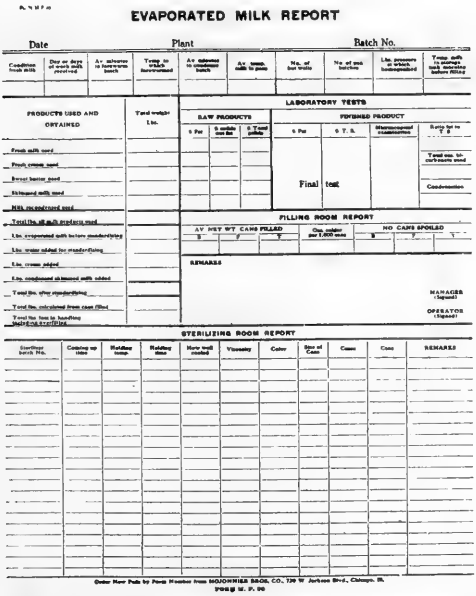
Make a retest for fat and T. S.

(11.) Divide the percentage of fat by the percentage of T. S. to get the ratio between the T. S. and the fat in the finished product.

(12.) Complete all possible or necessary calculations upon the evaporated milk report, Fig. 60.

BLANK FOR RECORDING STANDARDIZING DATA.

It is important to use proper blank reports for recording all data in connection with the standardization of evaporated milk. A specially designed blank report is illustrated under Fig. 60. The blank is designed so that the necessary facts covering an entire day's milk can be ascertained at a glance.



EVAPORATED MILK REPORT

Date Plant Batch No.

LABORATORY TESTS

PRODUCTS USED AND OBTAINED

RAW PRODUCTS

FINISHED PRODUCT

Final test

FILLING ROOM REPORT

NO. CANS SPOILED

REMARKS

MANAGER (Signed)

OPERATOR (Signed)

STERILIZING ROOM REPORT

REMARKS

Fig. 60. Blank Report for Evaporated Milk.

HOW TO GET THE WEIGHT OF THE FINISHED BATCH OF EVAPORATED MILK.

Ascertain the weight of fresh milk in the batch, and the weight of the finished product. The latter can be obtained in several ways, as follows:

(A.) By weighing the entire batch in a drop tank near the pan. This is the most exact method of all.

(B.) By means of a graduated brass bar or rod at the storage tank. This method is open to many variations, particularly if the tank surface is extensive. Variations in the concentration will also obviously affect the weight of any given volume, and may therefore cause considerable variation in the weight. The bar should be graduated by weighing definite successive portions of milk into the tank, and marking upon the bar the number of pounds corresponding to that in the tank at the given level.

(C.) From the condensation. This method involves collecting an accurate composite sample of the raw milk that goes to make up the batch, and testing the same for T. S. If cream or skim-milk are added for standardizing, the T. S. test of the same should be ascertained, and the average T. S. test of the entire batch should be calculated. In turn when the finished product comes from the pan, this is to be tested for T. S., and the weight of condensed product obtained as indicated by the following example:

Lbs. of fresh milk in the batch	=6800
Lbs. of cream used in standardizing	= 40
Lbs. total of all raw products	=6840
T. S. test of the fresh milk	= 12.01%
T. S. test of the cream	=49.28%
Average T. S. test of the mixed milk and cream	= 12.23%
T. S. test of the finished product	= 26.50%

26.50 ÷ 12.23 = 2.167, or the condensation.

6840 ÷ 2.167 = 3156, the lbs. of evaporated milk which the batch contains.

By means of the Green Gauge, which automatically indicates the weight of milk in tanks.

The Green Gauge may be attached to any tank used for holding fresh milk, condensed milk or any other liquid product.

The mercury column in the gauge rises and falls as the milk in the tank rises and falls. The scale back of the mercury column is calibrated to fit the particular tank to which it is attached so that when the mercury column stops opposite a number or graduation it indicates accurately the number of pounds of milk in the tank. The calibrating is usually done by dumping into the tank carefully weighed quantities of water and marking the height to which the mercury column rises. In this way an accurate calibration is obtained.

The Green Gauge operates on the hydrostatic mercuric principle. The air trap is connected to the tank outlet by 1″ Sanitary Tubing. When filling tank the pet cock at bottom of air trap is opened until a few drops of milk flow out. The pet cock is then closed sealing a pocket of air in the air trap. The air trap is connected to the mercury gauge by a 1/8″ copper tube. The weight of the milk in the tank is exerted on the air in the air trap and in turn on the mercury column in the gauge on the wall.

This Green Gauge is a very convenient appliance for use in any liquid, as it practically places the tank to which it is attached on scales.

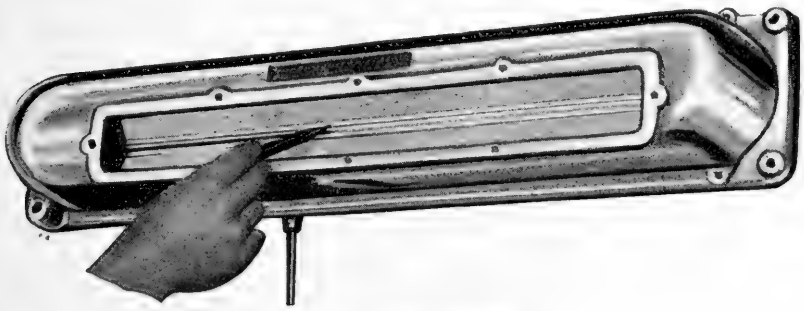


Fig. 61. Green Gauge.

HOW TO CALCULATE THE POINT AT WHICH TO STRIKE THE BATCH IN THE PAN.

The striking point at the vacuum pan requires very careful watching, in order that the product from the pan may be as near the standard desired as possible. Evaporated milk of a given composition and temperature has a definite specific gravity. As

a starting point it is necessary to know the specific gravity under certain temperature conditions of the product which it is desired to manufacture.

The two following tables give the specific gravity of evaporated milk of the two compositions mentioned above at different temperatures, and expressed in different specific gravity scales.

TABLE 26.

Specific gravity of evaporated milk testing 7.80 per cent fat, and 25.50 per cent total solids compared with water at 60° F. Samples furnished by National Dairy Co Specific gravity determinations made by J. A. Cross and H. J. Liedel.

Temperature ° F.	Specific Gravity			Temperature ° F.	Specific Gravity		
	Specific Gravity Degrees	Baume Degrees	Twaddell Degrees		Specific Gravity Degrees	Baume Degrees	Twaddell Degrees
40	1.0702	9.51	14.04	110	1.0546	7.51	10.92
60	1.0662	9.00	13.24	120	1.0518	7.14	10.36
80	1.0625	8.52	12.50	130	1.0490	6.78	9.80
100	1.0572	7.83	11.44	140	1.0457	6.35	9.14

TABLE 27.

Specific gravity of evaporated milk testing 8.00 per cent fat, and 26.15 per cent total solids; compared with water at 60° F. Samples furnished by National Dairy Co. Specific gravity determinations made by J. A. Cross and H. J. Liedel.

Temperature ° F.	Specific Gravity			Temperature ° F.	Specific Gravity		
	Specific Gravity Degrees	Baume Degrees	Twaddell Degrees		Specific Gravity Degrees	Baume Degrees	Twaddell Degrees
40	1.0718	9.71	14.36	110	1.0559	7.67	11.18
60	1.0679	9.22	13.58	120	1.0533	7.35	10.66
80	1.0638	8.70	12.76	130	1.0505	6.97	10.10
100	1.0588	8.05	11.76	140	1.0472	6.53	9.44

The specific gravity at temperatures between the extremes given in the above tables, and at temperatures not given in the tables can be readily ascertained by referring to the graph included in this chapter, and which relates to the specific gravity of evaporated milk at various temperatures and of different compositions, but of a constant ratio between the fat and the total solids.

THE RELATION BETWEEN THE TEMPERATURE AND SPECIFIC GRAVITY IN EVAPORATED MILK.

In the case of evaporated milk, testing either 7.8 per cent fat and 25.50 per cent T. S., or 8.00 per cent fat and 26.15 per cent T. S., the relation between temperature and specific gravity is nearly alike. This is indicated in Table 28.

TABLE 28.

Unit Relation of Temperature to Specific Gravity in Evaporated Milk.

Temperature Range	Decrease in Specific Gravity for Each Degree F. Increase in Temperature		
	Specific Gravity	Baume	Twaddell
40° to 80° F.....	.00020	.025	.040
80° to 110° F.....	.00026	.034	.053
110° to 140° F.....	.00029	.039	.058

Important use of the above relation can be made when striking the pan. If the milk should have a temperature either higher or lower than the standard desired, at the time of making the specific gravity test, the reading can be reduced to the standard desired by a simple calculation.

Example A: Baume reading at 135° F. is 6.57. What is the Baume reading at 130° F.?

135—130=5, degrees F. over the standard desired.

.039×5=.195, degrees Baume to be added to reading made at 135° F.

6.57+.195=6.77, the Baume reading reduced to 130° F.

Example B: Baume reading at 120° F. is 7.14. What is the Baume reading at 130° F.?

130—120=10, degrees F. under the standard desired.

.039×10=.39, degrees Baume to be subtracted from reading made at 120° F.

RELATION BETWEEN SPECIFIC GRAVITY AND COMPOSITION IN EVAPORATED MILK.

When the hold-over system is used in the manufacture of evaporated milk, it is most desirable to make a preliminary test for fat or T. S., usually the test for one constituent being sufficient. This test should be timed so that the result is available before the milk for the last pan batch is all out of the hot wells. It is then possible to change the striking point upon the last pan batch so that the test of the milk in the hold-over batch will be much closer to the desired standard than is usually possible where this practice is not followed. The great advantage is the fact that the water to be added can be reduced to a minimum.

The relation between the composition and the specific gravity of evaporated milk in which the fat and the S. N. F. are in the ratio of 8.00 to 18.15, is indicated in Table 29.

From the following table it is ascertained that a difference of .10° Baume is equal to about .30 per cent of total solids in the case of evaporated milk of the composition indicated. Upon the specific gravity scale each .01 degree is equal to about .36 per cent total solids, and upon the Twaddell scale each .10 degrees is equal to about .18 per cent total solids. This information is of large practical value in fixing the striking point of the last pan batch used to make up a hold-over batch.

Example: The fresh milk that makes up a hold-over batch totals 60,000 pounds. This is condensed in six pan batches of 10,000 pounds each. The T. S. test of the first five batches, or, in other words, the test of the condensed product obtained from 50,000 pounds of whole milk was 26.75 per cent, and the total weight of the product 22,820 pounds. The test desired was 26.40 per cent. Therefore 22,820 x .35 per cent equals 79.87 pounds of T. S. that are overcondensed. The last pan batch should yield about 5,000 pounds of condensed product testing 26.40 per cent T. S. Since a drop of .10 degees Baume would make a corresponding drop of .30 per cent in T. S. in this example each .10 degree

TABLE 29.

Relation Between Specific Gravity and Composition in Evaporated Milk.

Composition Per Cents	Specific Gravity at 60°/60° F.			Specific Gravity at 100°/60° F.			Specific Gravity at 120°/60° F.			Specific Gravity at 140°/60° F.		
	Specific Gravity	Baume	Twaddell	Specific Gravity	Baume	Twaddell	Specific Gravity	Baume	Twaddell	Specific Gravity	Baume	Twaddell
26.15 T. S. 8.00 fat	1.0679	9.22	13.58	1.0588	8.05	11.76	1.0533	7.35	10.66	1.0472	6.53	9.44
25.50 T. S. 7.80 fat	1.0662	9.00	13.24	1.0572	7.83	11.44	1.0518	7.14	10.33	1.0457	6.35	9.14
24.52 T. S. 7.50 fat	1.0628	8.57	12.56	1.0544	7.47	10.88	1.0490	6.77	9.80	1.0429	5.96	8.58
22.63 T. S. 7.00 fat	1.0591	8.10	11.82	1.0503	6.95	10.06	1.0451	6.27	9.02	1.0394	5.50	7.88
21.25 T. S. 6.50 fat	1.0550	7.55	11.00	1.0459	6.35	9.18	1.0410	5.72	8.20	1.0350	4.90	7.00
19.61 T. S. 6.00 fat	1.0496	6.86	9.92	1.0416	5.78	8.32	1.0366	5.12	7.32	1.0310	4.35	6.20
17.98 T. S. 5.50 fat	1.0458	6.35	9.16	1.0378	5.28	7.56	1.0330	4.64	6.60	1.0268	3.78	5.36
16.34 T. S. 5.00 fat	1.0411	5.73	8.22	1.0336	4.72	6.72	1.0293	4.13	5.86	1.0228	3.22	4.56

Baume would correct for 15.00 pounds of T. S. Since the over-condensation amounts to 79.87 pounds, dividing this amount by 15.00 gives 5.3 or the number of .10 degees Baume necessary to deduct from the normal striking point of the last batch.

The graph under Fig. 62 shows the relation between temperature, specific gravity and composition in the case of evaporated milk in which the ratio between S. N. F. and fat is as 1 is to .4407, or T. S. to fat as 1 is to .3059.

The range of composition is from 5.00 per cent fat and 16.34 per cent T. S. to 8.00 per cent fat and 26.15 per cent T. S.

Several practical uses can be made of this graph as shown by the following examples:

(a.) Example: What is the specific gravity of evaporated milk testing 7.80 per cent fat and 25.50 per cent T. S. at 50° F.? Answer. 1.0738.

(b.) Example: What is the composition of evaporated milk in which the ratio between the S. N. F. and fat is as 1 to .4407? Baume reading 6.53. Temperature 140° F. Answer: 8.00 per cent fat and 26.15 per cent T. S.

(c.) Example: The specific gravity test of evaporated milk containing 7.50 per cent fat and 24.52 per cent T. S. at 140° F. is .596 Baume. What is the Baume reading at 120° F.? Answer: 6.77° Baume.

HOW TO CALCULATE THE BAUME READING OF A CONDENSED MILK PRODUCT FOR ANY DESIRED CONDENSATION, IF THE BAUME TEST AT ANY OTHER CONDENSATION IS KNOWN.

This method of calculation was devised by J. A. Cross.

Calculate the weight in grams of 100 c. c. of the product of which the specific gravity and the composition are known. Also calculate the amount of water to be evaporated in order to produce the desired concentration, and the volume occupied by the water to be evaporated. Then deduct the weight and the volume of the desired product from that of the known product. Obtain the specific gravity from these calculations, and in turn look up the corresponding Baume reading.

Example: The Baume test of evaporated milk containing 5.0 per cent fat and 16.35 per cent T. S. is 3.22° at 140° F. What will

Key to Fig. 62

Curve	1	2	3	4	5	6	7	8
Fat	5.00	5.50	6.00	6.50	7.00	7.50	7.80	8.00
Total Solids	16.34	17.98	19.61	21.25	22.63	24.52	25.50	26.15

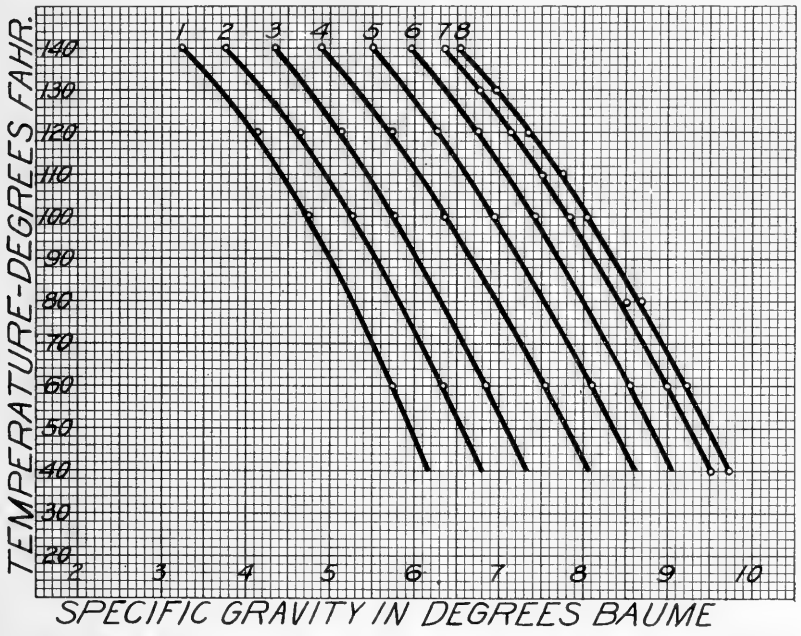


Fig. 62. Relation between temperature, specific gravity and composition in the case of evaporated milk in which the ratio between S. N. F. and fat is as 1 to .4407. Results obtained by J. A. Cross and H. J. Liedel.

the Baume test be in the case of evaporated milk testing 8.0 per cent fat and 26.15 per cent T. S. at 140° F.?

3.22° B. = 1.0226 specific gravity.

100 c. c. = 102.26 grams.

To raise the test from 5.0 per cent to 8.0 per cent requires the evaporation of 37.5 per cent water.

$$\left[100 - \left(\frac{100 \times 5}{100 \times 8}\right)\right] = 37.50$$

102.26×37.50=38.34, grams water to be evaporated.

The specific volume of water at 140° F. is .9834.

38.34÷.9834=39, c. c. of water to be evaporated.

100—39=61, c. c. in product desired.

102.26—38.34=63.92, grams in product desired.

63.92÷61=1.0473, specific gravity or 6.53° B.

HOW TO STRIKE THE PAN BATCH.

Several methods are available for striking the batch at the pan. These all depend upon obtaining the specific gravity of the condensed product. Two principal methods of sampling at the pan are recommended. One is by means of a sampling device attached to the waist of the pan. This is illustrated under Fig. 63. The second is attached to the outlet of the pan, and is illustrated under Fig. 64. It is sometimes possible to obtain the specific gravity by placing the hydrometer directly into the tube of the

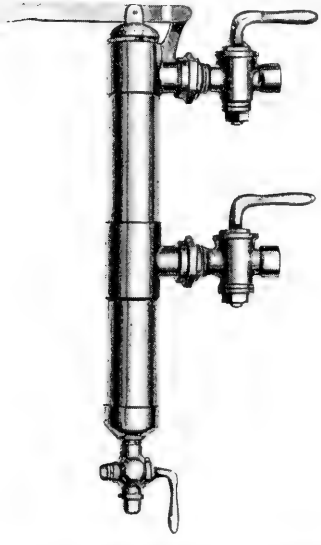


Fig. 63. Pan Striker for Attaching to Waist of Pan.

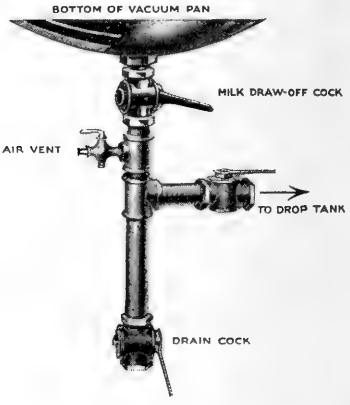


Fig. 64. Pan Striker for Attaching to Outlet of Pan.

device attached to the waist of the pan. The most common practice is to draw the sample into a hydrometer jar and to place the hydrometer directly therein. The hydrometer jar that is recom-

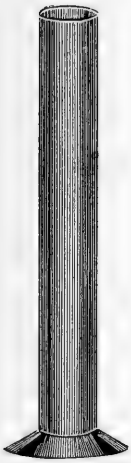


Fig. 65.
Hydrometer
Cylinder.

mended is illustrated under Fig. 65. Hydrometers with several scales are used. The one most commonly used has a range of 5 to 12 graduated into tenths upon the Baume scale. This corresponds to 1.0357 to 1.1154 upon the specific gravity scale. This type of hydrometer is illustrated under Fig. 66.

Fig. 66.
Baume
Hydrometer.

HOLDING TANKS FOR STANDARDIZING EVAPORATED MILK.

Two methods of handling the condensed product are possible, namely, the multibatch and the hold-over method. In the first method each pan batch is handled as one complete unit. In the hold-over method all, or a part of the total pan batches making up the day's run are mixed in one large tank. If the product is canned the same day that it is condensed, artificial refrigeration is not necessary. If the product is held over night under either method, it must be cooled to about 40° F. The multibach method is applicable to small plants, handling under 10,000 pounds of milk daily, while the hold-over method is applicable to all evaporated milk plants handling more than this amount of milk.

In Fig. 67 is illustrated a jacketed copper tank very suitable to the use of small plants. Either brine or water can be used as the cooling medium. In Fig. 68 is illustrated a glass enamelled tank. These can be furnished in sizes to suit the needs of the plant, either in the horizontal or vertical type. For small tanks single propeller blade agitators, as illustrated, are very satisfactory for obtaining a proper mixture. For large horizontal tanks it is recommended that two propeller agitators be used—one in each end.

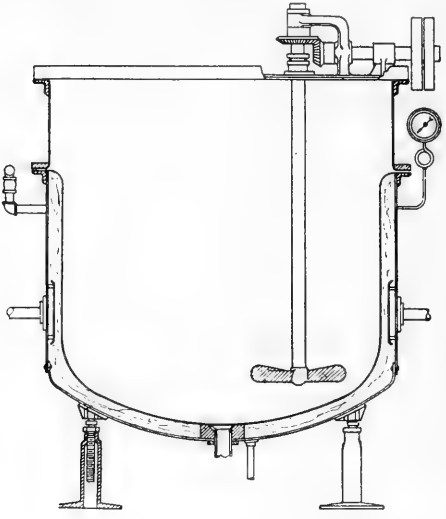


Fig. 67. Jacketed Copper Tank.

The hold-over tanks should be placed either in a refrigerated room or they should be insulated with not less than four inches of the best cork board and finished with two coats of cement plaster, the last coat being brought to a smooth, float finish. Tanks must be fitted with suitable thermometers, so the temperature of the milk can be properly observed at all times.

THE USE OF TABLES IN SHORTENING CALCULATIONS.

Much time can be saved by the use of properly prepared tables covering the products which it is desired to manufacture. This chapter contains two tables applicable to the manufacture of evaporated milk upon the double basis of 7.80 per cent of fat and 25.50 per cent of T. S., and 8.00 per cent fat and 26.15 per cent of T. S.

Table 30 gives the per cent of fat and the per cent of S. N. F. in the proper ratio one to the other for standardizing both of the above products as shown in Table 25. The ratios between S. N. F. and fat in the two products are so near alike that the same values can be applied to solve problems involving either product. The

Fig. 68. Glass Enameled Tank.
Courtesy of the Pfaudler Co.

table has a range from .01 to 4.99 per cent of fat and from .02 to 11.32 per cent of S. N. F.

The table can be used in several ways, as follows:

(1.) To determine the per cent of S. N. F. required to standardize the fat in any given skim-milk. Example: Skim-milk tests .16 per cent fat. Reference to the table shows that .36 per cent of S. N. F. is required to standardize .16 per cent of fat.

(2.) To determine the per cent of fat required to standardize the S. N. F. in any given cream. Example: Cream tests 7.10 per cent of S. N. F. Reference to the table shows that 3.13 per cent of fat is required to standardize 7.10 per cent of S. N. F.

(3.) To determine the per cent of fat required to standardize the S. N. F. in any given whole milk or vice versa. Example: Whole milk tests 4.00 per cent of fat. Reference to the table shows that 9.08 per cent of S. N. F. are required to standardize 4.00 per cent of fat.

The same results as given in the table can be obtained by multiplying the per cent of fat by .4407, or by dividing the per cent of S. N. F. by .4407, but the use of the table dispenses with these long calculations and helps to prevent errors. This table is intended primarily for use when standardizing before condensing, although it can sometimes be applied in part upon some problems covering standardization after condensing. This applies particularly to the use of cream as in the example given above.

TABLE 30.

Per cents fat and S. N. F. in the proper ratio to standardize evaporated milk upon the basis of either 7.80 per cent of fat and 25.50 per cent of T. S. or 8.00 per cent of fat and 26.15 per cent of T. S. Ratio being 1 S. N. F. to .4407 fat.

Per Cent Fat	Per Cent S. N. F.	Per Cent Fat	Per Cent S. N. F.	Per Cent Fat	Per Cent S. N. F.	Per Cent Fat	Per Cent S. N. F.
.01	.02	.40	.91	.78	1.77	1.17	2.65
.02	.05	.41	.93	.79	1.79	1.18	2.68
.03	.07	.42	.95	.80	1.82	1.19	2.70
.04	.09	.43	.98	.81	1.84	1.20	2.72
.05	.11	.44	1.00	.82	1.86	1.21	2.75
.06	.14	.45	1.02	.83	1.88	1.22	2.77
.07	.16	.46	1.04	.84	1.91	1.23	2.79
.08	.18	.47	1.07	.85	1.93	1.24	2.81
.09	.20	.48	1.09	.86	1.95	1.25	2.84
.10	.23	.49	1.11	.87	1.97	1.26	2.86
.11	.25	.50	1.13	.88	2.00	1.27	2.88
.12	.27	.51	1.16	.89	2.02	1.28	2.90
.13	.29	.52	1.18	.90	2.04	1.29	2.93
.14	.32	.53	1.20	.91	2.06	1.30	2.95
.15	.34	.54	1.23	.92	2.09	1.31	2.97
.16	.36	.55	1.25	.93	2.11	1.32	3.00
.17	.39	.56	1.27	.94	2.13	1.33	3.02
.18	.41	.57	1.29	.95	2.16	1.34	3.04
.19	.43	.58	1.32	.96	2.18	1.35	3.06
.20	.45	.59	1.34	.97	2.20	1.36	3.09
.21	.48	.60	1.36	.98	2.22	1.37	3.11
.22	.50	.61	1.38	.99	2.25	1.38	3.13
.23	.52	.62	1.41	1.00	2.27	1.39	3.15
.24	.54	.63	1.43	1.01	2.29	1.40	3.18
.25	.57	.64	1.45	1.02	2.31	1.41	3.20
.26	.59	.65	1.47	1.03	2.34	1.42	3.22
.27	.61	.66	1.50	1.04	2.36	1.43	3.24
.28	.64	.67	1.52	1.05	2.38	1.44	3.27
.29	.66	.68	1.54	1.06	2.41	1.45	3.29
.30	.68	.69	1.57	1.07	2.43	1.46	3.31
.31	.70	.70	1.59	1.08	2.45	1.47	3.34
.32	.73	.71	1.61	1.09	2.47	1.48	3.36
.33	.75	.72	1.63	1.10	2.50	1.49	3.38
.34	.77	.73	1.66	1.11	2.52	1.50	3.40
.35	.79	.74	1.68	1.12	2.54	1.51	3.43
.36	.82	.75	1.70	1.13	2.56	1.52	3.45
.37	.84	.76	1.72	1.14	2.59	1.53	3.47
.38	.86	.77	1.75	1.15	2.61	1.54	3.49
.39	.88			1.16	2.63	1.55	3.52

TABLE 30 (Continued).

Per Cent Fat	Per Cent S. N. F.	Per Cent Fat	Per Cent S. N. F.	Per Cent Fat	Per Cent S. N. F.	Per Cent Fat	Per Cent S. N. F.
1.56	3.54	2.00	4.54	2.44	5.54	2.88	6.54
1.57	3.56	2.01	4.56	2.45	5.56	2.89	6.56
1.58	3.59	2.02	4.58	2.46	5.58	2.90	6.58
1.59	3.61	2.03	4.61	2.47	5.60	2.91	6.60
1.60	3.63	2.04	4.63	2.48	5.63	2.92	6.63
1.61	3.65	2.05	4.65	2.49	5.65	2.93	6.65
1.62	3.68	2.06	4.67	2.50	5.67	2.94	6.67
1.63	3.70	2.07	4.70	2.51	5.70	2.95	6.69
1.64	3.72	2.08	4.72	2.52	5.72	2.96	6.72
1.65	3.74	2.09	4.74	2.53	5.74	2.97	6.74
1.66	3.77	2.10	4.77	2.54	5.76	2.98	6.76
1.67	3.79	2.11	4.79	2.55	5.79	2.99	6.78
1.68	3.80	2.12	4.81	2.56	5.81	3.00	6.81
1.69	3.83	2.13	4.83	2.57	5.83	3.01	6.83
1.70	3.86	2.14	4.86	2.58	5.85	3.02	6.85
1.71	3.88	2.15	4.88	2.59	5.88	3.03	6.88
1.72	3.90	2.16	4.90	2.60	5.90	3.04	6.90
1.73	3.93	2.17	4.92	2.61	5.92	3.05	6.92
1.74	3.95	2.18	4.95	2.62	5.95	3.06	6.94
1.75	3.97	2.19	4.97	2.63	5.97	3.07	6.97
1.76	3.99	2.20	4.99	2.64	5.99	3.08	6.99
1.77	4.02	2.21	5.01	2.65	6.01	3.09	7.01
1.78	4.04	2.22	5.04	2.66	6.04	3.10	7.03
1.79	4.06	2.23	5.06	2.67	6.06	3.11	7.06
1.80	4.08	2.24	5.08	2.68	6.08	3.12	7.08
1.81	4.11	2.25	5.11	2.69	6.10	3.13	7.10
1.82	4.13	2.26	5.13	2.70	6.13	3.14	7.13
1.83	4.15	2.27	5.15	2.71	6.15	3.15	7.15
1.84	4.18	2.28	5.17	2.72	6.17	3.16	7.17
1.85	4.20	2.29	5.20	2.73	6.19	3.17	7.19
1.86	4.22	2.30	5.22	2.74	6.22	3.18	7.22
1.87	4.24	2.31	5.24	2.75	6.24	3.19	7.24
1.88	4.27	2.32	5.26	2.76	6.26	3.20	7.26
1.89	4.29	2.33	5.29	2.77	6.29	3.21	7.28
1.90	4.31	2.34	5.31	2.78	6.31	3.22	7.31
1.91	4.33	2.35	5.33	2.79	6.33	3.23	7.33
1.92	4.36	2.36	5.36	2.80	6.35	3.24	7.35
1.93	4.38	2.37	5.38	2.81	6.38	3.25	7.37
1.94	4.40	2.38	5.40	2.82	6.41	3.26	7.40
1.95	4.42	2.39	5.42	2.83	6.42	3.27	7.42
1.96	4.45	2.40	5.44	2.84	6.44	3.28	7.44
1.97	4.47	2.41	5.47	2.85	6.47	3.29	7.47
1.98	4.49	2.42	5.49	2.86	6.49	3.30	7.49
1.99	4.52	2.43	5.51	2.87	6.51	3.31	7.51

TABLE 30 (Continued).

Per Cent Fat	Per Cent S. N. F.	Per Cent Fat	Per Cent S. N. F.	Per Cent Fat	Per Cent S. N. F.	Per Cent Fat	Per Cent S. N. F.
3.32	7.53	3.74	8.49	4.16	9.44	4.58	10.39
3.33	7.56	3.75	8.51	4.17	9.46	4.59	10.42
3.34	7.58	3.76	8.53	4.18	9.49	4.60	10.44
3.35	7.60	3.77	8.55	4.19	9.51	4.61	10.46
3.36	7.62	3.78	8.58	4.20	9.53	4.62	10.48
3.37	7.65	3.79	8.60	4.21	9.56	4.63	10.51
3.38	7.67	3.80	8.62	4.22	9.58	4.64	10.53
3.39	7.69	3.81	8.65	4.23	9.60	4.65	10.55
3.40	7.72	3.82	8.67	4.24	9.62	4.66	10.57
3.41	7.74	3.83	8.69	4.25	9.64	4.67	10.60
3.42	7.76	3.84	8.71	4.26	9.67	4.68	10.62
3.43	7.78	3.85	8.74	4.27	9.69	4.69	10.64
3.44	7.81	3.86	8.76	4.28	9.71	4.70	10.67
3.45	8.83	3.87	8.78	4.29	9.73	4.71	10.69
3.46	7.85	3.88	8.80	4.30	9.76	4.72	10.71
3.47	7.87	3.89	8.83	4.31	9.78	4.73	10.73
3.48	7.90	3.90	8.85	4.32	9.80	4.74	10.76
3.49	7.92	3.91	8.87	4.33	9.83	4.75	10.78
3.50	7.94	3.92	8.90	4.34	8.85	4.76	10.80
3.51	7.96	3.93	8.92	4.35	9.87	4.77	10.82
3.52	7.99	3.94	8.94	4.36	9.89	4.78	10.85
3.53	7.01	3.95	8.96	4.37	9.92	4.79	10.86
3.54	8.03	3.96	8.99	4.38	9.94	4.80	10.89
3.55	8.06	3.97	9.01	4.39	9.96	4.81	10.91
3.56	8.08	3.98	9.03	4.40	9.98	4.82	10.94
3.57	8.10	3.99	9.05	4.41	10.01	4.83	10.96
3.58	8.12	4.00	9.08	4.42	10.13	4.84	10.98
3.59	8.15	4.01	9.10	4.43	10.05	4.85	11.01
3.60	8.17	4.02	9.12	4.44	10.08	4.86	11.03
3.61	8.19	4.03	9.14	4.45	10.10	4.87	11.05
3.62	8.21	4.04	9.17	4.46	10.12	4.88	11.07
3.63	8.24	4.05	9.19	4.47	10.14	4.89	11.10
3.64	8.26	5.06	9.21	4.48	10.17	4.90	11.12
3.65	8.28	4.07	9.24	4.49	10.19	4.91	11.14
3.66	8.31	4.08	9.26	4.50	10.21	4.92	11.16
3.67	8.33	4.09	9.28	4.51	10.23	4.93	11.19
3.68	8.35	4.10	9.30	4.52	10.26	4.94	11.21
3.69	8.37	4.11	9.33	4.53	10.28	4.95	11.23
3.70	8.40	4.12	9.35	4.54	10.30	4.96	11.26
3.71	8.42	4.13	9.37	4.55	10.32	4.97	11.28
3.72	8.44	4.14	9.39	4.56	10.35	4.98	11.30
3.73	8.46	4.15	9.42	4.57	10.37		

TABLE 31.

Percentages of fat, S. N. F. and T. S. in product after condensing, all in the proper ratio to standardize upon the basis of either 7.80 per cent of fat and 25.50 per cent of T. S., or 8.00 per cent of fat and 26.15 per cent of T. S. Ratio in either case being 1 S. N. F. to .4407 of fat. Also the factor of over-condensation from 7.80 to 9.00 per cent, and from 8.00 to 9.00 per cent of fat.

Fat	S. N. F.	T. S.	Over-condensation		Fat	S. N. F.	T. S.	Over-condensation	
			7.80-25.50 Standard	8.00 26.15 Standard				7.80-25.50 Standard	8.00-26.15 Standard
7.00	15.88	22.88	.....	.....	7.15	16.23	23.38	.....	.....
7.00	15.89	22.89	.....	.....	7.16	16.24	23.40	.....	.....
7.01	15.90	22.91	.....	.....	7.16	16.25	23.41	.....	.....
7.01	15.91	22.92	.....	.....	7.17	16.26	23.42	.....	.....
7.02	15.92	22.94	.....	.....	7.17	16.27	23.44	.....	.....
7.02	15.93	22.95	.....	.....	7.17	16.28	23.45	.....	.....
7.02	15.94	22.96	.....	.....	7.18	16.29	23.47	.....	.....
7.03	15.95	22.98	.....	.....	7.18	16.30	23.48	.....	.....
7.03	15.96	22.99	.....	.....	7.19	16.31	23.50	.....	.....
7.04	15.97	23.01	.....	.....	7.19	16.32	23.51	.....	.....
7.04	15.98	23.02	.....	.....	7.20	16.33	23.53	.....	.....
7.05	15.99	23.04	.....	.....	7.20	16.34	23.54	.....	.....
7.05	16.00	23.05	.....	.....	7.21	16.35	23.56	.....	.....
7.06	16.01	23.07	.....	.....	7.21	16.36	23.57	.....	.....
7.06	16.02	23.08	.....	.....	7.21	16.37	23.58	.....	.....
7.06	16.03	23.09	.....	.....	7.22	16.38	23.60	.....	.....
7.07	16.04	23.11	.....	.....	7.22	16.39	23.61	.....	.....
7.07	16.05	23.12	.....	.....	7.23	16.40	23.63	.....	.....
7.08	16.06	23.14	.....	.....	7.24	16.41	23.64	.....	.....
7.08	16.07	23.15	.....	.....	7.24	16.42	23.66	.....	.....
7.09	16.08	23.17	.....	.....	7.25	16.43	23.67	.....	.....
7.09	16.09	23.18	.....	.....	7.25	16.44	23.69	.....	.....
7.10	16.10	23.20	.....	.....	7.25	16.45	23.70	.....	.....
7.10	16.11	23.21	.....	.....	7.26	16.46	23.71	.....	.....
7.10	16.12	23.22	.....	.....	7.26	16.47	23.73	.....	.....
7.11	16.13	23.24	.....	.....	7.27	16.48	23.74	.....	.....
7.11	16.14	23.25	.....	.....	7.27	16.49	23.76	.....	.....
7.12	16.15	23.27	.....	.....	7.28	16.50	23.77	.....	.....
7.12	16.16	23.28	.....	.....	7.28	16.51	23.79	.....	.....
7.13	16.17	23.30	.....	.....	7.28	16.52	23.80	.....	.....
7.13	16.18	23.31	.....	.....	7.29	16.53	23.81	.....	.....
7.13	16.19	23.32	.....	.....	7.29	16.54	23.83	.....	.....
7.14	16.20	23.34	.....	.....	7.30	16.55	23.84	.....	.....
7.14	16.21	23.35	.....	.....	7.30	16.56	23.86	.....	.....
7.15	16.22	23.37	.....	.....	7.31	16.57	23.87	.....	.....

TABLE 31 (Continued).

Fat	S. N. F.	T. S.	Over-condensation		Fat	S. N. F.	T. S.	Over-condensation	
			7.80-25.50 Standard	8.00-26.15 Standard				7.80-25.50 Standard	8.00-26.15 Standard
7.31	16.58	23.89	.....	.....	7.49	16.99	24.48	.....	.....
7.32	16.59	23.90	.....	.....	7.49	16.01	24.49	.....	.....
7.32	16.60	23.92	.....	.....	7.50	17.01	24.51	.....	.....
7.32	16.61	23.93	.....	.....	7.50	17.02	24.52	.....	.....
7.33	16.62	23.94	.....	.....	7.51	17.03	24.54	.....	.....
7.33	16.63	23.96	.....	.....	.51	17.04	24.55	.....	.....
7.34	16.64	23.97	.....	.....	7.51	17.05	24.56	.....	.....
7.34	16.65	23.99	.....	.....	7.52	17.06	24.58	.....	.....
7.35	16.66	24.00	.....	.....	7.52	17.07	24.59	.....	.....
7.35	16.67	24.02	.....	.....	7.53	17.08	24.61	.....	.....
7.35	16.68	24.03	.....	.....	.53	17.09	24.62	.....	.....
7.36	16.69	24.05	.....	.....	.54	17.10	24.64	.....	.....
7.36	16.70	24.06	.....	.....	7.54	17.11	24.65	.....	.....
7.36	16.71	24.07	.....	.....	7.54	17.12	24.66	.....	.....
7.37	16.72	24.09	.....	.....	7.55	17.13	24.68	.....	.....
7.37	16.73	24.10	.....	.....	7.55	17.14	24.69	.....	.....
7.38	16.74	24.12	.....	.....	7.56	17.15	24.71	.....	.....
7.38	16.75	24.13	.....	.....	7.56	17.16	24.72	.....	.....
7.39	16.76	24.15	.....	.....	7.57	17.17	24.74	.....	.....
7.39	16.77	24.16	.....	.....	7.57	17.18	24.75	.....	.....
7.39	16.78	24.17	.....	.....	7.58	17.19	24.77	.....	.....
7.40	16.79	24.19	.....	.....	7.58	17.20	24.78	.....	.....
7.40	16.80	24.20	.....	.....	7.58	17.21	24.79	.....	.....
7.41	16.81	24.22	.....	.....	7.59	17.22	24.81	.....	.....
7.41	16.82	24.23	.....	.....	7.59	17.23	24.82	.....	.....
7.42	16.83	24.25	.....	.....	7.60	17.24	24.84	.....	.....
7.42	16.84	24.26	.....	.....	7.60	17.25	24.85	.....	.....
7.43	16.85	24.28	.....	.....	7.61	17.26	24.87	.....	.....
7.43	16.86	24.29	.....	.....	.61	17.27	24.88	.....	.....
7.43	16.87	24.30	.....	.....	7.62	17.28	24.90	.....	.....
7.44	16.88	24.32	.....	.....	7.62	17.29	24.91	.....	.....
7.44	16.89	24.33	.....	.....	.62	17.30	24.92	.....	.....
7.45	16.90	24.35	.....	.....	....	.....	.....	.....	.....
7.45	16.91	24.36	.....	.....	.63	17.31	24.94	.....	.....
7.46	16.92	24.38	.....	.....	7.63	17.32	24.95	.....	.....
7.47	16.93	24.39	.....	.....	7.64	17.33	24.97	.....	.....
7.47	16.94	24.41	.....	.....	7.64	17.34	24.98	.....	.....
7.47	16.95	24.42	.....	.....	7.65	17.35	25.00	.....	.....
7.47	16.96	24.43	.....	.....	7.65	17.36	25.01	.....	.....
7.48	16.97	24.45	.....	.....	7.65	17.37	25.02	.....	.....
7.48	16.98	24.46	.....	.....	7.66	17.38	25.04	.....	.....
					.66	17.39	25.05	.....	.....

TABLE 31 (Continued).

Fat	S. N. F.	T. S.	Over-condensation		Fat	S. N. F.	T. S.	Over-condensation	
			7.80-25.50 Standard	8.00-26.15 Standard				7.80-25.50 Standard	8.00 26.15 Standard
7.67	17.40	25.07	.....	.....	7.85	17.82	25.67	.0066	.....
7.67	17.41	25.08	.....	.....	7.86	17.83	25.69	.0074	.....
7.68	17.42	25.10	.....	.....	7.86	17.84	25.70	.0078	.....
7.68	17.43	25.11	.....	.....	7.87	17.85	25.72	.0086	.....
7.69	17.44	25.13	.....	.....	7.87	17.88	25.73	.0090	.....
7.69	17.45	25.14	.....	.....	7.88	17.87	25.75	.0098	.....
7.69	17.46	25.15	.....	.....	7.88	17.86	25.76	.0101	.....
7.70	17.47	25.17	.....	.....	7.88	17.89	25.77	.0105	.....
7.70	17.48	25.18	.....	.....	7.89	17.90	25.79	.0113	.....
7.71	17.49	25.20	.....	.....	7.89	17.91	25.80	.0117	.....
7.71	17.50	25.21	.....	.....	7.90	17.92	25.82	.0125	.....
7.72	17.51	25.23	.....	.....	7.90	17.93	25.83	.0129	.....
7.72	17.52	25.24	.....	.....	7.91	17.94	25.85	.0137	.....
7.73	17.53	25.26	.....	.....	7.91	17.95	25.86	.0141	.....
7.73	17.54	25.27	.....	.....	7.91	17.96	25.87	.0145	.....
7.73	17.55	25.28	.....	.....	7.92	17.97	25.89	.0152	.....
7.74	17.56	25.30	.....	.....	7.93	17.98	25.90	.0156	.....
7.74	17.57	25.31	.....	.....	7.93	17.99	25.92	.0164	.....
7.75	17.58	25.33	.....	.....	7.93	18.00	25.93	.0168	.....
7.75	17.59	25.34	.....	.....	7.94	18.01	25.95	.0176	.....
7.76	17.60	25.36	.....	.....	7.94	18.02	25.96	.0180	.....
7.76	17.61	25.37	.....	.....	7.95	18.03	25.98	.0188	.....
7.77	17.62	25.39	.....	.....	7.95	18.04	25.99	.0192	.....
7.77	17.63	25.40	.....	.....	7.95	18.05	26.00	.0196	.....
7.77	17.64	25.41	.....	.....	7.96	18.06	26.02	.0203	.....
7.78	17.65	25.43	.....	.....	7.96	18.07	26.03	.0207	.....
7.78	17.66	25.44	.....	.....	7.97	18.08	26.05	.0215	.....
7.79	17.67	25.46	.....	.....	7.97	18.09	26.06	.0219	.....
7.79	17.68	25.47	.....	.....	7.98	18.10	26.08	.0227	.....
7.80	17.69	25.49	.....	.....	7.98	18.11	26.09	.0231	.....
7.80	17.70	25.50	.....	.....	7.99	18.12	26.11	.0239	.....
7.80	17.71	25.51	.0004	.....	7.99	18.13	26.12	.0243	.....
7.81	17.72	25.52	.0007	.....	7.99	18.14	26.13	.0246	.....
7.81	17.73	25.54	.0015	.....	8.00	18.15	26.15	.0254	.....
7.82	17.74	25.56	.0023	.....	8.00	18.16	26.16	.0258	.0004
7.82	17.75	25.57	.0027	.....	8.01	18.17	26.18	.0266	.0008
7.83	17.76	25.59	.0035	.....	8.01	18.18	26.19	.0270	.0015
7.83	17.77	25.60	.0039	.....	8.02	18.19	26.21	.0278	.0023
7.84	17.78	25.62	.0047	.....	8.02	18.20	26.22	.0282	.0027
7.84	17.79	25.63	.0050	.....	8.03	18.21	26.24	.0290	.0034
7.84	17.80	25.64	.0054	.....	8.03	18.22	26.25	.0294	.0038
7.85	17.81	25.66	.0062	.....	8.03	18.23	26.26	.0297	.0042

TABLE 31 (Continued).

Fat	S. F. F.	T. S.	Over-condensation-		Fat	S. N. F.	T. S.	Over-condensation	
			7.80-25.50 Standard	8.00-26.15 Standard				7.80-25.50 Standard	8.00-26.15 Standard
8.04	18.24	26.28	.0305	.0050	8.22	18.66	26.88	.0540	.0279
8.04	18.25	26.29	.0309	.0054	8.23	18.67	26.90	.0548	.0287
8.05	18.26	26.31	.0317	.0061	8.23	18.68	26.91	.0552	.0291
8.05	18.27	26.32	.0321	.0065	8.24	18.69	26.93	.0560	.0298
8.06	18.28	26.34	.0329	.0073	8.24	18.70	26.94	.0564	.0302
8.06	18.29	26.35	.0333	.0076	8.25	18.71	26.96	.0572	.0310
8.06	18.30	26.36	.0337	.0080	8.25	18.72	26.97	.0576	.0314
8.07	18.31	26.38	.0344	.0088	8.25	18.73	26.98	.0580	.0317
8.07	18.32	26.39	.0348	.0092	8.26	18.74	27.00	.0588	.0325
8.08	18.33	26.41	.0356	.0099	8.26	18.75	27.01	.0591	.0329
8.08	18.34	26.42	.0360	.0103	8.27	18.76	27.03	.0599	.0336
8.09	18.35	26.44	.0366	.0111	8.27	18.77	27.04	.0603	.0340
8.09	18.36	26.45	.0372	.0115	8.28	18.78	27.06	.0611	.0348
8.10	18.37	26.47	.0380	.0122	8.28	18.79	27.07	.0615	.0352
8.10	18.38	26.48	.0384	.0126	8.29	18.80	27.09	.0623	.0359
8.10	18.39	26.49	.0388	.0130	8.29	18.81	27.10	.0627	.0363
8.11	18.40	26.51	.0395	.0133	8.29	18.82	27.11	.0631	.0667
8.11	18.41	26.52	.0400	.0141	8.30	18.83	27.13	.0338	.0375
8.12	18.42	26.54	.0407	.0149	8.30	18.84	27.14	.0642	.0379
8.12	18.43	26.55	.0412	.0153	8.31	18.85	27.16	.0650	.0386
8.13	18.44	26.57	.0417	.0161	8.31	18.86	27.17	.0654	.0390
8.13	18.45	26.58	.0423	.0164	8.32	18.87	27.19	.0662	.0398
8.14	18.46	26.60	.0431	.0172	8.32	18.88	27.20	.0666	.0402
8.14	18.47	26.61	.0435	.0176	8.32	18.89	27.21	.0670	.0407
8.14	18.48	26.62	.0439	.0180	8.33	18.90	27.23	.0678	.0413
8.15	18.49	26.64	.0446	.0187	8.33	18.91	27.24	.0682	.0417
8.15	18.50	26.65	.0450	.0191	8.34	18.92	27.26	.0689	.0424
8.16	18.51	26.67	.0458	.0199	8.34	18.93	27.27	.0693	.0428
8.16	18.52	26.68	.0462	.0203	8.35	18.94	27.29	.0701	.0436
8.17	18.53	26.70	.0470	.0210	8.35	18.95	27.30	.0705	.0440
8.17	18.54	26.71	.0471	.0214	8.36	18.96	27.32	.0713	.0447
8.17	18.55	26.72	.0478	.0218	8.36	18.97	27.33	.0717	.0451
8.18	18.56	26.74	.0486	.0226	8.36	18.98	27.34	.0721	.0455
8.18	18.57	26.75	.0490	.0229	8.37	18.99	27.36	.0729	.0463
8.19	18.58	26.77	.0497	.0237	8.37	19.00	27.37	.0733	.0467
8.19	18.59	26.78	.0501	.0241	8.38	19.01	27.39	.0740	.0474
8.20	18.60	26.80	.0509	.0249	8.38	19.02	27.40	.0744	.0478
8.20	18.61	26.81	.0513	.0252	8.39	19.03	27.42	.0752	.0486
8.21	18.62	26.83	.0521	.0260	8.39	19.04	27.43	.0756	.0489
8.21	18.63	26.84	.0525	.0264	8.39	19.05	27.45	.0764	.0497
8.21	18.64	26.85	.0529	.0268	8.40	19.06	27.46	.0768	.0501
8.22	18.65	26.87	.0537	.0275	8.40	19.07	27.47	.0772	.0505

TABLE 31 (Continued).

Fat	S. N. F.	T. S.	Over-condensation		Fat	S. N. F.	T. S.	Over-condensation	
			7.80-25.50 Standard	8.00-26.15 Standard				7.80-25.50 Standard	8.00-26.15 Standard
8.41	19.08	27.49	.0780	.0512	8.59	19.50	28.09	.1015	.0742
8.41	19.09	27.50	.0784	.0516	8.60	19.51	28.11	.1023	.0750
8.42	19.10	27.52	.0792	.0524	8.60	19.52	28.12	.1027	.0753
8.42	19.11	27.53	.0796	.0528	8.61	19.53	28.14	.1035	.0761
8.43	19.12	27.55	.0803	.0535	8.61	19.54	28.15	.1039	.0765
8.43	19.13	27.56	.0807	.0539	8.62	19.55	28.17	.1047	.0772
8.43	19.14	27.57	.0811	.0543	8.62	19.56	28.18	.1050	.0776
8.44	19.15	27.59	.0819	.0551	8.62	19.57	28.19	.1054	.0780
8.44	19.16	27.60	.0823	.0554	8.63	19.58	28.21	.1062	.0788
8.45	19.17	27.62	.0831	.0562	8.63	19.59	28.22	.1066	.0792
8.45	19.18	27.63	.0835	.0566	8.64	19.60	28.24	.1074	.0799
8.46	19.19	27.65	.0843	.0574	8.64	19.61	28.25	.1078	.0803
8.46	19.20	27.66	.0847	.0577	8.65	19.62	28.27	.1086	.0811
8.47	19.21	27.68	.0854	.0585	8.65	19.63	28.28	.1090	.0815
8.47	19.22	27.69	.0858	.0589	8.66	19.64	28.30	.1098	.0822
8.47	19.23	27.70	.0862	.0593	8.66	19.65	28.31	.1101	.0826
8.48	19.24	27.72	.0870	.0600	8.66	19.66	28.32	.1105	.0830
8.48	19.25	27.73	.0874	.0604	8.67	19.67	28.34	.1113	.0837
8.49	19.26	27.75	.0882	.0612	8.67	19.68	28.35	.1117	.0841
8.49	19.27	27.76	.0886	.0616	8.68	19.69	28.37	.1125	.0849
8.50	19.28	27.78	.0894	.0623	8.68	19.70	28.38	.1129	.0853
8.50	19.29	27.79	.0898	.0627	8.69	19.71	28.40	.1137	.0860
8.51	19.30	27.80	.0901	.0631	8.69	19.72	28.41	.1141	.0864
8.51	19.31	27.82	.0909	.0639	8.70	19.73	28.43	.1149	.0872
8.51	19.32	27.83	.0913	.0642	8.70	19.74	28.44	.1152	.0876
8.52	19.33	27.85	.0921	.0650	8.70	19.75	28.45	.1156	.0880
8.52	19.34	27.86	.0925	.0654	8.71	19.76	28.47	.1164	.0887
8.53	19.35	27.88	.0933	.0661	8.71	19.77	28.48	.1168	.0891
8.53	19.36	27.89	.0937	.0665	8.72	19.78	28.50	.1176	.0899
8.54	19.37	27.91	.0945	.0673	8.72	19.79	28.51	.1180	.0902
8.54	19.38	27.92	.0949	.0677	8.73	19.80	28.53	.1188	.0910
8.55	19.39	27.94	.0956	.0685	8.73	19.81	28.54	.1192	.0914
8.55	19.40	27.95	.0960	.0688	8.73	19.82	28.55	.1195	.0918
8.55	19.41	27.96	.0964	.0692	8.74	19.83	28.57	.1203	.0925
8.56	19.42	27.98	.0972	.0700	8.74	19.84	28.58	.1207	.0929
8.56	19.43	27.99	.0976	.0704	8.75	19.85	28.60	.1215	.0937
8.57	19.44	28.01	.0984	.0711	8.75	19.86	28.61	.1219	.0941
8.57	19.45	28.02	.0988	.0715	8.76	19.87	28.63	.1227	.0948
8.58	19.46	28.04	.0996	.0723	8.76	19.88	28.64	.1231	.0952
8.58	19.47	28.05	.1000	.0727	8.77	19.89	28.66	.1239	.0960
8.58	19.48	28.06	.1003	.0730	8.77	19.90	28.67	.1243	.0964
8.59	19.49	28.08	.1011	.0738	8.77	19.91	28.68	.1247	.0967

TABLE 31 (Continued).

Fat	S. N. F.	T. S.	Over-condensation		Fat	S. N. F.	T. S.	Over-condensation	
			7.80-25.50 Standard	8.00-26.15 Standard				7.80-25.50 Standard	8.00-26.15 Standard
8.78	19.92	28.70	.1254	.0975	8.89	20.18	29.07	.1400	.1117
8.78	19.93	28.71	.1258	.0979	8.90	20.19	29.09	.1407	.1124
8.79	19.94	28.73	.1266	.0987	8.90	20.20	29.10	.1411	.1128
8.79	19.95	28.74	.1270	.0990	8.91	20.21	29.12	.1419	.1136
8.80	19.96	28.76	.1278	.0998	8.91	20.22	29.13	.1423	.1140
8.80	19.97	28.77	.1282	.1002	8.92	20.23	29.15	.1431	.1147
8.81	19.98	28.79	.1290	.1010	8.92	20.24	29.16	.1435	.1151
8.81	19.99	28.80	.1294	.1013	8.92	20.25	29.17	.1443	.1155
8.81	20.00	28.81	.1298	.1017	8.93	20.26	29.19	.1447	.1163
8.82	20.01	28.83	.1305	.1025	8.93	20.27	29.20	.1450	.1166
8.82	20.02	28.84	.1309	.1029	8.94	20.28	29.22	.1458	.1174
8.83	20.03	28.86	.1317	.1036	8.94	20.29	29.23	.1462	.1178
8.83	20.04	28.87	.1321	.1040	8.95	20.30	29.25	.1470	.1185
8.84	20.05	28.89	.1329	.1048	8.95	20.31	29.26	.1474	.1189
8.84	20.06	28.90	.1333	.1052	8.96	20.32	29.28	.1483	.1197
8.84	20.07	28.91	.1337	.1058	8.96	20.33	29.29	.1486	.1201
8.85	20.08	28.93	.1345	.1063	8.96	20.34	29.30	.1490	.1205
8.85	20.09	28.94	.1349	.1067	8.97	20.35	29.32	.1498	.1212
8.86	20.10	28.96	.1356	.1075	8.97	20.36	29.33	.1501	.1216
8.86	20.11	28.97	.1360	.1078	8.98	20.37	29.35	.1509	.1224
8.87	20.12	28.99	.1368	.1086	8.98	20.38	29.36	.1513	.1228
8.87	20.13	29.00	.1372	.1090	8.99	20.39	29.38	.1521	.1235
8.88	20.14	29.02	.1380	.1098	8.99	20.40	29.39	.1525	.1239
8.88	20.15	29.03	.1384	.1101	8.99	20.41	29.40	.1529	.1243
8.88	20.16	29.04	.1388	.1105	9.00	20.42	29.42	.1537	.1250
8.89	20.17	29.06	.1396	.1113					

Table 31 gives the percentage of fat, S. N. F. and T. S. all in the proper ratio one to the other for standardizing evaporated milk upon the double basis of 7.80 per cent of fat, and 25.50 per cent of T. S., and 8.00 per cent of fat and 26.15 per cent of T. S. The table has a range from 7.00 per cent to 9.00 per cent of fat, and from 15.88 per cent to 20.52 per cent of S. N. F. The table also gives the factor of overcondensation from 7.80 to 9.00 and from 8.00 to 9.00.

This table is intended to be used when standardizing after condensing, and also when standardizing with the use of condensed milk products. One example will suffice to show its use. Example: Evaporated milk after condensing contains 8.25 per

cent of fat and 19.21 per cent S. N. F. Reference to the table shows that for 8.25 per cent of fat the S. N. F. should be 18.71 per cent. The difference between 19.21 and 18.71 is .50 or the per cent of S. N. F. that is to be standardized. The table gives results that could not be obtained otherwise than by a long calculation, and it also helps to prevent errors. The method for applying the factor of overcondensation will be discussed in another paragraph of this chapter.

KEY TO FORMULAS FOR STANDARDIZING EVAPORATED MILK.

The following key gives the information required for substituting values or figures for letters in the formulas found in this chapter:

A = The desired per cent of fat in the standardized product.
B = The desired per cent of S. N. F. in the standardized product.
B^1 = The per cent of S. N. F. in evaporated milk, before standardizing.
C = The desired per cent of T. S. in the standardized product.
D = The per cent of T. S. in condensed whole milk.
D^1 = The pounds of evaporated milk, before standardizing.
D^2 = The pounds of unsweetened condensed whole milk.
F = The per cent of fat in the whole milk.
F^1 = The per cent of fat in butter.
G = The per cent of fat in the cream.
J = The per cent of S. N. F. in the cream.
J^1 = The per cent of T. S. in the cream.
J^2 = The per cent of S. N. F. in the evaporated milk before standardizing.
K^1 = The per cent of fat in the skim-milk.
K^2 = The per cent of fat in the evaporated milk, before standardizing.
K = The per cent of fat in the unsweetened condensed whole milk.
L = The pounds of skim-milk required.
L^1 = The pounds of unsweetened condensed skim-milk.
M = The per cent of S. N. F. in the condensed whole milk.
N = The per cent of S. N. F. in the skim-milk.
O = The pounds of cream required.
O^1 = The per cent of T. S. in the mixed batch.

P = The pounds of whole milk in the batch.
P^1 = The pounds of butter.
Q = The per cent of S. N. F. in the condensed skim-milk.
R = The desired ratio of S. N. F. to fat.
R^1 = The desired ratio of T. S. to fat.
S = The per cent of S. N. F. in the whole milk.
S^1 = The average per cent of fat in the mixed batch.
S^2 = The average per cent of S. N. F. in the mixed batch.
T = The per cent of T. S. in whole milk.
T^1 = The per cent of T. S. in evaporated milk.
T^2 = The per cent of T. S. in condensed skim-milk.
W = The pounds of water to be added.

PROVIDING FACTOR OF SAFETY.

In all the problems given, the calculations are made upon the basis of the absolute standard without allowing any factor of safety. It is recommended that in practice, in the case of evaporated milk, a factor of safety of about .05 per cent of fat, and about .20 per cent of T. S. be allowed. When plenty of time is available for retests this factor of safety may be very slightly reduced.

PROBLEM 7. STANDARDIZING EVAPORATED MILK BEFORE CONDENSING. HOW TO CALCULATE POUNDS OF SKIM-MILK TO ADD TO WHOLE MILK.

The ratio between the percentage of S. N. F. and the percentage of fat in the whole milk must be more than the required ratio.

Solution of Problem 7, Based Upon Rule 4:

(1.) Divide the percentage of fat in the skim-milk by the ratio between the S. N. F. and the fat in the product desired. Subtract answer from the S. N. F. in the skim-milk. Call remainder A., or the percentage of S. N. F. in the skim-milk available for standardizing.

(2.) Divide the percentage of fat in the whole milk by the ratio between the S. N. F. and the fat in the product desired. Call the result B. Subtract from B the percentage of S. N. F. present in the whole milk. Multiply the remainder by the pounds of

whole milk present in the batch. Call the result C, or the pounds S. N. F. short.

(3.) Divide C by A. The answer will be the pounds of skim-milk necessary to standardize the batch to the required ratio.

Solution of Problem 7, Based Upon Formula 6:

$$L = \frac{\left(\frac{F}{R} - S\right)P}{N - \frac{K}{R}}$$

Problem 7, Example 9:

Products	Pounds	Per Cent		
		Fat	S. N. F.	T. S.
Milk	10,000	3.79	8.31	12.10
Skim-milk		.16	8.47	8.63
Composition desired		7.80	17.70	25.50

Ratio 1 S. N. F. to .4407 fat desired.

Ratio 1 S. N. F. to .4561 fat in whole milk.

Solution of Problem 7, Example 9, Based Upon Rule 4:

(1.) **To calculate the available S. N. F. in the skim-milk.**

.16 ÷ .4407 = .36, per cent of S. N. F. required to equalize the fat in the skim-milk.

8.47—.36=8.11, per cent of S. N. F. available for standardizing.

(2.) **To calculate the pounds of S. N. F. short.**

3.79 ÷ .4407 = 8.60, per cent of S. N. F. required.

8.60 — 8.31 = .29, per cent of S. N. F. short.

10000 × .0029 = 29, pounds of S. N. F. short.

(3.) **To calculate the pounds of skim-milk required.**

29÷.0811=358, pounds of skim-milk required.

Solution of Problem 7, Based Upon Formula 6:

$$L = \frac{\left(\frac{.0379}{.4407} - .0831\right) \times 10{,}000}{.0847 - \frac{.0016}{.4407}} = 358$$

Proof of Problem 7, Example 9:

Products	Pound	Pounds			Per Cent		
		Fat	S. N. F.	T. S.	Fat	S. N. F.	T. S.
Milk	10,000	379	831	1210	3.79	8.31	12.10
Skim-milk	358	1	30	31	.16	8.47	8.63
Standardized product	10,358	80	861	124	3.66	8.31	11.01

Ratio 1 S. N. F. to .4407 fat obtained in product after standardizing.

STANDARDIZING EVAPORATED MILK BEFORE CONDENSING.

Problem 8: How to Calculate Pounds of Cream to Add to Whole Milk:

Ratio between the percentage of S. N. F. and fat in the whole milk must be less than the required ratio.

Solution of Problem 8, Based Upon Rule 5:

(1.) Multiply the percentage of S. N. F. in the cream by the ratio between the S. N. F. and the fat in the product desired. Subtract the result from the percentage of fat in the cream. Call the reminder A, or the percentage of fat in the cream available for standardizing.

(2.) Multiply the percentage of S. N. F. in the whole milk by the ratio between the S. N. F. and the fat in the product desired. Call the result B, or the percentage of fat required. Subtract from B the percentage of fat in the whole milk. Multiply the remainder by the pounds of whole milk in the batch. Call the result C, or the pounds of fat short.

3. Divide C by A. The answer will be the pounds of cream required to standardize the batch to the desired ratio.

Solution of Problem 8, Based Upon Formula 7:

$$O = \frac{[(S\,R) - F]\ P}{G - (J\,R)}$$

Problem 8, Example 10:

Products	Pounds	PER CENT		
		Fat	S. N. F.	T. S.
Milk	10,000	3.35	8.63	11.98
Cream		26.38	6.44	32.82
Composition desired after condensing		7.80	17.70	25.50

Ratio of 1 S. N. F. to .4407 fat desired.

Ratio of 1 S. N. F. to .3793 fat in whole milk.

Solution of Problem 8, Example 10, Based Upon Rule 5:

(1.) **To calculate the available fat in the cream.**

$6.44 \times .4407 = 2.84$, per cent of fat required to equalize the S. N. F. in the cream.

$26.38 - 2.84 = 23.54$, per cent of fat available for standardizing.

(2.) **To calculate the pounds of fat short.**

$8.63 \times .4407 = 3.80$, per cent of fat required.

$3.80 - 3.35 = .45$, per cent of fat short.

$10000 \times .0045 = 45$, pounds of fat short.

(3.) **To calculate the pounds of cream required.**

$45 \div .2354 = 192$, pounds of cream required.

Solution of Problem 8, Example 10, based upon Formula 7:

$$O = \frac{[(.0863 \times .4407) - .0335] \times 10{,}000}{.2638 - (.0644 \times .4407)} = 192$$

Proof of Problem 8, Example 10:

Products	Pounds	Pounds			Per Cent		
		Fat	S. N. F.	T. S.	Fat	S. N. F.	T. S.
Milk	10,000	335	863	1198	3.35	8.63	11.98
Cream	192	51	12	63	26.38	6.44	32.82
Standardized product	10,192	386	875	1261	3.79	8.59	12.38

Ratio 1 S. N. F. to .4407 fat obtained in product after standardizing.

STANDARDIZING EVAPORATED MILK BEFORE CONDENSING.

Problem 9: How to Calculate the Pounds of Cream to Add to Skim-milk.

Solution of Problem 9, Based Upon Rule 6:

(1.) Multiply the percentage of S. N. F. in the cream by the ratio between the S. N. F. and the fat in the product desired. Subtract the result from the percentage of fat in the cream. Call the remainder A, or the percentage of fat in the cream available for standardizing.

(2.) Multiply the percentage of S. N. F. in the skim-milk by the ratio between the S. N. F. and the fat in the product desired. Call the result B. Subtract from B the percentage of fat in the skim-milk. Multiply the remainder by the pounds of skim-milk in the batch. Call the result C.

(3.) Divide C by A. The answer will be the number of pounds of cream necessary to standardize the batch to the required ratio.

Solution of Problem 9, Based Upon Formula 8:

$$O = \frac{[(NR) - K]\ L}{G - (JR)}$$

Problem 9, Example 11.

Products	Pounds	Per Cent		
		Fat	S. N. F.	T. S.
Skim-milk	10,000	.20	8.63	8.83
Cream		26.38	6.44	32.82
Composition desired after condensing		7.80	17.70	25.50

Desired ratio between S. N. F. and fat is 1 to .4407.

Solution of Problem 9, Example 11, Based Upon Rule 6:

(1.) **To calculate the available fat in the cream.**

$6.44 \times .4407 = 2.84$, per cent of fat required to equalize the S. N. F. in the cream.

$26.38 - 2.84 = 23.54$, per cent of fat in the cream available for standardizing.

(2.) **To calculate the pounds of fat short.**

$8.63 \times .4407 = 3.80$, per cent of fat required.

$3.80 - .20 = 3.60$, per cent of fat short.

$10000 \times .036 = 360$, pounds of fat short.

(3.) **To calculate the pounds of cream required.**

$360 \div .2354 = 1530$, pounds of cream required.

Solution of Problem 9, Example 11, Based Upon Formula 8:

$$O = \frac{[(.0863 \times .4407) - .0020] \times 10{,}000}{.2638 - (.0644 \times .4407)} = 1530.34$$

Proof of Problem 9, Example 11:

Products	Pounds	Pounds			Per Cent		
		Fat	S. N. F.	T. S.	Fat	S. N. F.	T. S.
Skim-milk	10,000	20.00	863	883	.20	8.63	8.83
Cream	1,530.33	403.74	98.48	502.22	26.38	6.44	32.82
Standardized product	11,530.33	423.74	961.48	1385.22	3.675	8.33	12.00

Ratio of 1 S. N. F. to .4407 fat obtained in product after standardizing.

STANDARDIZING EVAPORATED MILK BEFORE CONDENSING.

Problem 10. How to Calculate the Weight of Cream to Add, Knowing the Weight of the Whole Milk and the Skim-milk on Hand, and the Percentages of Fat and Solids Not Fat of All Three Products.

Solution of Problem 10, Based Upon Rule 7:

(1.) If the ratio between the percentage of fat and the S. N. F. in the fresh milk is less than the required ratio, standardize the fresh milk with the skim-milk, using Rule 4. Deduct the weight of the skim-milk required to standardize the fresh milk from the total weight of skim-milk on hand.

(2.) If the ratio between the percentage of fat and S. N. F. in the fresh milk is less than the required ratio, standardize the fresh milk with cream, using Rule 5.

(3.) Now standardize the skim-milk remaining under 1, or all the skim-milk on hand, as in the case under number 2, using Rule 5 to arrive at amount of cream necessary to add in either case. Make the necessary calculations to get proper weights under the double standardization.

Solution of Problem 10, Based Upon the Use of Formulas as Indicated:

(1.) To calculate the pounds of cream to add to the whole milk.

Use Formula 7, page 195.

(2.) To calculate the pounds of cream to add to the skim-milk.

Use Formula 8, page 196.

Problem 10, Example 12:

Products	Pounds	Per Cent		
		Fat	S. N. F.	T. S.
Whole Milk	10,000	3.58	8.40	11.98
Skim-milk	75	.16	8.47	8.63
Cream		28.38	6.44	34.82

Desired ratio of S. N. F. to fat is 1 to .4407.

Solution of Problem 10, Example 12, Based Upon Rule 7:

A. (1.) **To calculate the available fat in the cream.**

6.44 × .4407 = 2.84, per cent of fat required to equalize the S. N. F. in the cream.

26.38 — 2.84 = 23.54, per cent of fat available for standardizing.

(2.) **To calculate the pounds of fat short.**

8.40 × .4407 = 3.70, per cent of fat required.

3.70 — 3.58 = .12, per cent fat short.

10000 × .0012 = 12, pounds of fat short.

(3.) **To calculate the pounds of cream required.**

12÷.2354=51.75, the pounds of cream required to standardize the whole milk.

Should the whole milk require skim-milk instead of cream, use Rule 4, and subtract the pounds of skim-milk required from the total pounds of skim-milk and then standardize the balance of the skim-milk, using Rule 5.

B. Calculating available fat in the cream.

(1.) To calculate the available fat in the cream.

Same as under A (1) above. It equals 23.54%.

(2.) **To calculate pounds fat short.**

8.47 × .4407 = 3.73, per cent of fat required.

3.73 — .16 = 3.57, per cent of fat short.

75 × .0357 = 2.68, pounds of fat short.

(3.) **To calculate the pounds of cream required.**

2.68÷.2354=11.4, the pounds of cream required to standardize the skim-milk.

C. Adding together answers obtained under A and B=51.75 plus 11.43 = 63.18 pounds cream required to standardize the entire batch.

Solution of Problem 10, Example 12, based upon Formulas 7 and 8.

(1.) To calculate the pounds of cream to add to the whole milk.

$$O = \frac{[(.0840 \times .4407) - .0358] \times 10{,}000}{.2638 - (.0644 \times .4407)} = 51.75$$

(2.) To calculate the pounds of cream to add to the skim-milk.

$$O = \frac{[(.0847 \times .4407) - .0016]75}{.2638 - (.0644 \times .4407)} = 11.43$$

$51.75 + 11.43 = 63.18$, or total pounds of cream required.

Proof of Problem 10, Example 12:

Products	Pounds	Pounds			Per Cent		
		Fat	S. N. F.	T. S.	Fat	S. N. F.	T. S.
Whole milk.....	10,000	358	840	1198	3.58	8.40	11.98
Skim-milk.....	75	.12	6.35	6.47	.16	8.47	8.63
Cream.....	63.18	16.64	4.20	20.84	26.38	6.44	32.82
Standardized product.....	10,138.18	374.76	850.55	1225.31	3.69	8.38	12.07

Ratio of S. N. F. to fat obtained is 1 to .4407.

STANDARDIZING EVAPORATED MILK BEFORE CONDENSING.

Problem 11: How to Calculate the Pounds of Butter to Add.

Butter can frequently be used to good advantage in standardizing evaporated milk. Several methods of calculation are possible, but only the one that gives the desired result in the smallest number of calculations is given herewith.

Solution of Problem 11, based upon Rule 8:

(1.) Multiply the percentage of S. N. F. in the fresh milk by the ratio between the S. N. F. and the fat in the product desired. Subtract from this the percentage of fat in the fresh milk. Multiply the remainder by the pounds of the fresh milk in the batch. Divide the product by the percentage of fat in the butter, which will give the answer, or the pounds of butter to be added to the entire batch.

Solution of Problem 11, Example 13:

Products	Pounds	Per Cent		
		Fat	S. N. F.	T. S.
Milk	10,000	3.58	8.40	11.98
Butter		80.00		
Composition desired after condensing		7.80	17.70	25.50

Desired ratio of S. N. F. to fat is 1 to .4407.

Solution of Problem 11, Example 13, based upon Rule 8:

(1.) To calculate the pounds of butter required.

8.40 × .4407 = 3.70, per cent of fat required to equalize the S. N. F. in the whole milk.

3.70—3.58=.12, per cent of fat short.

10000×.0012=12.0, pounds of fat short.

12.0÷.80=15, pounds of butter required.

Solution of Problem 11, Example 13, based upon Formula 8:

$$P^1 = \frac{[(.0840 \times .4407) - .0358] \quad 10000}{.80} = 15$$

Proof of Problem 11, Example 13:

Products	Pounds	Pounds			Per Cent		
		Fat	S. N. F.	T. S.	Fat	S. N. F.	T. S.
Milk	10,000	358	840	1198	3.58	8.40	11.98
Butter	15.23	12.18		12.18	80.00		
Standardized product	10,015.23	370.18	840	1210.18	3.69	8.38	12.08

Ratio 1 S. N. F. to .4407 fat obtained in product after standardizing.

STANDARDIZING EVAPORATED MILK BEFORE CONDENSING.

Problem 12: How to Calculate the Pounds of Cream or Skim-milk to Use, when Mixing Together Fresh Milk and Bulk Condensed Whole Milk.

Solution of Problem 12, based upon Rule 9:

(1.) Calculate the average fat and S. N. F. test of the mixed fresh milk and bulk condensed milk. Get ratio of fat to S. N. F. in the mixed milk.

(2.) If skim-milk is required, calculate the amount necessary to add to the mixture by means of Rule 4.

(3.) If cream is required, calculate the amount necessary to add to the mixture by means of Rule 5.

Solution of Problem 12, based upon Formula 9:

(1.) To calculate the percentage of fat in the batch after mixing together the whole milk and the bulk condensed whole milk.

$$S^1 = \frac{(PF) + (D^2K^2)}{P + D^2}$$

(2.) To calculate the percentage of T. S. in the batch, after mixing together the whole milk and the bulk condensed whole milk.

$$O^1 = \frac{(PT) + (D^2D)}{P + D}$$

(3.) If skim-milk is required calculate according to Formula 6, page 193.

(4.) If cream is required, calculate according to Formula 7, page 195.

Problem 12, Example 14:

Products	Pounds	Per Cent		
		Fat	S. N. F.	T. S.
Milk	10,000	3.58	8.41	11.99
Bulk condensed milk	872	10.73	25.27	36.00
Cream		26.38	6.44	32.82
Composition desired after condensing		7.80	17.70	25.50

Desired ratio of solids not fat to fat is 1 to .4407.

Solution of Problem 12, Example 14, based upon Rule 9:

(1.) To calculate the average fat and T. S. tests of the mixed fresh milk and bulk condensed milk.

Products	Total Pounds	FAT		T. S.	
		Per Cent	Pounds	Per Cent	Pounds
Whole milk.....	10,000	3.58	358.00	11.99	1199.00
Bulk condensed whole milk.....	872	10.73	93.60	36.00	313.92
Mixed milk.....	10,872	4.15	451.60	13.91	1512.92

(2.) To calculate the pounds of cream required follow solution of Problem 8, Example 10, based upon Rule 5, page 194. The answer will be 68.18 or the pounds of cream necessary to add. Should the mixed milk require skim-milk instead of cream, follow the solution of Problem 7, Example 9, based upon Rule 4, page 192.

Solution of Problem 12, Example 14, based upon Formula 9:

(1.) To calculate the percentage of fat in the batch after mixing together the whole milk and the bulk condensed whole milk.

$$S^1 = \frac{(10000 \times .0358) + (872 \times .1073)}{10000 + 872} = 4.15$$

(2.) To calculate the percentage of T. S. in the batch after mixing together the whole milk and the bulk condensed whole milk.

$$O^1 = \frac{(10000 \times .1199) + (872 \times .36)}{10000 + 872} = 13.91$$

(3.) To calculate the pounds of cream required, follow the solution of Problem 8, Example 10, based upon Formula 7, page 195. The answer will be 68.18, or the pounds of cream necessary to add. Should the mixture require skim-milk instead of cream, follow the solution of Problem 7, Example 9, based upon Formula 6, page 193.

Proof of Problem 12, Example 14:

Products	Pounds	Pounds			Per Cent		
		Fat	S. N. F.	T. S.	Fat	S. N. F.	T. S.
Milk	10,000	358.00	841.00	1199.00	3.58	8.41	11.99
Bulk cond. milk	872	93.6	220.22	313.82	10.73	25.27	36.00
Cream	68.18	17.98	4.20	22.18	26.38	6.44	32.82
Standardized product	10,940.18	469.58	1065.42	1535.00	4.29	9.73	14.02

Ratio of 1 S. N. F. to .4407 fat obtained in product after standardizing.

STANDARDIZING EVAPORATED MILK BEFORE CONDENSING.

Problem 13: How to Calculate When Adding Water Only.

Ascertain from the test of the condensed product the ratio between the percentage of S. N. F. and the percentage of fat. If the ratio is the same as in the standard, standardize with water only. In case the ratio between the S. N. F. and the fat is different than the desired ratio, and if it should be possible or practicable to standardize with water only, standardize down to the lowest constituent that may happen to govern—that is, the fat or the S. N. F. If this is not done, the resulting product will be low in either fat or S. N. F. Two solutions of this problem are given.

Solution of Problem 13, based upon Rule 10:

(1.) Subtract the percentage of T. S. desired from the percentage of T. S. in the milk that is to be standardized. Divide the remainder by the percentage of T. S. desired. Multiply the answer by the pounds of milk in the batch. The answer will be the pounds of water required.

The above coefficient of overcondensation can be ascertained directly by referring to Table 31, which gives this value upon the double basis of 7.80 per cent of fat and 25.50 per cent of T. S. and 8.00 per cent of fat and 26.15 per cent of T. S. When Table 31 is available, this makes the simplest method of calculating the amount of water required.

Solution of Problem 13, based upon Formula 10:

$$W = \frac{(T^1 - C)}{C} D^1$$

Problem 13, Example 15:

Products	Pounds	Per Cent		
		Fat	S. N. F.	T. S.
Evaporated milk.....	4644	8.106	18.40	26.506
Composition desired.....	.....	7.80	17.70	25.500

Solution of Problem 13, Example 15, based upon Rule 10:

26.50 — 25.50 = 1.00, per cent of T. S. in excess.
1.00 ÷ 25.50 = .0392, coefficient of overcondensation.
4644 × .0392 = 182, pounds of water required.

Solution of Problem 12, Example 15, based upon Formula 10:

$$W = \left(\frac{26.50 - 25.50}{25.50}\right) \times 4644 = 182$$

Solution of Problem 13, based upon Rule 11:

(1.) Subtract the percentage of fat desired from the percentage of fat in the batch that is to be standardized. Multiply the pounds of milk in the batch by the remainder. Divide the product by the percentage of fat desired. The answer will be the pounds of water required to standardize the batch.

By this method the T. S. can be used as a basis for making the calculations as well as the fat. This is the simpler of the two methods, unless in the case of the preceding method the factor of overcondensation can be obtained directly from a table which can be especially prepared to cover any standard that might be desired, and covering a wide range of tests.

Solution of Problem 13, based upon Formula 11:

$$W = \frac{(K^2 - A)}{A} D^1$$

Solution of Problem 13, Example 15, based upon Rule 11:

8.106 — 7.80 = .306, per cent of fat in excess.

4644×.00306=14.21, pounds of fat in excess.
14.21÷.0780=182, pounds of water required.

Solution of Problem 13, Example 15, based upon Formula 11:

$$W = \frac{(.08106—.078)\ 4644}{.078} = 182$$

Proof of Problem 13, Example 15, covering both Rules 10 and 11:

Products	Pounds	Pounds			Per Cent		
		Fat	S. N. F.	T. S.	Fat	S. N. F.	T. S.
Evaporated milk..	4644	376.4	854.4	1230.8	8.106	18.40	26.50
Water.....	182	.....	.....	.....	.....	.....	.....
Standardized product.....	4826	376.4	854.4	1230.8	7.80	17.70	25.50

No factor of safety was allowed in the above problem. It is recommended that a margin be allowed of .05 per cent upon fat and .20 per cent upon T. S., where the product is standardized upon the basis of both the fat and the S. N. F. The same margin is recommended where the standardization is based upon one constituent only.

STANDARDIZING EVAPORATED MILK BEFORE CONDENSING.

Problem 14: How to Calculate When Both Condensed Skim-milk and Water are Required for Standardizing.

Solution of Problem 14, based upon Rule 12:

(1.) Subtract the percentage of fat desired from the percentage of fat in the batch before standardizing. Multiply the remainder by the pounds of milk in the batch. Divide the product by the percentage of fat desired. Call answer A, or the total pounds that the batch is short.

(2.) Divide the percentage of fat in the batch to be standardized by the ratio between the T. S. and the fat, in the product desired. Subtract from the answer the percentage of T. S. in the batch to be standardized. Multiply the remainder by the pounds in the batch before standardizing. Divide the product by the percentage of T. S. in the skim-milk to be used for standardizing.

Call the answer B, or the pounds of skim-milk required. Subtract B from A. Call the remainder C, or the pounds of water required.

(3.) Add A and C to the pounds in the batch before standardizing. The sum will be the total pounds in the batch after standardizing with both water and skim-milk.

Solution of Problem 14, based upon Formula 12:

(1.) To calculate the pounds of condensed skim-milk required.

$$L^1 = \frac{\left(\frac{K^1}{R^1} - T^1\right) D^1}{T^2}$$

(2.) To calculate the pounds of water required.

$$W = \left[\frac{(K^1 - A)\ D^1}{A}\right] - L^1$$

Problem 14, Example 16:

Products	Pounds	Per Cent		
		Fat	S. N. F.	T. S.
Evaporated milk.....	10000	8.00	18.00	26.00
Condensed skim-milk....	.....	.....	.....	25.50
Water.....	.....	.....	.....	.....
Composition desired.....	.....	7.80	17.70	25.50

Solution of Problem 14, Example 16, based upon Rule 12:

(1.) To calculate the pounds that the batch is short.

8.00 — 7.80 = .20, per cent of fat in excess.

10000 × .0020 = 20, pounds of fat in excess.

20 ÷ .0780 = 256, total pounds that the batch is short.

(2.) To calculate the pounds of condensed skim-milk and pounds water necessary to add.

8.00 ÷ .3059 = 26.15, per cent of total solids necessary to equalize the fat in the batch.

26.15 — 26.00 = .15, per cent of total solids required to be added to equalize the fat in the batch.

10000 × .0015 = 15, pounds of total solids required.

15 ÷.255 = 59, pounds of condensed skim-milk required.
256 — 59 = 197, pounds of water required.
(3.) Material in batch after standardizing.
59 pounds of condensed skim-milk.
197 pounds of water.
10,000 pounds before standardizing.

10,256 pounds total after standardizing.

Solution of Problem 14, Example 16, based upon Formula 12:

(1.) To calculate the pounds of condensed skim-milk required.

$$L^1 = \frac{\left(\frac{.0800}{.3059} - .2600\right) \times 10000}{.2550} = 59.6$$

(2.) To calculate the pounds of water required.

$$W = \left[\frac{(8.00 - 7.80) \times 10000}{7.80}\right] - 59 = 196.8$$

Proof of Problem 14, Example 16:

Products	Pounds	Pounds			Per Cent		
		Fat	S. N. F.	T. S.	Fat	S. N. F.	T. S.
Evaporated milk..	10,000.0	800	1800	2600	8.00	18.00	26.00
Condensed skim-milk	59.6	.....	15	15	.....	25.50	25.50
Water.....	197.0	.....	.....	.....	.....	.....	.....
Standardized product.....	10,256.6	800	1815	2615	7.80	17.70	25.50

No factor of safety allowed in the above problem.

STANDARDIZING EVAPORATED MILK AFTER CONDENSING.

Problem 15: How to Calculate When Both Cream and Water are Required for Standardizing.

Solution of Problem 15, based upon Rule 13:

(1.) Subtract the percentage of S. N. F. desired from the percentage of S. N. F. in the batch before standardizing. Multi-

ply the remainder by the pounds of milk in the batch. Divide the product by the percentage of S. N. F. desired. Call the answer A, or the pounds that the batch is short.

(2.) Multiply the percentage of S. N. F. in the batch by the ratio between the S. N. F. and the fat in the product desired. Subtract from the answer the percentage of fat in the batch to be standardized. Multiply the remainder by the pounds in the batch before standardizing. Divide the product by the percentage of fat in the cream to be used for standardizing. Call the answer B, or the pounds of cream required. Subtract B from A. Call the answer C, or the pounds of water required.

(3.) Add A and C to the pounds in the batch before standardizing. The sum of the three values will be the total pounds in the batch after standardizing with both water and cream.

Solution of Problem 15, based upon Formula 13:

(1.) **To calculate the pounds of cream required:**

$$O = \frac{[(B^1 \times R) - K^2] \times D^1}{G}$$

(2.) **To calculate the pounds of water required.**

$$W = \left[\frac{(B^1 - B) \times D^1}{B}\right] - O$$

Problem 15, Example 16:

Products	Pounds	Per Cent		
		Fat	S. N. F.	T. S.
Evaporated milk	10,000	7.00	20.00	27.00
Cream		40.00		
Water				
Composition desired		7.80	17.70	25.50

Solution to Problem 15, Example 16, based upon Rule 13:

(1.) **To calculate the pounds that the batch is short.**

20.00 — 17.7 = 2.30, per cent of S. N. F. in excess.

10000 × .023 = 230, pounds of S. N. F. in excess.

230 ÷ .177 = 1299, pounds that the batch is short.

(2.) **To calculate the pounds of cream and water necessary.**

20.00 × .4407 = 8.81, per cent of fat necessary to equalize the S. N. F. in the unstandardized batch.

8.81 — 7.00 = 1.81, per cent of fat required to equalize the S. N. F. in the batch.

10000×.0181=181, pounds of fat required.

181 ÷ .40 = 453, pounds of 40% cream required.

1299 — 453 = 846, pounds of water required.

(3.) **Material in batch after standardizing.**

453 pounds of 40% cream.

846 pounds of water.

10000 pounds before standardizing.

11299 pounds total in batch after standardizing.

Solution of Problem 15, Example 16, based upon Formula 13:

(1.) **To calculate the pounds of cream required.**

$$O = \frac{[(.20 \times .4407) - .07] \times 10000}{.40} = 453$$

(2.) **To calculate the pounds of water required.**

$$W = \left[\frac{(.20 - .1770) \times 10000}{.1770}\right] - 453 = 846$$

Proof of Problem 15, Example 16:

Products	Pounds	Pounds			Per Cent		
		Fat	S. N. F.	T. S.	Fat	S. N. F.	T. S.
Evaporated milk..	10,000	700	2000	2700	7.00	20.00	27.00
Cream.....	453	181.4	.....	181	40.00	.....	.....
Water.....	846	.....	.....	.....	.....	.....	.....
Standardized product.....	11,299	881.4	2000	2881	7.80	17.70	25.50

No factor of safety allowed in the above calculation. Also the S. N. F. in the cream was disregarded in the calculation. In the above example this would increase the total solids to the extent of about 27 pounds, making the actual total solids 25.65 per cent instead of 25.50 per cent as indicated in the proof.

STANDARDIZING EVAPORATED MILK AFTER CONDENSING.

Problem 16: How to Calculate When Condensed Whole Milk, Condensed Skim-milk and Water Are Required for Standardizing.

Solution of Problem 16, based upon Rule 14:

(1.) Call the T. S. in the condensed skim-milk A, or the percentage of S. N. F. in the condensed skim-milk that is available for standardizing. Subtract the percentage of fat desired from the percentage of fat in the condensed milk. Call the remainder B, or the percentage of fat in the condensed whole milk that is available for standardizing. Subtract the percentage of S. N. F. desired from the percentage of S. N. F. in the condensed whole milk. Call the remainder C, or the percentage of S. N. F. in the condensed whole milk available for standardizing.

(2.) Divide the percentage of fat in the batch by the ratio between the S. N. F. and the fat in the product desired. Subtract from the answer the percentage of S. N. F. in the batch and multiply the remainder by the pounds of milk in the batch. Call answer D, or the pounds of S. N. F. short. Subtract the S. N. F. that the batch should contain from the S. N. F. in the condensed whole milk. Divide D by the remainder. Call the answer E, or the pounds of condensed whole milk required.

(3.) Multiply E by B. Divide the product by the ratio between the S. N. F. and fat in the product desired. Divide the answer by A. Call the answer F, or the pounds of condensed skim-milk required to equalize the excess fat in the condensed whole milk.

(4.) Multiply the pounds of milk in the batch before standardizing, by the percentage of S. N. F. in the batch. Call the answer G, or the pounds S. N. F. in the batch. Multiply E and F by the S. N. F. test of each respectively, and add the two results. Call the answer H. Call the sum of G and H, I or the pounds of S. N. F. in the entire batch, after standardizing. Add to the pounds in the batch before standardizing, the sum of E and F. Call the answer J. Divide the answer into I. Call the answer K, or the percentage of S. N. F. in the batch after standardizing with condensed whole milk, and condensed skim-milk. Subtract from K

the percentage of S. N. F. in the product desired. Multiply the remainder by J, and divide the product by the percentage of S. N. F. desired. Call the answer K, or the pounds of water required.

(5.) Add to the pounds of whole milk before standardizing, the sum of E, plus F, plus J. The answer will be the total pounds in the batch after standardizing.

Solution of Problem 16, based upon Formula 14:

(1.) **To calculate the pounds of condensed whole milk required.**

$$D^2 = \frac{\left[\frac{K^2}{R} - B^1\right] D^1}{M - \left(\frac{K^2}{R}\right)}$$

(2.) **To calculate the pounds of condensed skim-milk required.**

$$L^1 = \frac{\left(\frac{(K - A)\, D^2}{R}\right)}{Q}$$

(3.) **To calculate the percentage of S. N. F. in the batch after adding the condensed whole and skim-milks. Note: S^2 now represents the percentage of S. N. F. in the mixture.**

$$S^2 = \frac{(D^1 J^2) + (D^2 M) + (L^1 O)}{D^1 + D^2 + L^1}$$

(4.) **To calculate the pounds of water required.**

$$W = \frac{(S^1 - A) \times (D^1 + D^2 + L^1)}{A}$$

Problem 16, Example 17:

Products	Pounds	PER CENT		
		Fat	S. N. F.	T. S.
Evaporated milk.....	10,000	8.00	17.00	25.00
Condensed whole milk....	.....	10.50	25.50	36.00
Condensed skim-milk....	.....	.....	25.50	.....
Water.....	.....	.....	.....	.....
Composition desired.....	.....	7.80	17.70	25.50

Solution of Problem 16, Example 17, based upon Rule 14:

(1.) **To calculate in the above two products the percentage of fat and the percentage of S. N. F. available for standardizing.**

25.50 = S. N. F. (the fat is disregarded), or total solids in condensed skim-milk available for standardizing.

10.50 — 7.80 = 2.70, per cent of fat in condensed whole milk available for standardizing.

25.50 — 17.70 = 7.80, per cent S. N. F. in condensed whole milk available for standardizing.

(2.) **To calculate the pounds of condensed whole milk required.**

8.00 ÷ .4407 = 18.15, per cent of S. N. F. that the evaporated milk should have.

18.15 — 17.00 = 1.153, per cent of S. N. F. short.

.0115 × 10000 = 115.3 pounds S. N. F. short.

25.50 — 18.15 = 7.35, per cent of S. N. F. available for standardizing in condensed milk.

115.3 ÷ .0735 = 1568 pounds condensed whole milk required to provide the S. N. F. short.

(3.) **To calculate the pounds of condensed skim-milk required.**

1568 × .027 = 43, pounds of fat in excess over amount required in the condensed whole milk.

43 ÷ .4407 = 96, pounds of S. N. F. required to equalize the excess of fat in the condensed whole milk.

96÷.255=377, pounds of condensed skim-milk required to equalize the excess fat in the condensed whole milk.

(4.) **To calculate the pounds of water required.**

10000 × .17=1700, pounds of S. N. F. in batch before standardizing.

(1568 + 377) × .255 = 496, pounds of S. N. F. in condensed whole milk and condensed skim-milk required.

1700 + 496 = 2196, pounds of S. N. F. in batch after adding condensed whole milk and condensed skim-milk.

10000 + 1568 + 377 = 11945, total pounds in batch after adding condensed whole milk and condensed skim-milk.

2196 ÷ 11945 = 18.38, per cent S. N. F. in batch after adding condensed whole milk and condensed skim-milk.

18.38 — 17.70 = .68, per cent S. N. F. in excess after adding condensed whole milk and condensed skim-milk.

11945 × .0068 = 82, pounds S. N. F. in excess.

82 ÷ .1770 = 463, pounds of water required.

(5.) **Material in batch after standardizing.**

1568 pounds condensed whole milk.
377 pounds condensed skim-milk.
10000 pounds before standardizing.
463 pounds water.

12408 pounds total after standardizing.

Solution of Problem 16, Example 17, based upon Formula 14:

(1.) **To calculate the pounds of condensed whole milk required.**

$$D = \frac{\left[\left(\frac{.08}{.4407}\right) - .17\right] \times 10000}{.2550 - \left(\frac{.08}{.4407}\right)} = 1568.$$

(2.) **To calculate the pounds of condensed skim-milk required to standardize the excess of fat in the whole milk.**

$$L^1 = \frac{\left(\frac{.105 - .078) \times 1568.6}{.4407}\right)}{.255} = 377$$

(3.) **To calculate the percentage of S. N. F. in the batch after adding the condensed whole and skim-milk.**

$$S^2 = \frac{(10000 \times .17) + (1568 \times .2550) + (377 \times .2550)}{10000 + 1568 + 377} = 18.38$$

(4.) **To calculate the pounds of water required.**

$$W = \frac{(.1838 - .177) \times (10000 + 1568 + 377)}{.177} = 463$$

Proof of Problem 16, Example 17:

Products	Pounds	Pounds			Per Cent		
		Fat	S. N. F.	T. S.	Fat	S. N. F.	T. S.
Evaporated milk..	10,000	800	1700	2500	8.00	17.00	25.00
Condensed whole milk.....	1568	164.7	400	564	10.50	25.50	36.00
Condensed skim-milk.....	377	.....	96	96	.....	25.50	25.50
Water.....	463	.....	.....	.....	.....	.....	.....
Standardized product.....	12,408	964.7	2196	3160	7.80	17.70	25.50

STANDARDIZING EVAPORATED MILK AFTER CONDENSING.

Problem 17: How to Calculate When Both Condensed Whole Milk and Cream Are Required for Standardizing:
Solution of Problem 17, Based Upon Rule 15:

(1.) Subtract the percentage of fat desired from the percentage of fat in the cream. Call the answer A, or the percentage of fat in the cream available for standardizing. Subtract the percentage of S. N. F. in the cream from the percentage of S. N. F. desired. Call the answer B, or the percentage of S. N. F. short in the cream, under that desired. Subtract the percentage of fat desired from the percentage of fat in the condensed whole milk. Call the answer C, or the percentage of fat in the condensed whole milk available for standardizing. Subtract the percentage of S. N. F. desired from the percentage of S. N. F. in the condensed whole milk. Call the remainder D, or the percentage of S. N. F. in the condensed whole milk available for standardizing.

(2.) Subtract the percentage of fat in the batch from the percentage of fat desired. Call the remainder E, or the percentage of fat short. Multiply the pounds of milk in the batch by E. Call the product F, or the pounds of fat short. Subtract the percentage of S. N. F. in the batch from the percentage of S. N. F. desired. Call the remainder G, or the percentage of S. N. F. short. Multiply the pounds milk in the batch by G. Call the product H, or the pounds of S. N. F. short.

(3.) Divide H by the percentage of fat desired. Call the answer I, or the pounds of condensed whole milk required to provide the S. N. F. short in the batch.

(4.) Multiply I by C. Call the product J, or the pounds fat available in the condensed whole milk added. Subtract J from E. Call the answer K, or the pounds fat to be provided by cream. Divide K by A. Call the answer L, or the pounds of cream required to provide the fat short.

(5.) Multiply L by B. Call the product M, or the pounds of S. N. F. short in the cream. Divide M by D. Call the answer N, or the pounds of condensed whole milk necessary to provide the S. N. F. required to standardize the cream added.

(6.) Add to the pounds of milk in the batch before standardizing the sum of I, L and N. The answer will be the total pounds in batch after standardizing.

Solution of Problem 17, Based Upon Formula 15:

(1.) **To calculate the pounds of condensed whole milk required to provide the S. N. F. short in the evaporated milk.**

$$D^2 = \frac{[(B - B^1)\ D^1]}{A}$$

(2.) **(To calculate the pounds of cream required to provide the fat short in the evaporated milk.**

$$O = \frac{[(A - K^1)\ D^1] - [(K - A)\ D^2]}{G - A}$$

(3.) **To calculate the pounds of condensed whole milk required to provide the S. N. F. short in the cream.**

$$D^2 = \frac{(B - J)\ O}{A}$$

Note: The sum of D^2 part (1) and D^2 part (2) of the formula equals the total number of pounds of condensed whole milk used.

Problem 17, Example 18:

Products	Pounds	PER CENT		
		Fat	S. N. F.	T. S.
Evaporated milk.....	10,000	7.36	17.46	24.82
Condensed whole milk....	.....	10.50	25.50	36.00
Cream.....	.....	40.00	5.00	45.00
Composition desired.....	.....	7.80	17.70	25.50

Solution of Problem 17, Example 18, based upon Rule 15:

(1.) **To calculate in the above two products the percentages of fat and S. N. F. available for standardizing.**

40 — 7.8 = 32.2, per cent, of fat in cream available for standardizing.

17.7 — 6.0 = 11.7, per cent of S. N. F. short in cream.

10.50 — 7.80 = 2.70, per cent of fat in condensed whole milk available for standardizing.

25.50 — 17.70 = 7.80, per cent of S.N. F. in condensed whole milk available for standardizing.

(2.) **To calculate pounds of fat and S. N. F. short.**

7.80 — 7.36 = .44, per cent of fat short.

10000×.44= 44, pounds of fat short.

17.70 — 17.46 = .24, per cent of S. N. F. short.

10000×.0024=24, pounds of S .N. F. short.

(3.) **To calculate the pounds of condensed whole milk required to provide S. N. F. short in batch.**

24.0÷.078=308, pounds of condensed whole milk required to provide the S. N. F. short in the batch.

(4.) **To calculate the pounds of cream required:**

308×.027= 8.3, pounds of fat available in condensed whole milk added.

44 — 8.30 = 35.7, pounds of fat to be provided by cream.

35.7÷.322=111, pounds of cream required to provide the fat short.

(5.) **To calculate the pounds of condensed whole milk required to equalize the S. N. F. short in the cream added for standardizing.**

111×.117=13.0, pounds of S. N. F. short in cream.
13.0÷.078= 167, pounds of condensed whole milk necessary to provide the S. N. F. required to standardize the cream added.

(6.) **Material in batch after standardizing.**

308 pounds of condensed whole milk required by batch.
167 pounds of condensed whole milk required by cream.
111 pounds of cream.
10000 pounds before standardizing.
10586 pounds total after standardizing.

Solution of Problem 17, Example 18, Based Upon Formula 15:

(1.) **To calculate the pounds of condensed whole milk required to provide the S. N. F. short in the evaporated milk.**

$$D^2 = \frac{(.177—.1746)\times 10000}{.078} = 308$$

(2.) **To calculate the pounds of cream required to provide the fat short in the evaporated milk.**

$$O = \frac{[(.078—.0736)\times 10000]—[(.1050—.078)\times 308]}{.40—.078} = 111$$

(3.) **To calculate the pounds of evaporated whole milk required to provide the S. N. F. short in the cream.**

$$D^2 = \frac{(.177—.06)\times 111}{.078} = 167$$

Proof of Problem 17, Example 18:

Products	Pounds	Pounds			Per Cent		
		Fat	S. N. F.	T. S.	Fat	S. N. F.	T. S.
Evaporated milk..	10,000	736	1746	2482	7.36	17.46	24.82
Condensed whole milk.....	475	50	121	171	10.50	25.50	36.00
Cream.....	111	44	61	50	40.00	6.00	46.00
Standardized product.....	10,586	830	1873	2703	7.83	17.69	25.52

The surplus fat in the condensed whole milk added to standardize the cream was disregarded in the calculation. This method does not give absolutely correct standardization but the results are within very narrow limits of those desired.

CHAPTER XII

STANDARDIZING SWEETENED CONDENSED MILK

The principles underlying the standardization of sweetened condensed milk are very similar to those underlying the standardization of evaporated milk, namely, mixing together fat, milk S. N. F. and in addition sucrose obtained from either cane or beet sugar, in the ratio one to the other that these are to occur in the finished product which it is desired to manufacture. These ratios can be obtained upon any desired composition of product by dividing the percentage of one constituent into the percentage of another constituent of the standard product. Table 32 contains these ratios in the case of a product testing 8.00 per cent of fat, 20.00 per cent of milk S. N. F. and 44.50 per cent sucrose, and also in the case of sweetened condensed skim-milk.

Theoretically it would be possible under certain conditions to standardize sweetened condensed milk after condensing. However, the possibilities for trouble under conditions of this kind are so numerous that it is deemed best not to encourage the practice at the present stage of our knowledge. The practice of standardizing before condensing is a simple and a logical one, and this will be fully discussed in this chapter.

Under the older methods the standardization is, as a rule, crude and inefficient, and concerns itself chiefly with obtaining a product either of a certain fat or of a certain T. S. test. The method commonly used is to add a certain number of pounds of sugar for every one hundred pounds of whole milk that go to make up the batch. Sometimes the ratio of pounds of sugar to pounds of milk is varied with the season of the year, the range being in the case of whole milk, from 18 to 20 pounds. Under this method, the resulting product varies greatly both in chemical composition, and in its physical properties.

TABLE 32.

Constants for Sweetened Condensed Milk.

Constants.	Product from	
	Whole milk.	Skim-milk.
Percentage fat. Federal standard	8.00	None
Percentage S. N. F. Federal standard	20.00	28.00
Percentage T. S. Federal standard	28.00	28.00
Ratio percentage fat to percentage milk solids	3.5000	None
Ratio percentage fat to T. S. (8.00 per cent fat to 72.5 per cent T. S.)	9.06	None
Ratio percentage fat to percentage milk S. N. F.	2.5000	None
Ratio percentage milk S. N. F. to percentage fat	.4000	None
Ratio percentage milk S. N. F. to percentage T. S.	1.4000	None
Ratio percentage total milk solids to percentage fat	.2857	None
Ratio percentage sugar to percentage fat, using 44.50 per cent sugar	.1798	None
Ratio percentage sugar to percentage total milk solids, using 44.50 per cent sugar	.4493	None
Ratio percentage sugar to percentage total milk solids, using 42.00 per cent sugar	....	.6667

Under the methods given in this chapter, the aim is to standardize the sweetened condensed milk upon the triple basis of fat, milk S. N. F. and sucrose. This makes possible a product of uniform chemical composition and physical properties, at all times, other things being equal.

SUCCESSIVE STEPS IN STANDARDIZING SWEETENED CONDENSED MILK.

The steps involved in standardizing sweetened condensed milk are as follows:

(1.) Obtaining a representative composite sample of the entire lot of whole milk which goes to make up the batch; likewise the skim-milk, cream or other product which might be used in standardizing.

(2.) Testing of all the above products involved for both fat, S. N. F. or T. S. by means of the Mojonnier Milk Tester. In the case of the S. N. F. in the cream, it usually suffices to obtain the S. N. F. from Table 22, inasmuch as the amount is not large.

(3.) Calculating the weight of each product to be used by methods which will follow, in order to make the fat, the milk S. N. F. and the sugar in the initial product of the same ratio as these are to occur in the case of the finished product.

(4.) When the initial product has been standardized so that the fat, the milk S. N. F. and the sugar are in the required ratio, the same is to be condensed down to the desired specific gravity to yield a finished product of the test required. In practice, it is well to condense the batch to a little higher concentration than desired, in order to provide the necessary factor of safety. If the concentration of the batch should be less than the required concentration, it becomes necessary either to recondense part of the batch, or to condense another batch to add to it, provided the facilities are at hand for thoroughly mixing the two batches. It is not recommended at this stage of our knowledge of the sweetened condensed milk business to add water to the batch in case it is overcondensed. Under some conditions, it may be possible to add condensed skim-milk, but this is not very often practicable unless this can be added to the milk in the pan instead of to the milk in the mixing tanks after cooling. At the present time the only method that is recommended for correcting improper condensing is by mixing together the batch that is improperly condensed with another batch that is condensed in the proper way to correct the error in the case of the first batch.

METHOD OF COLLECTING COMPOSITE MILK SAMPLES.

No fixed method of sampling is recommended that can be applied to meet all the varying conditions of different plants. This important matter will need careful study in each plant, in order to determine the procedure that will give the most accurate samples. The reader is referred to Chapter VI for complete information upon this point.

METHOD OF TESTING.

Use the Mojonnier Tester for making all fat and T. S. determinations upon all products used in standardizing. The skim-milk and cream should be tested before the composite sample of the whole milk reaches the laboratory. The S. N. F. in the cream can be obtained from Table 22 as the total amount of the same is

usually small, so the possibility for error that may result on account of not making actual determinations of S. N. F. is a very negligible one. As it is necessary to complete the fat and T. S. tests of the whole milk while the last forewarmer is being heated and drawn into the pan, these tests should be made as rapidly as possible. A short time before the sample is ready, the temperature of the hot plates and ovens upon the Mojonnier Milk Tester should be regulated; fat and T. S. dishes cooled and weighed; clean glassware and a weigh cross prepared for use, and everything put in readiness for making the test. By systematizing the successive steps, the time for completing the fat and T. S. tests, including the total time for making the calculations, should not exceed twenty-five or thirty minutes, counting from the time the sample reaches the laboratory. Under some conditions, it may be desirable to give the operator a helper, while making the tests, as this will greatly expedite the operations.

ORDER OF OPERATIONS IN STANDARDIZING SWEETENED CONDENSED MILK BEFORE CONDENSING, USING MOJONNIER TESTER.

(1.) Test, as far in advance as possible, the cream samples for fat. Obtain the S. N. F. test of the cream from Table 22. If skim-milk, sweetened condensed skim-milk, or sweetened condensed whole milk are to be used for standardizing, test each of these products for both fat and T. S. as far in advance as possible.

(2.) About half an hour before the composite whole milk sample is ready, do everything necessary to begin making the fat and T. S. test of the whole milk. It is recommended that the tests be made in duplicate. If the operator is very careful in his work, a single determination may suffice.

(3.) Keep the fat and the T. S. dishes in the respective ovens for five minutes under proper heat, and with the vacuum on.

(4.) Transfer the dishes from the ovens to the cooling desiccators. Keep the water circulating. Weigh the T. S. dish with the cover on, at the end of five minutes; and the fat dish alone at the end of seven minutes. Record weights and numbers upon the laboratory report.

(5.) As soon as the composite whole milk sample reaches the laboratory, mix the same thoroughly by pouring back and forth at least six times using two vessels.

(6.) Fill the two gram pipette to the mark and transfer the milk to the previously weighed dish, and weigh the dish with the milk immediately. Or, if preferred, the sample in the two gram pipette can be weighed from the weigh cross.

(7.) While the operator is weighing the sample, as directed under 6, the second operator pipettes out ten grams into the butterfat extraction flask.

(8.) One operator now prepares the T. S. sample for the T. S. oven, and the second operator the fat sample for the fat oven. Dishes and contents are heated in ovens, cooled in cooling desiccators and weighed in accordance with the directions.

(9.) Calculate the percentage of fat and the percentage of T. S. and transfer the results to the sweetened condensed milk report blank.

(10.) Calculate the pounds of material to add, using the rule that may apply, selecting the proper one beginning with Rule 16, and ending with Rule 23. The sugar to be used can be ascertained by referring to Table 32.

(11.) Test the finished product for fat and T. S. and enter the result upon the sweetened condensed milk report.

(12.) Divide the percentage of T. S. by the percentage of fat to get the ratio of fat to T. S. in the finished product.

(13.) If the condensation is not otherwise obtained, divide the percentage of T. S. in the finished product by the percentage of T. S. in the initial product, or divide the percentage of fat in the finished product by the percentage of fat in the initial product.

(14.) Divide the total pounds of raw products used by the condensation to obtain the pounds in the batch after condensing. Or, obtain the pounds in the batch by weighing the same in a suitable tank as it comes from the pan.

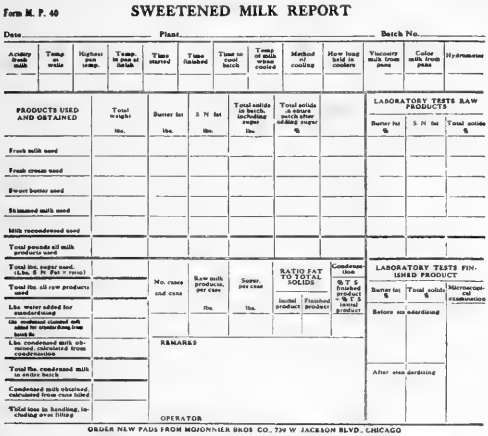
(15.) Calculate the pounds of raw milk products per case. likewise the pounds of sugar per case.

BLANK FOR RECORDING THE STANDARDIZING DATA.

It is very important to keep a systematic record of all data in connection with the standardization of any given batch. A blank especially designed for this purpose is illustrated under Fig. 69.

METHOD OF GETTING WEIGHTS.

The person who does the standardizing should be sure that the pounds of whole milk, likewise the pounds of cream and skim-milk used, are correctly reported and properly checked. If this part of the work is not properly done, large errors may be introduced in the work.



Form M. P. 40 SWEETENED MILK REPORT

Date_____ Plant_____ Batch No._____

Acidity fresh milk	Temp. on weigh	Highest pan temp.	Temp. in pan at finish	Time started	Time finished	Time to cool batch	Temp. of milk when cooled	Method of cooling	How long held in coolers	Viscosity milk from pans	Color milk from pans	Hydrometer

PRODUCTS USED AND OBTAINED	Total weight lbs.	Butter fat lbs.	S. N. fat lbs.	Total solids in batch, including sugar lbs.	Total solids in entire batch after adding sugar %		LABORATORY TESTS RAW PRODUCTS: Butter fat %	S. N. fat %	Total solids %
Fresh milk used									
Fresh cream used									
Sweet butter used									
Skimmed milk used									
Milk recondensed used									
Total pounds all milk products used									

		No. cases and cans	Raw milk produced, per cans lbs.	Sugar, per cans lbs.	RATIO FAT TO TOTAL SOLIDS: Incited product	Finished product	Condensation: lb. T. S. in finished product ÷ % T. S. in final product.	LABORATORY TESTS FINISHED PRODUCT: Butter fat %	Total solids %	Microscopical examination
Total lbs. sugar used. (Lbs. 2 to 1 to 1 cane)										
Total lbs. all raw products used										
Lbs. water added for standardizing										
Lbs. condensed skimmed milk added for standardizing from batch lbs.										
Lbs. condensed milk obtained, calculated from condensation		REMARKS								
Total lbs. condensed milk in entire batch								Before standardizing		
Condensed milk obtained, calculated from cans filled								After standardizing		
Total loss in handling, including over filling										

OPERATOR

ORDER NEW PADS FROM MOJONNIER BROS. CO., 739 W. JACKSON BLVD., CHICAGO

Fig. 69.
Blank Report for Sweetened Condensed Milk.

The pounds of finished product should be correctly ascertained. The methods suggested in Chapter XI, for getting the weight of the finished batch of evaporated milk can be applied with a few modifications to sweetened condensed milk. Where possible the weight of each batch as the same is dropped from the pan, should be obtained.

HOW TO CALCULATE THE POINT AT WHICH TO STRIKE THE BATCH IN THE PAN.

On account of the impossibility of correcting for overcondensation, as in the case of evaporated milk, the striking point upon sweetened condensed milk requires most careful watching. Exact knowledge is necessary as to just what striking point is required to produce a certain concentration of product.

Table 35 gives the specific gravity at different temperatures of sweetened condensed milk in which the constituents are in the following ratio: 8.00 per cent of fat, 20.00 per cent of milk S. N. F., 44.50 per cent of sucrose and 72.50 per cent of T. S. The actual composition was 8.05 per cent fat, 20.13 per cent of milk S. N. F. and 73.00 per cent of T. S.

TABLE 33.

Specific gravity at various temperatures of sweetened condensed whole milk testing 8.00 per cent of fat; 20.00 per cent of milk S. N. F., and 72.50 per cent of T. S. Sample furnished by Carnation Milk Products Co. Tests made by J. A. Cross and H. J. Liedel.

Temperature °F.	Specific Gravity	Degrees Baume	Degrees Twaddell	Temperature °F.	Specific Gravity	Degrees Baume	Degrees Twaddell
40	1.3157	34.8	63.14	110	1.2881	32.4	57.62
60	1.3065	34.0	61.30	120	1.2853	32.2	57.06
80	1.2986	33.3	59.72	130	1.2818	31.9	56.36
100	1.2918	32.8	58.36	140	1.2789	31.6	55.78

Based upon the foregoing table, the unit temperature and specific gravity relation in sweetened condensed whole milk of the test indicated is as shown in Table 34.

TABLE 34.

Unit relation of temperature to specific gravity in sweetened condensed whole milk testing 8.00 per cent fat; 20.00 per cent M. S. N. F., and 72.50 per cent T. S.

Temperature Range	Decrease in specific gravity (or vice versa), for each degree F. increase in temperature.		
	Specific Gravity	Baume	Twaddell
40° to 80° F.....	.00043	.038	.085
80° to 110° F.....	.00035	.030	.070
110° to 140° F.....	.00030	.027	.060

The above relation can be used to advantage in reducing specific gravity to a definite temperature, when striking the batch at the pan.

Example:—Baume reading at 135° F. is 31.75. What is the Baume reading at 130° F.?

135—130=5, degrees F. over standard desired.

.027× 5 =.135, degree Baume to be added to reading.

31.75+.135=31.9, the 135° F. Baume reading reduced to 130° F.

RELATION BETWEEN SPECIFIC GRAVITY AND COMPOSITION IN SWEETENED CONDENSED WHOLE MILK.

Whenever it may be necessary to change the composition of a given batch of sweetened condensed milk, it is important to know the relation between specific gravity and composition so that the striking point of additional batches may be so altered as to yield a mixed product of the desired test. Table 35 gives this relation in the case of a product in which the constituents are in the ratio 8.00 per cent fat, 20.00 per cent of milk S. N. F., 44.50 per cent of sucrose and 72.50 per cent of T. S.

TABLE 35.

Relation Between Specific Gravity and Composition in Sweetened Condensed Whole Milk.

Composition	At 60° F.			At 100° F.			At 120° F.			At 140° F.		
	Specific Gravity	°Baume	°Twaddell	Specific Gravity	°Baume	°Twaddell	Specific Gravity	°Baume	°Twaddell	Specific Gravity	°Baume	°Twaddell
73.00 T. S. 20.12 M.S.N.F. 8.05 fat	1.3087	34.2	61.74	1.2947	33.0	58.94	1.2883	32.5	57.76	1.2819	31.9	56.38
72.50 T. S. 20.00 M.S.N.F. 8.00 fat	1.3065	34.0	61.30	1.2918	32.8	58.32	1.2853	32.2	57.06	1.2789	31.6	55.78
71.25 T. S. 19.66 M.S.N.F. 7.86 fat	1.3044	33.8	60.88	1.2888	32.5	57.76	1.2826	31.9	56.52	1.2753	31.3	55.06
70.00 T. S. 19.33 M.S.N.F. 7.73 fat	1.2988	33.4	59.76	1.2842	32.1	56.84	1.2778	31.5	55.56	1.2699	30.8	53.98
68.75 T. S. 19.06 M.S.N.F. 7.59 fat	1.2923	32.8	58.46	1.2787	31.6	55.74	1.2724	31.0	54.48	1.2651	30.4	53.02
67.50 T. S. 18.63 M.S.N.F. 7.45 fat	1.2857	32.2	57.14	1.2728	31.1	54.56	1.2665	30.5	53.30	1.2599	29.9	51.99
66.25 T. S. 18.28 M.S.N.F. 7.31 fat	1.2793	31.7	55.86	1.2673	30.6	53.46	1.2601	29.9	52.02	1.2541	29.4	50.82

From the above table it is ascertained that a difference of .10 degrees Baume is equal to about .27 per cent of T. S. in the case of sweetened condensed whole milk of the above composition.

This information is applied in practice as shown by the following example: The condensed milk in the standardizing tank weighs 35,100 pounds and tests 8.22 per cent of fat and 74.50 per

KEY TO FIG. 70

Curve.....	1	2	3	4	5	6	7
Fat per cent...	7.45	7.55	7.72	7.86	7.94	8.00	8.05
Sugar per cent.	41.43	42.23	42.96	43.74	44.20	44.50	44.83
Total Solids per cent.....	67.50	68.75	70.00	71.25	72.00	72.50	73.00

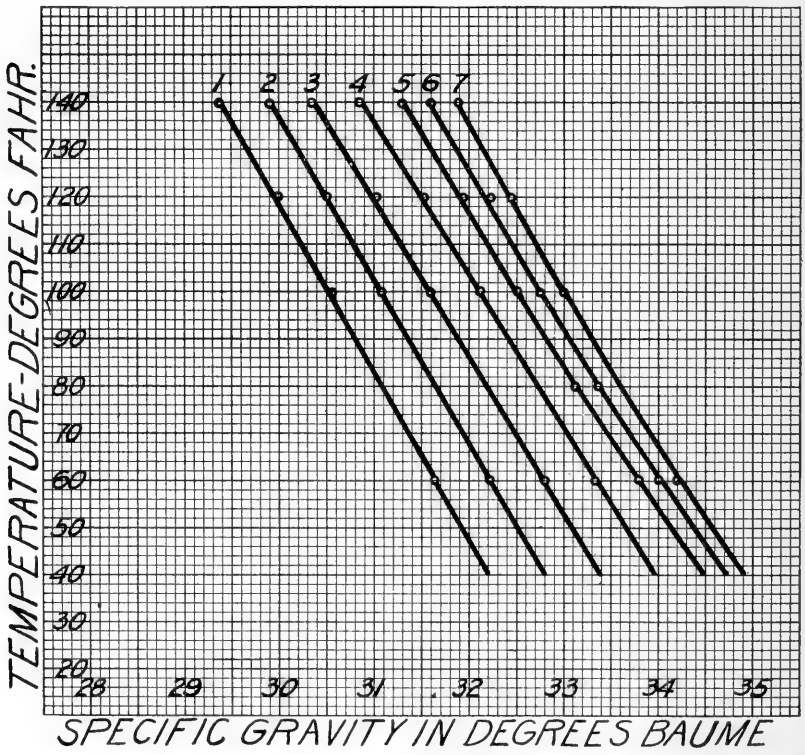


Fig. 70. Relation between temperature, specific gravity and composition in the case of sweetened condensed milk in which the ratio between M. S. N. F. and fat is as 1 to .40, Results obtained by J. A. Cross and H. J. Liedel.

cent of T. S. The test desired is 8.11 per cent of fat and 73.50 per cent of T. S. $74.50 - 73.50 = 1.00$ per cent of T. S. in excess of that required. 35100×1.00 per cent $= 351$, or pounds of T. S. that are overcondensed. The milk in the last pan batch available should yield normally about 5700 pounds of condensed milk testing 73.50 per cent of T. S., and 34.4° Baume at 140° F. Since .10 degree Baume varies the T. S. test .28 per cent, upon 5700 pounds the variation would be equivalent to 15.96 pounds of T. S. per .10 degree Baume. Dividing 351 by 15.96 equals 22.0, or the number of .10 degree Baume necessary to deduct from the normal striking point of the last pan batch, namely 34.4° Baume. Therefore $34.4 - 2.20 = 32.2$° Baume, or the striking point upon the last batch, necessary to make the correction desired.

The graph under Fig. 70 gives the composition, temperature and specific gravity in Baume degrees, in the case of sweetened condensed whole milk of the composition named above. This graph can be used within its limits to find the composition at any given Baume test, and temperature; or vice versa, the Baume test at any given composition and temperature.

RELATION BETWEEN SPECIFIC GRAVITY AND COMPOSITION IN SWEETENED CONDENSED SKIM-MILK.

The above relation, expressed in several ways, is given in Tables 36 and 37, and by graph under Fig. 71. The values given are based upon careful and accurate pycnometer determinations, under exact temperature control.

TABLE 36.

Specific gravity sweetened condensed skim-milk testing .50 per cent fat, 27.50 per cent M. S. N. F., and 70.00 per cent T. S. Tests made by J. A. Cross and H. J. Liedel.

Temperature °F.	Specific Gravity	Degrees Baume	Degrees Twaddell	Temperature °F.	Specific Gravity	Degrees Baume	Degrees Twaddell
40	1.3483	37.5	69.66	110	1.3306	36.0	66.12
60	1.3436	37.1	68.72	120	1.3265	35.7	65.30
80	1.3386	36.7	67.72	130	1.3232	35 4	64.64
100	1.3328	36.3	66.56	140	1.3198	35.1	63.96

TABLE 37.

The relation between specific gravity and composition in sweetened condensed skim-milk testing in the ratio of .50 per cent fat; 27.50 per cent M. S. N. F., and 70.00 per cent T. S. Tests made by J. A. Cross and H. J. Liedel.

Per Cent T. S.	AT 60° F.			AT 100° F.		
	Specific Gravity	°Baume	°Twaddell	Specific Gravity	°Baume	°Twaddell
70.0	1.3436	37.1	68.72	1.3328	36.3	66.56
68.0	1.3329	36.3	66.58	1.3227	35.4	64.54
65.0	1.3134	34.6	62.68	1.3035	33.8	60.70
60.0	1.2836	32.0	56.72	1.2735	31.1	54.70
55.0	1.2588	29.8	51.72	1.2480	28.8	49.60
50.0	1.2284	27.0	45.68	1.2180	25.9	43.60

Per Cent T. S.	AT 120° F.			AT 140° F.		
	Specific Gravity	°Baume	°Twaddell	Specific Gravity	°Baume	°Twaddell
70.0	1.3265	35.7	65.30	1.3198	35.1	63.96
68.0	1.3175	34.9	63.50	1.3099	34.3	61.98
65.0	1.2968	33.2	59.36	1.2896	32.6	57.92
60.0	1.2683	30.7	53.66	1.2612	30.0	52.24
55.0	1.2419	28.2	48.38	1.2355	27.6	47.10
50.0	1.2119	25.3	42.38	1.2060	24.8	41.20

From the above table it is ascertained that a difference of .10 degree Baume is equal to about .20 per cent T. S. in the case of sweetened condensed skim-milk of the composition given. Practical application of this fact is made as follows: The condensed milk in the standardizing tank weighs 10,000 pounds, and tests

69.00 per cent T. S. The test desired is 70.00 per cent T. S. 70.0 — 69.0 = 1.00 per cent of T. S. short of that required. 10,000 × .01=100 pounds of T. S. short. The condensed product from the last batch should yield normally about 5,000 pounds, testing 70.0 per cent of T. S. and 34.7° Baume at 140° F. Since .10 Baume varies the T. S. test .20 per cent, upon 5000 pounds this variation would be equivalent to 10.0 pounds of T. S. per .10 degree Baume. (100 ÷ 10) × .10 = 1.0 degree Baume necessary to add to the normal striking point. Therefore 34.7 + 1.0 = 35.7 or the striking point upon the last pan batch necessary to make the correction desired.

Based upon the foregoing tables, the unit temperature and specific gravity relation in sweetened condensed skim-milk of the test indicated, is given in Table 38.

TABLE 38.

Unit relation of temperature to specific gravity in sweetened condensed skim-milk testing .50 per cent fat, 27.50 per cent milk S. N. F. and 70.00 per cent T. S.

Temperature range.	Decrease in specific gravity (or vice versa) for each degree F. increase in temperature.		
	Specific gravity.	Baume.	Twaddell.
40° to 80° F.	.00025	.020	.050
80° to 110° F.	.00027	.020	.054
110° to 140° F.	.00036	.020	.072

The above relation can be used to advantage in reducing specific gravity to a definite temperature when striking the batch at the pan.

Example: Baume reading at 120° F. is 35.7. What is the Baume reading at 125° F.?

125—120= 5, degrees F. over standard desired.

5×.03= .15, degree Baume to be deducted from the reading at 120° F.

35.7—.5=35.55, the Baume reading at 120° F.

The graph under Fig. 71 gives the composition, temperature and specific gravity relation in Baume degrees in the case of sweetened condensed skim-milk of the composition named above.

This graph can be used within its limits to find the composition at any given Baume test and temperature; or vice versa, the Baume test at any given composition and temperature.

KEY TO FIG. 71

Curve	1	2	3	4	5	6
Fat per cent	.36	.39	.43	.46	.48	.50
Sugar per cent	30.00	33.00	36.00	39.00	40.80	42.00
Total Solids per cent	50.00	55.00	60.00	65.00	68.00	70.00

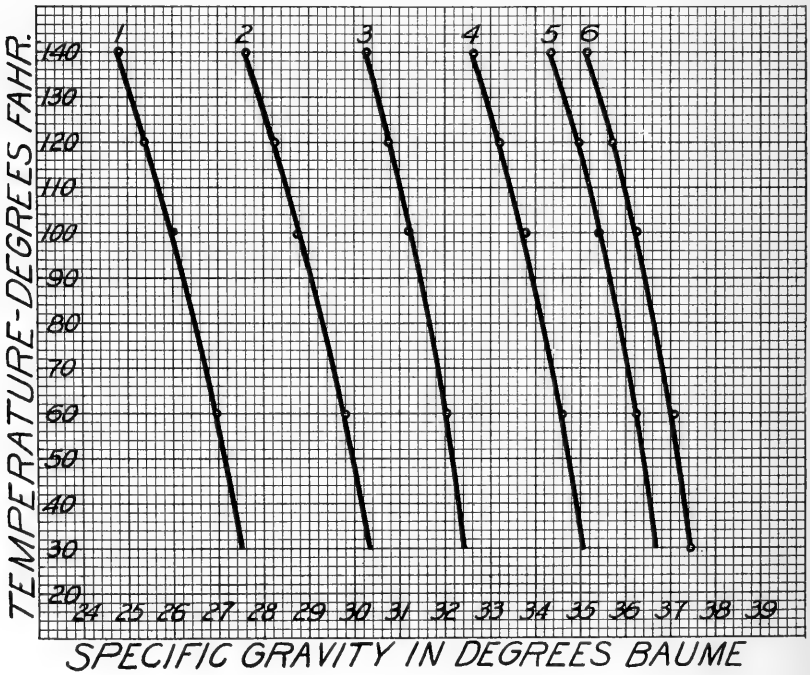


Fig. 71. Relation specific gravity and composition in sweetened condensed skim-milk in which the constituents are in following ratio: .50 fat, 42.00% sugar, 70.00% total solids. Tests made by J. A. Cross and H. J. Liedel.

HOW TO STRIKE THE PAN BATCH.

The method of striking sweetened condensed milk is very similar to that given in Chapter XI for striking evaporated milk.

The hydrometer most commonly used has a range of 26 to 37 graduated into tenths upon the Baume scale. This corresponds to 1.2185 to 1.3426 upon the specific gravity scale.

Another common method consists in the use of a pycnometer cup such as illustrated under Fig. 72. The cup is designed for a narrow limit of volume adjustment. The weight of the cup filled with the condensed product varies with the specific gravity of the product, and the condensation is continued until the desired weight is obtained.

Fig. 72.
Pycnometer Cup.

IMPROVED METHOD AND EQUIPMENT FOR MANUFACTURING SWEETENED CONDENSED MILK.

For plants handling 10,000 pounds or more of whole milk to be manufactured into sweetened condensed milk, the use of the equipment illustrated under Fig. 73 will make it possible to manufacture the best possible quality of product. The complete unit is furnished in standard sizes and capacities to meet various requirements. Table 39 lists the principal standard sizes, with capacities based upon a ten-hour working day. The capacities can be increased by increasing the hours of operation.

The different items making up the system are placed in the proper relation one to the other to best facilitate the handling of the condensed product. From the vacuum pan the condensed product flows by gravity into a weigh tank set upon a scale where the weight of the batch is obtained. From the drop tank the milk is pumped by means of a high pressure pump through a coil cooler, and from there it discharges into standardizing tanks set preferably upon the second floor. These tanks are fitted with specially designed power agitators, and they are of such size as to hold the condensed product from at least an entire day's run.

TABLE 39.

Capacities and Sizes of Standard Equipment for Manufacturing Sweetened Condensed Milk, Using the Mojonnier Process.

Pounds of whole milk handled in 10 hour day	Diameter of vacuum pan in inches	Capacity of vacuum pan in pounds of sweetened condensed whole milk per hour	Capacity of drop tank in gallons	Size of Hydraulic Pressure Pump			Capacity of sweetened condensed milk Cooler in lbs. of sweetened condensed milk cooled per hour	Capacity holding and agitating tank in gallons
				Diam. steam cylinder in inches	Diam. of milk cylinder in inches	Stroke in inches		
10,000 to 15,000	50	1,000	300	12	2	12	3,000	500
15,000 to 25,000...	60	1,500	400	12	2	12	3,000	1,000
25,000 to	72	2,650	800	14	3½	12	6,000	1,500
40,000...	78	2,950	800	14	3½	12	6,000	1,500
40,000 to 75,000...	84	3,350	1,000	14	3½	12	6,000	3,000
75,000 to 125,000..	84	3,350	1,000	14	3½	12	6,000	5,000

The advantages of this system over all other methods for handling sweetened condensed milk are briefly as follows:

(1) The condensed product is not exposed to the air between the vacuum pan and the filling machines, thus helping to prevent mold growth.

(2) The method of agitation used makes it possible to obtain a finished product with small milk sugar crystals, rendering it smooth to the taste and helping to prevent the settling of the milk sugar upon the bottom of the cans.

(3) Control of the composition between closer limits than is possible by any other method.

Figs. 76, 77 and 78 illustrate three other types of sweetened condensed milk coolers that are in common use.

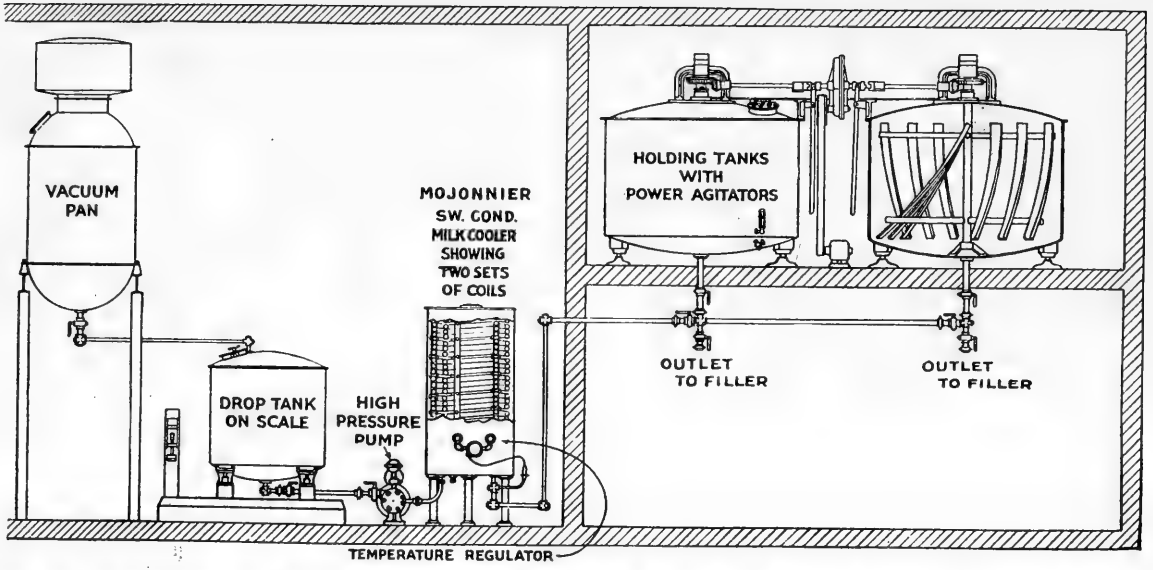


Fig. 73. Equipment for Handling Sweetened Condensed Milk Using Mojonnier Process. (Patents Pending.)

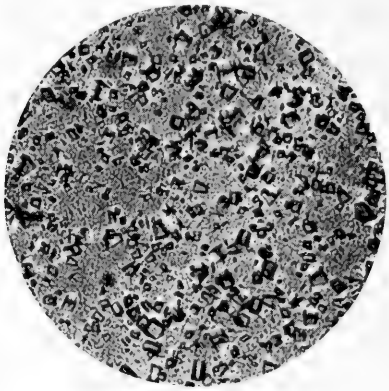


Fig. 74.

Milk Sugar Crystals in Sweetened, Condensed Milk of Good Crystalline Quality. By Miss Lucy Klein. Magnified 100 Diameters.

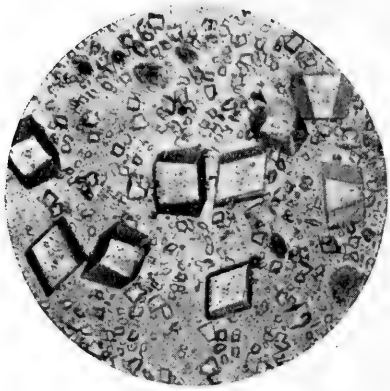


Fig. 75.

Milk Sugar Crystals in Sweetened, Condensed Milk of Poor Crystalline Quality. By Miss Lucy Klein. Magnified 100 Diameters.

Fig. 74 is a photomicrograph of milk sugar crystals in sweetened condensed milk of good crystalline quality, that is, one that is smooth to the taste. Fig. 75 is a photomicrograph of sweetened condensed milk of poor crystalline quality. The latter product is of low commercial value, and is one in which the milk sugar is very likely to deposit upon the bottom of the containers.

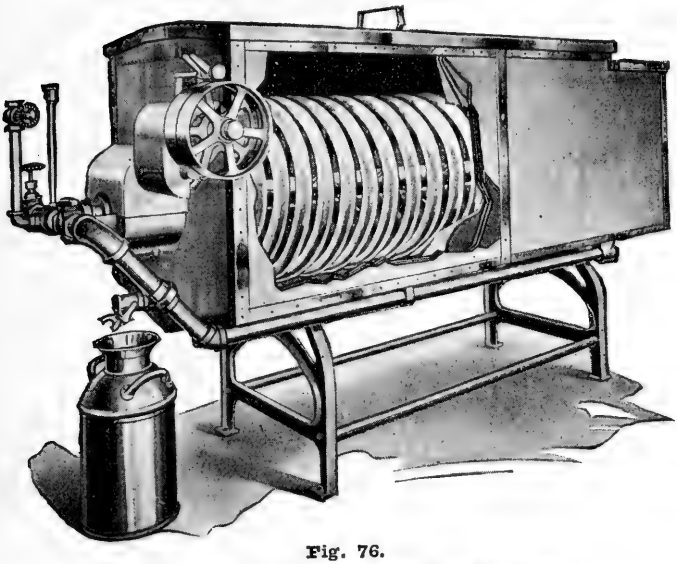


Fig. 76.

Fig. 76. Sweetened Condensed Milk Cooler.
Courtesy Creamery Package Mfg. Co.

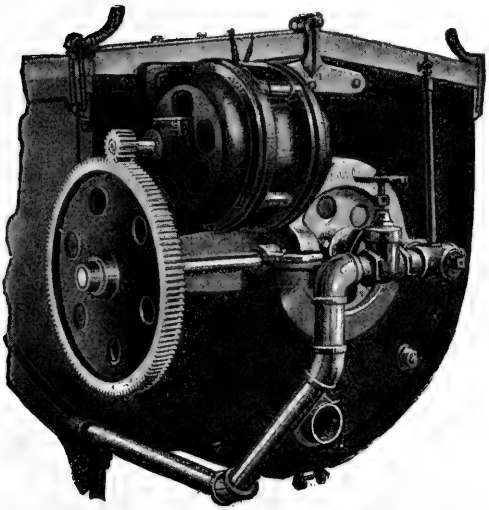


Fig. 77. Sweetened Condensed Milk Cooler.
Courtesy Manning Mfg. Co.

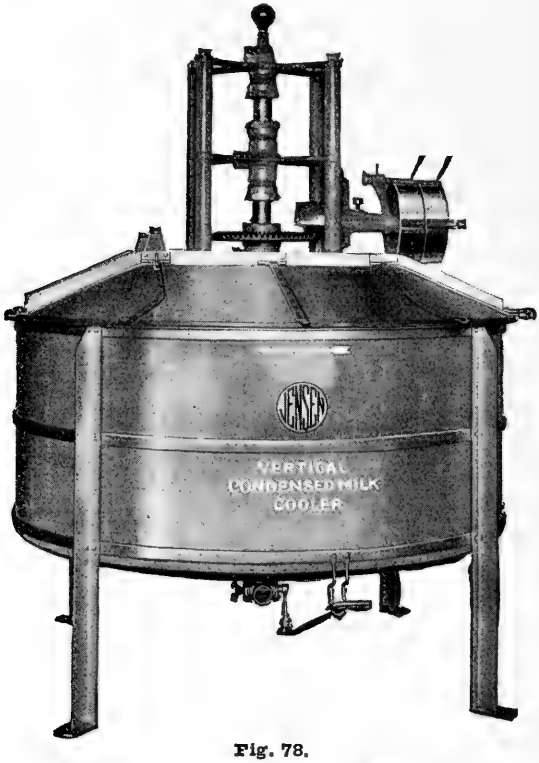


Fig. 78.

Fig. 78. Sweetened Condensed Milk Cooler.
Courtesy Jensen Creamery Machinery Co.

THE USE OF TABLES IN SHORTENING CALCULATIONS.

Properly prepared tables can be used to save much time in making the standardizing calculations upon sweetened condensed milk. Tables can be prepared to cover any composition of product that it may be desired to manufacture. This chapter contains tables for a product having a composition of 8.00 per cent of fat, 20.00 per cent of milk S. N. F. and 44.50 per cent of sucrose, making 72.50 per cent of T. S. These are the minimum values, and it is recommended in practice to condense the product sufficiently to yield a product of the following test:

8.10 per cent of fat.
20.25 per cent of milk S. N. F.
45.05 per cent of sucrose.
73.40 per cent of T. S.

By following the above practice the finished product contains each constituent in the proper ratio one to the other, and in sufficient amounts to provide the necessary factor of safety.

Sweetened condensed milk of various compositions is manufactured. The Federal Standard calls for a minimum of 8.00 per cent of fat and 20.00 per cent of milk S. N. F., but the content of sucrose is not governed by law. The composition just given is that recommended when the product is put up in tin cans for household use.

Partly skimmed sweetened condensed milk is manufactured in large quantities, the same being marketed in barrels. The composition recommended for this product is given in Table 40.

TABLE 40.

Composition of Partly Skimmed Sweetened Condensed Milk.

Constituents.	Minimum standard no factor of safety.	Standard recommended, including proper factor of safety.
Fat	5.00	5.10
Milk S. N. F	23.00	23.46
Sucrose	44.00	44.88
T. S.	72.00	73.44

Sweetened condensed skim-milk is marketed largly in barrels. The composition recommended for this product is given in Table 41.

TABLE 41.

Composition of Sweetened Condensed Skim-milk.

Constituents.	Minimum standard no factor of safety.	Standard recommended, including proper factor of safety.
Milk solids	28.00	28.20
Sucrose	42.00	42.30
T. S.	70.00	70.50

Table 42 gives the percentage of fat and milk S. N. F. in the proper ratio one to the other. The range is from .01 to 8.99 per cent of fat, and .03 to 22.48 per cent of milk S. N. F. It also gives the pounds of sugar to use for any corresponding pounds of fat from 6 to 5000.

The table can be used in several different ways, as follows:

(1.) **To determine the per cent of S. N. F. required to standardize the fat in any given skim-milk.**

Example: Skim-milk tests .16 per cent of fat. Reference to the table shows that .40 per cent of S. N. F. is required to standardize .16 per cent of fat.

2. **To determine the per cent of fat required to standardize the S. N. F. in any given cream.**

Example: Cream tests 7.10 per cent of S. N. F. Reference to the table shows that 2.84 per cent of fat are required to standardize 7.10 per cent of S. N. F.

(3.) **To determine the per cent S. N. F. required to standardize the fat in any given whole milk, or vice versa.**

Example: Whole milk tests 4.00 per cent of fat. Reference to the table shows that 10.00 per cent of milk S. N. F. are required to standardize 4.00 per cent of fat.

(4.) **To determine the pounds of sugar required for any given size of batch.**

Example: The total pounds of fat in the whole milk and in the cream used to make up the batch amounts to 640 pounds. Turn to the table under percentage of fat; disregard the decimal point and consider the percentage as a whole number. The amount in the sugar column opposite 6.40 is 3554, or the pounds of sugar required for the total batch.

TABLE 42.

Percentage of fat, S. N. F. in the proper ratio to standardize sweetened condensed milk upon the basis of 8.00 per cent of fat, 20.00 per cent of milk S. N. F., and 44.50 per cent of sugar. Also the pounds of sugar to use for any given number of pounds of fat. Ratios are as follows: 1 milk S. N. F. to .40 fat; 1 fat to 5.75 sugar, and 1 sugar to .1798 fat.

Per Cent Fat	Per Cent Milk S. N. F.	Lbs. Sugar to use for corresponding wt. of Fat	Per Cent Fat	Per Cent Milk S. N. F.	Lbs. Sugar to use for corresponding wt. of Fat.	Per Cent Fat	Per Cent Milk S. N. F.	Lbs. Sugar to use for corresponding wt. of Fat
.....	.....	.....	.36	.90	200	.72	1.80	400
.01	.03	6	.37	.93	206	.73	1.83	408
.02	.05	11	.38	.95	211	.74	1.85	412
.03	.08	17	.39	.98	217	.75	1.88	417
.04	.10	22	.40	1.00	222	.76	1.90	423
.05	.13	28	.41	1.03	228	.77	1.93	428
.06	.15	33	.42	1.05	234	.78	1.95	434
.07	.18	39	.43	1.08	239	.79	1.98	439
.08	.20	44	.44	1.10	245	.80	2.00	445
.09	.23	50	.45	1.13	250	.81	2.03	451
.10	.25	56	.46	1.15	256	.82	2.05	458
.11	.28	61	.47	1.18	261	.83	2.08	462
.12	.30	67	.48	1.20	265	.84	2.10	467
.13	.33	72	.49	1.23	273	.85	2.13	473
.14	.35	78	.50	1.25	278	.86	2.15	478
.15	.38	83	.51	1.28	284	.87	2.18	484
.16	.40	89	.52	1.30	289	.88	2.20	489
.17	.43	95	.53	1.33	295	.89	2.23	495
.18	.45	100	.54	1.35	300	.90	2.25	501
.19	.48	106	.55	1.38	306	.91	2.28	506
.20	.50	111	.56	1.40	311	.92	2.30	512
.21	.53	117	.57	1.43	317	.93	2.33	515
.22	.55	122	.58	1.45	323	.94	2.35	523
.23	.58	128	.59	1.48	328	.95	2.38	528
.24	.60	133	.60	1.50	334	.96	2.40	534
.25	.63	139	.61	1.53	339	.97	2.43	539
.26	.65	145	.62	1.55	345	.98	2.45	545
.27	.68	150	.63	1.58	350	.99	2.48	551
.28	.70	156	.64	1.60	356	1.00	2.50	556
.29	.73	161	.65	1.63	362	1.01	2.53	562
.30	.75	167	.66	1.65	367	1.02	3.55	567
.31	.78	173	.67	1.68	373	1.03	2.58	573
.32	.80	178	.68	1.70	378	1.04	2.60	578
.33	.83	184	.69	1.73	384	1.05	2.63	584
.34	.85	189	.70	1.75	389	1.06	2.65	590
.35	.88	195	.71	1.78	395	1.07	2.68	595

TABLE 42 (Continued).

Per Cent Fat	Per Cent Milk S. N. F.	Lbs. Sugar to use for corresponding wt. of Fat.	Per Cent Fat	Per Cent Milk S. N. F.	Lbs. Sugar to use for corresponding wt. of Fat.	Per Cent Fat	Per Cent Milk S. N. F.	Lbs. Sugar to use for corresponding wt. of Fat.
1.08	2.70	601	1.51	3.78	840	1.94	4.85	1079
1.09	2.73	605	1.52	3.80	845	1.95	4.88	1085
1.10	2.75	612	1.53	3.83	851	1.96	4.90	1090
1.11	2.78	617	1.54	3.85	857	1.97	4.93	1096
1.12	2.80	623	1.55	3.88	862	1.98	4.95	1101
1.13	2.83	628	1.56	3.90	868	1.99	4.98	1107
1.14	2.85	634	1.57	3.93	873	2.00	5.00	1112
1.15	2.88	640	1.58	3.95	879	2.01	5.03	1118
1.16	2.90	645	1.59	3.98	884	2.02	5.05	1123
1.17	2.93	651	1.60	4.00	890	2.03	5.08	1129
1.18	2.95	658	1.61	4.03	895	2.04	5.10	1135
1.19	2.98	662	1.62	4.06	901	2.05	5.13	1140
1.20	3.00	667	1.63	4.08	907	2.06	5.15	1146
1.21	3.03	673	1.64	4.10	912	2.07	5.18	1151
1.22	3.05	679	1.65	4.13	918	2.08	5.20	1157
1.23	3.08	684	1.66	4.15	923	2.09	5.23	1162
1.24	3.10	690	1.67	4.18	929	2.10	5.25	1168
1.25	3.13	695	1.68	4.20	934	2.11	5.28	1174
1.26	3.15	701	1.69	4.23	940	2.12	6.30	1179
1.27	3.18	706	1.70	4.25	945	2.13	5.33	1185
1.28	3.20	712	1.71	4.28	951	2.14	5.35	1190
1.29	3.23	717	1.72	4.30	957	2.15	5.38	1196
1.30	3.25	723	1.73	4.33	962	2.16	5.40	1201
1.31	3.28	729	1.74	4.35	968	2.17	5.43	1207
1.32	3.30	734	1.75	4.38	973	2.18	5.45	1212
1.33	3.33	740	1.76	4.40	979	2.19	5.48	1218
1.34	3.36	745	1.77	4.43	984	2.20	5.50	1224
1.35	3.38	751	1.78	4.45	990	2.21	5.53	1229
1.36	3.40	756	1.79	4.48	996	2.22	5.55	1233
1.37	3.43	762	1.80	4.50	1001	2.23	5.58	1240
1.38	3.45	768	1.81	4.53	1007	2.24	5.60	1246
1.39	3.48	773	1.82	4.55	1012	2.25	5.63	1351
1.40	3.50	779	1.83	4.58	1018	2.26	5.65	1257
1.41	3.53	784	1.84	4.60	1023	2.27	5.68	1263
1.42	3.55	790	1.85	4.63	1028	2.28	5.70	1268
1.43	3.58	795	1.86	4.65	1034	2.29	5.73	1274
1.44	3.60	801	1.87	4.68	1040	2.30	5.75	1279
1.45	3.63	806	1.88	4.70	1046	2.31	5.78	1285
1.46	3.65	812	1.89	4.73	1051	2.32	5.80	1290
1.47	3.68	818	1.90	4.75	1057	2.33	5.83	1293
1.48	3.70	823	1.91	4.78	1062	2.34	5.85	1301
1.49	3.73	829	1.92	4.80	1068	2.35	5.88	1307
1.50	3.75	834	1.93	4.83	1073	2.36	5.90	1313

TABLE 42 (Continued).

Per Cent Fat	Per Cent Milk S. N. F.	Lbs. Sugar to use for corresponding wt. of Fat	Per Cent Fat	Per Cent Milk S. N. F.	Lbs. Sugar to use for corresponding wt. of Fat	Per Cent Fat	Per Cent Milk S. N. F.	Lbs. Sugar to use for corresponding wt. of Fat.
2.37	5.93	1318	2.80	7.00	1557	3.23	8.08	1796
2.38	5.96	1324	2.81	7.03	1563	3.24	8.10	1802
2.39	5.98	1329	2.82	7.05	1568	3.25	8.13	1808
2.40	6.00	1335	2.83	7.08	1574	3.26	8.15	1813
2.41	6.03	1340	2.84	7.10	1580	3.27	8.18	1819
2.42	6.05	1346	2.85	7.13	1585	3.28	8.20	1824
2.43	6.08	1352	2.86	7.15	1591	3.29	8.23	1830
2.44	6.10	1357	2.87	7.18	1596	3.30	8.25	1835
2.45	6.13	1363	2.88	7.20	1602	3.31	8.28	1841
2.46	6.15	1368	2.89	7.23	1607	3.32	8.30	1846
2.47	6.18	1374	2.90	7.25	1613	3.33	8.33	1852
2.48	6.20	1379	2.91	7.28	1618	3.34	8.35	1858
2.49	6.23	1385	2.92	7.30	1624	3.35	8.38	1863
2.50	6.25	1390	2.93	7.33	1630	3.36	8.40	1869
2.51	6.28	1398	2.94	7.35	1635	3.37	8.43	1874
2.52	6.30	1401	2.95	7.39	1641	3.38	8.45	1880
2.53	6.33	1407	2.96	7.40	1646	3.39	8.48	1885
2.54	6.35	1413	2.97	7.43	1651	3.40	8.50	1891
2.55	6.38	1418	2.98	7.45	1657	3.41	8.53	1897
2.56	6.40	1424	2.99	7.48	1663	3.42	8.55	1902
2.57	6.43	1429	3.00	7.50	1669	3.43	8.58	1908
2.58	6.45	1436	3.01	7.53	1674	3.44	8.60	1913
2.59	6.48	1440	3.02	7.55	1680	3.45	8.63	1919
2.60	6.50	1446	3.03	7.58	1685	3.46	8.65	1924
2.61	6.53	1452	3.04	7.60	1691	3.47	8.68	1930
2.62	6.56	1457	3.05	7.63	1696	3.48	8.70	1935
2.63	6.58	1462	3.06	7.65	1702	3.49	8.73	1941
2.64	6.60	1468	3.07	7.68	1707	3.50	8.75	1947
2.65	6.63	1474	3.08	7.70	1713	3.51	8.78	1952
2.66	6.65	1479	3.09	7.73	1719	3.52	8.80	1958
2.67	6.68	1485	3.10	7.75	1724	3.53	8.83	1963
2.68	6.70	1491	3.11	7.78	1730	3.54	8.85	1969
2.69	6.73	1496	3.12	7.80	1735	3.55	8.88	1974
2.70	6.76	1502	3.13	7.83	1741	3.56	8.90	1980
2.71	6.78	1507	3.14	7.85	1746	3.57	8.93	1986
2.72	6.80	1513	3.15	7.88	1752	3.58	8.95	1991
2.73	6.83	1518	3.16	7.90	1758	3.59	8.98	1997
2.74	6.85	1524	3.17	7.93	1763	3.60	9.00	2002
2.75	6.88	1529	3.18	7.95	1769	3.61	9.03	2008
2.76	6.90	1539	3.19	7.98	1774	3.62	9.05	2013
2.77	6.93	1541	3.20	8.00	1780	3.63	9.08	2019
2.78	6.96	1546	3.21	8.03	1785	3.64	9.10	2124
2.79	6.98	1552	3.22	8.05	1791	3.65	9.13	2030

TABLE 42 (Continued).

Per Cent Fat	Per Cent Milk S. N. F.	Lbs. Sugar to use for corresponding wt. of Fat	Per Cent Fat	Per Cent Milk S. N. F.	Lbs. Sugar to use for corresponding wt. of Fat	Per Cent Fat	Per Cent Milk S. N. F.	Lbs. Sugar to use for corresponding wt. of Fat
3.66	9.15	2036	4.09	10.23	2275	4.52	11.30	2514
3.67	9.18	2041	4.10	10.25	2280	4.53	11.33	2519
3.68	9.20	2047	4.11	10.28	2286	4.54	11.35	2525
3.69	9.23	2053	4.12	10.30	2291	4.55	11.38	2531
3.70	9.25	2058	4.13	10.33	2297	4.56	11.40	2536
3.71	9.28	2064	4.14	10.35	2303	4.57	11.43	2542
3.72	9.30	2069	4.15	10.38	2308	4.58	11.45	2547
3.73	9.33	2075	4.16	10.40	2314	4.59	11.48	2553
3.74	9.35	2080	4.17	10.43	2319	4.60	11.50	2558
3.75	9.38	2086	4.18	10.45	2325	4.61	11.53	2564
3.76	9.40	2091	4.19	10.48	2330	4.62	11.55	2570
3.77	9.43	2097	4.20	10.50	2336	4.63	11.58	2575
3.78	9.45	2102	4.21	10.53	2341	4.64	11.60	2581
3.79	9.48	2108	4.22	10.55	2347	4.65	11.63	2586
3.80	9.50	2113	4.23	10.58	2353	4.66	11.65	2592
3.81	9.53	2119	4.24	10.60	2358	4.67	11.68	2597
3.82	9.55	2125	4.25	10.63	2364	4.68	11.70	2603
3.83	9.58	2130	4.26	10.65	2369	4.69	11.73	2608
3.84	9.60	2136	4.27	10.68	2375	4.70	11.75	2614
3.85	9.63	2141	4.28	10.70	2380	4.71	11.78	2620
3.86	9.65	2147	4.29	10.73	2386	4.72	11.80	2625
3.87	9.68	2152	4.30	10.75	2392	4.73	11.83	2631
3.88	9.70	2158	4.31	10.78	2397	4.74	11.85	2636
3.89	9.73	2164	4.32	10.80	2403	4.75	11.88	2642
3.90	9.75	2169	4.33	10.83	2408	4.76	11.90	2647
3.91	9.78	2175	4.34	10.85	2414	4.77	11.93	2653
3.92	9.80	2180	4.35	10.88	2419	4.78	11.95	2659
3.93	9.83	2186	4.36	10.90	2425	4.79	11.98	2664
3.94	9.85	2191	4.37	10.93	2430	4.80	12.00	2670
3.95	9.88	2197	4.38	10.95	2436	4.81	12.03	2675
3.96	9.90	2202	4.39	10.98	2442	4.82	12.05	2681
3.97	9.93	2208	4.40	11.00	2447	4.83	12.08	2686
3.98	9.95	2214	4.41	11.03	2453	4.84	12.10	2692
3.99	9.98	2219	4.42	11.05	2458	4.85	12.13	2697
4.00	10.00	2225	4.43	11.08	2464	4.86	12.15	2703
4.01	10.03	2230	4.44	11.10	2469	4.87	12.18	2709
4.02	10.05	2236	4.45	11.13	2475	4.88	12.20	2714
4.03	10.08	2241	4.46	11.15	2481	4.89	12.23	2720
4.04	10.10	2247	4.47	11.18	2486	4.90	12.25	2725
4.05	10.13	2253	4.48	11.20	2492	4.91	12.28	2731
4.06	10.15	2258	4.49	11.23	2497	4.92	12.30	2736
4.07	10.18	2264	4.50	11.25	2503	4.93	12.33	2742
4.08	10.20	2269	4.51	11.28	2508	4.94	12.35	2747

TABLE 42 (Continued).

Per Cent Fat	Per Cent Milk S. N. F.	Lbs. Sugar to use for corresponding wt. of Fat	Per Cent Fat	Per Cent Milk S. N. F.	Lbs. Sugar to use for corresponding wt. of Fat	Per Cent Fat	Per Cent Milk S. N. F.	Lbs. Sugar to use for corresponding wt. of Fat
4.95	12.38	2753	5.38	13.45	2992	5.81	14.53	3231
4.96	12.40	2759	5.39	13.48	2998	5.82	14.55	3237
4.97	12.43	2764	5.40	13.50	3003	5.83	14.58	3242
4.98	12.45	2770	5.41	13.53	3008	5.84	14.60	3248
4.99	12.48	2775	5.42	13.55	3014	5.85	14.63	3254
5.00	12.50	2781	5.43	13.58	3020	5.86	14.65	3259
5.01	12.53	2786	5.44	13.60	3026	5.87	14.68	3265
5.02	12.55	2793	5.45	13.63	3031	5.88	14.70	3270
5.03	12.58	2798	6.46	13.65	3037	5.89	14.73	3276
5.04	12.60	2803	5.47	13.68	3042	5.90	14.75	3281
5.05	12.63	2809	5.48	13.70	3048	5.91	14.78	3287
5.06	12.65	2814	5.49	13.73	3053	5.92	14.80	3293
5.07	12.68	2820	5.50	13.75	3059	5.93	14.83	3298
5.08	12.70	2825	5.51	13.78	3065	5.94	14.85	3304
5.09	12.73	2831	5.52	13.80	3070	5.95	14.88	3309
5.10	12.75	2836	5.53	13.83	3076	5.96	14.90	3315
5.11	12.78	2842	5.54	13.85	3081	5.97	14.93	3320
5.12	12.80	2848	5.55	13.88	3087	5.98	14.95	3326
5.13	12.83	2853	5.56	13.90	3092	5.99	14.98	3331
5.14	12.85	2859	5.57	13.93	3098	6.00	15.00	3337
5.15	12.88	2864	5.58	13.95	3103	6.01	15.03	3343
5.16	12.90	2870	5.59	13.98	3109	6.02	15.05	3348
5.17	12.93	2875	5.60	14.00	3315	6.03	15.08	3354
5.18	12.95	2881	5.61	14.03	3120	6.04	15.10	3359
5.19	12.98	2887	5.62	14.05	3126	6.05	15.13	3365
5.20	13.00	2892	5.63	14.08	3131	6.06	15.15	3370
5.21	13.03	2898	5.64	14.10	3137	6.07	15.18	3376
5.22	13.05	2903	5.65	14.13	3142	6.08	15.20	3382
5.23	13.08	2909	5.66	14.15	3148	6.09	15.23	3387
5.24	13.10	2914	5.67	14.18	3154	6.10	15.25	3393
5.25	13.13	2920	5.68	14.20	3159	6.11	15.28	3398
5.26	13.15	2925	5.69	14.23	3165	6.12	15.30	3404
5.27	13.18	2931	5.70	14.25	3170	6.13	15.33	3409
5.28	13.20	2937	5.71	14.28	3176	6.14	15.35	3415
5.29	13.23	2942	5.72	14.30	3181	6.15	15.38	3420
5.30	13.25	2948	5.73	14.33	3187	6.16	15.40	3426
5.31	13.28	2953	5.74	14.35	3192	6.17	15.43	3432
5.32	13.30	2959	5.75	14.38	3198	6.18	15.45	3437
5.33	13.33	2964	5.76	14.40	3204	6.19	15.48	3443
5.34	13.35	2970	5.77	14.43	3209	6.20	15.50	3448
5.35	13.38	2976	5.78	14.45	3215	6.21	15.53	3454
5.36	13.40	2981	5.79	14.48	3220	6.22	15.55	3459
5.37	13.43	2987	5.80	14.50	3226	6.23	15.58	3465

TABLE 42 (Continued).

Per Cent Fat	Per Cent Milk S. N. F.	Lbs. Sugar to use for corresponding wt. of Fat.	Per Cent Fat	Per Cent Milk S. N. F.	Lbs. Sugar to use for corresponding wt. of Fat.	Per Cent Fat	Per Cent Milk S. N. F.	Lbs. Sugar to use for corresponding wt. of Fat.
6.24	15.60	3471	6.67	16.68	3710	7.10	17.75	3949
6.25	15.63	3476	6.68	16.70	3715	7.11	17.78	3954
6.26	15.65	3482	6.69	16.73	3721	7.12	17.80	3960
6.27	15.68	3487	6.70	16.75	3726	7.13	17.83	3966
6.28	15.70	3493	6.71	16.78	3732	7.14	17.85	3971
6.29	15.73	3498	6.72	16.80	3737	7.15	17.88	3977
6.30	15.75	3504	6.73	16.83	3743	7.16	17.90	3982
6.31	15.78	3509	6.74	16.85	3749	7.17	17.93	3988
6.32	15.80	3515	6.75	16.88	3754	7.18	17.95	3993
6.33	15.83	3521	6.76	16.90	3760	7.19	17.98	3999
6.34	15.85	3528	6.77	16.93	3765	7.20	18.00	4004
6.35	15.88	3532	6.78	16.95	3771	7.21	18.03	4010
6.36	15.90	3543	6.79	16.98	3776	7.22	18.05	4016
6.37	15.93	3545	6.80	17.00	3782	7.23	18.08	4021
6.38	15.95	3548	6.81	17.03	3788	7.24	18.10	4027
6.39	15.98	3554	6.82	17.05	3793	7.25	18.13	4032
6.40	16.00	3560	6.83	17.08	3799	7.26	18.15	4038
6.41	16.03	3565	6.84	17.10	3804	7.27	18.18	4043
6.42	16.05	3571	6.85	17.13	3810	7.28	18.20	4049
6.43	16.08	3576	6.86	17.15	3815	7.29	18.23	4055
6.44	16.10	3582	6.87	17.18	3821	7.30	18.25	4060
6.45	16.13	3587	6.88	17.20	3826	7.31	18.28	4066
6.46	16.15	3593	6.89	17.23	3832	7.32	18.30	4071
6.47	16.18	3598	6.90	17.25	3838	7.33	18.33	4077
6.48	16.20	3604	6.91	17.28	3843	7.34	18.35	4082
6.49	16.23	3610	6.92	17.30	3849	7.35	18.38	4088
6.50	16.25	3615	6.93	17.33	3854	7.36	18.40	4093
6.51	16.28	3621	6.94	17.35	3860	7.37	18.43	4099
6.52	16.30	3626	6.95	17.38	3865	7.38	18.45	4105
6.53	16.33	3632	6.96	17.40	3871	7.39	18.48	4110
6.54	16.35	3637	6.97	17.43	3877	7.40	18.50	4116
6.55	16.38	3643	6.98	17.45	3883	7.41	18.53	4121
6.56	16.40	3648	6.99	17.48	3888	7.42	18.55	4127
6.57	16.43	3654	7.00	17.50	3893	7.43	18.58	4132
6.58	16.45	3660	7.01	17.53	3899	7.44	18.60	4138
6.59	16.48	3665	7.02	17.55	3904	7.45	18.63	4143
6.60	16.50	3671	7.03	17.58	3910	7.46	18.65	4148
6.61	16.53	3676	7.04	17.60	3915	7.47	18.68	4155
6.62	16.55	3682	7.05	17.63	3921	7.48	18.70	4160
6.63	16.58	3687	7.06	17.65	3927	7.49	18.73	4166
6.64	16.60	3693	7.07	17.68	3932	7.50	18.75	4171
6.65	16.63	3699	7.08	17.70	3938	7.51	18.78	4177
6.66	16.65	3704	7.09	17.73	3943	7.52	18.80	4182

TABLE 42 (Continued).

Per Cent Fat	Per Cent Milk S. N. F.	Lbs. Sugar to use for corresponding wt. of Fat	Per Cent Fat	Per Cent Milk S. N. F.	Lbs. Sugar to use for corresponding wt. of Fat	Per Cent Fat	Per Cent Milk S. N. F.	Lbs. Sugar to use for corresponding wt. of Fat
7.53	18.83	4188	7.96	19.90	4427	8.39	20.98	4666
7.54	18.85	4194	7.97	19.93	4433	8.40	21.00	4672
7.55	18.87	4199	7.98	19.95	4438	8.41	21.03	4677
7.56	18.90	4205	7.99	19.98	4444	8.42	21.05	4683
7.57	18.93	4210	8.00	20.00	4449	8.43	21.08	4689
7.58	18.95	4216	8.01	20.03	4455	8.44	21.10	4695
7.59	18.97	4221	8.02	20.05	4460	8.45	21.13	4700
7.60	19.00	4227	8.03	20.08	4466	8.46	21.15	4705
7.61	19.03	4232	8.04	20.10	4472	8.47	21.18	4711
7.62	19.05	4238	8.05	20.13	4477	8.48	21.20	4716
7.63	19.08	4244	8.06	20.15	4483	8.49	21.23	4722
7.64	19.10	4249	8.07	20.18	4488	8.50	21.25	4727
7.65	19.13	4255	8.08	20.20	4494	8.51	21.28	4733
7.66	19.15	4260	8.09	20.23	4499	8.52	21.30	4739
7.67	19.18	4266	8.10	20.25	4505	8.53	21.33	4744
7.68	19.20	4271	8.11	20.28	4511	8.54	21.35	4750
7.69	19.23	4277	8.12	20.30	4516	8.55	21.38	4756
7.70	19.25	4283	8.13	20.33	4522	8.56	21.40	4761
7.71	19.28	4288	8.14	20.35	4527	8.57	21.43	4766
7.72	19.30	4294	8.15	20.38	4533	8.58	21.45	4772
7.73	19.33	4299	8.16	20.40	4538	8.59	21.48	4778
7.74	19.35	4303	8.17	20.43	4544	8.60	21.50	4783
7.75	19.37	4310	8.18	20.45	4549	8.61	21.53	4789
7.76	19.40	4316	8.19	20.48	4555	8.62	21.55	4794
7.77	19.43	4321	8.20	20.50	4561	8.63	21.58	4800
7.78	19.45	4327	8.21	20.53	4566	8.64	21.60	4805
7.79	19.48	4333	8.22	20.55	4572	8.65	21.63	4811
7.80	19.50	4338	8.23	20.58	4577	8.66	21.65	4816
7.81	19.53	4344	8.24	20.60	4583	8.67	21.68	4822
7.82	19.55	4349	8.25	20.63	4588	8.68	21.70	4828
7.83	19.58	4355	8.26	20.65	4594	8.69	21.73	4833
7.84	19.60	4360	8.27	20.68	4600	8.70	21.75	4839
7.85	19.63	4366	8.28	20.70	4605	8.71	21.78	4844
7.86	19.65	4371	8.29	20.73	4611	8.72	21.80	4850
7.87	19.68	4377	8.30	20.75	4616	8.73	21.83	4855
7.88	19.70	4383	8.31	20.78	4622	8.74	21.85	4861
7.89	19.73	4388	8.32	20.80	4627	8.75	21.88	4867
7.90	19.75	4394	8.33	20.83	4633	8.76	21.90	4872
7.91	19.78	4399	8.34	20.85	4638	8.77	21.93	4878
7.92	19.80	4405	8.35	20.88	4644	8.78	21.95	4883
7.93	19.83	4410	8.36	20.90	4650	8.79	21.98	4889
7.94	19.85	4416	8.37	20.93	4655	8.80	22.00	4894
7.95	19.88	4422	8.38	20.95	4661	8.81	22.03	4900

TABLE 42 (Continued).

Per Cent Fat	Per Cent Milk S. N. F.	Lbs. Sugar to use for corresponding wt. of Fat	Per Cent Fat	Per Cent Milk S. N. F.	Lbs. Sugar to use for corresponding wt. of Fat	Per Cent Fat	Per Cent Milk S. N. F.	Lbs. Sugar to use for corresponding wt. of Fat
8.82	22.05	4905	8.88	22.20	4939	8.94	22.35	4972
8.83	22.08	4911	8.89	22.23	4944	8.95	22.38	4978
8.84	22.10	4917	8.90	22.25	4950	8.96	22.40	4983
8.85	22.13	4922	8.91	22.28	4956	8.97	22.43	4989
8.86	22.15	4928	8.92	22.30	4961	8.98	22.45	4994
8.87	22.18	4933	8.93	22.33	4967	8.99	22.48	5000

KEY TO FORMULAS FOR STANDARDIZING SWEETENED CONDENSED MILK.

D = The pounds of condensed whole milk.
F = The percentage of fat in the whole milk.
G = The percentage of fat in the cream.
G^1 = The percentage of fat in the unsweetened condensed skim-milk.
I = The percentage of S. N. F. in the sweetened condensed skim-milk.
I^1 = The percentage of S. N. F. in the unsweetened condensed skim-milk.
J = The percentage of S. N. F. in the cream.
K = The percentage of fat in the skim-milk.
K^1 = The percentage of fat in the condensed whole milk.
L = The pounds of skim-milk.
L^1 = The pounds of sweetened condensed skim-milk.
M = The percentage of fat in the sweetened condensed skim-milk.
N = The percentage of S. N. F. in the skim-milk.
N^1 = The percentage of T. S. in the skim-milk.
O = The pounds of cream.
P = The pounds of whole milk.
Q = The pounds of condensed skim-milk.
R = The ratio of S. N. F. to fat in the desired product.
S = The percentage of S. N. F. in the whole milk.
S^1 = The average percentage of fat in the mixed batch.
S^2 = The percentage of S. N. F. in the unsweetened condensed whole milk.
S^3 = The percentage of S. N. F. in the mixed batch.

U = The pounds of sugar required.
V = The percentage of S. N. F. in the cream.
V^1 = The percentage of S. N. F. in the mixed batch.
Y = The ratio of sugar to fat.
Y^1 = The ratio of sugar to total solids.
Y^2 = The ratio of total milk solids to sugar.
Z = The percentage of sugar in the sweetened condensed milk.

PROVIDING FACTOR OF SAFETY.

In all the problems given in this chapter, the calculations are made upon the basis of the absolute standard without allowing any factor of safety. It is recommended that in practice in the case of sweetened condensed milk, a factor of safety be allowed of about .10 per cent upon the fat and .30 per cent upon the T. S. It may be possible under the best conditions of plant operation to reduce this factor slightly.

STANDARDIZING SWEETENED CONDENSED MILK BEFORE CONDENSING.

Problem 18: How to Calculate the Pounds of Skim-milk to Add to Whole Milk.

The ratio between the percentage of milk S. N. F. and the percentage of fat in the whole milk must be more than the required ratio.

Solution of Problem 18, based upon Rule 16:

(1.) Divide the percentage of fat in the skim-milk by the ratio between the S. N. F. and the fat in the product desired. Subtract the answer from the S. N. F. in the skim-milk. Call the remainder A, or the percentage of S. N. F. available for standardizing.

(2.) Divide the percentage of fat in the whole milk by the ratio between the S. N. F. and the fat in the product desired. Call answer B. Subtract from B the percentage of S. N. F. present in the whole milk. Multiply the remainder by the pounds of whole milk in the batch. Call the result C.

(3.) Divide C by A. The answer will be the pounds of skim-milk necessary to standardize the batch to the required ratio.

(4.) Multiply the pounds of whole milk by the fat test of the whole milk. Call the product D. Multiply the pounds of skim-milk by the fat test of the skim-milk. Call the product E.

Add D plus E and divide the sum by the ratio between the sugar and the fat, in the product desired. The answer will be the pounds of sugar required for the total batch.

Solution of Problem 18, based upon Formula 16:

(1.) **To calculate the pounds of skim-milk required.**

$$L = \frac{\left[\left(\frac{F}{R}\right) - S\right]P}{N - \frac{K}{R}}$$

(2.) **To calculate the pounds of sugar to add.**

$$U = \frac{(PF) + (LK)}{Y}$$

Problem 18, Example 19:

PRODUCTS	PER CENT				
	Pounds	Fat	M.S.N.F.	Sugar	T. S.
Milk	10,000	3.79	8.31		12.10
Skim-milk		.16	8.47		8.63
Composition desired after condensing		8.00	20.00	44.50	72.50

Solution of Problem 18, Example 19, based upon Rule 16:

(1.) **To calculate the available S. N. F. in the skim-milk.**

.16÷.40=.40, per cent of milk S. N. F. required to equalize the fat in the skim-milk.

8.47—.40=8.07, per cent of milk S. N. F. available for standardizing.

(2.) **To calculate the pounds of S. N. F. short.**

3.79÷ .40=9.48, per cent of S. N. F. required.

9.48—8.31=1.17, per cent of S. N. F. short.

10000×.0117=117, pounds of S. N. F. short.

(3.) **To calculate the pounds of skim-milk required.**

117÷.0807=1443,, pounds of skim-milk required.

(4.) **To calculate the pounds of sugar required.**

10000×.0379=379, pounds of fat in the whole milk.

1443×.0016= 2, pounds of fat in the skim-milk.
379+ 2= 381, or total pounds of fat in the entire batch.
381÷.1798=2120, pounds of sugar required for total batch.

Condense sufficiently high to provide the proper factor of safety.

Solution of Problem 18, Example 19, based upon Formula 16:

(1.) **To calculate the pounds of skim-milk required.**

$$L = \frac{\left(\frac{.0379}{.40} - .0831\right) \times 10000}{.0847 - \frac{.0016}{.40}} = 1443$$

(2.) **To calculate the pounds of sugar required.**

$$U = \frac{(10000 \times .0379) + (1443 \times .0016)}{.1798} = 2120$$

Proof Problem 18, Example 19:

Products		POUNDS				PER CENT			
		Fat	M.S. N.F.	Sugar	T.S.	Fat	M.S. N.F.	Sugar	T.S.
Milk.....	10000	379	831		1210	3.79	8.31		12.10
Skim-milk.....	1443	2.3	122		124.3	.16	8.47		8.73
Sugar.....	2120			2120	2120			100	100
Standardized product.....	13563	381.3	953	2120	3454.3	2.76	7.02	15.64	25.60

Ratio of M. S. N. F. to fat obtained is 381.3 ÷ 953 = .40.

STANDARDIZING SWEETENED CONDENSED MILK BEFORE CONDENSING.

Problem 19: How to Calculate the Pounds of Cream to Add to Whole Milk.

The ratio between the percentage of milk S. N. F. and fat in the whole milk must be less than the required ratio.

Solution of Problem 19, based upon Rule 17:

(1.) Multiply the percentage of S. N. F. in the cream by the ratio between the S. N. F. and the fat in the product desired,

Subtract the result from the percentage of fat in the cream. Call the remainder A, or the per cent of fat in the cream available for standardizing.

(2.) Multiply the percentage of S. N. F. in the whole milk by the ratio between the S. N. F. and the fat in the product desired. Call the result B, or the percentage of fat required. Subtract from B the percentage of fat present in the whole milk. Multiply the remainder by the pounds of whole milk in the batch. Call the result C, or the pounds of fat short.

(3.) Divide C by A. The answer will be the pounds of cream required to standardize the batch to the desired ratio.

(4.) Multiply the pounds of whole milk by the fat test of the whole milk. Call the answer D. Multiply the pounds of cream by the fat test of the cream. Call the result E. Add D to E, and divide the sum by the ratio between the percentage of sugar and the percentage of fat in the product desired. The answer will be the number of pounds of sugar required for the total batch.

Solution of Problem 19, based upon Formula 17:

(1.) **To calculate the pounds of cream required.**

$$O = \frac{[\,(SR) - F]\,P}{G - VR}$$

(2.) **To calculate the pounds of sugar required.**

$$U = \frac{(PF) + (OG)}{Y}$$

Problem 19, Example 20:

Products	Pounds	PER CENT			
		Fat	M. S. N. F.	Sugar	T. S.
Milk.....	10000	3.35	8.63		11.98
Cream.....		26.38	6.44		32.82
Sugar.....					100.00
Composition desired after condensing.....		8.00	20.00	44.50	72.50

Solution of Problem 19, Example 20, based upon Rule 17:

(1.) **To calculate the available fat in the cream.**

6.44 × .40 = 2.56, per cent of fat required to equalize the S. N. F. in the cream.

26.38 — 2.56 = 23.80, per cent of fat available for standardizing.

(2.) **To calculate the pounds of fat short.**

8.63 × .40 = 3.45, per cent of fat required.

3.45 — 3.35 = .10, per cent of fat short.

10000 × .0010 = 10 pounds, of fat short.

(3.) **To calculate the pounds of cream required.**

10 ÷ .2380 = 43, pounds of cream required.

(4.) **To calculate the pounds of sugar required.**

10000 × .0335 = 335, pounds of fat in whole milk.

43 × .2638 = 11, pounds of fat in cream.

335 + 11 = 346, total pounds of fat in entire batch.

346 ÷ .1796 = 1926, pounds of sugar required for the total batch.

Condense sufficiently to provide the proper factor of safety.

Solution of Problem 19, Example 20, based upon Formula 17:

(1.) **To calculate the pounds of cream required.**

$$O = \frac{[(.0863 \times .40) - .0335] \times 10000}{.2638 - (.0644 \times .40)} = 42.85$$

(2.) **To calculate the pounds of sugar required.**

$$U = \frac{(10000 \times .0335) + (42.85 \times .2638)}{.1798} = 1926$$

Proof of Problem 19, Example 20:

Products		POUNDS				PER CENT			
		Fat	M. S. N. F.	Sugar	T. S.	Fat	M. S. N. F.	Sugar	T. S.
Milk....	10000	335.00	863		1198	3.35	8.63		11.98
Cream...	42.85	11.39	2.76		14.06	26.38	6.44		32.82
Sugar....	1926.00			1926	1926.00			100	100.00
Stand'zed Product	11968.85	346.30	865.76	1926	3138.06	2.83	7.23	16.09	26.15

Ratio of M. S. N. F. to fat obtained is $346.3 \div 865.7 = .40$.
Ratio of sugar to fat obtained is $346.3 \div 1926 = .1798$.

STANDARDIZING SWEETENED CONDENSED MILK BEFORE CONDENSING.

Problem 20: How to Calculate the Pounds of Cream to Add to Skim-milk.

Solution of Problem 20, based upon Rule 18:

(1.) Multiply the percentage of S. N. F. in the cream by the ratio between the S. N. F. and the fat in the product desired. Subtract the result from the percentage of fat in the cream. Call the remainder A, or the percentage of fat in the cream available for standardizing.

(2.) Multiply the percentage of S. N.F. in the skim-milk by the ratio between the S. N. F. and the fat in the product desired. Call the result B. Subtract from B the percentage of fat in the skim-milk and multiply the remainder by the pounds of skim-milk in the batch. Call the result C. Divide C by A. The answer will be the pounds of cream required to standardize the batch to the required ratio.

(3.) Multiply the pounds of skim-milk in the batch by the percentage of fat in the skim-milk. Call the answer D. Multiply the pounds of cream required by the percentage of fat in the cream. Call answer E. Add D to E and divide the sum of the two by the ratio between the percentage of cane sugar and the percentage of fat in the product desired. The answer will be the pounds of sugar required for the total batch.

Solution of Problem 20, based upon Formula 18:

(1.) **To calculate the pounds of cream required.**

$$O = \frac{[\,(NR) - K]\ L}{G - (JR)}$$

(2.) **To calculate the pounds of sugar required.**

$$U = \frac{(LK) + (OG)}{Y}$$

Problem 20, Example 21:

Products	Pounds	PER CENT			
		Fat	M. S. N. F.	Sugar	T. S.
Skim-milk...	10000	.20	8.63		8.83
Cream.....		26.38	6.44		32.82
Sugar.....				100.00	100.00
Composition desired after condensing.....		8.00	20.00	44.50	72.50

Solution of Problem 20, Example 21, based upon Rule 18:

(1.) **To calculate the available fat in the cream.**

$6.44 \times .40 = 2.58$, per cent of fat required to equalize the S. N. F. in cream.

$26.38 - 2.58 = 23.80$, per cent of fat in the cream available for standardizing.

(2.) **To calculate the pounds of fat short.**

$8.63 \times .40 = 3.45$, per cent of fat required.

$3.45 - .20 = 3.25$, per cent of fat short.

$10000 \times .0325 = 325$, pounds of fat short.

(3.) **To calculate the pounds of cream required.**

$325 \div .2380 = 1366$, pounds of cream required.

(4.) **To calculate the pounds of sugar required.**

$10000 \times .0020 = 20$, pounds of fat in skim-milk.

$1366 \times .2638 = 360$, pounds of fat in cream.

$20 + 360 = 380$, total pounds of fat in the batch.

$380 \div .1798 = 2115$, pounds of sugar required for the total batch.

Solution of Problem 20, Example 21, based upon Formula 18:

(1.) **To calculate the pounds of cream required.**

$$O = \frac{[(.0863 \times .40) - .002] \times 10000}{.2638 - (.0644 \times .40)} = 1366$$

(2.) **To calculate the pounds of sugar required.**

$$U = \frac{(10000 \times .002) + (1366 \times .2638)}{.1798} = 2115$$

Proof of Problem 20, Example 21:

Products		POUNDS				PER CENT			
		Fat	M. S. N. F.	Sugar	T. S.	Fat	M. S. N. F.	Sugar	T. S.
Skim-milk.....	10000	20	863		883	.20	8.63		8.83
Cream...	1366	360	88		448	26.38	6.44		32.82
Sugar....	2115			2115	2115			100.00	100.00
Stand-ardized product	13481	380	951	2115	3446	2.82	7.05	15.52	25.38

Ratio of M. S. N. F. to fat obtained is $380 \div 950 = .40$.
Ratio of sugar to fat obtained is $380 \div 2115 = .1798$.

STANDARDIZING SWEETENED CONDENSED MILK BEFORE CONDENSING.

Problem 21: How to Calculate the Pounds of Cream to Add, Knowing the Pounds of Whole and Skim-milk on Hand, and the Percentage of Fat and S. N. F. in All Three Products.

Solution of Problem 21, based upon Rule 19:

(1.) If the ratio between the S. N. F. and the fat in the fresh milk is more than the required ratio, standardize the fresh milk with the skim-milk, using Rule 16. Deduct the pounds of skim-

milk required to standardize the fresh milk from the total pounds of skim-milk on hand.

(2.) If the ratio between the percentage of S. N. F. and the percentage of fat in the fresh milk is less than the required ratio, standardize the fresh milk with cream, using Rule 17.

(3.) Now standardize the skim-milk remaining under (1), or all the skim-milk on hand, as in the case under (2), using Rule 18 to arrive at the amount of cream necessary to add in either case. Make the necessary calculations to get the proper weights under the double standardization.

(4.) Multiply the pounds of whole milk in the batch by the percentage of fat in the whole milk. Call the answer A. Multiply the pounds of skim-milk by the fat test of the skim-milk. Call the answer B. Multiply the pounds of cream required by the fat test of the cream. Call the answer C. Divide the sum of A, B and C by the ratio between the percentage of sugar and the percentage of fat in the product desired. The answer will be the number of pounds of sugar required for the total batch.

Solution of Problem 21, based upon Formula 19:

(1.) **To calculate the pounds of cream required to standardize the whole milk.**

$$O = \frac{[(S\,R) - F]\,P}{G - (JR)}$$

(2.) **To calculate the pounds of cream required to standardize the skim-milk.**

$$O = \frac{[(N \times R) - K]\,L}{G - (J \times R)}$$

(3.) **To calculate the pounds of sugar to add.**

$$U = \frac{(P \times F) + (L \times K) + (O \times G)}{Y}$$

Note—The value of O in part (3) of the formula equals the value of O in part (1) plus the value of O in part (2) of the formula.

Problem 21, Example 22:

Products	Pounds	PER CENT			
		Fat	M. S. N. F.	Sugar	T. S.
Milk.....	10,000	3.20	8.40		11.60
Skim-milk...	600	.16	8.47		8.63
Cream.....		26.38	6.44		32.82
Composition desired.....		8.00	20.00	44.50	72.50

Desired ratio of milk solids not fat to fat is 1 to .40.

Desired ratio of sugar to fat is 1 to .1798.

Solution of Problem 21, Example 22, based upon Rule 19:

A. Standardize the whole milk, using Rule 17:

(1.) **To calculate the available fat in the cream.**

$6.44 \times .40 = 2.58$, per cent of fat required to equalize the S. N. F. in cream.

$26.38 - 2.58 = 23.80$, per cent of fat available for standardizing.

(2.) **To calculate the pounds of fat short.**

$8.40 \times .40 = 3.36$, per cent of fat required.

$3.36 - 3.20 = .16$, per cent of fat short.

$10000 \times .0016 = 16$, pounds of fat short.

(3.) **To calculate the pounds of cream required.**

$16 \div .2380 = 67$, or the pounds of cream required to standardize the whole milk.

Should the whole milk require skim-milk instead of cream, use Rule 16 and subtract pounds of skim-milk required from the total pounds of skim-milk, and then standardize the balance of the skim-milk, using Rule 18.

B. Standardize the skim-milk with cream, using Rule 18.

(1.) **To calculate the available fat in the cream.**

Same as under A (1) above = 23.80.

$8.47 \times .40 = 3.39$, per cent of fat required.

$3.39 - .16 = 3.23$, per cent of fat short.

$600 \times .0323 = 19$, pounds of fat short.

(3.) **To calculate the pounds of cream required**

$21 \div .2380 = 81$, pounds of cream required to standardize the skim-milk.

C. Adding together answer obtained under A and B = 67 plus 81 = 148, pounds of cream required to standardize the entire batch.

(4.) D. **To calculate the pounds of sugar required.**

$10000 \times .0320 = 32$, pounds of fat in whole milk.

$600 \times .0016 = 1$, pounds of fat in skim-milk.

$(67 + 81) \times .2638 = 39$, pounds of fat in cream.

$320 + 1 + 39 = 360$, pounds of fat in entire batch.

$360 \div .1798 = 2003$, pounds of sugar required for total batch.

Solution of Problem 21, Example 22, based upon Formula 19:

(1.) **To calculate the pounds of cream required to standardize the whole milk.**

$$O = \frac{[\,(.0840 \times .40) - .0320] \times 10000}{.2638 - (.0644 \times .40)} = 67.20$$

(2.) **To calculate the pounds of cream required to standardize the skim-milk.**

$$O = \frac{[\,(.0847 \times .40) - .0016] \times 600}{.2638 - (.0644 \times .40)} = 81.36$$

(3.) **To calculate the pounds of sugar to add.**

$$U = \frac{(10000 \times .0320) + (600 \times .0016) + (148.56 \times .2638)}{.1798} = 2003$$

Proof of Problem 21, Example 22:

Products	Pounds	POUNDS				PER CENT			
		Fat	M. S. N. F.	Sugar	T. S.	Fat	M. S. N. F.	Sugar	T. S.
Milk....	10000	320.00	840.00		1160.0	3.20	8.40		11.60
Skim-milk.....	600	.96	51		51.9	.16	8.47		8.63
Cream...	148	39.19	9		48.1	26.38	6.44		32.82
Sugar....	2003.0			2003.0	2003.0			100.00	100.
Standardized product..	12751	360	900	2003.0	3263.0	2.82	7.05	15.70	25.57

The ratio of M. S. N. F. to fat obtained is 1 to .40.
The ratio of sugar to fat obtained is 1 to .1798.

STANDARDIZING SWEETENED CONDENSED MILK BEFORE CONDENSING.

Problem 22: How to Calculate the Pounds of Sweetened Condensed Skim-milk to Add to Whole Milk.

Solution of Problem 22, based upon Rule 20:

(1.) Divide the fat in the condensed skim-milk by the ratio between the S. N. F. and the fat in the product desired. Subtract the answer from the percentage of S. N. F. in the skim-milk. Call remainder A, or the percentage of milk S. N. F. in the condensed skim-milk available for standardizing.

(2.) Divide the percentage of fat in the whole milk by the ratio between the S. N. F. and the fat in the product desired. Call the answer B. Subtract from B the percentage of S. N. F. present in the whole milk and multiply the remainder by the pounds of whole milk in the batch. Call the result C.

(3.) Divide C by A. The answer will be the pounds of condensed skim-milk required to standardize the batch to the required ratio.

(4.) Multiply the pounds of whole milk by the fat test of the whole milk. Call the product D. Multiply the pounds of con-

densed skim-milk by the fat test of the skim-milk. Call the product E. Add D and E and divide the sum of the two by the ratio between the sugar and the fat in the product desired. The answer will be the pounds of sugar required for the total batch.

Solution of Problem 22, based upon Formula 20:

(1.) **To calculate the pounds of sweetened condensed skim-milk required.**

$$L^1 = \left[\left(\frac{F}{R} - S\right)P\right] \div \left(I - \frac{M}{R}\right)$$

(2.) **To calculate the pounds of sugar required.**

$$U = \left[\frac{(P \times F) + (L^1 \times M)}{Y}\right] - (L^1 \times Z)$$

Problem 22, Example 23:

Products	Pounds	PER CENT			
		Fat	M. S. N. F.	Sugar	T. S.
Whole milk	10000	3.70	8.40		12.10
Sweetened condensed Skim-milk		1.00	28.00	42.00	71.00
Composition desired		8.00	20.00	44.50	72.50

Desired ratio of M. S. N. F. to fat is 1 to .40.
Desired ratio of sugar to fat is 1 to .1798.

Solution of Problem 22, Example 23, based upon Rule 20:

(1.) **To calculate the percentage of available S. N. F. in the condensed skim-milk.**

$1.00 \div .4 = 2.50$, per cent of milk S. N. F. required to equalize the fat in the skim-milk.

$28.00 - 2.50 = 25.5$, per cent of milk S. N. F. available for standardizing.

(2) **To calculate the pounds of milk S. N. F. short.**

$3.7 \div .4. = 9.25$ per cent of milk S. N. F. required.

$9.25 - 8.40 = .85$, per cent of milk S. N. F. short.

$10000 \times .0085 = 85$, pounds of milk S. N. F. short.

(3.) **To calculate pounds of condensed skim-milk required.**

$85 \div .255 = 333$, pounds of condensed skim-milk.

(4.) **To calculate the pounds of sugar required.**

$10000 \times .037 = 370$, pounds of fat in whole milk.

$333 \times .01 = 3.3$, pounds of fat in condensed skim-milk.

$370 + 3.3 = 373.3$, total pounds of fat in batch.

$373.3 \div .1798 = 2076$, pounds of sugar required for total batch.

$333 \times .42 = 140$, pounds of sugar added in condensed skim-milk.

$2076 - 140 = 1936$, pounds of sugar to be added to whole milk.

Solution of Problem 22, Example 23, based upon Formula 20:

(1.) **To calculate the pounds of sweetened condensed skim-milk required.**

$$L^1 = \frac{\left(\frac{.0370}{.40} - .0840\right) \times 10000}{.2800 - \frac{.0100}{.40}} = 333.3$$

(2.) **To calculate the pounds of sugar required.**

$$U = \left[\frac{(10000 \times .0370) + (333.3 \times .0100)}{.1798}\right] - (333.3 \times .42) = 1936.$$

Proof of Problem 22, Example 23:

Products	Pounds	POUNDS				PER CENT			
		Fat	M. S. N. F.	Sugar	T. S.	Fat	M. S. N. F.	Sugar	T. S.
Milk....	10000	370	840		1210	3.70	8.40		
Sweet'd Cond. Skim milk	333	3.3	93	140	236	1.00	28.00	42.00	71.00
Sugar...	1936			1936	1936			100.00	100.00
Stand-ardized product..	12269	373.3	933	2076	3382	3.00	7.51	16.72	27.23

Ratio of M. S. N. F. to fat obtained is $373.3 \div 933 = .40$.

Ratio of sugar to fat obtained is $373.3 \div 2076 = .1798$.

STANDARDIZING SWEETENED CONDENSED MILK BEFORE CONDENSING.

Problem 23: How to Calculate the Pounds of Unsweetened Condensed Skim-milk to Add to Whole Milk.

Solution of Problem 23, based upon Rule 21:

(1.) Divide the percentage of fat in the unsweetened condensed skim-milk by the ratio between the S. N. F. and the fat desired. Subtract the answer from the S. N. F. in the unsweetened condensed skim-milk. Call the remainder A, or the percentage of S. N. F. available for standardizing in the unsweetened condensed skim-milk.

(2.) Divide the percentage of fat in the whole milk by the ratio between the S. N. F. and the fat, in the product desired. Call the answer B. Subtract B from the percentage of S. N. F. present in the whole milk, and multiply the remainder by the pounds of whole milk in the batch. Call the result C.

(3.) Divide C by A. The result will be the pounds of skim-milk required to standardize the batch to the required ratio.

(4.) Multiply the pounds of whole milk by the fat test of the whole milk. Call the product D. Multiply the pounds of unsweetened condensed skim-milk by the fat test of the unsweetened condensed skim-milk. Call the product E. Add D and E, and divide the sum by the ratio between the sugar and the fat in the product desired. The answer will be the pounds of sugar required for the total batch.

Solution of Problem 23, based upon Formula 21:

(1.) **To calculate the pounds of unsweetened condensed skim-milk required.**

$$Q = \left[\left(\frac{F}{R} - S\right)P\right] \div \left(I^1 = \frac{G^1}{R}\right)$$

(2.) **To calculate the pounds of sugar required.**

$$U = \frac{(P \times F) + (Q \times G^1)}{Y}$$

Problem 23, Example 24:

Products	Pounds	PER CENT			
		Fat	M. S. N. F.	Sugar	T. S.
Milk.....	10000	3.70	8.40		12.10
Unsweetened condensed skim-milk...		.05	29.95		30.00
Composition desired after condensing..		8.00	20.00	44.50	72.50

Desired ratio of M. S. N. F. to fat is 1 to .40.

Desired ratio of sugar to fat is 1 to .1798.

Solution of Problem 23, Example 24, based upon Rule 21:

(1.) **To calculate the available S. N. F. in the condensed skim-milk.**

.05÷.4=.13, per cent of milk S. N. F. required to equalize the fat in the condensed skim-milk.

29.95 — .13 = 29.82, per cent of milk S. N. F. available for standizing.

(2.) **To calculate the pounds of milk S. N. F. short.**

3.7 ÷ .4 = 9.25, per cent of milk S. N. F. required.

9.25 — 8.40 = .85, per cent of milk S. N. F. short.

10000 × .0085=85, pounds of milk S. N. F. short.

(3.) **To calculate the pounds of condensed skim-milk required.**

85÷.2982=285, pounds of condensed skim-milk required.

(4.) **To calculate the pounds of sugar required.**

10000 × .0370 = 370, pounds of fat in the whole milk.

285 × .0005 = .14, pounds of fat in condensed skim-milk.

370.14 ÷ .1798 =2059, pounds of sugar required for total batch.

Solution of Problem 23, Example 24, based upon Formula 21:

(1.) **To calculate the pounds of unsweetened condensed skim-milk required.**

$$Q = \frac{\left[\left(\frac{.0370}{.40} - .0840\right) \times 10000\right]}{.2995 - \left(\frac{.0005}{.40}\right)} = 285$$

(2.) **To calculate the pounds of sugar required.**

$$U = \frac{(10000 \times .0370) + (285 \times .0005)}{.1798} = 2059$$

Proof of Problem 23, Example 24:

Products	Pounds	POUNDS				PER CENT			
		Fat	M. S. N. F.	Sugar	T. S.	Fat	M. S. N. F.	Sugar	T. S.
Milk....	10000	370	840		1210	3.70	8.40		12.10
Unsweetened condensed skim-milk	285	.14	85		85.14	.05	29.95		30.00
Sugar....	2059			2059	2059			100.00	100.00
Standardized product..	12344	370.14	925	2059	3354	3.00	7.50	16.68	27.10.

Ratio of M. S. N. F. to fat obtained is $370.15 \div 925 = .40$.
Ratio of sugar to fat obtained is $370.15 \div 2059 = .1798$.

STANDARDIZING SWEETENED CONDENSED MILK BEFORE CONDENSING.

Problem 24: How to Calculate the Pounds of Unsweetened Condensed Whole Milk to Add to Whole Milk.

Solution of Problem 24, based upon Rule 22:

(1.) Multiply the pounds of whole milk in the batch by the test of the whole milk. Call the answer A. Multiply the pounds of condensed whole milk in the batch by the fat test of the condensed whole milk. Call the answer B. Add A to B. Call the

sum C, or the pounds of fat in the mixed batch. Divide C by the weight of whole milk and condensed whole milk in the batch. Call the answer D or the percentage of fat in the mixed batch. Multiply the pounds of whole milk by the percentage of S. N. F. in the whole milk. Call the answer E. Multiply the pounds of condensed whole milk in the batch by the percentage of S. N. F. in the batch. Call the answer F, or the pounds of S. N. F. in the condensed whole milk. Add E and F. Call the sum G, or the pounds of S. N. F. in the mixed batch. Divide G by the pounds of whole milk plus the pounds of condensed whole milk in the batch. Call the answer H, or the percentage of S. N. F. in the mixed batch. Divide the percentage of fat in the unsweetened condensed skim-milk by the ratio between the S. N. F. and the fat in the product desired. Call the answer I. Subtract I from the percentage of S. N. F. in the unsweetened condensed skim-milk. Call the remainder J.

(2.) Divide the percentage of fat in the mixed batch by the ratio between the S. N. F. and the fat in the product desired. Call the answer K. Subtract from K the percentage of S. N. F. in the mixed batch. Call the remainder L. Multiply the total pounds of whole milk and condensed whole milk in the batch by L. Call the product M, or the pounds of fat short.

(3.) Divide M by the percentage of S. N. F. available for standardizing in the condensed skim-milk. Call answer N, or the pounds of condensed skim-milk required.

(4.) Multiply the total pounds of whole milk and condensed whole milk by the average fat test of the mixed batch. Call the product O. Multiply the pounds of unsweetened condensed skim-milk by the fat test of the unsweetened condensed skim-milk. Call the product P. Divide the sum of O and P by the ratio between the sugar and the fat in the product desired. The answer will be the number of pounds of sugar required for the total batch.

Solution of Problem 24, based upon Rule 22:

(1.) **To calculate the percentage of fat in the mixed batch.**

$$S^1 = \frac{(PF) + (DK^1)}{P + D}$$

(2.) **To calculate the percentage of S. N. F. in the mixed batch.**

$$V^1 = \frac{(PS) + (DS^2)}{P + D}$$

(3.) **To calculate the pounds of unsweetened condensed skim-milk required.**

$$Q = \left[\left(\frac{S^1}{R} - V^1\right)P\right] \div \left(S^2 - \frac{G^1}{R}\right)$$

(4.) **To calculate the pounds of sugar required.**

$$U = \frac{(S^1 P) + (G^1 Q)}{Y}$$

Problem 24, Example 25:

Products	Pounds	PER CENT			
		Fat	M. S. N. F.	Sugar	T. S.
Milk.....	10000.0	3.70	8.40		12.10
Condensed Whole milk	1000.0	10.00	28.00		38.00
Condensed Skim-milk...		.05	29.95		30.00
Composition desired after condensing..		8.00	20.00	44.50	72.50

Desired ratio of fat to milk solids not fat is .40 to 1.
Desired ratio of sugar to fat is .1798.

Solution of Problem 24, Example 25, based upon Rule 22:

(1.) **To calculate the average test of the mixed milk.**

100000 × .0370 = 370, pounds of fat in whole milk.
1000 × .10 = 100, pounds of fat in condensed whole milk.
370 + 100 = 470, pounds of fat in mixed batch.
470 ÷ 11000 = 4.27, per cent of fat in mixed batch.
10000 × .0840 = 840, pounds of S. N. F. in whole milk.

1000 × .28 = 280, pounds of S. N. F. in condensed whole milk.

840 + 280 = 1120, pounds of S. N. F. in the mixed batch.

10000 + 1000 = 11000, total of pounds whole milk and condensed whole milk in the batch.

1120 ÷ 11000 = 10.18, per cent of S. N. F. in mixed batch.

.05 ÷ .4 = .13, per cent milk S. N. F. required to equalize the fat in the skim-milk.

29.95 — .13 = 29.82, per cent S. N. F. available in the skim-milk for standardizing.

(2.) **To calculate the pounds of milk S. N. F. short.**

4.27 ÷ .40 = 10.68, per cent of milk S. N. F. required.

10.68 — 10.18 = .50, per cent of milk S. N. F. short.

10000 × .005 = 50, pounds of milk S. N. F. short.

(3.) **To calculate the pounds of condensed skim-milk required.**

50 ÷ .2982 = 166, pounds of condensed skim-milk required.

(4.) **To calculate the pounds of sugar required.**

11000 × .0427 = 470, pounds of fat in the mixed batch.

166 × .0005 = .08, pounds of fat in the condensed skim-milk.

470 ÷ .1798 = 2614, pounds of sugar required for the total batch.

Solution of Problem 24, Example 25, based upon Formula 22.

(1.) **To calculate the percentage of fat in the mixed batch.**

$$S^1 = \frac{(10000 \times .037) + (1000 \times .10)}{10000 + 100} = 4.27$$

(2.) **To calculate the percentage of S. N. F. in the mixed batch.**

$$S^3 = \frac{(10000 \times .084) + (1000 \times .28)}{10000 + 1000} = 10.18$$

(3.) **To calculate the pounds of unsweetened condensed skim-milk required.**

$$Q = \frac{\left[\left(\frac{.0427}{.40} - .1018\right) \times 10000\right]}{.2995 - \frac{.0005}{.40}} = 166$$

(4.) **To calculate the pounds of sugar required.**

$$U = \frac{(11000 \times .0427) + (166 \times .0005)}{.1798} = 2614.$$

Proof of Problem 24, Example 25:

Products		POUNDS				PER CENT			
		Fat	M. S. N. F.	Sugar	T. S.	Fat	M. S. N. F.	Sugar	T. S.
Milk....	10000.00	370.0	840.00		1210.0	3.70	8.40		12.10
Cond. whole milk.....	1000.00	100.0	280.00		380.0	10.00	28.00		38.00
Cond. skim-milk	166.0	.08	49.72		49.8	.05	29.95		30.00
Sugar....	2614.0			2614.0	2614.0			100.00	100.00
Standardized product..	13780.0	470.08	1169.72	2614.0	4253.8	3.41	8.50	18.96	30.87

Ratio of S. N. F. to fat obtained is 1 to .40.
Ratio of sugar to fat obtained is 1 to .1798.

STANDARDIZING SWEETENED CONDENSED SKIM-MILK BEFORE CONDENSING

Problem 25: How to Calculate the Pounds of Sugar to Use in Sweetened Condensed Skim-milk.

Solution of Problem 25, based upon Rule 23:

(1.) Multiply the pounds of skim-milk in the batch by the total solids test of the skim-milk. Multiply the answer by the ratio between the total milk solids and the sugar in the product desired. The result will be the pounds of sugar to add to the entire batch.

Solution of Problem 25, based upon Formula 23.

$$U = (LN^1)Y^2$$

Problem 25, Example 26:

Products	Pounds	M. S. N.F.	Sugar	T. S.
Skim-milk.....	10000	8.83		8.83
Composition desired.....		28.00	42.00	70.00

Desired ratio of milk solids to sugar is 1 to 1.50.

Solution of Problem 25, Example 26, based upon Rule 23:

(1.) **To calculate the pounds of sugar required.**

$10000 \times .0883 = 883$, pounds of milk solids in the skim-milk.

$883 \times 1.50 = 1325$, pounds of sugar to use.

Condense the batch sufficiently high to provide the proper factor of safety.

Solution of Problem 25, Example 26, based upon Formula 23:

$$U = (10000 \times .0883) \times 1.5 = 1325$$

Proof of Problem 25, Example 26:

Products		POUNDS			PER CENT		
		M.S.N.F	Sugar	T.S.	M.S.N.F.	Sugar	T.S.
Skim-milk.....	10000	883		883	8.83		8.83
Sugar.....	1325		1325	1325		100.00	100.00
Standardized product	11325	883	1325	2208	7.37	16.42	23.79

Condense the batch high enough to provide the proper factor of safety.

TABLES FOR ASCERTAINING SUGAR REQUIRED.

The quantity of sugar to use for any corresponding weight of T. S. when manufacturing sweetened condensed skim-milk, can be ascertained from tables compiled for any composition desired, and for any quantity range necessary. The use of such tables helps to prevent errors, and it saves calculations. It makes it neces-

sary in practice simply to ascertain the pounds of total solids in the batch, and then by reference to the table, to obtain the weight of sugar to produce a product of the composition desired.

In Problem 25, Example 26, the product is to have a composition of 28.00 per cent total milk solids and 42.00 per cent sugar, or in the ratio 1 part T. M. S. to 1.5 parts sugar. This is the composition desired in the case of nearly all sweetened condensed skim-milk manufactured in the United States. In view of the fact that the above ratio is so simple, but little time, if any, could be saved by compiling tables for this composition. For any who might desire to compile a table either for a product of the above composition, or of any composition desired, specimen Table 43 has been prepared.

TABLE 43.

Ratios between pounds of total milk solids in the batch, and pounds of sugar required, to make sweetened condensed skim-milk testing 28.00 per cent total milk solids, 42.00 per cent sugar, and 70 per cent total solids.

Pounds T.M.S.	Pounds Sugar	Pounds T.M.S.	Pounds Sugar	Pounds T.M.S.	Pounds Sugar	Pounds T.M.S.	Pounds Sugar	Pounds T.M.S.	Pounds Sugar
100	150	250	375	500	750	1000	1500	2500	3750
101	152	251	377	501	752	1001	1502	2501	3752
102	153	252	378	502	753	1002	1503	2502	3753
103	155	253	380	503	755	1003	1505	2503	3755
104	156	254	381	504	756	1004	1506	2504	3756
105	158	255	383	505	758	1005	1508	2505	3758
106	159	256	384	506	759	1006	1509	2506	3759
107	161	257	386	507	761	1007	1511	2507	3761
108	162	258	387	508	762	1008	1512	2508	3762
109	164	259	389	509	764	1009	1514	2509	3764

CHAPTER XIII

THE COMPOSITION AND STANDARDIZATION OF ICE CREAM MIXES

SUGGESTED COMPOSITIONS OF VARIOUS ICE CREAM MIXES.

It is possible to compound satisfactory ice cream mixes varying widely in composition, and there is probably no other dairy product that shows such large variations in composition both in the same and in the different localities, and even in the product of any single manufacturer where no attempt is made at exact chemical control. This is so because the ingredients used in making up an ice cream mix are so different in character and each fluctuates so much in composition. Again, it is sometimes desirable to manufacture more than one quality of ice cream. Table 43 gives the composition of thirteen different ice cream mixes. The proper composition can be selected from the list to meet the needs of manufacturers in all localities. Ice cream of these several compositions is now manufactured in many different localities, and all have given satisfactory products.

THE PHYSICAL AND CHEMICAL PROPERTIES OF VARIOUS ICE CREAM MIXES.

The physical and chemical properties of nine of the most common composition of ice cream mix are given in Table 44. Unless otherwise indicated, the values named are based upon actual determinations. One batch of mix corresponding to each composition named, was carefully compounded and in turn these were used to make the various determinations. The raw materials used to compound these mixes consisted of cream testing 36.00 per cent of fat, superheated bulk condensed whole milk testing 8.00 per cent of fat, sugar and gelatin.

TABLE 43.

Suggested Compositions of Ice Cream Mixes.

No. of Mix	PER CENT				
	Fat	Milk S. N. F.	Sugar	Gelatin	T. S.
1	8.00	11.50	13.00	.50	33.00
2	8.00	12.50	13.00	.50	34.00
3	8.50	12.00	13.00	.50	34.00
4	9.00	11.50	13.00	.50	34.00
5	10.00	10.50	14.00	.50	35.00
5A	11.00	10.50	14.00	.50	36.00
6	12.00	8.50	14.00	.50	35.00
7	12.00	9.50	14.00	.50	36.00
7A	13.00	8.50	14.00	.50	36.00
7B	14.00	9.50	14.00	.50	38.00
7C	15.00	8.50	14.00	.50	38.00
8	16.00	7.50	14.00	.50	38.00
9	18.00	7.50	14.00	.50	40.00

Composition Ratios. In standardizing ice cream mix it is usually necessary to know the ratio between the fat and the M. S. N. F., or that between the fat and the T. S. Both of these ratios are given for each of the nine compositions of mix. Obviously, there is quite a variation in these several ratios.

Viscosity. This was determined by means of the Mojonnier-Doolittle viscosimeter described in Chapter XVII. The viscosity was determined at various temperatures immediately after preparing at 40° F., after aging 24, 48, and 72 hours each respectively. The results of this experiment prove: (1) The viscosity of all mixes regardless of composition, increases as the holding temperature decreases. (2) Viscosity in the case of freshly prepared mix is the same at equal temperatures, regardless of composition when compounded from the same products. (3) viscosity increases with the age of the mix. The increase with age is much greater in the case of ice cream mix high in milk solids not fat. This is no doubt largely due to the action of the acid that develops during aging, upon the casein and albumin contained in the mix. The gelatin content of the mix may also

exert a large influence upon its viscosity. The quality and quantity of the gelatin used determines largely the extent of its effect upon the viscosity of the mix.

Titratable Acidity. This was usually higher both immediately after preparing, and also after aging, in the case of all mixes, containing the higher percentage of milk solids not fat. There is a close correlation between titratable acidity and viscosity.

The percentage of titratable acidity in fresh ice cream mix is dependent upon the quantity of acid contained in the raw materials used, and it is derived chiefly from the milk solids not fat in the raw materials.

There is no general agreement as to what constitutes the most desirable percentage of acidity in ice cream mix at the time of freezing. A mix containing 12.00 per cent of milk solids not fat made from whole milk testing .16 per cent of titratable acidity and containing 8.60 per cent of milk solids not fat and from sweet butter without acid should test after condensing about .23 per cent of titratable acidity. Controlling the acid content of the mix between close limits would no doubt favorably influence the uniformity of the flavor. The higher the content of milk solids not fat in the mix, the higher will be the titratable acidity in the same, when the same raw products are used.

Specific Gravity. This value increases as the temperature decreases, regardless of composition. Changes in composition are immediately reflected in the specific gravity. Obviously the higher the fat content the lower the specific gravity for any given percentage of S. N. F.

Weight per U. S. Gallon of Mix. This is based upon the specific gravity determinations at the various temperatures, compared with water weighing 8.34 pounds per U. S. gallon.

Weight per U. S. Gallon of Ice Cream. The weight of one gallon of mix at 40° F. was taken as unity. The weight of one gallon of ice cream at various percentages of overrun was calculated from the above unit basis. The results in Table 44 indicate the differences in the weight of ice cream of various compositions, at the same overrun.

Available Heat of Combustion. This is given upon the basis both of one pound of mix, and of one U. S. gallon of ice cream

at 100 and at 80 per cent of overrun, respectively expressed as calories and as B. T. U. The factors given by Richmond[1] were used. These were based upon the combustion of the three constituents in the human body, and take into consideration that portion of the protein which is not combusted, but which is voided in the form of urea. The gelatin was added to the milk proteins. The factors are as follows:—

Available heat of combustion one kilogram butter fat=9.230 Calories.

Available heat of combustion one kilogram milk sugar=3.950 Calories.

Available heat of combustion one kilogram cane sugar=3.955 Calories.

Availiable heat of combustion one kilogram protein=4.970 Calories.

Specific Heat. This was calculated from the values given by Hammer & Johnson.[2] The calculations were all made upon the basis of a temperature of zero degrees F., using the following formula:—

$$\text{Specific Heat} = \left(\frac{\text{Per cent fat}}{100}\right).445 + \left(\frac{100-\text{per cent fat}}{100}\right).940$$

It was assumed in these calculations that the specific heat of the cane sugar added to the mix, was the same as the specific heat of milk serum.

Freezing Point. The freezing points were determined by the depression method using a Beckman thermometer. This value showed comparatively little fluctuation. The largest part of the depression is caused by the milk sugar and the cane sugar that are in the solution. A solution containing 6.00 per cent milk sugar and 14.00 per cent cane sugar was found to have a freezing point of 29.38° F.

Calculated upon the basis of the water content only, the sum of the percentages of milk sugar and the cane sugar is proportionately larger than in ice cream mix. Mix No. 1 contains a total of about 19.21 per cent of milk sugar and cane sugar. Calculated upon a water content of 67.00 per cent this is equivalent to a concentration of 22.25 per cent, based upon the water content only, or 28.67 parts of the two sugars per 100 parts of water.

Heat Units Required to Melt Ice Cream. The feeling of coldness experienced in eating ice cream is due to the heat units that are absorbed in the mouth due to the melting of the ice cream. This is the sum of the normal heat and the latent heat. The calculation is shown in the case of ice cream containing 100 per cent overrun, and therefore weighing 4.60 lbs. per U. S. gallon, raised in temperature from 20° F. to 60° F. The method of calculation used is illustrated in the case of ice cream mix No. 1 as follows:—

Normal heat $=(4.60\times.900)\times 40=165.6$ B. T. U.

Latent heat $=(4.60\times.6700)\times144=443.8$ B. T. U.

Total .....$=609.4$ B. T. U.

These values in this table explain why the feeling of coldness varies with different ice creams. Ice cream made from mix No. 9 will feel about 12.00 per cent warmer to the tongue than ice cream made from mix No. 1.

Nutritive Ratios. These are expressed from the standpoints of both, composition in the ratio:—fat : sugar : protein; and available heat units in the ratio:—protein : (fat+sugar).

It is most significant that it is possible to compound a high quality of ice cream mix in which the various constituents are in very nearly the right proportions to best stimulate growth and sustain life. Extremes in composition do not produce this favorable result.

For children, ice cream testing 10.00 per cent fat; 10.50 per cent milk solids not fat; 14.00 per cent sugar and .50 per cent gelatin;—totaling 35.00 per cent total solids, most nearly approaches the theoretical requirements of a properly balanced ration. For adults ice cream testing 8.00 per cent fat; 12.50 per cent milk solids not fat; 13.00 per cent sugar, and .50 per cent gelatin,—totaling 34.00 per cent total solids, approaches very closely the theoretical requirements.

The above ratios apply only when ice cream is consumed alone. It is very frequently consumed as a dessert, in which case its nutritive value influences the balance of the diet. The questions of flavor and palatability also exert an important influence upon this problem. Ice creams rich in butter fat are preferred by

TABLE 44.

The Physical and Chemical Properties and the Nutritive Ratio of Ice Cream Mix.

No. of Mix	Composition of Mix Per Cent						Composition Ratios		Viscosity				(° Retardation)			Titratable Acidity (in Per Cent)			
	Fat	Milk S. N. F.	Sugar	Gelatin	T. S.	Water	Ratio Fat to M. S. N. F.	Ratio Fat to T. S	Immediately After Preparing Temp. F.				After Aging 24 Hours	After Aging 48 Hours	After Aging 72 Hours	Immediately After Preparing	After Aging 24 Hours	After Aging 48 Hours	After Aging 72 Hours
									140	120	60	40	40°	40°	40°				
1	8.00	11.50	13.00	.50	33.00	67.00	1 : 1.4375	1 : 4.1250	16	20	25	30	40	55	80	.36	.38	.44	.68
2	8.00	12.50	13.00	.50	34.00	66.00	1 : 1.5625	1 : 4.2500	16	21	25	30	55	80	110	.33	.35	.40	.56
3	8.50	12.00	13.00	.50	34.00	66.00	1 : 1.4118	1 : 4.0000	16	20	25	30	55	80	100	.34	.37	.38	.50
4	9.00	11.50	13.00	.50	34.00	66.00	1 : 1.2778	1 : 3.7778	16	20	25	30	50	70	70	.35	.35	.36	.46
5	10.00	10.50	14.00	.50	35.00	65.00	1 : 1.0500	1 : 3.5000	16	20	25	30	40	60	65	.31	.34	.36	.45
6	12.00	8.50	14.00	.50	35.00	65.00	1 : .7083	1 : 2.9167	16	20	25	30	45	45	50	.26	.26	.27	.38
7	12.00	9.50	14.00	.50	36.00	64.00	1 : .7917	1 : 3.0000	16	20	25	30	45	45	55	.28	.29	.30	.50
8	16.00	7.50	14.00	.50	38.00	62.00	1 : .4688	1 : 2.3750	16	20	25	30	40	45	60	.21	.25	.29	.41
9	18.00	7.50	14.00	.50	40.00	60.00	1 : .4167	1 : 2.2222	16	20	25	30	45	55	65	.24	.24	.30	.40

No. of Mix	Composition of Mix Per Cent						Specific Gravity (Compared with Water at 60° F.) Temperature						Weight One U. S. Gallon of Mix at °F. (1 Gal. Water = 8.34 Pounds		
	Fat	Milk S. N. F.	Sugar	Gelatin	T. S.	Water	140	120	100	70	50	40	140	70	40
1	8.00	11.50	13.00	.50	33.00	67.00	1.0772	1.0834	1.0876	1.0957	1.1016	1.1022	8.98	9.14	9.19
2	8.00	12.50	13.00	.50	34.00	66.00	1.0815	1.0880	1.0906	1.0978	1.1030	1.1043	9.02	9.16	9.21
3	8.50	12.00	13.00	.50	34.00	66.00	1.0917	1.0839	1.0887	1.0970	1.1010	1.1031	9.00	9.15	9.20
4	9.00	11.50	13.00	.50	34.00	66.00	1.0738	1.0808	1.0859	1.0923	1.0949	1.0954	8.96	9.11	9.13
5	10.00	10.50	14.00	.50	35.00	65.00	1.0728	1.0792	1.0849	1.0927	1.0985	1.1005	8.95	9.11	9.18
6	12.00	8.50	14.00	.50	35.00	65.00	1.0616	1.0680	1.0735	1.0822	1.0880	1.0899	8.85	9.03	9.09
7	12.00	9.50	14.00	.50	36.00	64.00	1.0667	1.0727	1.0779	1.0867	1.0928	1.0946	8.90	9.06	9.13
8	16.00	7.50	14.00	.50	38.00	62.00	1.0558	1.0617	1.0677	1.0764	1.0835	1.0848	8.81	8.98	9.05
9	18.00	7.50	14.00	.50	40.00	60.00	1.0526	1.0586	1.0648	1.0749	1.0811	1.0841	8.78	8.96	9.04

TABLE 44 (Continued).

No. of Mix	Composition of Mix Per Cent						Weight One U. S. Gallon Frozen Ice Cream at Different Percentages of Overrun (In Pounds)							Available Heat of Combustion One Pound of Mix Calculated	
	Fat	Milk S. N. F.	Sugar	Gelatin	T. S.	Water	110	100	90	80	70	60	50	Calories	B. T. U.
1	8.00	11.50	13.00	.50	33.00	67.00	4.38	4.60	4.84	5.11	5.41	5.74	6.13	.78833	3.128
2	8.00	12.50	13.00	.50	34.00	66.00	4.38	4.60	4.85	5.12	5.42	5.76	6.14	.80664	3.201
3	8.50	12.00	13.00	.50	34.00	66.00	4.38	4.60	4.84	5.11	5.41	5.75	6.13	.81850	3.248
4	9.00	11.50	13.00	.50	34.00	66.00	4.35	4.57	4.81	5.07	5.37	5.71	6.09	.83034	3.295
5	10.00	10.50	14.00	.50	35.00	65.00	4.37	4.59	4.83	5.10	5.40	5.73	6.12	.87204	3.460
6	12.00	8.50	14.00	.50	35.00	65.00	4.33	4.55	4.78	5.05	5.35	5.69	6.06	.91938	3.648
7	12.00	9.50	14.00	.60	36.00	64.00	4.35	4.57	4.81	5.07	5.37	5.71	6.09	.93756	3.720
8	16.00	7.50	14.00	.50	38.00	62.00	4.31	4.53	4.76	5.03	5.32	5.66	6.03	1.06870	4.241
9	18.00	7.50	14.00	.50	40.00	60.00	4.30	4.52	4.76	5.02	5.32	5.65	6.03	1.15244	4.573

No. of Mix	Composition of Mix Per Cent						Available Heat of Combustion One Gallon Frozen Ice Cream at Different Per Cents of Overrun Calculated				Specific Heat at 0° F. Calculated from Factors:- S.H. = (Fat x.445)+ (100—Fat) x.940	Freezing Points = Temp. °F.	Heat Units Required to Raise Temperature from 20° F. to 60° F. in One U. S. Gallon Ice Cream Containing 100 Per Cent Overrun.		Nutritive Ratio Fat: Sugar: Protein Theoretical for Infant (Richmond P. 336) 2 : 4 : 1 Theoretical for Adults (Atwater) 2 : 4.22 : 1.32	Nutritive Ratio Expressed as Available Heat Units in the Ratio:- Protein : (Fat + Sugar) Theoretical for Adults (Atwater) 1 : 6.8
	Fat	Milk S. N. F.	Sugar	Gelatin	T. S.	Water	100		80				Calories	B. T. U.		
							Calories	B. T. U.	Calories	B. T. U.						
1	8.00	11.50	13.00	.50	33.00	67.00	3.626	14.38	4.028	15.98	.900	28.27	153.56	609.4	2 : 4.8 : 1.20	1 : 7.7
2	8.00	12.50	13.00	.50	34.00	66.00	3.710	14.72	4.129	16.39	.900	28.00	151.90	602.8	2 : 4.9 : 1.30	1 : 7.2
3	8.50	12.00	13.00	.50	34.00	66.00	3.765	14.94	4.182	16.59	.898	28.15	151.90	602.8	2 : 4.6 : 1.20	1 : 7.6
4	9.00	11.50	13.00	.50	34.00	66.00	3.794	15.06	4.209	16.70	.895	28.27	150.90	598.8	2 : 4.3 : 1.10	1 : 8.1
5	10.00	10.50	14.00	.50	35.00	65.00	4.002	15.88	4.447	17.65	.891	28.25	149.88	594.8	2 : 3.9 : .90	1 : 9.4
6	12.00	8.50	14.00	.50	35.00	65.00	4.183	16.60	4.642	18.42	.881	28.48	148.60	589.68	2 : 3.1 : .62	1 : 12.2
7	12.00	9.50	14.00	.50	36.00	64.00	4.284	17.00	4.753	18.86	.881	28.40	147.60	585.7	2 : 3.2 : .69	1 : 11.2
8	16.00	7.50	14.00	.50	38.00	62.00	4.841	19.22	5.375	21.33	.861	28.37	143.01	567.5	2 : 2.3 : .42	1 : 16.1
9	18.00	7.50	14.00	.50	40.00	60.00	5.208	20.68	5.785	22.97	.851	28.30	139.28	552.7	2 : 2 : .38	1 : 17.5

many because of their different palatability as compared with those low in fat. Likewise the relative vitamine content is a very important factor. As yet no exact methods have been elaborated for measuring these constituents, but in all probability the most favorable vitamine content exists in creams that approach in composition the theoretical nutritive ratios. Ice cream of this composition is rich in both fat soluble A and water soluble B, but like whole milk itself, it is deficient in water soluble C vitamin.

RELATIVE COMMERCIAL MERIT OF ICE CREAM MIX OF VARIOUS COMPOSITIONS.

From a commercial standpoint, the composition of the ice cream mix is an extremely important factor. First in importance is the influence of composition in stimulating consumption and creating demand. Second, the factor of cost per gallon as influenced by composition. Increase in fat content and unit cost, practically parallel each other. The manufacturer must determine what composition will best stimulate demand, at the same time giving due regard to costs. Frequently the manufacturer is limited to a range of composition that is arbitrarily determined, either or both, by legal standards or by competitive trade standards. The unit cost per gallon of ice cream is of more interest to the manufacturer than the unit cost of the mix itself. The unit cost of the ice cream is determined very largely by the overrun. Ice cream made from mix of low composition is not satisfactory if the overrun is too high. Within reasonable limits the best ice cream is obtained when prepared from mix of high quality, accompanied by a liberal overrun. The improvement in the quality is obtained at practically no increase in cost. Finally there is the great influence of composition upon manufacturing operations with particular reference to its effect upon the overrun. This will be discussed further in Chapter XV.

Table 45 gives detailed information upon the above discussion in the case of ice cream mixes of nine different compositions. The cost figures as given are purely arbitrary, and obviously would fluctuate with market changes in the case of the products involved.

TABLE 45.

Commercial Factors as Influenced by Composition of Ice Cream Mix.

No. of Mix	COMPOSITION OF MIX						Cost per U. S. Gallon Mix at 40° F. Fat =$0.40 per lb. Milk S.N.F. = .08 per lb. Sugar = .06 per lb. Gelatin = .50 per lb. (Materials only)	Percentage Overrun Yielding Very Satisfactory Commercial Ice Cream	Cost per U. S. Gallon Ice Cream Containing Percentages of Overrun Indicated (Materials only)	REMARKS
	Fat Per Cent	Milk S. N. F. Per Cent	Sugar Per Cent	Gelatin Per Cent	T. S. Per Cent	Water Per Cent				
1	8.00	11.50	13.00	.50	33.00	67.00	$0.473	85	.256	A fair commercial ice cream.
2	8.00	12.50	13.00	.50	34.00	66.00	.482	90	.254	A good commercial ice cream.
3	8.50	12.00	13.00	.50	34.00	66.00	.496	90	.261	A good commercial ice cream.
4	9.00	11.50	13.00	.50	34.00	66.00	.507	100	.254	An excellent commercial ice cream.
5	10.00	10.50	14.00	.50	35.00	65.00	.545	100	.273	Extra fine commercial ice cream.
6	12.00	8.50	14.00	.50	35.00	65.00	.597	100	.299	Extra fine commercial ice cream. Milk solids not fat a little low.
7	12.00	9.50	14.00	.50	36.00	64.00	.607	100	.304	Extra fine commercial ice cream.
8	16.00	7.50	14.00	.50	38.00	62.00	.732	85	.396	Excellent quality French ice cream. Low milk solids not fat. Difficult to obtain high overrun.
9	18.00	7.50	14.00	.50	40.00	60.00	.804	85	.435	Extra fine quality French ice cream. Low milk solids not fat. Difficult to obtain high overrun.

FUNCTIONS OF THE VARIOUS CONSTITUENTS OF ICE CREAM MIX.

Each constituent of ice cream plays an important part in determining the quality of the finished product. Briefly these are as follows:

(1) **Fat.**—The butter fat determines to a large extent the flavor and the palatability of the product. It is rich in vitamines and in heat units. The food value is rated largely by the fat content.

(2). **Milk Solids Not Fat.**—The role played by the milk solids not fat is not sufficiently appreciated. Too high milk solids not fat may cause sandy ice cream, due to the presence of excessive milk sugar. Too low, may render it very difficult to obtain satisfactory overrun. The casein and albumin exert the largest influence upon the overrun. The milk solids not fat also largely influence the nutritive value of the ice cream, due to their bone and muscle forming ingredients, present in the salts and protein rspectively. These are also rich in water soluble B vitamines, and to a lesser extent in the water soluble C. It is most important to pay close attention to the content of milk solids not fat.

(3). **Sugar.**—While the sugar added is obviously for the purpose of sweetening the product, and thus increasing its palatability, it also possesses high food value. It is the one constituent that exerts the most influence upon the freezing point of the ice cream. Pure solutions of cane sugar of different concentrations were found to have the following freezing points:—

10.00 per cent, 30.87° F.; 12.00 per cent, 30.64° F.; 14.00 per cent, 30.38° F., and 16.00 per cent, 30.11° F. Based upon the water content only, of the ice cream mix, the concentration is greatly in excess of these figures.

(4) **Gelatin.**—Gelatin is a colloid, and a non-crystallizable substance. Its presence in ice cream helps to prevent the crystalloids from separating in the form of large crystals. The principal crystalloids are the milk and cane sugars and the water. In ice cream mix of the proper composition the crystallization of the two sugars is not likely to be a troublesome factor. Water crystals are however always a factor of great importance as influencing the smoothness to the taste of the finished product. One

of the chief functions of gelatin in ice cream, is its influence upon the water crystals. The gelatin retards the formation of water crystals, and helps to produce small water crystals, thus making a product more smooth to the taste than otherwise possible.

Relation of Gelatin to Viscosity.—Gelatin has a large influence upon the viscosity of ice cream mix. This influence does not manifest itself until several hours after the mix has been kept at a low temperature. This is owing to the fact that the hydration of the gelatin is a slow process, and that many hours are required to complete the "setting." This is probably the principal advantage gained by aging ice cream mix. In turn the increased viscosity produced by aging is a large factor in helping both to obtain and to retain the overrun in the ice cream itself.

The ability of gelatin to increase the viscosity of water solutions is largely influenced by the quality of the gelatin. Admitted that all edible gelatins are made from fresh, clean stock, there still exists a wide difference in the viscosity of water solutions of equal strength all prepared from edible gelatin of high commercial quality. It has not been demonstrated if this difference is due to the difference in the original raw materials from which the gelatin was made, or to the destruction during manufacturing processes, or by other causes, of the jellying power, or viscosity producing power of the gelatin.

From a number of samples of edible gelatin, three samples were selected that were termed good, medium and poor respectively. Water solutions of different concentrations were prepared from each of the samples, and the viscosity of each solution was determined, after holding them in ice water for twenty-four hours, by means of the Mojonnier-Doolittle viscosimeter as described in Chapter XVII. The results are given in Table 46.

The results in the following table show plainly the large influence of the quality of the gelatin upon viscosity. It explains why varying results are obtained in practice, when using equal amounts of different gelatins in which the quality varies.

Relation of Gelatin to Incorporation of Air.—The ability of gelatin solutions to incorporate and hold air is best demonstrated

by the Frohring gelatin air test. This test is described in Chapter XVII.

TABLE 46.

Influence of Gelatin Varying in Quality Upon the Viscosity of Water Solutions.

Percentage of gelatin.	Viscosity expressed in degrees retardation at end 24 hours 50°F.		
	Good quality gelatin.	Medium quality gelatin.	Poor quality gelatin.
Water only. No gelatin.	3.6	3.6	3.6
.10	7.0	6.0	6.0
.25	7.0	6.0	6.0
.50	8.5	8.0	7.0
.60	14.0	9.0	7.5
.75	235.0	9.0	7.5
1.00	Too viscous to determine viscosity	47.0	8.0
1.50	Too viscous to determine viscosity by above method.	Too viscous to determine viscosity by above method.	42.0

Table 47 gives the results of several experiments that had for their object the determination of the volume of air that can be incorporated in different concentrations of gelatin solutions. The results show a marked difference between the different samples. The ability to hold air increases up to a concentration of about 60 per cent, after which it decreases with increasing concentration. When a concentration ranging from one to two per cent is reached the mixture will no longer retain any air. In the sample treated with the liquefying organism B. proteus there was a marked reduction in the air retaining properties of the mixture.

Other Influences of Gelatin.—Gelatin constitutes an important addition to the food value of ice cream. Bogue[3] points out that it functions as a true food, but that it is not a complete food nor is it the equivalent in food value of the casein and albumin. It is incapable of supplying more than one third or one half of the nitrogenous matter required in the diet. It helps to preserve the nitrogenous constituents of the body; is easily digested, and is readily burned in the production of energy. Gelatin functions as a protective colloid, and prevents the coagulation of the casein in large lumps, thus aiding digestion and assimilation of all the constituents of the ice cream even in the case of the very young. From a dietary standpoint the presence of good gelatin in ice cream is very beneficial.

TABLE 47.

Air Whipped Into Various Gelatin Solutions of Different Concentrations.

Percentage of Gelatin in Entire Solution	Good Food Gelatin, 7X Quality, Whipped After Cooling in Ice Water One Hour		Poor Quality Food Gelatin Whipped After Cooling in Ice Water One Hour		Ice Cream Mix Testing 8.00 Per Cent Fat and 34.00 Per Cent Total Solids		Good Gelatin After Having Been Treated with Liquefying Organism (B Proteus) Incubating for 12 Hours at 68°F. Cooled in Ice Water, and Whipped After One Hour	
	Increase in Volume Due to Whipping:—		Increase in Volume Due to Whipping:—		Increase in Volume Due to Whipping:—		Increase in Volume Due to Whipping:—	
	Immediately After Whipping cc.	30 Minutes After Whipping cc.	Immediately After Whipping cc.	30 Minutes After Whipping cc.	Immediately After Whipping cc.	30 Minutes After Whipping cc.	Immediately After Whipping cc.	30 Minutes After Whipping cc.
.10	.....	.....	46	30	7	0	16	5
.20	51	22	68	49	10	0	32	28
.30	54	32	77	67	13	0	48	40
.40	78	57	82	74	17	4	54	43
.50	118	89	92	77	24	4	58	48
.60	135	128	125	105	30	10	67	59
.70	132	116	110	91	30	7	65	51
.80	130	115	104	88	24	4	65	46
.90	127	115	95	83	10	0	64	43
1.00	106	76	85	73	0	0	62	43
2.00	0	0	35	28	.....	.....	.....	.....

SOURCES OF SUPPLY OF INGREDIENTS MAKING UP ICE CREAM MIX.

The ingredients composing ice cream mix are obtainable from a variety of different sources. The sources of supply of each ingredient are as follows:—

(1). **Fat.**—This is present in all dairy products used for making ice cream. These include whole milk, skim-milk, cream, butter, sweetened condensed milk both whole and skim, plain bulk condensed milk, both whole and skim, evaporated milk and whole and skim-milk powders. Obviously in the above products that have been skimmed the percentage of fat is small, but in nearly all cases enough still remains to be taken into account.

(2). **Milk Solids Not Fat.**—The sources of supply for M. S. N. F. are the same as in the case of fat. The selection of material to use is governed by local conditions, market prices, and quality available. If the materials used are of the proper quality, and are properly handled, the M. S. N. F. from the several sources mentioned will yield equally satisfactory ice cream. Products in which the milk sugar has crystallized out, should be so handled that the milk sugar will all pass into solution before freezing the mix. If this is not done, sandy ice cream is very likely to result.

(3). **Sugar.**—Either cane or beet sugar, both known as sucrose can be used to equally good advantage. When sucrose is not available, malt sugar, or corn sugar may be substituted to the extent of about 25 per cent to 40 per cent of the normal sugar or sucrose requirements.

The common belief that the sweetening power of sucrose can be increased by inverting it by means of a weak acid solution has been discredited by the researches of Sale and Skimmer.[4] "When 342,236 (molecular weight) units of sucrose or ordinary sugar are inverted, 180.126 units of dextrose and 180.126 units of levulose are obtained theoretically. The mixture of dextrose and levulose is known as "invert sugar." Their experiments show "that if sucrose is assigned sweetening value of 100, the sweetening value of invert sugar is only 85. Since 100 units of sucrose by inversion become 105 units of invert sugar the net loss in

sweetening power by the inversion of 100 units of sucrose is about 11 units."

According to previous experiments in the same laboratory, and also according to the investigations of Paul upon the sweetening power of lactose cited by the above authors the comparisons of the relative sweetening qualities of various common sugars are as follows: Sucrose=100, dextrose=50; levulose=150; maltose =60; and lactose=28.

(4) **Gelatin.**—Only gelatin prepared especially for food purposes should be used, and this should be free from all injurious chemicals. According to Cromley,[5] "a good gelatin is one that solidifies in the shortest space of time; has a low percentage of ash, a clean inoffensive odor; makes a clear solution, and is without chemical or physical impurities."

The water content of the gelatin should be determined as this will influence its commercial value. The usual range is between ten and fifteen per cent.

(5) **Miscellaneous Products.**—Starch and eggs are sometimes used as fillers. These perceptibly increase the total solids of the mix. Their use is limited to special ice creams. It is products of this kind that make ice cream stand up in the dish after serving. Gum tragacanth is frequently substituted for gelatin, and functions the same as gelatin. Several commercial products commonly known by the general term "ice cream improvers" are in common use. These consist of rennet or pepsin mixed with certain powders such as milk sugar. These products react upon the casein in the mix, causing an increase in the viscosity. They need to be used with care, and their action should be fully understood. In addition to the above products there is a large quantity of fruits and flavors used in making ice cream. The composition of a few of the most important of these substances together with a brief description of each is given in Table 48. The list includes one sherbet formula that will yield a fine product for use in connection with ice cream upon the Mojonnier Ice Cream Packaging Machine wherein the ice cream is packaged directly from the freezer into the carton, while still in the plastic condition, and then in turn hardened in the carton.

TABLE 48.

Name and Description of Flavors, Fruits and Nuts Used in Ice Cream. Also Sherbet Base.

NAME AND DESCRIPTION OF PRODUCTS	Ether Soluble Constituents	Cane Sugar	Fruit Sugars	Total Solids
	Per Cent	Per Cent	Per Cent	Per Cent
Cocoa Syrup [6] and [7]. Formula[1]: 2 lbs. sugar; 1½ lbs. cocoa; 1 quart water, and ¼ oz. cinnamon extract. Thoroughly mix the cocoa and sugar. Add the water; heat to 175° F. and hold for 20 minutes with constant stirring. Do not allow to boil. When cool add ¼ oz. cinnamon extract. The above is sufficient for 5 gallons of ice cream mix, or 10 gallons of ice cream	7.16	35.70	.....	61.50
Cocoa Syrup[7]. Formula [2]: 1 lb. sugar; ¾ lb. cocoa, and 1 quart water. Prepare and use the same as above	5.27	26.26	.....	45.18
Cocoa Syrup[7]. Formula[3]: 2 lbs. sugar; 1 lb. cocoa, and 1 quart of water. Prepare and use the same as above	3.32	39.63	.....	58.65
Chocolate Syrup[7]. Formula: 1 lb. bitter chocolate; 1 lb. sugar; 1 quart water, and ¼ oz. cinnamon extract. Heat one pint of water to boiling; add the shredded chocolate, and stir until a pasty consistency is reached. Now add second pint of water, and heat until it simmers, stirring constantly. When cool add ½ oz. cinnamon. The above makes enough syrup for 10 gallons of ice cream	14.64	24 48	.....	52.73
Caramel[8]	5.22	26.10	.....	82.07
Sherbet Base[7]. Recommended for use upon Mojonnier Ice Cream Packaging Machine. Formula: 30 lbs. sugar; 18 ozs. of a 50 per cent solution of citric acid; 9 ozs. gelatin; 10 ozs. color; 2 gals. condensed skim-milk containing 25.5 per cent total solids; and 6½ gallons water. In case condensed skim-milk is not available, equally satisfactory results are obtained by making the following substitutions in the above formula:—(1) 4 gallons of whole milk and 4½ gallons of water, or (2) 5 gallons of skim-milk and 3 gallons of water. The above quantity makes up 10 gallons which should be frozen to yield 16 gallons of product, or 60 per cent of overrun. The above can be used as a base to which any desired flavor can be added. When fresh fruits are used omit enough water to bring the total volume up to 10 gallons. Mix all above products together cold, adding the citric acid just before freezing	.30	28.75	.....	34.15

TABLE 48 (Continued).

NAME AND DESCRIPTION OF PRODUCTS	Ether Soluble Constituents	Cane Sugar	Fruit Sugars	Total Solids
	Per Cent	Per Cent	Per Cent	Per Cent
Apples[9], average 29 analyses	.50	.....	.....	15.40
Apricots[9], average 11 analyses	.50	.....	.....	15.00
Bananas[9], average 6 analyses	.60	.....	.....	24.70
Blackberries[9], average 9 analyses	1.00	.....	.....	13.70
Cherries[9], edible portion, average 16 analyses	.80	.....	.....	19.10
Cherries[7], maraschino	.26	.68	19.72	33.08
Cranberries[9], average 3 analyses	.60	.....	.....	11.10
Currants[9], average 1 analysis	.....	.....	.....	15.00
Figs[9], average 28 analyses	.....	.....	.....	20.90
Figs[9], dried average 3 analyses	.30	.....	.....	81.20
Grapes[9], edible portion, average 5 analyses	1.60	.....	.....	22.60
Grapes[9], dried, average 1 analysis	.60	.....	.....	65.20
Huckleberries[9], average 1 analysis	.60	.....	.....	18.10
Lemons[9], edible portion, average 4 analyses	.70	.....	.....	10.70
Muskmelons[9], edible portion, average 1 analysis	.....	.....	.....	10.50
Oranges[9], edible portion, average 23 analyses	.20	.....	.....	13.10
Peaches[9], edible portion, average 2 analyses	.10	.....	.....	10.60
Peaches[7], canned	.05	.....	.....	9.35
Pears[7], edible portion, average 2 analyses	.50	.....	.....	15.60
Pineapple[9], edible portion, average 1 analysis	.30	.....	.....	10.70
Pineapple[7], preserve, red, average 1 analysis	.16	19.73	33.14	60.34
Pineapple[7], preserve, white, average 1 analysis	.23	18.18	41.40	58.29
Prunes[9], edible portion, average 20 analyses	.....	.....	.....	24.40
Raspberries[9], black, average 3 analyses	1.00	.....	.....	15.90
Strawberries[9], edible portion, average 22 analyses	.60	.....	.....	9.60
Strawberry Preserve[7]	.41	31.65	17.32	57.51
Strawberries, cold packed[7]	.23	.....	.....	24.02
Bitter Chocolate[7]	54.77	.....	.....	98.61
Zanzibar Cocoa[7]	25.38	.....	.....	96.01
Vanilla Extract[7]	.....	.....	.....	9.07
Gelatin[7]	.....	.....	.....	86.08
English Walnuts[9], average 2 analyses	63.40	.....	.....	97.50
English Walnuts[7], average 2 analyses	64.22	.....	.....	96.31
Pecans[9], edible portion	70.50	.....	.....	97.30
Pecans[7], edible portion	64.68	.....	.....	98.35
Sajo Starch[9], as purchased	.....	.....	.....	87.80
Eggs[9], hens, edible portion, average 19 analyses	12.00	.....	.....	26.80
Eggs, hens, white	.20	.....	.....	13.80
Eggs, hens, yolk	33.30	.....	.....	50.50

THE RELATION OF COMPOSITION TO ICE CREAM DEFECTS.

Many defects in ice cream attributed to other causes are due to defects in composition.

(1) **Fat.**—Too low a content of fat sacrifices both the palatability and the food value of the ice cream. Too high fat produces an ice cream that is difficult to assimilate, because of its large content of heat units. This is more objectionable in summer than in winter. The outside ranges for good commercial ice cream are from 8.00 per cent to 14.00 per cent of fat. Above 14.00 per cent the ice cream enters a special class commonly called French ice cream.

(2) **Milk Solids Not Fat.**—Improper control of the milk solids not fat is responsible for many ice cream defects. The ability both to obtain and retain overrun in ice cream depends largely upon its content of casein and albumin. The minimum should be not under 4.00 per cent of total protein. The reader is referred to Chapter XV for further discussion of this problem.

Sandy Ice Cream, Cause and Prevention.—The content of milk solids not fat has a direct bearing upon the defect commonly known by the term "sandy ice cream." A careful investigation of this subject was made by one of the authors[10] and several assistants. In the course of these investigations several papers have appeared upon this subject namely: by Bothell,[11,12] Zoller and Williams[13] and Williams[14].

Sandiness in ice cream is readily detected by the consumer. It ranks as the worst of all the common ice cream defects, and it is responsible for large losses among ice cream manufacturers. Its occurrence is well night universal. It is caused by the milk sugar which is only about one fourth as sweet as sucrose and comparatively insoluble in the mix, particularly at the reduced temperatures used in making and holding ice cream.

Milk sugar crystallizes in keystone shaped crystals, that are described by P. Groth[15] as:

Monoclinic-sphenoidal. Cleavage in three directions nearly at right angles. Refractive indices, $\alpha=1.517$; $\beta=1.542$;=Y 1.550 +0.005 Bx^a c=10°, a=99°. 2E=33½°. Sign—, sp. gr. 1.525 —1.534.

The sharp corners of the milk sugar crystals stick to the tongue giving the sensation of eating sand, from which the defect derives its name. The name is, however, slightly a misnomer, since milk sugar dissolves slowly in unsaturated water solutions while sand is insoluble, and the crystals crumble fairly readily under the pressure of the tongue or the teeth, which would not be true in the case of sand.

Conditions That May Cause Sandy Ice Cream.—There are two general conditions under which sandy ice cream can be produced.

(1) By using products containing crystallized milk sugar regardless of the composition of the mix, when the mix is not pasteurized. Such products include sweetened condensed milk, both whole and skim, and sometimes also plain bulk condensed milk both whole and skim. To produce sandy ice cream under these conditions, the ingredients composing the mix must be mixed cold, and frozen before the milk sugar has had sufficient time to go into solution. If the mix is standardized to the proper composition and it is then pasteurized before freezing, there can be no danger of producing sandy ice cream when using products containing crystallized milk sugar.

When sandiness is due to the use of products containing crystallized milk sugar, the sandy condition can be detected as soon as the ice cream is drawn from the freezer. If the mix was of the proper composition, the sandiness will not increase while hardening, since only the milk sugar that was actually crystallized before freezing will appear as sand. This cannot go into solution after freezing.

(2) By using a mix of improper composition, regardless of the products used, and also regardless of whether or not the mix has been pasteurized. In this case, the sandiness will not appear until the ice cream has stood in the hardening room long enough for the milk sugar to crystallize out.

Experimental Evidence.—A number of careful experiments were conducted, and these are reported herewith.

(A) **Influence of size of crystals and temperature upon the solubility of milk sugar crystals.**

(1) One lot of ice cream mix testing 18.50 per cent milk solids not fat and 40.00 per cent total solids was prepared by using a smooth sweetened condensed milk containing small milk sugar crystals as the source of the milk solids not fat. This was heated rapidly with constant agitation, taking 10 minutes to reach 140 deg. F. It required one minute to dissolve the milk sugar crystals.

(2) Another lot of ice cream mix was prepared and handled the same as above, excepting that in this case, coarse, sweetened condensed milk containing large milk sugar crystals was used. It required three minutes to dissolve the milk sugar.

(3) In a third experiment, a 5 per cent mixture of water and both fine and coarse milk sugar crystals were prepared. The solubility of the two sizes of crystals in water at different temperatures was carefully noted. The results are given in Table 49.

TABLE 49.

Influence of Temperature and of Size of Crystals Upon Solubility of Milk Sugar Crystals.

Sample No.	Size of crystals.	Temperature of water. Deg. F.	Time required to dissolve crystals. Minutes.
1	small	40	33.00
2	small	68	2.50
3	small	140	.16
4	large	40	64.00
5	large	68	14.00
6	large	140	2.00

The results of the above experiments show the influence of the size of the milk sugar crystals upon the length of time required to effect their solution at pasteurizing and other temperatures—obviously the larger the crystals, the longer the time required to dissolve them.

(B) Influence of Pasteurization—There was prepared one lot of ice cream mix testing 12.50 per cent milk solids not fat and 34.00 per cent total solids, using cream, skimmilk powder, gelatin,

sugar and water. The gelatin was dissolved in the added water, and the solution cooled before adding to the other ingredients, keeping the entire mixture down to about 40° F.

One half of the above lot was frozen immediately without pasteurizing. The other half was pasteurized at 140 deg. F. for 30 minutes, cooled and then frozen. Slight sandiness began to appear in both lots after being in the hardening room 24 days.

(2) There was prepared a second lot of ice cream mix testting 18.50 per cent milk solids not fat and 40.00 per cent total solids, using the same ingredients, and proceeding otherwise as described under (A). The ice cream from both the pasteurized and the unpasteurized portions began to show slight sandiness after being in the hardening room 7 days.

The results of this experiment show that sandiness is not influenced by pasteurization when milk solids not fat are obtained from milk powder, under the conditions named above.

Influence of Composition of Mix—Ten bottles of ice cream mix of different composition were compounded. The raw materials used consisted of pasteurized cream, plain condensed skim-milk, sugar and gelatin, all being of high quality. A sample from each batch was frozen, and then transferred to a hardening room with a temperature of —5° F. to 5° F.

The essential facts and results of this experiment are given in Table 50.

TABLE 50.

Influence of Composition of Mix on Milk Sugar Crystallization.

No. of Mix	COMPOSITION OF BATCHES					No of days in hardening room before sandiness appeared	Extent of sandiness
	Fat Per Cent	M.S.N.F. Per Cent	Sugar Per Cent	Gelatin Per Cent	T. S. Per Cent		
1	8.00	11.50	13.00	.50	33.00	56	Slight
2	8.00	12.50	13.00	.50	34.00	27	Considerable
3	8.50	12.00	13.00	.50	34.00	27	Considerable
4	9.00	11.50	13.00	.50	34.00	36	Slight
5	10.00	10.50	14.00	.50	35.00	87	Slight
6	12.00	8.50	14.00	.50	35.00	No sandiness at end 87 days	None
7	12.00	9.50	14.00	.50	36.00	do.	None
8	16.00	7.50	14.00	.50	38.00	do.	None
9	18.00	7.50	14.00	.50	40.00	do.	None
10	8.00	18.50	13.00	.50	40.00	6	Very heavy

The results of this experiment are most significant and prove conclusively the importance of the exact control of composition upon sandiness, particularly with regards to the milk solids not fat. The mix containing 18.50 per cent of milk solids not fat, showed sandiness at the end of six days while up to 9.50 per cent no sandiness appeared up to 87 days.

(D) **Influence of Amount of Overrun.**—One lot of ice cream testing 8.00 per cent fat, 18.50 per cent milk solids not fat, 13.00 per cent sugar, and .50 per cent gelatin making 40.00 per cent total solids, was divided into two portions.

One portion was frozen with as little overrun as possible, about 10 per cent, and the other portion with as much as possible, about 100 per cent. Sandiness appeared in both lots of ice cream after they had been in the hardening room six days. The crystals in the lot with low overrun appeared throughout the experiment to be somewhat larger, and therefore more noticeable to the taste than in the case of of the lot with high overrun. The difference was probably due to the greater concentration of crystals in a given volume of the frozen product. The amount of overrun was not found to be of practical significance as affecting sandiness.

(E) **Influence of Miscellaneous Factors Upon Sandiness.** The results obtained in this experiment indicate that the consistency to which the ice cream was frozen, the addition of lactic acid,

TABLE 51.

Influence of Miscellaneous Factors.

Method of handling ice cream.	Number of days in holding room before sandiness appeared.	Remarks
Frozen to hard consistency.....	5	All samples alike
Frozen to soft consistency.....	5	as regards sandi-
.2 per cent lactic acid added.....	5	ness.
.4 per cent lactic acid added.....	5	
.6 per cent lactic acid added.....	5	
1 per cent pulverized nuts added....	5	

or of pulverized nuts, had no influence upon sandiness. The milk sugar crystallized out about equally in all cases.

(F.) **Influence of the Solubility of Milk Sugar.** The solubility of milk sugar has been studied by Dubrunfaut;[16] by C. S. Hudson[17]; by E. Soillard[18] and by Mack & Liedel[19]. Confirmatory tests were made by Liedel in the Research Laboratories of Mojonnier Bros. Co. at the temperatures used by the above authorities and in addition the solubility was determined at temperatures both higher and lower than those reported by other authorities.

Tabulating all of the results reported, we find the solubility of milk sugar to range as indicated in Table 3, and Fig. 7, Chap. II.

The solubility of milk sugar was determined in water containing various substances, such as varying amounts of lactic acid, common salt and lime. The results thus obtained are given in Table 52.

TABLE 52.
Solubility of Milk Sugar in the Presence of Other Products.

Compositions of Water Solutions	Solubility of Milk Sugar in 100 parts at:				
	41° F.	50° F.	59° F.	70° F.	84° F.
.20 per cent lactic acid....	13.51	14.80	17.12	21.06	23.80
.40 per cent lactic acid....	13.42	14.63	17.06	20.87	24.72
.60 per cent lactic acid....	13.38	14.42	17.00	20.73	24.60
1.00 per cent lactic acid....	13.20	14.31	16.95	20.45	24.49
.20 per cent salt (NaCl)....	13.60	13.77	17.06	20.21	24.85
.50 per cent salt (NaCl)....	13.55	13.26	16.71	20.50	24.68
1.00 per cent salt (NaCl)....	13.48	13.13	16.90	20.43	24.80
Saturated Lime Water.....	13.60	14.85	17.60	20.84	25.02
Water only.....	13.36	14.90	16.78	19.50	24.40

The results given in Table 52 are not entirely consistent, due to analytical errors caused by the difficulties involved in making double solubility determinations. The differences found are so slight as to prove that the solubility of milk sugar in acid, alkaline and salt solutions within the limits of the experiment, is the same as in water only.

In another experiment, the separation of milk sugar from ice under different conditions was carefully determined. The water solutions were transferred to a hardening room with temperature about 0° F. At the end of ten days the frozen samples were all returned to the laboratory, and immediately after the ice was melted, the water was decanted and the precipitated milk sugar was separated and weighed upon a Gooch crucible, in all cases where this was possible. The results of this experiment are given in Table 53.

TABLE 53.

Separation of Milk Sugar from Ice Under the Various Conditions Named.

Water Used C. C.	Grams Lactic Acid Used	Grams Milk Sugar Used	Days in Hardening Room before Crystals Separated	Total Days in Hardening Room	Grams Milk Sugar Separated	Remarks
99.0	none	1.00	5	..	not determined	..
98.0	"	2.00	4	..	"	..
97.0	"	3.00	3	..	"	..
96.0	"	4.00	3	..	"	..
95.0	"	5.00	2	10	.86	..
100.0	"	10.00	2	10	1.30	..
99.8	.2	1.00	5	10	none	Milk sugar redissolved when ice melted.
99.8	.2	5.00	2	10	.85	..
99.8	.2	10.00	2	10	1.32	..
99.6	.4	1.00	5	10	none	do
99.6	.4	5.00	2	10	.80	..
99.4	.6	1.00	5	10	none	do
99.4	.6	5.00	2	10	.86	..

The results given above prove that milk sugar crystallizes from ice, when present in amounts as small as one per cent. Such crystals are readily detected with the human eye. The amount actually crystallized could not be determined accurately

by the method used, since a considerable part of the milk sugar passed back into solution as fast as the ice melted. The quantitative determinations that were made show that the amount of sugar which separated from an acid solution of milk sugar, was no larger than in the case of pure water solution. The milk sugar which separated from the ice appeared to be more amorphous than crystalline. Its water content was not studied.

The solubility of milk sugar in ice cream mix and in sucrose solution formed the basis of a careful study by Travis.[20] He found the relative final solubility of lactose in different media at various temperatures as shown in Table 54.

TABLE 54.

Relative Final Solubility of Lactose at Various Temperatures and in Different Media According to Travis.

Media.	Grams of lactose per 100 Grams of water at:		
	0° C.	10° C.	25° C.
Water (Hudson results).....	12.50	15.92	22.8
Sucrose, 14 per cent solution..	8.40	9.95	13.25
Ice cream mix testing 12.00 per cent fat; 14.00 per cent sugar; .50 per cent gelatin and 36.00 per cent total solids..	17.50	24.60	Not reported

As the results in Table 54 show, lactose was found by Travis to be less soluble in sucrose solutions than in pure water, and more soluble in ice cream mix than in pure water. He attributes this difference to the possible effect of "some colloid or colloids in the ice cream mix."

In view of the ease with which lactose crystals separate from ice even at as low concentrations as one per cent, as shown in Table 54, Travis' results offer an explanation as to why its separation in the form of sandiness in ice cream is not larger than usually encountered.

Conclusions:—(1). Sandiness in ice cream is caused by the milk sugar contained in the mix. The largest single factor caus-

ing sandiness is an improper content of milk solids not fat. A mix containing 18.50 per cent milk of solids not fat developed sandiness in the frozen product at the end of six days, while all mixes containing 9.50 per cent or less of milk solids not fat, did not show any sandiness after the frozen product had been in the hardening room 87 days. Ice cream mix containing 12.50 per cent of milk solids not fat did not show any sandiness until the ice cream was 27 days old. It is probably very seldom that ice cream is kept for this length of time. A content of 12.50 per cent of milk solids not fat is equal to about 6.70 per cent of milk sugar, or about the limit recommended by Bothell (cited above). Ice cream can contain more than the above limit of milk solids not fat, but if it goes quickly into consumption there will be no complaints from sandy ice cream.

The next largest single factor causing sandiness is the age of the ice cream. The older the ice cream, the more likely is sandiness to appear. Complaints from sandiness are most liable to come from small dealers who move their ice cream slowly, or in the case of special flavors that meet with a limited demand.

(2). Solutions containing as little as one per cent of milk sugar contain crystallized milk sugar after being in the hardening room for eight days or less.

The increased solubility of milk sugar in ice cream mix as reported by Travis may account for the fact that larger quantities of milk sugar can be safely used without causing sandiness in ice cream, over the amount that would theoretically produce sandiness.

The greater the concentration of milk sugar in ice cream, the sooner will the crystals become apparent to the taste. In all cases the milk sugar crystals will be visible under the microscope, before they become apparent to the taste. The size of the milk sugar crystals was found under the microscope to vary considerably. The larger the crystals obviously the more apparent to the taste is the sandiness of the ice cream.

(3). Pasteurization of the mix, particularly where the milk products used contain crystallized milk sugar, helps to retard sandiness in the case of a mix containing an excess of milk sugar, over that suggested by good practice, and it helps to prevent it entirely when the mix is of the right composition. A mix com-

pounded from milk products containing crystallized milk sugar, if not pasteurized, will show up sandiness immediately after freezing regardless of the composition of the mix—the larger the milk sugar crystals in the raw products, the more apparent will be the sandiness in the finished product.

(4). **Sugar.**—Too low sugar content gives a product that is insufficiently sweet; too much sugar, one that is excessively sweet. A product containing excessive sugar has a low freezing point, and consequently is more difficult to keep in good condition in the dealers' cabinets. The best range of sugar is from 13.00 to 14.00 per cent. Also the more sugar that is used, the more difficult it is to obtain the desired overrun. Further discussion of this subject will be made under Chapter XV.

(5). **Gelatin.**—One of the most important physical properties of ice cream is its texture, or in other words, its smoothness to the taste. This is caused principally by the size of the water crystal—obviously small water crystals producing an ice cream that is smooth to the taste and large water crystals one coarse to the taste. Several factors influence the size of the water crystals, but probably no single factor has greater influence than the gelatin content of the ice cream.

A careful experiment was made to determine the proper limits of gelatin to use. A quantity of ice cream mix was prepared testing 8.00 per cent fat, 12.50 per cent milk solids not fat, 13.00 per cent sugar, making 33.50 per cent total solids. This was divided into different lots and these in turn handled as shown in Table 55. The various lots were all frozen quickly, and then transferred to a hardening room with temperature around 0° F., and kept therein for the time indicated in Table 55.

The results given in the following table prove the value of adding gelatin to ice cream. The best results were obtained by adding .50 per cent gelatin to the mix before pasteurizing. Gelatin usually contains only about 83.00 per cent of total solids. The addition of .60 per cent of gelatin will provide about .50 per cent of the water free substance. An excess of gelatin produces an ice cream that does not melt readily upon the tongue, besides it unnecessarily increases the cost of the ice cream.

The possible influence, if any, that gelatin may exert upon the crystallization of the milk sugar is not known at this time.

It would be theoretically possible for the gelatin to retard the crystallization of the milk sugar, as well as the crystallization of the water.

(6.) **Water.**—The water content of ice cream influences both its chemical and physical properties. Excessive water impairs the food value of the ice cream. The maximum limit under good practice is 67.00 per cent water, corresponding to 33.00 per cent total solids. The minimum limit is 60.00 per cent of water corresponding to 40.00 per cent total solids.

TABLE 55.

Influence of Gelatin Upon the Physical Properties of Ice Cream.

How Mix was Treated	How Gelatin was Added	Percentage Gelatin Added	Condition of Ice Cream one day after Freezing	Condition of Ice Cream eight days after Freezing	Numerical Quality Rank of various lots of Ice Cream at end of Eight Days
Pasteurized at 140° F. held for 4 days at 40° F.	Before pasteurizing	.50	Smooth	Smooth	1
Not pasteurized held for 4 days at 40°F.	After holding 4 days. Just before freezing	none	Coarse, grainy	Coarse, not fit for sale	6
"	"	.20	Coarse	Coarse	5
"	"	.40	Slight grain	Coarse	4
"	"	.50	Smooth	Smooth	2
"	"	.60	Smooth	Smooth	2
"	"	.70	Smooth but Ice Cream did not melt readily	Smooth but slimy	3
"	"	1.00	Smooth but Ice Cream did not melt	Slimy. Not fit for sale	6

The influence of the water content upon the physical property of ice cream is usually not fully understood nor fully appreciated. It is the size of the water crystals that determines the texture or smoothness of the product.

The best work reported to date upon this subject is that by Hall.[21] Scale showing relative diameter of smooth and coarse textured crystals is reproduced under Fig 79. Hall found that, "Cream which left the freezer having 10 per cent of its water frozen, upon reaching 20 degrees had 42 per cent of its water frozen; at 10 degrees, 55 per cent, and at minus 5 degrees 67 per

cent. It is doubtful if over 70 per cent of the water in ice cream is ever frozen. No matter at what temperature the ice cream may leave the freezer, the continued freezing in the hardening room follows the law as represented by the curve under Fig. 80.

Fig. 79. Scale Showing Relative Diameters of Smooth and Coarse Texture Crystals.

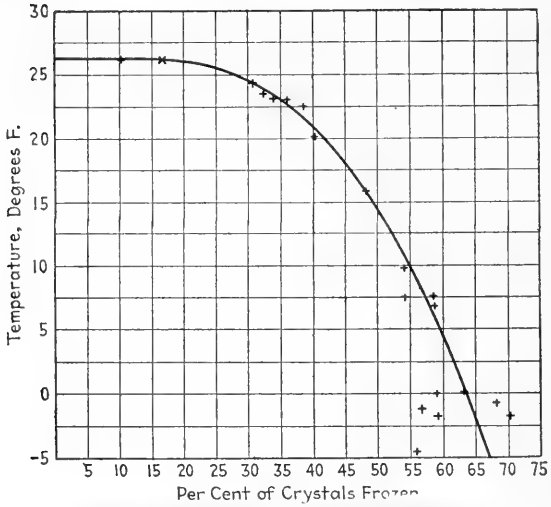


Fig. 80. Per Cent of Frozen Crystals.

Hall applies the same principles of crystallization to freezing the water content of ice cream mix as are described in this book for controlling the milk sugar crystals in sweetened condensed milk. Namely, "slowly formed crystals are large, and quickly formed crystals are small." He recommends placing the ice cream as it comes from the freezers in a hardening room of very low temperature, say —15° F. Then after the ice cream has hardened, transferring it to the regular hardening room with temperature of about 5° F. He further points out the fact already recognized by many manufacturers that "small cans on account of being quickly frozen, usually contain smoother texture cream than large cans."

THE STANDARDIZATION OF ICE CREAM MIX.

Definition and Advantages.—The standardization of ice cream in a broad sense, has reference to the control of the fat, milk solids not fat, sugar, flavor, color, and of the overrun in the finished product. This chapter will treat more especially of the chemical control of the ingredients making up the mix, while Chapter XV treats of the control of the overrun. In no other branch of the dairy industry can such important results be obtained by complete standardization as in the ice cream industry. The three main advantages to be gained are (1) turning out a product of uniform composition; (2) manufacturing with the greatest possible degree of economy; and (3) avoiding the marketing of a product under the legal or trade standards.

Steps Involved.—The steps involved in standardizing ice cream mix are as follows: (1). Ascertaining the pounds, and the fat and T. S. tests of all materials on hand or available that are to be used for making up the batch. If the tests of the available materials are made at the plant, all of the precautions usually required in collecting the samples must be observed. Accuracy of the tests can be of little value unless the samples upon which the tests are based are exactly representative of the entire lot of material in question.

(2). As a rule, it is not necessary for standardizing purposes to test with the Mojonnier Tester all the materials available for making up the batch. However, it is recommended that all materials purchased be tested, as that is the only satisfactory method of checking purchases, and at the same time this affords a large help in compounding the mixes. Also, if the exact test of the materials available for standardizing is known it will make for greater accuracy in the final standardization.

(3). Determining the pounds that the batch is to contain, and the percentage of fat, M. S. N. F., sugar and other ingredients, that the batch is to contain after standardizing. It is usually necessary to manufacture not more than two different standardized products. The standards to be followed are sometimes set by State or Federal authorities, and again individual manufacturers may elect to set special standards of their own—the same being higher in fat or T. S., or both, than the legal standards that might otherwise govern.

(4). Calculating the pounds of fat and T. S. that the batch should contain, and with this as a basis, determining the pounds of various materials required to make up the batch.

(5). After the materials for the batch have all been very thoroughly mixed, a sample is taken to be tested for both fat and T. S., also record is made of the total pounds of each material composing the batch. Great care is necessary to get a sample that is representative of the entire batch.

(6). Computing the material required for standardizing the batch to the desired standard upon the basis of the weights and tests as found under (5).

GENERAL METHODS OF COMPOUNDING ICE CREAM MIX.

Several methods are available for compounding and standardizing ice cream mix, as follows:

(A). **By Using a Vacuum Pan.**—This is commonly known as the Mojonnier method, and is covered by the pending process patents of one of the authors and his brother.[22]

Where this method is possible, it has numerous advantages over all other methods. The whole milk is sampled and tested for fat and T. S., and the necessary fat in the form of cream or butter, and the necessary sugar and gelatin, are added to the milk in the hot wells. The batch is then condensed to the point desired. After condensing, the batch is weighed, homogenized, cooled, tested for fat and T. S. and standardized to the point desired. Under some conditions, it may be desirable to condense the product considerably in excess of the concentration desired, and to dilute it back with water to the proper concentration just before freezing. Mix, so prepared, can be stored for a considerable time, and shipped considerable distances.

Peterson and Tracy[23] made a study of ice cream mix prepared in a vacuum pan. Their findings confirmed the foregoing statements. They also made a bacteriological study of mix prepared as above, and of ice cream produced from it. The number of bacteria found by them in the different stages of manufacture are given in Table 56.

TABLE 56.

Number of Bacteria per cc. in Ice Cream Mix Prepared in a Vacuum Pan at Different Stages of Manufacture.

Before heating in hot wells.	Direct from vacuum pan.	Direct from homogenizer.	After addition of gelatin.	In the frozen ice cream.
9,600,000	800	1,400	1,450	2,600
2,260,000	20,000	26,200	26,250	31,000

The best practice is to add the gelatin to the hot wells before heating the milk, rather than to the mix after condensing. This will help to reduce the bacteria count.

Mix prepared under vacuum was found to have very excellent keeping qualities as found by the results indicated in Table 57.

TABLE 57.

Keeping Qualities of Ice Cream Mix Prepared Under Vacuum and Stored at 32° to 35°F.

Day in storage.	Bacteria per cc.	Condition of mix.
0	1,400	Very good
5	1,700	Very good
14	762,000	Good
23	42,210,000	Fair
32	188,500,000	Fair (frozen into ice cream)

The results in Table 57 show both the low content of bacteria in mix made as described above, and the excellent keeping qualities of the same. Handling operations after condensing, if care is taken, do not appreciably increase the bacteria count. The mix stored at the temperatures named were of excellent keeping quality, and remained in good condition up to two weeks.

The specific gravity of ice cream mixes of nine different compositions, and at various temperatures, are indicated upon the

chart under Fig. 81. This can be used as the basis for arriving at the proper striking point, when finishing the batch at the pan.

Key to Fig. 81.

Curve.....	1	2	3	4	5	6	7	8	9
Fat.....	8.00	8.00	8.50	9.00	10.00	12.00	12.00	16.00	18.00
T. S.....	33.00	34.00	34.00	34.00	35.00	35.00	36.00	38.00	40.00
Sugar.....	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
Gelatin.....	.50	.50	.50	.50	.50	.50	.50	.50	.50

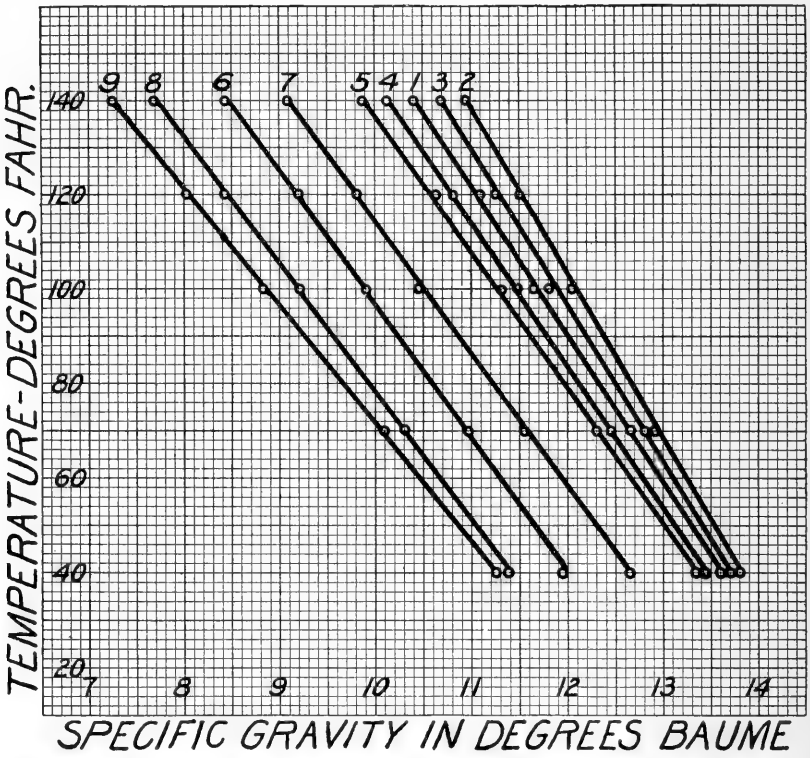


Fig. 81. Specific Gravity of Nine Different Compositions of Ice Cream Mix at Various Temperatures.

This chapter contains elsewhere methods of calculation recommended to cover problems of this kind.

(B). **By mixing condensed products of various kinds.** A large variety of combinations are possible, and usually if the proper methods of calculation are used, such dairy products of the proper quality, that may be available, can be mixed together and made to yield a satisfactory quality of mix. One extreme example would be skim-milk and cream; another would be skim-milk powder and butter. Problems involving these various combinations will be found elsewhere in this chapter.

SUCCCESSIVE STEPS INVOLVED IN STANDARDIZING ICE CREAM MIX.

Unless the mix is compounded at the vacuum pan, two methods of standardizing are possible as follows: (1) Ascertain the exact fat and T. S. tests of all products available, and upon the basis of these tests mix the same in the right proportion to obtain a product of the test desired. This method is not recommended, as it involves considerable work not required by the method immediately following. It is well, however, to test all products purchased for fat and T. S. to determine if they comply with the purchase specifications.

(2). Compound the mix upon the basis of the approximate tests of the materials on hand. Test the mixture for fat and T. S., using the Mojonnier Tester.

(3). Calculate by methods that follow in this chapter, the materials that will be required to standardize the batch to the proper content of fat, M. S. N. F. and sugar.

How to Sample, Test and Weigh the Batch. Follow method of sampling recommended under Chapter VI. Use the Mojonnier Tester for making all fat and T. S. determinations. Where possible, obtain directly the weight of the batch. If impossible to weigh the batch, obtain the total gallonage, and calculate the pounds from the figures given in Table 58. Use the Green Gauge instead of a scale to ascertain the total pounds of mix in the holding tank.

Order of Operations in Standardizing Ice Cream Mix: (1). Test both for fat and T. S. as far in advance as possible all products that are to be used for standardizing.

TABLE 58.

Approximate Weight per Gallon of Water and of Various Dairy Products. Temperature About 68° F.

Name of Product	Percentage Fat	Percentage Total Solids	Pounds in One U. S. Gallon	Name of Product	Percentage Fat	Percentage Total Solids	Pounds in One U. S. Gallon
Water.....	.....	.....	8.34	Cream.....	30.00	36.24	8.35
Skim-milk.....	.20	8.80	8.64	Cream.....	35.00	40.79	8.31
Whole Milk.....	3.00	11.40	8.59	Cream.....	40.00	45.35	8.38
Whole Milk.....	3.50	11.60	8.60	Ice Cream Mix....	8.00	34.00	9.16
Whole Milk.....	4.00	12.30	8.61	Plain condensed skim-milk.....	1.00	26.00	9.18
Whole milk.....	5.00	13.00	8.62	Plain condensed whole milk.....	8.00	30.00	9.05
Mixed milk and cream.....	10.00	18.02	8.54	Evaporated milk...	8.00	26.15	8.90
Mixed milk and cream.....	15.00	22.57	8.47	Evaporated milk...	7.80	25.50	8.88
Cream.....	20.00	27.13	8.43	Sweetened condensed skim-milk	1.00	70.00	11.16
Cream.....	25.00	31.68	8.39	Sweetened condensed whole milk	8.00	73.00	10.90

(2). About half an hour before the sample from the batch is ready, do everything necessary to begin making fat and T. S. tests.

(3). Keep the fat and T. S. dishes in the respective ovens for 5 minutes, under proper heat and with the vacuum on.

(4). Transfer the dishes from the ovens to the coolers. Keep the water circulating. Weigh the T. S. dish with cover at the end of 5 minutes, and the fat dish alone at the end of 7 minutes. Record the weights and numbers upon the laboratory report Fig. 53, Chap. VII. Replace the dishes in the coolers.

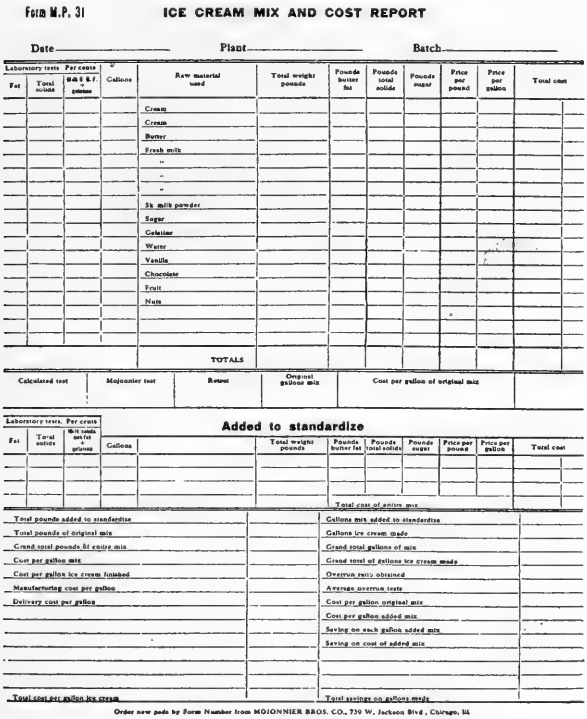
(5). Mix the sample thoroughly.

(6). Fill the one gram pipette to the mark, and transfer the milk to the previously weighed dish, and weigh the dish with milk immediately. Fill the 5 gram pipette to the mark, and by means of the weighing cross, weigh about 5 grams into the fat extraction flask.

(7). Prepare the sample for the T. S. and the fat ovens respectively; heat in the ovens, cool in the coolers, and weigh as directed.

(8). Calculate the percentages of fat and T. S. and transfer the results to the ice cream mix and cost report, Fig. 82.

(9). Calculate the pounds of material necessary to add, selecting and using the rule that may apply.



FORM M.P. 31 **ICE CREAM MIX AND COST REPORT**

Date _____ Plant _____ Batch _____

Laboratory tests. Per cents												
Fat	Total solids	Milk solids not fat + grimes	Gallons	Raw material used	Total weight pounds	Pounds butter fat	Pounds total solids	Pounds sugar	Price per pound	Price per gallon	Total cost	
				Cream								
				Cream								
				Butter								
				Fresh milk								
				"								
				"								
				"								
				Sk. milk powder								
				Sugar								
				Gelatine								
				Water								
				Vanilla								
				Chocolate								
				Fruit								
				Nuts								
				TOTALS								

Calculated test	Majonnier test	Retest	Original gallons mix	Cost per gallon of original mix	

Added to standardize

Laboratory tests. Per cents											
Fat	Total solids	Milk solids not fat + grimes	Gallons		Total weight pounds	Pounds butter fat	Pounds total solids	Pounds sugar	Price per pound	Price per gallon	Total cost
										Total cost of entire mix	

Total pounds added to standardize		Gallons mix added to standardize	
Total pounds of original mix		Gallons ice cream made	
Grand total pounds of entire mix		Grand total gallons of mix	
Cost per gallon mix		Grand total of gallons ice cream made	
Cost per gallon ice cream finished		Overrun ratio obtained	
Manufacturing cost per gallon		Average overrun tests	
Delivery cost per gallon		Cost per gallon original mix	
		Cost per gallon added mix	
		Saving on each gallon added mix	
		Saving on cost of added mix	
Total cost per gallon ice cream		Total savings on gallons made	

Order new pads by Form Number from MOJONNIER BROS. CO., 730 W. Jackson Blvd., Chicago, Ill.

Fig. 82. Ice Cream Mix and Cost Report.

(10). Add the standardizing materials to the batch. Mix thoroughly. Make a retest for fat and T. S. Complete all possible or necessary calculations upon the above report blank.

The use of this blank reduces the possibilities of errors to a minimum; provides a means of computing the cost per gallon of the mix, and gives a clear history of every batch of ice cream made. Any troubles that may arise can be more readily traced if a record of this kind is kept.

Standardizing and Holding Tanks for Ice Cream Mix. Several different designs of suitable tanks are available for the mixing and holding of ice cream mix. In small plants the same tank can be used as a batch mixer, pasteurizer, cooler and holder. Figs. 83,

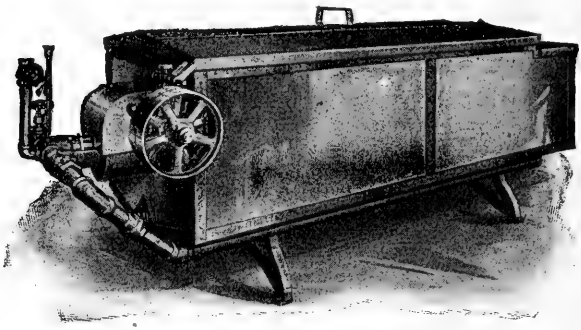


Fig. 83. Ice Cream Batch Mixer.
Courtesy Creamery Package Mfg. Co.

84 and 85 illustrate tinned copper tanks of this kind. Figs. 86 and 88 illustrate glass enamelled batch mixers, and Fig. 87 a glass enamelled standardizing and holding tank. The size of tank to

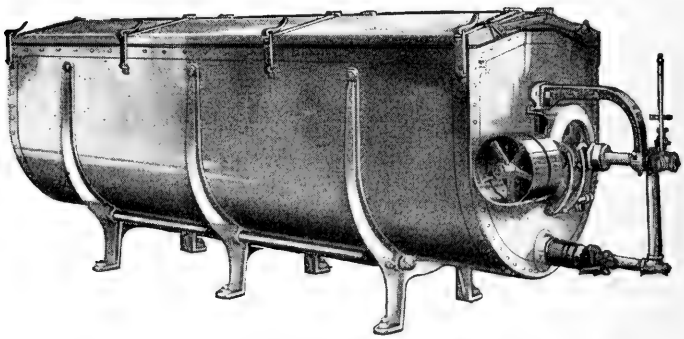


Fig. 84. Ice Cream Batch Mixer.
Courtesy J. G. Cherry Co.

use is governed by the quantity of the output. Where the output so warrants, the larger the tanks used, the fewer the stand-

ardizations that are necessary, and the more exact the control that can be maintained over the finished product.

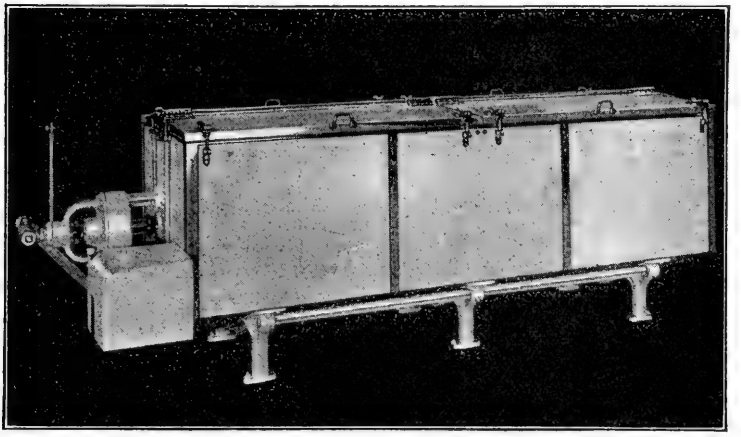


Fig. 85. Ice Cream Batch Mixer.
Courtesy Davis-Watkins Dairymen's Mfg. Co.

Fig. 86. Ice Cream Batch Mixer.

Fig. 87. Ice Cream Holding Tank.

Courtesy The Pfaudler Co.

Kinds of Problems Encountered in Standardizing Ice Cream Mix. Numerous methods have been suggested and used for standardizing ice cream mix, but usually the attempt has been

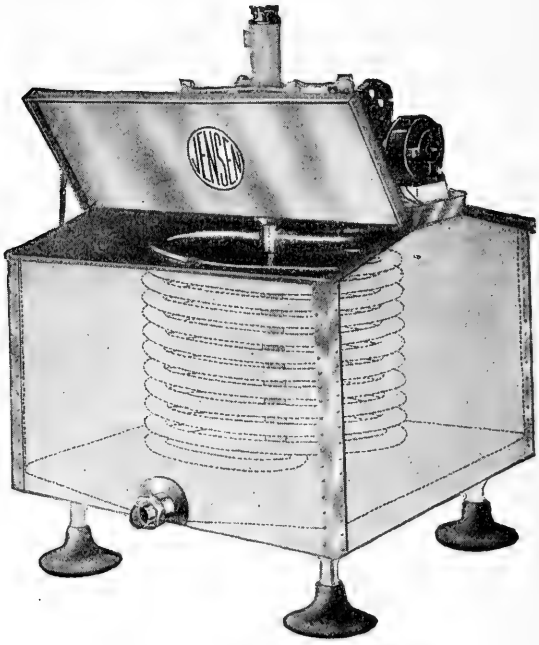


Fig. 88. Ice Cream Batch Mixer.
Courtesy Jensen Creamery Machinery Co.

to standardize the fat only, paying but comparatively little attention to the solids other than the fat. In the methods which follow, the fat, M. S. N. F. and the sugar are taken into consideration, and if these methods are used as recommended, all can be standardized with equal accuracy. Several different combinations of results are possible, all requiring different calculations as follows:

(1). **Fat Under, and T. S. Over the Standard Desired.** The same method of calculations can be used when both the fat and the T. S. are over the standard desired, but with the fat in a

lower ratio than the T. S. This is covered by problems 29 and 30.

(2). **Both the Fat and T. S. Are Under the Standard Desired.** Three methods of calculations are given for this combination. This is covered by problems 31, 32 and 33.

(3). **Fat Over, and T. S. Under the Standard Desired.** The same method of calculation can be used when both the fat and the T. S. are over the standard desired, but with the fat in a higher ratio than the T. S. This is covered by problems 34 and 35.

(4). **Both the Fat and the T. S. Over the Standard Desired,** and in the proper ratio one to another, making it necessary to add sugar and water only. This is covered by problem 36.

The above problems are solved in this chapter both by rules and formulas, and also by examples under each rule and formula.

KEY TO FACTORS IN FORMULAS FOR STANDARDIZING.

ICE CREAM MIX

A = The percentage of fat desired in mix.
A^1 = The percentage of fat short.
B = The percentage of M. S. N. F. desired in mix.
B^1 = The percentage of water-free gelatin desired in the mix.
C = The percentage of fat in the cream.
C^1 = The percentage of fat in the condensed milk.
D = The percentage of M. S. N. F. in the cream.
D^1 = The percentage of M. S. N. F. in the whole milk.
E = The percentage of fat in cream available for standardizing.
E^1 = The percentage of fat in butter.
E^2 = The percentage of fat in the whole milk.
F = The percentage of fat in the ice cream mix before standardizing.
F^1 = The percentage of fat in the condensed whole milk.
F^2 = The percentage of fat in the whole milk.
F^3 = The percentage of M. S. N. F. in the condensed whole milk.
G = The pounds of M. S. N. F. in mix after adding cream.

H = The pounds of M. S. N. F. short.
H^1 = The pounds of condensed whole milk
K = The pounds of mix short.
K^1 = The pounds of mix possible to make.
L = The pounds of fat short.
M = The pounds of mix before standardizing.
M^1 = The pounds of mix after adding cream.
M^2 = The pounds of mix desired.
N = The percentage of M. S. N. F. in the original mix.
N^1 = The percentage of M. S. N. F. in the mix after adding the cream.
O = The pounds of cream required.
O^1 = The pounds of butter required.
P = The percentage of M. S. N. F. in the mix after adding condensed milk and cream.
P^1 = The pounds of whole milk on hand.
P^2 = The pounds of whole milk required.
R = The ratio of fat to M. S. N. F.
S = The percentage of M. S. N. F. in the milk powder.
S^2 = The pounds of milk powder.
S = The pounds of gelatin required.
U = The pounds of sugar required.
V = The percentage of sugar desired.
V^1 = The percentage of T. S. in the gelatin.
W = The pounds of water required.

COMPOUNDING AN ICE CREAM MIX TO APPROXIMATE TESTS.

The procedure to follow in making up the batch of ice cream mix before testing and accurately standardizing is illustrated and explained in the directions here given, and by using the ice cream mix report illustrated under Fig 82.

The first column of the left hand side of the report shows the raw materials on hand from which it is necessary to select the materials that are to be used in making up the batch. The percentages of fat and M. S. N. F. in the different materials should be determined by tests made in advance, or the percentage may be taken from former tests of these substances received from the same source, provided that the composition does not vary

widely in different deliveries. In this problem, the percentages of fat and M. S. N. F. in the different materials used were determined in advance and may be found in their respective places in the report at the upper right hand side.

When gelatin or other stabilizers are used they may be included with the M. S. N. F. In this batch .50 of one per cent of gelatin was added.

Table 59 gives the average composition of the products most commonly used for making up ice cream mix. These results are accurate enough to use when compounding a mix to an approximate test.

TABLE 59.

Approximate Composition of Products Used in Ice Cream Mix.

Name of Product	Per Cent Fat	Per Cent M.S.N.F.	Per Cent T. S.	Name of Product	Per Cent Fat	Per Cent M.S.N.F.	Per Cent Sugar	Per Cent T. S.
Butter	84.00	1.50	85.50	Plain cond. Skim-milk	.50	25.50	.....	26.00
Skim-milk	.10	8.70	8.80					
Fresh milk	3.50	8.50	12.00	Plain cond. whole milk	6.00	22.00	.....	28.00
Cream	15.00	7.88	22.88	" "	8.00	27.00	.....	33.00
Cream	18.00	7.59	25.59					
Cream	20.00	7.41	27.41	Sweetened cond. skim-milk	.50	27.50	42.00	70.00
Cream	25.00	6.94	31.94	Sweetened cond. whole milk	8.00	20.00	42.00	70.00
Cream	30.00	6.48	36.48	Skim-milk powder	1.00	94.00	.....	95.00
Cream	40.00	5.55	45.55	Whole milk powder	26.00	69.00	.....	95.00
Cream	50.00	4.63	54.63	Sugar	.....	.....	100.00	100.00
Evaporated whole milk	7.80	17.70	25.50	Gelatin	.....	.....	.....	86.00
Evaporated skim-milk	.40	22.00	22.40					

Example 27:

PROBLEM 26: HOW TO COMPOUND ICE CREAM MIX TO APPROXIMATE TESTS.

Products	Pounds	Per Cent		Pounds	
		Fat	M. S. N. F.	Fat	M. S. N. F.
Whole milk.....	3400	4.00	8.50	136.00	299.00
Skim-milk.....	1360	....	8.70	.....	118.32
Condensed skim-milk	1300	....	25.00	.....	325.00
Butter.....	....	84.00	.....	.....	.....
Skim-milk powder....	....	....	95.00	.....	.....

The above products are on hand and it is desired to utilize completely the first three products named, to make up a batch of 10,000 pounds, the same to test 8.00 per cent of fat, 12.50 per cent of milk S. N. F., .50 per cent of gelatin, 13.00 per cent of sugar, making 34.00 per cent T. S.

Solution Problem 26, Example 27:

(1). **To calculate the pounds of fat, M. S. N. F. and gelatin required.**

10000×.08=800, pounds of fat required.

10000×.125=1250, pounds M. S. N. F. required.

10000×.005=50, pounds gelatin required.

(2). **To calculate the pounds of butter required.**

3400×.04=136.00, pounds of fat in whole milk.

800—136=664.00, pounds of fat to be supplied by the butter.

664÷.80=790.5, pounds of butter required.

(3). **To calculate the pounds of skim-milk powder required.**

3400×.085=289.00, pounds of M. S. N. F. in whole milk.

1360×.087=118.32, pounds of M. S. N. F. in skim-milk.

1300×.25=325.00, pounds of M. S. N. F. in condensed whole milk.

10000×.005=50.00, pounds of gelatin required.

289.00+118.32+325.00=732.32, pounds of M. S. N. F. in four products to be added.

1250—732.32=517.68, pounds of M. S. N. F. to be provided.
517.68÷.95=544.68, pounds of skim-milk powder to use.

4. To Calculate the Pounds of Sugar Required.

10000×.13=1300, pounds of sugar.

5. To calculate the pounds of water required.

3400+1360+1300+50+790.50+544.68+1300=8745.18 pounds of materials in mix.
10000—8745.18=1254.82 pounds of water required.

The complete batch after standardizing to approximate tests will contain the following materials:

Whole milk	3400.00 pounds
Skim-milk	1360.00 pounds
Plain condensed skim-milk	1300.00 pounds
Butter	790.50 pounds
Skim-milk powder	544.68 pounds
Gelatin	50.00 pounds
Sugar	1300.00 pounds
Water	1254.82 pounds
	10,000.00 pounds.

The materials in the quantities as determined are mixed together, homogenized and accurately sampled. The samples are immediately tested for fat and T. S. on the Mojonnier Tester. From the results obtained the final calculations are made to determine the materials to add in order to secure accurate standardization. In making the calculation select and use the proper rule from those that follow in this chapter. When the percentage of fat or of M. S. N. F. in the mix are below the desired percentage it is much more difficult to determine the exact amount of materials to add for correction, than it is to calculate the materials to add when the fat and M. S. N. F. are present in excess. For this reason the aim should be always to have a small excess of fat and M. S. N. F. in the mix when this is made up before it is tested by the Mojonnier Tester for final accurate standardization.

Providing Factor of Safety. In all problems given in this chapter the calculations are made upon the basis of an absolute standard. A proper factor of safety should be allowed, and it is recommended that this be about .10 per cent upon the fat and .20 per cent upon the T. S.

STANDARDIZING ICE CREAM MIX.

Problem 27. How to calculate when making a definite weight of mix using a vacuum pan.

Solution of Problem 27, Based Upon Rule 24:

(1). Multiply the pounds of mix desired by the percentage of M. S. N. F. desired. Divide the answer by the percentage of M. S. N. F. desired The answer will be the pounds of whole milk required.

(2). Multiply the pounds of mix desired by the percentage of fat desired. Subtract from this product the pounds of fat in the whole milk, and divide the remainder by the percentage of fat in the butter. The answer will be the pounds of butter required.

(3). Multiply the pounds of mix desired by the percentage of water free gelatin desired and divide the product by the percentage of T. S. in the gelatin. The answer will be the pounds of gelatin required.

Multiply the pounds of mix desired by the percentage of sugar desired. The answer will be the pounds of sugar required.

Solution of problem 27, based upon formula 24:

(1). **To calculate the pounds of whole milk required.**

$$P^2 = \frac{M^2 \times B}{D^1}$$

(2). **To calculate the pounds of butter required.**

$$O^1 = \frac{(M^2 \times A) - (P^2 \times E^2)}{E^1}$$

(3). **To calculate the pounds of gelatin and of sugar required.**

$$S^2 = \frac{M^2 \times B^1}{V^1}$$

$$U = M \times V$$

Problem 27, Example 28.

Products	Per Cent				
	Fat	M. S. N. F.	Gelatin	Sugar	T. S.
Whole milk.....	3.75	8.50	...	.....	12.25
Butter.....	84.00	.....	...	.....	84.00
Gelatin.....	.....	.....	84.00	.....	84.00
Sugar.....	.....	.....	...	100	100.00
Composition of mix desired.....	8.00	12.50	.50	13.00	34.00

It is desired to make 10,000 pounds of ice cream of the above tests, using the materials named.

Solution of Problem 27, Example 28, based upon rule 24.

(1). **To Calculate the Pounds of Whole Milk Required.**

$10000 \times .125 = 1250$, pounds of M. S. N. F. required.

$1250 \div .085 = 14706$, pounds of whole milk required.

(2). **To Calculate the Pounds of butter Required.**

$10000 \times .08 = 800.00$ pounds of fat required.

$14706 \times .0375 = 551.48$, pounds of fat in whole milk.

$800.00 - 551.48 = 248.52$, pounds of fat to be provided from butter.

$248.52 \div .84 = 295.90$, pounds of butter required.

(3). **To Calculate the Pounds of Gelatin and Sugar Required.**

$$\frac{10000 \times .005}{.84} = 60, \text{ pounds gelatin required.}$$

$10000 \times .13 = 1300$, pounds of sugar required.

Condense the above batch to such a concentration as to obtain 10000 pounds of finished product.

Solution of Problem 27, Example 28, based upon formula 24:

(1). **To calculate the pounds of whole milk required:**

$$\frac{P^2 = 10000 \times .125}{.085} = 14706$$

(2). **To calculate the pounds of butter required.**

$$\frac{O^1 \quad (10000 \times .08) - (14706 \times .0375)}{.84} = 295.90$$

(3). **To calculate the pounds of gelatin and of sugar required.**

$$\frac{S^2=10000\times.005}{.84}=60$$

$$U=10000\times.13=1300$$

Proof of Problem 27, Example 28:

Products	Pounds					
	Total	Fat	M. S. N. F.	Gelatin	Sugar	T. S.
Whole milk	14706	551.48	1250.0	....	....	1801.48
Butter	296.0	248.52	.....	....	....	248.52
Gelatin	60.0	.....	.....	60.0	....	50.0
Sugar	1300	.....	.....	....	1300	1300.0
Total pounds of batch after condensing and standardizing	10000	800.00	1250.0	60.0	1300	3400.0

Products	Per Cent				
	Fat	M. S. N. F.	Gelatin	Sugar	T. S.
Whole milk	3.75	8.50	.....	.....	12.25
Butter	84.00	.....	.....	.....	84.00
Gelatin	.....	.....	84.00	.....	84.00
Sugar	.....	.....	.....	100.00	100.00
Tests of batch after condensing and standardizing	8.00	12.50	.50	13.00	34.00

Problem 28. How to Calculate When Making an Indefinite Weight of Mix Using a Vacuum Pan.

Solution of Problem 28, Based Upon Rule 25:

(1). Multiply the pounds of whole milk by the percentage of M. S. N. F. in the whole milk. Divide the answer by the percentage of M. S. N. F. desired. Call the answer A, or the pounds of mix possible to make from the whole milk on hand. Multiply A by the percentage of fat desired. Subtract from the answer the pounds of fat in the whole milk, and divide the remainder by the percentage of fat in the butter. The answer will be the pounds of butter required.

(2). Multiply A by the percentage of water free gelatin desired and divide the product by the percentage of T. S. in the gelatin. The answer will be the pounds of gelatin required. Multiply A by the percentage of sugar desired. The answer will be the pounds of sugar required.

Solution of Problem 28, based Upon Formula 25:

(1). **To calculate the pounds of butter required.**

$$O^1=\frac{\left[\left(\frac{P^1\times D^1}{B}\right)\times A\right]-(P^1\times E^2)}{E^1}$$

(2). **To calculate the pounds of gelatin and of sugar required.**

$$S^2=\frac{K^1\times B^1}{V^1}$$

$$U=K^1\times V$$

Problem 28, Example 29.

Products	Pounds	Per Cent				
		Fat	M. S. N. F.	Gelatin	Sugar	T. S.
Whole milk.....	10,000	3.75	8.50	...	.....	12.25
Butter.....	.....	84.00	.....	...	.....	84.00
Gelatin.....	.....	.....	.....	...	.....	84.00
Sugar.....	.....	.....	.....	...	100.00	100.00
Composition of mix desired, including gelatin.....	.....	8.00	12.00	.50	13.00	33.50

It is desired to make all the ice cream mix possible from the above whole milk, using butter to supply extra fat required.

Solution of Problem 28, Example 29, Based Upon Rule 25:

(1). To calculate the pounds of butter to use.

10000×.085=850, pounds of M. S. N. F. in whole milk.
850÷.12=7083, pounds of mix possible to make.
7083×.08=567, pounds of fat required.
10000×.0375=375, pounds of fat in the whole milk.
567—375=192, pounds of fat to be provided by butter.
192÷.84=228, pounds of butter required.

(2). To calculate the pounds of gelatin and of sugar required.

7083×.005=35.4, pounds water free gelatin required.
35.4÷.84=42.0, pounds of gelatin required.
7083×.13=921, pounds of sugar required.

Solution of Problem 28, Example 29, Based Upon Formula 25:

(1). To calculate the pounds of butter required.

$$O^1=\frac{\left[\left(\frac{10000\times .085)}{.12}\right)\times 7.07\right]-(10000\times .0375)}{.84}=228$$

(2). To calculate the pounds of gelatin and of sugar required.

$$S^2=\frac{7083\times .005}{.84}=42$$

$$U=7083\times .13=921$$

Condense the above batch to such a concentration as to obtain 6800 pounds of finished product.

Proof of Problem 28, Example 29:

Products	Pounds				
	Total	Fat	M. S. N. F.	Sugar	Total
Whole milk	10000	375	850	...	1225
Butter	228	192	...	...	192
Gelatin	42	...	...	...	35
Sugar	921	...	...	921	921
Total pounds of batch	7083	567	850	921	2373

Products	Per Cent				
	Fat	M. S. N. F.	Gelatin	Sugar	T. S.
Whole milk	3.75	8.50	...	.....	12.25
Butter	84.00	.....	...	.....	84.00
Gelatin	.....	.....	.50	.....	84.00
Sugar	.....	.....	...	13.00	100.00
Tests of batch	8.00	12.00	.50	13.00	33.50

PROBLEM 29: HOW TO CALCULATE WHEN THE FAT IS UNDER AND THE T. S. OVER THE STANDARD DESIRED. ALSO WHEN BOTH THE FAT AND THE T. S. ARE OVER THE STANDARD DESIRED, BUT WITH THE FAT IN A LOWER RATIO THAN THE T. S.

See problem 30 for solution of second half of this problem. Cream sugar and water are to be used in standardizing.

Solution of Problem 29, Based Upon Rule 26.

(1). Divide the percentage of M. S. N. F. in the mix by the desired ratio between the fat and the M. S. N. F., and from the result, subtract the percentage of fat in the mix. Multiply the

difference by the pounds of mix. Call the product L.

Divide the percentage of M. S. N. F. in the cream by the desired ratio between the fat and the M. S. N. F., and subtract the result from the percentage of fat in the cream to be used for standardizing. Call the result E. Divide L by E. The quotient equals the pounds of cream to be added to the mix to bring the fat and the M. S. N. F. to the desired ratio.

(2). Multiply the pounds of mix by the percentage of M. S. N. F. in the mix, and multiply the pounds of cream required by the percentage of M. S. N. F. in the cream. Divide the sum of the two products by the weight of the mix plus the weight of the cream. From the quotient subtract the percentage of M. S. N. F. desired in the mix. Multiply this difference by the pounds of mix plus the pounds of cream required, and divide the product by the desired percentage of M. S. N. F. in the mix. The quotient equals the pounds of mix short after adding the cream.

(3). Add the pounds of cream required to the pounds of mix short, and multiply the sum by the percentage of sugar in the mix. The result equals the pounds of sugar to add.

(4). Subtract the pounds of sugar from the pounds of mix short after adding the cream. The difference equals the pounds of water required.

Solution of Problem 29, Based Upon Formula 26:

(1). To calculate the pounds of cream to add:

$$O=\left[M\times\left(\frac{N}{R}\right)-F\right]\div\left[\left(C-\left(\frac{D}{R}\right)\right]\right.$$

(2). To calculate the pounds of mix short after adding the cream.

$$N^1=\frac{(M\times N)+(O\times D)}{M^1}\quad\text{Then } K=\frac{(N^1-B)M^1}{B}$$

(3). To calculate the pounds of sugar to add.

$U=(K-O)\times V$

(4). To calculate the pounds of water required.

$W=K-U$

Problem 29, Example 30.

Products	Pounds	Per Cent			
		Fat	M. S. N. F.	Sugar	T. S.
Mix before standardizing	10000	7.79	13.80	13.00	34.59
Cream	.....	40.00	5.20	.....	45.20
Sugar	.....	.....	.....	100.00	100.00
Composition mix desired	.....	8.00	13.00	13.00	34.00

Ratio of fat to M. S. N. F. desired 1 to 1.625.

Mix before standardizing contains .50 per cent of gelatin which is included with the M. S. N. F.

Solution of Problem 29, Example 30, Based upon Rule 26:

(1). To calculate the pounds of cream to add.

13.80÷1.625=8.49, per cent of fat necessary to equalize M. S. N. F. in unstandardized mix.

8.49—7.79=.70, per cent of fat short.

10000.00×.007=70.00, pounds of fat short.

5.20÷1.625=3.20, per cent of fat to equalize the M. S. N. F. in the cream.

40.00—3.20=36.80, per cent of fat in the cream available for standardizing.

70.00÷.368=190.22, pounds of cream required.

(2). To calculate the pounds of mix short after adding the cream.

10000×.138=1380.00 pounds of M. S. N. F. in the mix.

190.22×.052=9.89, pounds of M. S. N. F. in the cream.

1380.00+9.89=1389.89, pounds of M. S. N. F. in the mix and cream together.

1389.89÷10190.22=13.64, per cent of M. S. N. F. in the mix and cream together.

13.64—13.00=.64, per cent excess M. S. N. F. in mix after adding the cream.

10190.22×.0064=65.12, pounds of excess M. S. N. F.

65.12÷.13=500.88, pounds of mix short.

(3). To calculate the pounds of sugar to add:

500.88+190.22=691.08, pounds of mix short plus pounds of cream.

691.08×.13=89.84, pounds of sugar to add.

(4). To calculate the pounds of water required.

500.88—89.84=411.04, pounds of water required.

Solution of Problem 29, Example 30, Based Upon Formula 26.

(1). To calculate the pounds of cream to add.

$$O=\frac{\left[10000\times\left(\frac{.138}{1.625}\right)-7.79\right)\right]}{\left[.40\times\left(\frac{.052}{1.625}\right)\right]}=190.22$$

(2). To calculate the pounds of mix short after adding the cream.

$$N^1=\frac{(10000\times.138)+(190.22\times.052)}{10190.22}=13.64$$

$$K=\frac{(.1364—.13)\times10190.22}{.13}=50.88$$

(3). To calculate the pounds of sugar to add.

U=(500.88+190.22)×.13=89.84

(4). To calculate the pounds of water required.

W=500.88—89.84=411.04

Proof of Problem 29, Example 30:

Materials in Batch		Pound			Per Cent			
		Fat	Milk S. N. F.	Sugar	Fat	Milk S. N. F.	Sugar	T. S.
Mix before standardizing.	10000	779.00	1380	1300	7.79	13.80	13.00	34.59
Cream added.....	190	76.00	10.00	....	40.00	5.20	.....	45.20
Sugar added.....	90	.....	.....	90	.....	.....	100.00	.....
Water added.....	411	.....	.....	....	.....	.....	.....	.....
Total after standardizing.	10691	855.00	1390	1390	8.00	13.00	13.00	34.00

PROBLEM 30. HOW TO CACULATE WHEN BOTH THE FAT AND THE T. S. ARE OVER THE STANDARD DESIRED, BUT WITH THE FAT IN A LOWER RATIO THAN THE T. S.

This problem is very similar to problem 29, but for the sake of clarity its complete solution is here given. Cream, sugar and water are to be used in standardizing.

Solution of Problem 30, Based Upon Rule 27:

(1). Divide the percentage of M. S. N. F. by the desired ratio between the fat and the M. S. N. F. and from the quotient subtract the percentage of fat in the mix. Multiply the difference by the pounds in the mix. Call the product L, or pounds of fat short. Divide the percentage of M. S. N. F. in the cream by the desired ratio between the fat and the M. S. N. F. and subtract the quotient from the percentage of fat in the cream. Call the difference E., or the percentage of fat available in the cream for standardizing. Divide L by E., and call the quotient O, or the pounds of cream required.

(2). Multiply the pounds in the original mix by the percentage of fat that it contains, and multiply the pounds of cream by the percentage of fat in it. Add the two products together and divide the sum by the number of pounds in the mix after adding the cream. From the quotient subtract the desired percentage of fat, and multiply the difference by the pounds of original mix plus the pounds of cream required. The product thus obtained, divided by the desired percentage of fat in the mix, equals the pounds of mix short after adding the cream.

(3). Add the pounds of cream required to the pounds of mix short and multiply the sum by the percentage of sugar desired. The product equals the pounds of sugar required.

(4). Subtract the pounds of sugar from the pounds of mix short. The difference equals the pounds of water to add.

Solution of Problem 30, Based Upon Formula 27:

(1). To calculate the pounds of cream required.

$$O = \left[M \times \left(\frac{N}{R}\right) - F\right] \div \left[C - \left(\frac{D}{R}\right)\right]$$

(2). To calculate the pounds of mix short after adding the cream.

$$K = \frac{\left[\frac{(M \times F) + (O \times C)}{M + O} - A\right] \times (M + O)}{A}$$

(3). To calculate the pounds of sugar required.

$$U = (K + O)V$$

(4). **To Calculate the Pounds of Water Required.**
W=K—U

Problem 30, Example 31:

Products	Pounds	Per Cent			
		Fat	M. S. N. F.	Sugar	T. S.
Mix.....	10,000	8.10	13.70	13.00	34.80
Cream.....	.....	40.00	5.20	.....	45.20
Sugar.....	.....	.....	.....	.....	100.00
Water.....	.....	.....	.....	.....	.....
Desired composition.....	.....	8.00	13.00	13.00	34.00

Mix before standardizing contains .50 per cent of gelatin which is included with the M. S. N. F.

Solution of Problem 30, Example 31, Based Upon Rule 27:

(4). **To calculate the pounds of cream required.**

13.70÷1.625=8.43, per cent of fat to equalize the M. S. N. F.
8.43—8.10=.330, per cent of fat short.
10000.00×.0033=33.00, pound of fat short.
5.20÷1.625=3.20, per cent fat required to equalize the M. S. N. F. in the cream.
40.00—3.20=36.80, per cent fat in the cream available for standardizing.
33.00÷.368=89.86, pounds of cream required.

(2). To calculate the pounds of mix short after adding the cream.

10000×.081=810.0, pounds of fat in the mix.
89.86×.40=35.95, pounds of fat in the cream.
810.00+35.946=845.95, pounds of fat in the mixture.
10000+89.86=10089.86, pounds of mix and cream.
845.95÷10089.86=8.384, per cent of fat in the mixture.
8.384—8.0=0.384, per cent fat excess.
10089.86×.00384=38.745, pounds of fat excess.
38.745÷.08=484.3, pounds of mix short after adding the cream.

(3). To calculate the pounds of sugar.

484.3+89.86=574.16, pounds of mix short plus pounds of cream.

574.16×.13=74.64, pounds of sugar required.

(4). To calculate the pounds of water required.

484.3—74.64=409.66, pounds of water required.

Solution of Problem 30, Example 31, Based Upon Formula 27:

(1). To calculate the pounds of cream required.

$$O = \frac{\left[10000 \times \left(\frac{.137}{1.625}\right) - .081\right]}{\left[.40 \times \left(\frac{.052}{1.725}\right)\right]} = 89.86$$

(2). To calculate the pounds of mix short after adding the cream.

$$K = \frac{\left[\frac{(10000 \times .081) + (89.86 \times .40)}{10000 + 89.86} - .08\right] \times 10000 + 8986)}{.08} = 484.3$$

(3). To calculate the pounds of sugar required.

U=(484.3+89.86)×.13=74.64

(4). To calculate the pounds of water required.

W=484.30—74.64=409.66

Proof of Problem 30, Example 31:

Materials in Batch		Pounds				Per Cent			
		Fat	M.S.N.F.	Sugar	T. S.	Fat	M.S.N.F.	Sugar	T. S.
Mix	10000	810.0	1370.	1300	3480.0	8.10	13.70	13.00	34.80
Cream	90	36.0	5.00	.....	71.0	40.00	5.20	.....	45.20
Sugar	75	.....	.....	75.	75.0	.....	.....	100.00	100.00
Water	409	.....	.....	.....	.....	.....	.....	.....	.....
After standardizing	10574	846	1375	1375	3596	8.00	13.00	13.00	34.00

PROBLEM 31: HOW TO CALCULATE WHEN THE FAT AND THE M. S. N. F. ARE BOTH UNDER THE STANDARD DESIRED.

Butter, skim-milk powder and sugar are to be used for standardizing under this problem. Example 32 shows how to

solve this problem when using these products. Concentrated cream and condensed whole milk can also be used, as indicated by the solution under problem 32.

Two methods of calculation are possible when using concentrated cream and condensed whole milk. The second method as indicated under example 34 was originated by J. A. Cross.

Solution of Problem 31, Based Upon Rule 28:

(1). Subtract the percentage of fat in the mix from the percentage of fat desired, and multiply the difference by the weight of the mix. Divide the product by the percentage of fat in the butter. The quotient will be the pounds of butter required.

(2). Subtract the percentage of M. S. N. F. in the mix from the percentage of M. S. N. F. desired, and multiply the difference by the weight of the mix. Divide the answer by the percentage of T. S. in the skim-milk powder. The answer will be the pounds of skim-milk powder required.

(3). The pounds of butter plus the pounds of skim-milk powder multiplied by the percentage of sugar required equals the pounds of sugar required. The pounds of butter plus the pounds of sugar plus the pounds of milk powder equals the total weight of material to be added for standardizing.

(4). Another calculation is necessary to standardize the material added which itself requires to be standardized. Multiply the total weight of material added for standardizing by the percentage of fat desired, and divide the product by the percentage of fat in the butter. The result equals the pounds of butter required.

(5). Multiply the total weight of material added for standardizing by the percentage of M. S. N. F. desired and divide the product by the percentage of T. S. in skim-milk powder. The quotient equals the pounds of skim-milk powder required.

(6). Multiply the total weight of materials added for standardizing by the percentage of sugar desired. The product equals the pounds of sugar required.

(7). The materials to be added under 3, plus the materials to be added under 4, 5, and 6, equals the total materials to be added in standardizing the batch. The batch will still not be

completely standardized because the products added under 5 and 6 require to be standardized also. An unstandardized remainder can thus be continued indefinitely, but the amount gradually becomes smaller and as a rule only one extra standardization is necessary.

Solution of Problem 31, Based Upon Formula 28:

(1). To calculate the pounds of butter required.

$$O^1 = \frac{[M \times (A - F)]}{E^1}$$

(2). To calculate the pounds of skim-milk powder required.

$$S^1 = \frac{[M \times (B - N)]}{S}$$

(3). To calculate the pounds of sugar required.

$$U = (O^1 + S^1) \times V$$

To calculate the extra pounds of each material necessary to standardize the material added in the first standardization.

(4). To calculate the pounds of butter required, second standardization.

$$O^1 = \frac{[(O^1 + S^1 + U)\ A]}{E^1}$$

(5). To calculate the pounds of skim-milk powder required, second standardization.

$$S^1 = \frac{[(O^1 + S^1 + U)\ B]}{S}$$

(6). To calculate the pounds of sugar required, second standarization.

$$U = [(O^1 + S^1 + U)\ V]$$

Note: In the second standardization the factors O^1, S^1 and U in the formula to the right of the equality sign represent the pounds of butter, skim-milk powder, and sugar respectively, as determined in the first standardization.

Problem 31, Example 32.

Products	Pounds	Per Cent			
		Fat	M. S. N. F.	Sugar	T. S.
Mix	10,000	7.60	12.10	13.00	32.70
Butter	.....	80.00	.....	.....	80.00
Skim-milk powder	.....	.....	95.00	.....	95.00
Sugar	.....	.....	.....	100.00	100.00
Composition desired	.....	8.00	13.00	13.00	34.00

Desired ratio of fat to M. S. N. F. in the mix is 1 to 1.625.

Mix before standardizing contains .50 per cent gelatin which is included with the above M. S. N. F.

Solution of Problem 31, Example 32, Based Upon Rule 28:

(1). To calculate the pounds of butter required.

8.00—7.60=.40, per cent of fat short.

10000.00×.004=40, pounds of fat short.

40.00÷.80=50, pounds of butter required.

(2). To calculate the pounds of skim-milk powder required.

13.00—12.10=.90, per cent of M. S. N. F. short.

10000×.009=90, pounds of M. S. N. F. short.

90÷.95=94.74, pounds of skim-milk powder short.

(3). To calculate the pounds of sugar required.

50+94.74=144.74, pounds of butter and skim-milk powder required.

144.74×.13=18.82, pounds of sugar required.

To calculate the extra pounds of each material necessary to standardize the material added in the first standardization.

(4). To calculate the pounds of butter required.

50+94.74+18.82=163.56, pounds of material added.

163.56×.08=13.08, pounds of fat required.

13.08÷.80=16.36, pounds of butter required.

(5). To calculate the pounds of skim-milk powder required.

50+94.74+18.82=163.56, pounds of material added.

163.56×.13=21.26, pounds of M. S. N. F. required.

21.26÷.95=22.40, pounds of skim-milk powder required.

(6). To calculate the pounds of sugar required.

50+94.74+18.82=163.36, pounds of material added.
163.36×.13=21.26, pounds of sugar required.

(7). To calculate total pounds of each material required.

50+16.36=66.36, pounds of butter required.
94.74+22.40=117.14, pounds of skim-milk powder required.
18.82+21.26=40.08, pounds of sugar required.

Solution to Problem 31, Example 32, Based Upon Formula 28:

(1). To calculate the pounds of butter required.

$$O=\frac{10000\times(.08-.076)}{.80}=50$$

(2). To calculate the pounds of skim-milk powder required.

$$S^1=\frac{10000\times(.13-.121)}{.95}=94.74$$

(3). To calculate the pounds of sugar required.

$$U=(50+94.74)\times.13=18.82$$

(4). To calculate the pounds of butter required, second standardization.

$$O^1=\frac{(50+94.74+18.82)\times.08}{.80}=16.36$$

(5). To calculate the pounds of skim-milk required, second standardization.

$$S^1=\frac{(50+94.74+18.82)\times.13}{.95}=22.40$$

(6). To calculate the pounds of sugar required, second standardization.

$$U=(50+94.74+18.82)\times.1300=21.26$$

The addition of butter and skim-milk powder is not practicable unless they can be added before the batch is pasteurized and homogenized.

Proof of Problem 31, Example 32.

Products		Pounds				Per Cent			
		Fat	M.S.N.F.	Sugar	T. S.	Fat	M.S.N.F.	Sugar	T. S
Mix	1000	760.00	1210.0	1300	3270	7.60	12.10	13.00	32.70
Butter	66.36	53.08	.....	.....	.....	80.00	.....	.....	80.00
Skim-milk powder	117.14	.....	105.7	.....	105.7	.....	95.00	.....	95.00
Sugar	40.08	.....	.....	40.08	.....	.....	.....	100.00	100.00
Standardized products	10223.00	813.08	1315.7	1340.08	3375.7	7.95	12.90	13.11	33.96

PROBLEM 32: HOW TO CALCULATE WHEN THE FAT AND T. S. ARE BOTH UNDER THE STANDARD DESIRED.

Solution of problem 32, based upon rule 29. Under this modification of problem 31, the use of concentrated cream and condensed whole milk is contemplated in effecting standardization.

(1). Subtract the percentage of fat desired from the percentage of fat in the mix. Multiply the remainder by the pounds of mix. Call the answer A. Divide the percentage of M. S. N. F. in the cream by the ratio between the fat and the M. S. N. F. desired and subtract the answer from the percentage of fat in the cream. Divide A by the remainder. The answer will be the pounds of cream required.

(2). Multiply the pounds of cream required and the pounds of mix by their respective percentages of M. S. N. F. and add the two products together. Divide the sum by the combined pounds of mix and cream required. The answer will be the percentage of M. S. N. F. in the mixture.

(3). Subtract the percentage of M. S. N. F. in the mixture from the percentage of M. S. N. F. desired and multiply the combined pounds of mix and cream by the remainder. Call the product B, or the pounds of M. S. N. F. short. Multiply the percentage of fat in the condensed milk by the ratio, and subtract the answer from the percentage of M. S. N. F. in the condensed milk. Divide B by the remainder. The answer will be the pounds of condensed milk required.

(4). Multiply the pounds of cream and condensed milk used by the percentage of sugar desired to obtain the pounds of sugar required.

Solution of Problem 32, Based Upon Formula 29:

(1). To calculate the pounds of cream required to supply the fat short in the mix.

$$O=\left[(A\times F)\times M\right]\div\left[C-\left(\frac{D}{R}\right)\right]$$

(2). **To calculate the percentage of M. S. N. F. in the mix after adding the cream.**

$$N^1=\frac{(O\times D)+(M\times N)}{(O+M)}$$

(3). **To calculate the pounds of condensed milk required after adding the cream.**

$$H^1=(B-N^1)\times(M+O)\div[F^3\times(C^1\times R)]$$

(4). **To calculate the pounds of sugar required.**

$$U=(O+H^1)V.$$

Problem 32, Example 33:

Products	Pounds	Per Cent			
		Fat	M. S. N. F.	Sugar	T. S.
Mix.....	10,000	7.60	12.70	13.00	33.30
Cream.....	.....	40.00	6.00	.....	46.00
Condensed milk.....	.....	10.50	25.50	.....	36.00
Composition desired.....	.....	8.00	13.00	13.00	34.00

Desired ratio of fat to M. S. N. F. is 1 to 1.625.

Mix before standardizing contains .50 per cent of gelatin which is included with the above M. S. N. F.

Solution of Problem 32, Example 33, based Upon Rule 29:

(1). **To calculate the pounds of cream required to supply the fat short in the mix.**

8.00—7.60=.40, per cent of fat short.

10000×.004=40, pounds of fat short.

6.00÷1.625=3.70, per cent of fat to equalize the M. S. N. F. in the cream.

40.00—3.70=36.30, per cent of fat available for standardizing in the cream.

40÷.363=110.2, pounds of cream required.

(2). **To calculate the percentage of M. S. N. F. in the mix after adding the cream.**

110.2×.06=6.61, pounds of M. S. N. F. in the cream.

10000×.127=1270, pounds of M. S. N. F. in the original mix.

1270+6.12=1276.12, pounds in both.

10000+110.2=10110.2, pounds of mix plus cream.

1276.12÷10110.2=12.62, per cent M. S. N. F. in the mixture.

(3). **To calculate the pounds of condensed milk required.**

13.00—12.62=.38, per cent of M. S. N. F. short.

10110.2×.0038=38.4, pounds of M. S. N. F. short.

10.50×1.625=17.06, per cent of M. S. N. F. to equalize the fat in the condensed milk.

25.5—17.06=8.44, per cent of M. S. N. F. available for standardizing in the condensed milk.

38.40÷.0844=443, pounds of condensed milk required.

(4). **To calculate the pounds of sugar required**

443+110.2=553.2, pounds of cream and condensed milk.

553.2×.13=73, pounds of sugar required.

Solution of Problem 32, Example 33, Based Upon Formula 29:

(1). **To calculate the pounds of cream required to supply the fat short in the mix.**

$$O=\frac{[(8.00—7.60)\times 10000]}{\left[40.00—\left(\frac{6.00}{1.625}\right)\right]}=110.2$$

(2). **To calculate the percentage of M. S. N. F. in the mix after adding the cream.**

$$N^1=\frac{(110.2\times 6.00)+(10000\times 12.70)}{[10000+110.2]}=12.62$$

(3). **To calculate the pounds of condensed milk required after adding the cream.**

$$H^1 = \frac{(.1300 \times .1262) \times (10000 - 110.2)}{.255 \times (.105 \times 1.625)} = 443$$

(4). **To calculate the pounds of sugar required.**

$U = (110.2 + 443) \times .13 = 73.00$

Proof of Problem 32, Example 33:

Products		Pounds				Per Cent			
		Fat	M S.N.F	Sugar	T. S.	Fat	M.S.N.F.	Sugar	T. S
Mix	10000	760.00	1270	1300	3330	7.60	12.70	13.00	33.30
Cream	110.2	44.08	6.12	.....	50.2	40.00	6.00	.....	46.00
Condensed whole milk	443.0	46.51	112.96	.....	159.47	10.50	25.50	.....	36.00
Sugar	73.0	.....	.....	73	73.00	.....	.....	100.00	100.00
Standardized product	10626.2	850.59	1389.08	1373	3612.67	8.00	13.07	12.92	33.00

The above method of standardization does not give results that check out exactly, as the proof indicates.

PROBLEM 33: HOW TO CALCULATE WHEN THE FAT AND THE M. S. N. S. ARE BOTH UNDER THE STANDARD DESIRED.

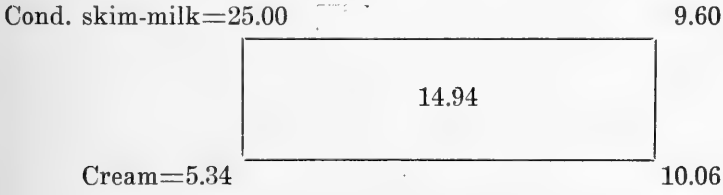
The problem is the same as problems 31 and 32. As in the case of these problems the use of concentrated cream and condensed skim-milk or of butter and skim-milk powder is contemplated in effecting standardization. The method of calculation shown under this problem is that originated by Jos. A. Cross. This method of calculation can be used upon problem 33, and also in the case of problems in which either the fat or T. S. are correct, but one or the other are low.

Principles of Cross Method of Calculation. This method is based upon making the calculations for two theoretical mixtures of dairy products from materials on hand available for standardizing. Mixture No. 1, to contain an excess of fat available for standardizing. Mixture No. 2, to contain an excess of M. S. N. F. available for standardizing. If the tests of the materials on hand are known, these calculations can be made before testing

the mix that is to be standardized, thereby saving time in making the final calculations. It is not necessary to make the actual mixtures of materials. The materials can be added in the proportions found necessary by the calculations. This method merits close study, and it is highly recommended since it gives absolutely accurate results all in one calculation.

How to Calculate Theoretical Mixtures No. 1, in which the M. S. N. F. is Standard and the Fat is Above Standard. When standardizing material is added to a batch of ice cream mix, a proportionate amount of sugar must be incorporated in order to produce no change in the sugar content of the standardized batch. If a mix tests 14.94 per cent of M. S. N. F. without sugar, it will test 13 per cent of S. N. F. after the correct amount of sugar is added in the case of a mix testing 8.00 per cent of fat, 13.00 per cent of M. S. N. F. and 13.00 per cent of sugar. This is found by subtracting 13.00 per cent of sugar from 100.00 and dividing 13.00 per cent of M. S. N. F. by 87. Likewise this mix will contain 9.20 per cent of fat found by dividing 8.00 per cent by 87. The following mix is calculated to test 14.94 per cent of M. S. N. F.

Materials to be used. Condensed skim-milk testing .50 per cent fat, 25.00 per cent S. N. F. and cream testing 40.00 per cent fat, 5.34 per cent M. S. N. F. Use Dr. Pearson's method for making the calculation, and calculate the percentage of fat available for standardizing in the mixture, as follows:



10.06+9.60=19.66, sum of condensed skim-milk and cream units to use.

9.60÷19.66=48.80, per cent of condensed skim-milk.

10.06÷19.66=51.20, per cent of cream.

51.2 parts of cream=20.46 parts of fat and 2.74 parts of M. S. N. F.

48.80 parts of condensed skim-milk=.24 parts of fat and 12.20 parts of M. S. N. F.

100.0=20.70 parts of fat, 14.94 parts of M. S. N. F.

20.7—9.20=11.50, available per cent of fat in the mixture which can be used for standardizing.

As calculated above, a mixture of 48.8 parts of 40 per cent cream and 51.2 parts of 25 per cent condensed skim-milk will test 14.94 per cent in solids not fat, which will be reduced to 13 per cent after the proper amount of sugar is added to the mix. Any desired amount of this mixture may be added to a batch of ice cream mix testing 13 per cent S. N. F. without changing S. N. F. test of the standardized mix. It tests, however, 11.50 per cent higher than standard in butter fat and every 100 pounds added (plus 14.94 pounds of sugar) will make up a deficit of 11.5 pounds of fat in the mix to be standardized and will leave the percentage of M. S. N. F. and the percentage of sugar unchanged.

It is, of course, unnecessary to actually make up this mixture. If the tests of the mixture to be standardized shows that it is standard in M. S. N. F. but requires 11.5 pounds of fat, add 48.8 pounds of the condensed and 51.2 pounds of 40 per cent cream and 14.94 pounds of sugar. If the deficit is 23 pounds of fat add twice the above amounts etc.

Other combinations using cream of different percentages and condensed milk of different concentration may be calculated and a record of the proportions necessary should be kept on file. These combinations may be made to cover any composition of mix desired.

A few combinations of commonly used standardizing materials are given in Table 60. These are all based upon a mix containing 8.00 per cent fat, 13.00 per cent of M. S. N. F., 13.00 per cent of sugar, making 34.00 per cent T. S. All of them will test 14.94 per cent of solids not fat and will have fat in excess and available for standardizing as indicated.

How to Calculate Theoretical Mixture No. 2 in Which the Fat is Standard and the M. S. N. F. is Above Standard. The calculation of this mixture is the same as in the case of mixture No. 1 except that it is made standard in fat, and used to raise the M. S. N. F. test of the mix to be standardized. In order to test 8.00 per cent of fat after sugar is added the mixture must test 9.20 per cent before adding the sugar, if it is to contain 13.00

per cent of sugar. Therefore, the following is calculated to test 9.20 per cent of fat and as much above 14.94 per cent of M. S. N. F. as possible.

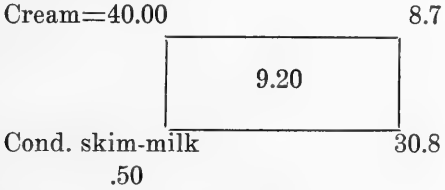
Materials to be used—40.00 per cent cream testing 5.34 per cent of M. S. N. F. and condensed skim-milk testing .50 per cent of fat, 25.00 per cent of M. S. N. F.

TABLE 60

A few combinations of cream and condensed milk containing an excess of fat available for standardizing.

Combination No.	Cream		Condensed Milk		Parts Cream to Use	Parts Condensed Milk to Use	Percentage Fat in Mixture Available for Standardizing.
	Per Cent		Per Cent				
	Fat	M. S. N. F.	Fat	M. S. N. F.			
1	20.00	7.12	.50	25.00	63.35	36.65	3.65
2	25.00	6.75	.50	25.00	55.12	44.88	4.80
3	30.00	6.23	.50	25.00	53.60	46.40	6.11
4	40.00	7.80	7.80	17.70	22.30	77.70	5.78
5	40.00	5.23	5.00	25.00	51.17	48.83	13.71

Use Dr. Pearson's method for making the calculation and calculate the percentage of M. S. N. F. available for standardizing in the mixture as follows:



8.7+30.8=39.5

8.70÷.396=22, per cent of cream.

30.80÷.396=78, per cent of condensed skim-milk .

78 parts of condensed skim-milk contains .40 parts fat, 19.5 parts M. S. N. F.

22 parts of cream contains 8.80 parts fat, 1.17 parts M. S. N. F.

100 parts of the mixture contain 9.20 parts fat 20.67, parts M. S. N. F.

20.67—14.94=5.73, per cent of M. S. N. F. above standard and available for raising the M. S. N. F. test of low testing ice cream mix.

As calculated above, a mixture of 78 parts of condensed skim-milk and 22 parts of cream will make a mix testing standard in fat, after 14.94 pounds of sugar is added per hundred. It will test, however, 5.73 per cent higher in M. S. N. F. than standard and therefore every hundred pounds added to an ice cream mix (with the proper amount of sugar) will make up a deficit of 5.73 pounds of M. S. N. F. without changing either the fat or the sugar test of the final mix.

Other combinations of dairy products with different tests are given in Table 61. Each will test standard in fat but will have an excess of M. S. N. F. as indicated.

TABLE 61

A few combinations of dairy products, containing an excess of M. S. N. F. available for standardizing.

Combination No.	Cream		Condensed Milk		Parts of Cream to Use	Parts Condensed Milk to Use	Percentage M. S. N. F. in Mixture Available for Standardizing
	Per Cent		Per Cent				
	Fat	M. S. N. F.	Fat	M. S. N. F.			
6	20.00	7.12	.50	25.00	44.60	55.40	2.08
7	30.00	6.23	.50	25.00	29.50	70.50	4.52
8	40.00	5.34	7.80	17.70	4.35	95.65	2.22
9	40.00	5.34	5.00	25.00	12.00	88.00	7.70
10	Butter 83.00	Skim-milk powder 1.00	1.00	95.00	BUTTER 10.00	SKIM-MILK POWDER 90.00	69.66

Having calculated the theoretical mixtures Nos. 1 and 2, and calculated the available percentage of fat and M. S. N. F. respectively, it then becomes a simple matter to calculate the pounds of dairy products and sugar necessary to add to raise the test of the mix to the point desired.

The method of calculation recommended is fully illustrated under example 34.

Problem 33, Example 34:

Products	Pounds	Per Cent			
		Fat	M. S. N. F.	Sugar	T. S.
Mix before standardizing	10,000	7.80	12.60	13.00	33.40
Cream.....	.....	40.00	5.40	.....	45.40
Condensed milk.....	.....	.50	25.00	.....	26.00
Composition desired.....	.....	8.00	13.00	13.00	34.00

Ratio of fat to M. S. N. F. desired is 1 to 1.625.

Mix before standardizing contains .50 per cent gelatin which is included with the above M. S. N. F.

Solution of Problem 33, Example 34, Based Upon Calculation only.

(1). To calculate the fat, and M. S. N. F. to provide, when sugar is to be added after standardizing. Also to calculate the percentage of sugar necessary when this is added to the standardized mix.

100—13=87.00, per cent of total products in mix besides sugar.

8.00÷.87=9.20, per cent of fat that the mix should contain if sugar is to be added after standardizing.

13.00÷.87=14.94, per cent of M. S. N. F. the mix should contain if sugar is to be added after standardizing.

13.00÷.87=14.94, per cent of sugar to add to milk products only to yield a mix containing 13.00 per cent of sugar.

(2). To calculate the fat available for standardizing in theoretical mixture No. 1.

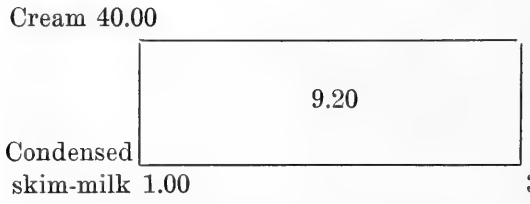
Condensed skim-milk=25.00 9.54

14.94

Cream=5.40 10.06

14.94—5.40=9.54, the units of condensed skim-milk to use.
25.00—14.94=10.06, the units of cream to use.
9.54+10.06=19.60, the sum of the condensed skim-milk and cream units to use.
9.54÷.196=48.67, the per cent of condensed skim-milk to use.
10.06÷.196=51.33, the per cent of cream to use.
48.67×.50=.24, per cent of fat in mixture derived from condensed skim-milk.
51.33×.40=20.53, per cent of fat in mixture derived from cream.
20.53+.24=20.77, per cent of fat in mixture derived from both condensed skim-milk and cream.
20.77—9.20=11.57, per cent of fat in mixture No. 1, available for standardizing.

(3). To calculate the available M. S. N. F. in theoretical mixture No. 2.



40.00—9.20=30.80, units of condensed skim-milk to use.
9.20—1.00=8.20, units of cream to use.
8.20+30.80=39.00, the sum of the condensed milk and cream units to use.
30.80÷.39=78.97, the per cent of condensed skim-milk required.
8.20÷.39=21.03, the per cent of cream to use.
78.97×.25=19.74, the per cent of M. S. N. F. in the mixture derived from the condensed skim-milk.
21.03×.054=1.14, the per cent of M. S. N. F. in the mixture derived from the cream.
19.74+1.14=20.88, the per cent of M. S. N. F. in the mixture derived from both the condensed skim-milk and cream.

20.88—14.94=5.94, the per cent of M. S. N. F. in mixture No. 2 available for standardizing.

(3). To calculate the pounds of fat short and the pounds of mixture No. 1 required to provide the pounds of fat short.

8.00—7.80=.20, the per cent of fat short.

10000×.004=40, pounds of M. S. N. F. short.

20÷.1157=173, pounds of mixture No. 1 required.

(4). To calculate the pounds of M. S. N. F. short, and the pounds of mixture No. 2 required to provide the pounds of M. S. N. F. short.

13.00—12.60=.40, per cent of M. S. N. F. short.

10000×.40=40, pounds of M. S. N. F. short.

40.00÷.0594=675, pounds of mixture No. 2 required.

(5). To calculate the pounds of cream and condensed skim-milk required under 3 and 4, also the extra sugar required.

173×.5133=88.80, pounds of cream required from mixture No. 1.

674×.2103=141.53, pounds of cream required from mixture No. 2.

88.80+141.53=230.44, total pounds of cream required.

173×.4867=84.20, pounds of condensed skim-milk required from mixture No. 1.

673×.7897=531.47, pounds of condensed skim-milk required from mixture No. 2.

84.20+531.47=615.66, total pounds of condensed skim-milk required.

230.33+615.66=845.99, total pounds of cream and condensed skim-milk required.

845.99×.1494=126.39, pounds of sugar required in standardizing.

Therefore add for standardizing:

230.33 pounds of 40.00 per cent cream.

615.66 pounds of 25.00 per cent condensed skim-milk.

109.98 pounds of sugar.

955.97 pounds total.

Proof of Problem 33, Example 34:

Products		Pounds				Per Cent			
		Fat	M.S.N.F.	Sugar	T. S.	Fat	M.S.N.F.	Sugar	T. S
Mix before standardizing	10000.00	780.00	1260.00	1300.00	.....	7.80	12.60	13.00	33.40
Cream	230.00	92.13	12.44	.....	.....	40.00	5.40	.....	45.40
Condensed skim-mik	615.66	3.08	153.92	.....	.....	.50	25.00	.....	26.00
Sugar	126.39	.....	.....	126.39	.....	.....	.....	.....	100.00
Mix after standardizing	10955.97	875.21	1426.36	1426.39	3727.96	8.00	13.00	13.00	34.00

PROBLEM 34: HOW TO CALCULATE WHEN THE FAT IS OVER AND THE M. S. N. F. OR THE T. S. UNDER THE STANDARD DESIRED. ALSO WHEN THE PERCENTAGES OF FAT AND M. S. N. F. OR T. S. ARE OVER THE STANDARD DESIRED BUT WITH THE FAT IN A HIGHER RATIO THAN THE T. S.

Skim-milk powder, sugar and water are to be added for standardizing. The calculation in problem 33, example 34, can be applied to the solution of this problem. However, after getting the M. S. N. F. in the proper ratio to the fat, water is to be added to bring the mix back to the standard desired.

Solution of Problem 34, Based Upon Rule 29:

(1). Subtract the percentage of fat desired from the percentage of fat in the mix, and multiply the remainder by the weight of the mix. Divide the result by the percentage of fat desired. The quotient equals the pounds of mix short.

(2). Multiply the percentage of fat in the mix by the ratio of fat desired to M. S. N. F. desired, and from the result subtract the percentage of M. S. N. F. in the batch. Multiply the remainder by the number of pounds in the batch, and divide the product by the percentage of M. S. N. F. in the skim-milk powder. The quotient equals the number of pounds of skim-milk powder required.

(3). Multiply the pounds of mix short by the percentage of sugar desired. The product equals the pounds of sugar required.

(4). The number of pounds of sugar required plus the number of pounds of skim-milk powder required subtracted from the number of pounds of mix short equals the number of pounds of water to add.

Solution Problem 34, Based Upon Formula 29a:

(1). To calculate the pounds of mix short.

$$K=\frac{(F—A)\times M}{A}$$

(2). To calculate the pounds of skim-milk powder required.

$$S^1=\frac{[(F\times R)—N\times M]}{S}$$

(3). To calculate the pounds of sugar required.

$$U=K\times V$$

(4). To calculate the pounds of water required.

$$W=M—(U—S^1)$$

Problem 34, Example 35:

Products	Pounds	Per Cent			
		Fat	M. S. N. F.	Sugar	T. S.
Mix	10,000	8.24	12.70	13.00	33.94
Skim-milk powder	.....	.....	95.00	.....	95.00
Sugar	1,300	.....	.....	100. 0	100.00
Composition desired	.....	8.00	13.00	13.00	34.00

Desired ratio of fat to M. S. N. F. is 1 to 1.625.

Mix before standardizing contains .50 per cent of gelatin, which is included with the M. S. N. F.

Solution of Problem 34, Example 35, Based Upon Rule 29:

(1). To calculate the pounds of mix short.

8.24—8.00=.24, per cent of excess fat.

10000×.0024=24, pounds of excess fat.

24÷.08=300, pounds of mix short.

(2). To calculate the pounds of skim-milk powder required.

8.24×1.625=13.39, per cent of M. S. N. F. to equalize the fat in the batch.

13.39—12.70=.69, per cent of M. S. N. F. short.

10000×.0069=69, pounds of M. S. N. F. short.

69÷.95=72.63, pounds of milk powder required.

(3). To calculate the pounds of sugar required.

$300 \times .1300 = 39$, pounds of sugar required.

(4). To calculate the pounds of water required.

$72.63 + 39 = 111.63$, pounds of sugar and milk powder.

$300 - 112 = 188$, pounds of water required.

Solution of Problem 34, Example 35, Based Upon Formula 29a:

(1). To calculate the pounds of mix short.

$$K = \frac{(.0824 - .0800) \times 10000}{.08} = 300$$

(2). To calculate the pounds of skim-milk powder required.

$$S^1 = \frac{[(.0824 \times 1.625) - .1270] \times 10000}{.95} = 72.63$$

(3). To calculate the pounds of sugar required.

$U = 300 \times .13 = 39$

(4). To calculate the pounds of water required.

$W = 300 - (72.63 + 39) = 188$

Proof of Problem 34, Example 35.

Products		Pounds				Per Cent			
		Fat	M.S.N.F.	Sugar	T. S.	Fat	M.S.N.F.	Sugar	T. S.
Mix	10000.00	824	1270	1300	3394	8.24	12.70	13.00	33.94
Skim-milk powder	72.63	.....	69	.....	69	.....	95.00	.....	95.00
Sugar	39.00	.....	.....	39	39	.....	.....	100.00	100.00
Water	188 37	.....	.....	.....	.....	.....	.....	.....	.....
Standardized product	10300.00	824	1339	1339	3502	8.00	13.00	13.00	34.00

Note: No account was taken of the small amount of fat in the skim-milk powder used. The addition of skim-milk powder is not practicable unless this can be added to the batch at pasteurizing temperatures.

PROBLEM 35: HOW TO CALCULATE WHEN THE PERCENTAGES OF FAT AND M. S. N. F. ARE BOTH OVER THE STANDARD DESIRED BUT WITH THE FAT IN A HIGHER RATIO THAN THE M. S. N. F.

Skim-milk powder, sugar and water are to be added for standardizing.

The calculation in problem 33, example 34, can be applied to the solution of this problem. However, after getting the M. S. N. F. in the proper ratio to the fat, water is to be added to bring the mix back to the standard desired.

Solution of Problem 35, Based Upon Rule 30:

(1). Subtract the percentage of fat desired from the percentage of fat in the mix, and multiply the remainder by the pounds of mix. Divide the product by the percentage of fat desired in the mix and the result equals the pounds of mix short.

(2). Multiply the percentage of fat in the batch by the ratio of fat to M. S. N. F., and subtract from the product the percentage of M. S. N. F. in the batch. Multiply the remainder by the pounds in the batch and divide the product by the percentage of M. S. N. F. in the skim-milk powder. The quotient equals the pounds of skim-milk powder required.

(3). Multiply the pounds of mix short by the percentage of sugar desired. The product equals the pounds of sugar required.

(4). The pounds of sugar required plus the pounds of skim-milk powder required subtracted from the pounds of mix short equals the pounds of water required.

Solution of Problem 35, Based Upon Formula 30:

(1). To calculate the pounds of mix short.

$$K=\frac{(F-A)\times M}{A}$$

(2). To calculate the pounds of skim-milk powder required.

$$S^1=\frac{[(F\times R)-N]\times M}{S}$$

(3). To calculate the pounds of sugar required.

$$U=K\times V$$

(4). To calculate the pounds of water required.

$$W=K-(S^1-U)$$

Problem 35, Example 35:

Products	Pounds	Per Cent			
		Fat	M. S. N. F.	Sugar	T. S.
Mix.....	10,000	8.30	13.20	13.00	34.50
Skim-milk powder.....	.....	.....	95.00	.....	95.00
Sugar.....	.....	.....	.....	100.00	100.00
Composition desired.....	.....	9.00	13.00	13.00	34.00

Desired ratio of fat to M. S. N. F. is 1 to 1.625.

The mix before standardizing contains .50 per cent of gelatin which is included with the M. S. N. F.

Solution of Problem 35, Example 36, Based Upon Rule 30.

(1). To calculate the pounds of mix short.

8.30—8.00=.30, per cent of fat in excess.

10000×.0030=30, pounds of fat in excess.

30÷.08=375, pounds of mix short.

(2). To calculate the pounds of skim-milk powder required.

1.625×8.30=13.48, per cent of M. S. N. F. necessary to standardize the fat in the batch.

13.48—13.20=.28, per cent of M. S. N. F. short.

.0028×10000=28, pounds of M. S. N. F. short.

28÷.95=29.47, pounds of milk powder required.

(3). To calculate the pounds of sugar required.

375×.1300=48.75, pounds of sugar required.

(4). To calculate the pounds of water required.

48.75+29.47=78.22, pounds of sugar and powder required.

375—78.22=296, pounds of water required.

Solution of Problem 35, Example 36, Based Upon Formula 30:

(1). To calculate the pounds of mix short.

$$K=\frac{(.083\times.080)\times10000}{.08}=375$$

(2). To calculate the pounds of skim-milk powder required.

$$S^1=\frac{[(.083\times1.625)-.132]\times10000}{.95}=29.47$$

(3). To calculate the pounds of sugar required.

$U=375\times.1300=48.75$

(4). To calculate the pounds of water required.

$W=375-(29.47+48.75)=296.$

Proof of Problem 35, Example 36.

Products		Pounds				Per Cent			
		Fat	M.S.N.F.	Sugar	T. S.	Fat	M.S.N.F.	Sugar	T. S
Mix	10000.00	830	1320	1300	3450	8.30	13.20	13.00	34.50
Skim-milk powder	29.47	.....	28	.....	28	.....	95.00	.....	95.00
Sugar	48.75	.....	.....	48.75	48.75	.....	.....	100.00	100.00
Water	296.00	.....	.....	.....	.....	.....	.....	.....	.....
Standardized product	10374.22	830	1348	1348	3526	8.00	13.00	13.00	34.00

PROBLEM 36: HOW TO CACULATE WHEN THE PERCENTAGES OF FAT AND M. S. N. F. ARE BOTH OVER THE STANDARD DESIRED MAKING IT NECESSARY TO ADD SUGAR AND WATER ONLY.

Solution of Problem 36, Based Upon Rule 31:

(1). Subtract the percentage of fat desired from the percentage of fat in the mix and multiply the pounds of mix by the difference. Divide the product by the percentage of fat desired. The answer will be the pounds of mix short.

(2). Multiply the pounds of mix short by the per cent of sugar desired. The answer will be the pounds of sugar required.

(3). Subtract the pounds of sugar required from the pounds of mix short. The answer wil be the pounds of water required.

Solution of Problem 36, Based Upon Formula 31:

(1). To calculate the pounds of mix short.

$$K=\frac{(F-A)\ M}{A}$$

(2). To calculate the pounds of sugar to add.

$$U=K\times V$$

(3). To calculate the pounds of water required.

$$W=K-U$$

Problem 36, Example 37:

Products	Pounds	Per Cent			
		Fat	M. S. N. F.	Sugar	T. S.
Mix.....	10,000	8.20	13.25	13.00	34.52
Sugar.....	.....	.....	.....	100.00	100.00
Composition desired.....	.....	8.00	13.00	13.00	34.00

Solution of Problem 36, Example 37, Based Upon Rule 31:

(1). To calculate the pounds of mix short.

8.20—8.00=.20, per cent of fat in excess.

10000×.0020=20, pounds of fat in excess.

20÷.08=250, pounds of mix short.

(2). To calculate the pounds of sugar required.

250×.13=32.50, pounds of sugar required.

(3). To calculate the pounds of water required.

250—32.50=217.5, pounds of water required.

Solution of Problem 36, Example 37, Based Upon Formula 31:

(1). To calculate the pounds of mix short.

$$K = \frac{(.082-.080)\times 10000}{.08} = 250$$

(2). To calculate the pounds of sugar to add.

U=250×.13=32.50

(3). To calculate the pounds of water to add.

W=250—32.50=217.5

Proof of Problem 36, Example 37:

Products		Pounds				Per Cent			
		Fat	M.S.N.F.	Sugar	T. S.	Fat	M.S.N.F.	Sugar	T.S.
Mix	10000.00	820	1332.5	1300	3452.5	8.20	13.325	13.00	34.525
Sugar	32.50	.....	.....	32.50	32.5	.....	.....	100.00	100.00
Water	217.50	.....	.....	.....	.....	.....	.....	.....	.....
Standardized product	10250.00	820	1332.5	1332.5	3485.0	8.00	13.00	13.00	34.00

HOW TO CALCULATE WHEN USING SWEETENED CONDENSED SKIM-MILK IN ICE CREAM MIX.

Sweetened condensed skim-milk can be used in the ice cream mix to furnish the entire sweetening necessary. The balance of the fat and M. S. N. F. can be made up by using cream or butter, and whole milk. Sweetened condensed skim-milk is an economical substance to use. A good quality may be purchased from reliable firms and stored, and it will keep indefinitely. It also has the advantage of being very easy to use. It would undoubtedly be used to a much greater extent than it is at present if manufacturers had formulas which would give good results when properly worked out.

The method of calculation given herewith for using this product was originated largely by J. A. Cross.

The average composition of sweetened condensed skim-milk is about 1.00 per cent fat, 28.00 per cent M. S. N. F. and 41.00 per cent sugar. All of these values are subject to fluctuations so that the actual test of the product should be ascertained.

In these calculations it is assumed that the M. S. N. F. in skim-milk serum is 8.90 per cent. This can be found exactly for any product by subtracting the percentage of fat in the product from 100 and dividing the percentage of M. S. N. F. by the remainder.

Example: Whole milk tests 3.75 per cent fat, 8.60 per cent M. S. N. F.

Solution:

$$\frac{8.60}{(100.00-3.75)} = 8.93,$$ or per cent of M.S.N.F. in skim-milk serum.

The above problem is solved herewith by rule, formula, and example. A new set of factors differing from those previously used in this chapter, are used in the formulas.

KEY TO FACTORS IN FORMULAS FOR USING SWEETENED CONDENSED SKIM-MILK.

A=The percentage of sugar desired.

B=The percentage of sugar in the sweetened condensed skim-milk.

C=The pounds of sweetened condensed skim-milk necessary to provide the sugar required.

D=The percentage of M. S. N. F. in the sweetened condensed skim-milk.

E=The pounds of M. S. N. F. in the sweetened condensed skim-milk.

F=The pounds of M. S. N. F. in the entire batch of mix.

G=The average percentage of M. S. N. F. in skim-milk serum.

H=The pounds of skim-milk serum required.

I =The pounds of fat required for the entire batch.

J=The pounds of fat contained in the sweetened condensed skim-milk.

K=The pounds of cream required.

L=The percentage of fat in K.

M=The percentage of fat in the whole milk.

N=The percentage of fat in the butter.

O=The pounds of butter required.

P=The pounds of whole milk required.

Q=The pounds of mix desired.

R=The pounds of sugar required.

S=The percentage of M. S. N. F. desired.

T=The percentage of fat required.

U=The percentage of fat in sweetened condensed skim-milk.

Problem 37. How to Calculate When Using Sweetened Condensed Skim-milk in Ice Cream Mix.

Solution of Problem 37, Based Upon Rule 32:

(1). To calculate the pounds of sweetened condensed milk necessary to furnish the sugar required. Multiply the pounds of mix desired by the percentage of sugar desired and divide by the percentage of sugar in the sweetened condnsed skim-milk. Call the answer A, or the pounds of sweetened condensed skim-milk required for the entire batch of mix to be made.

(2). To calculate the pounds of skim-milk serum required. Multiply the pounds of mix desired by the percentage of M. S. N. F. desired, and subtract the answer from the pounds of M. S. N. F. in the sweetened condensed skim-milk required, found by multiplying the pounds of sweetened condensed skim-milk by the percentage of M. S. N. F. contained in the same. Call the remainder B, or the pounds of M. S. N. F. to be supplied by cream or whole milk. Divide B by 8.90 (the average M. S.

N. F. test of skim-milk serum), and call the answer C, or the pounds of skim-milk serum required.

(3). To calculate the pounds of cream required and the percentage of fat in the same. Multiply the pounds of mix desired, by the percentage of fat desired. Subtract from the answer the pounds of fat in the sweetened condensed skim-milk found by multiplying the pounds of sweetened condensed skim-milk required by the percentage of fat in the same. Call the answer D, or the pounds of fat to be supplied by the cream.

C+D=E, pounds of cream required.

D÷E=Percentage of fat necessary in E.

(4). To calculate the pounds of whole milk, cream, or butter to use. Subtract from the percentage of fat in E, the percentage of fat in the whole milk, and divide the remainder by the difference between the percentage of fat in the butter and the percentage of fat in the whole milk. Multiply the answer by E. Call the result F, or the pounds of butter required. E—F=the pounds of whole milk required.

Solution Problem 37 Based Upon Formula 32:

(1). To calculate the pounds of sweetened condensed skim-milk necessary to furnish the sugar required.

$$C=\frac{Q\times A}{B}$$

(2). To calculate the pounds of skim-milk serum required.

$$H=\frac{(Q\times S)-(C\times D)}{G}$$

(3). To calculate the pounds of cream required.

$$K=(Q\times T)-(C\times U+H$$

(4). To calculate the percentage of fat required in the cream.

$$L=\frac{(Q\times T)-(C\times U)}{K}$$

(5). To calculate the pounds of whole milk and butter to use.

$$O=\frac{(N-M)}{(L-M)}\times K$$

$$P=K-O$$

Problem 37, Example 38.

Products	Pounds					Per Cent			
		Fat	M.S.N.F.	Sugar	T. S.	Fat	M.S.N.F.	Sugar	T. S.
Whole milk	.....	.....	.....	.....	.....	3.50	8.60	.....	12.00
Butter	.....	.....	.....	.....	.....	83.00	1.50	.....	84.50
Sweetened condensed skim-milk	.....	.....	.....	.....	.....	1.00	28.00	41.00	70.00
Gelatin	.....	.....	.....	.....	.....	.....	.....	.....	88.00
Water	.....	.....	.....	.....	.....	.....	.....	.....	.....
Pounds and composition of mix desired	10,000	800.00	1250.0	1300.0	3400.00	8.00	12.50	13.00	34.00

Solution of Problem 37, Example 38, Based Upon Rule 32.

(1). To calculate the pounds of sweetened condensed skim-milk required.

$10000 \times .13 = 1300$, pounds of sugar required.

$1300 \div .41 = 3171$, pounds of sweetened condensed skim-milk required to furnish the sugar.

(2). To calculate the pounds of skim-milk serum required.

$10000 \times .125 = 1250$, pounds of M. S. N. F. required.

$3171 \times .28 = 887.9$, pounds of M. S. N. F. in the sweetened condensed skim-milk.

$1250 - 887.9 = 362.10$, pounds of M. S. N. F. to be supplied by the whole milk and the butter.

$362.10 \div .089 = 4069$, pounds of skim-milk serum required.

(3). To calculate the pounds of cream required.

$10000 \times .08 = 800$, pounds of fat required.

$3171 \times .01 = 31.7$, pounds of fat in the sweetened condensed skim-milk.

$800 - 31.7 = 768.3$, pounds of fat to be supplied from whole milk and butter.

$4069 + 768.3 = 4837.3$, pounds of cream required.

$768.3 \div 4837.3 = 15.88$, per cent fat required in the cream.

(4). To calculate the pounds of whole milk and butter to use.

$$\frac{(.1588 - .0350)}{(.8300 - .0350)} \times 4837 = 753.5, \text{ pounds of butter required.}$$

$4837.3 - 753.5 = 4083.8$, pounds of whole milk required.

Solution Problem 37, Example 38, Based Upon Formula 32:

(1). To calculate the pounds of sweetened condensed milk necessary to furnish the sugar required.

$$C=\frac{10000\times.13}{.41}=3171$$

(2). To calculate the pounds of M. S. N. F. required.

$$H=\frac{(10000\times.125)-(3171\times.28)}{.089}=4069$$

(3). To calculate the pounds of cream required.

$$K=(10000\times.08)-(3171\times.01)+4069=4837.3$$

(4). To calculate the percentage of fat required in the cream.

$$L=\frac{(10000\times.08)-(3171\times.01)}{4837.3}=15.88$$

(5). To calculate the pounds of whole milk and butter to use.

$$O=\frac{(.1588-.0350)}{(.8300-.0350)}\times4837.3=753.5$$

$$P=4837.3-753.5=4083.8$$

Proof Problem 37, Example 38.

Products	Pounds					Per Cent			
		Fat	M.S.N.F.	Sugar	T. S.	Fat	M.S.N.F.	Sugar	T. S.
Whole milk	4083.8	142.9	351.1	.....	494.0	3.50	8.60	.....	12.10
Butter	753.5	625.4	11.3	.....	636.7	83.00	1.50	.....	84.50
Sweetened condensed skim-milk	3171	31.7	887.8	1300.0	2219.6	1.00	28.00	41.00	70.00
Gelatin	50.0	.....	.....	.....	44.0	.....	.....	.....	88.00
Water	1942.7	.....	.....	.....	.....	.....	.....	.....	.....
Pounds and composition of mix obtained	10000	800.0	1250.2	.....	3394.3	8.00	12.50	13.00	33.94

In the above proof the percentage of T. S. is slightly lower than desired, due to water contained in gelatin, but close enough under usual conditions of manufacture.

Recipe For Using Sweetened Condensed Skim-milk.

Upon the basis of the above solution the following recipe can be used, the same being based upon 100 pounds of mix.

48.4 pounds of cream testing 16.00 per cent fat.
31.7 pounds of sweetened condensed skim-milk.
.5 pounds of gelatin.
19.4 pounds of water.

100.0 pounds of total mix, testing 8.00 per cent fat; 12.50 per cent M. S. N. F.; 13.00 per cent sugar; .50 per cent gelatin; and 34.00 per cent T. S.

Whole milk, cream or butter of any composition can be substituted for the cream testing 16.00 per cent of fat, by using the foregoing methods of calculation.

Batches containing any desired number of gallons can be compounded upon the basis of the above recipe by multiplying the number of gallons desired by the pounds per gallon, and in turn the multiples of 100 pounds desired by the pounds given in the above recipe.

HOW TO CALCULATE FROM TABLES THE AMOUNT OF SWEETENED CONDENSED SKIM-MILK TO USE.

For the benefit of the ice cream maker mixing different sized batches, a great deal of calculation is eliminated and mistakes avoided by making out tables for his use, showing the exact number of pounds of each material necessary in all ordinary sizes of batches. The following tables may prove useful. They are in use in a number of factories, and give uniformly satisfactory results. The variations in fat tests of the different products cause some variation in the tests of finished products, but these may be easily adjusted by standardizing the finished mix.

In Table 62 and 63 the gallons of ice cream mix desired are noted at the top, materials to be used at the side, and the pounds of each material necessary directly under the number of gallons. These tables and those given in Table 64 are calculated to produce an ice cream mix testing 8.00 per cent fat, 12.50 per cent M. S. N. F., .50 per cent gelatin, 13.00 per cent sugar and

34.00 per cent T. S. All products named have the same composition as given under Problem 37, Example 38.

TABLE 62.

Table for making various gallons of ice cream mix using sweetened condensed skim-milk and other products. Composition as named above.

Products	Total number gallons of ice cream mix desired							
	150	200	250	300	350	400	450	500
Whole milk	lbs. 544	lbs. 726	lbs. 907	lbs. 1090	lbs. 1270	lbs. 1450	lbs. 1625	lbs. 1815
Butter	113	137	171	205	240	274	308	342
Sweetened condensed skim-milk	428	560	713	856	1000	1140	1283	1426
Gelatin	6.7	9	11.2	13.5	15.7	18	20.2	22.5
Water	265	353	441	530	618	706	794	895

In some cases whole milk is not always available in sufficient quantity. This is especially true in the south. In this case, skim-milk powder may be used to make up the deficit, and the following formulas are used where skim-milk powder is employed.

In Tables 63 and 64 just following, different proportions of skim-milk powder are used in each, thus making provision for varying amounts of whole milk that may be available.

TABLE 63.

Recipes for making various gallonages of ice cream mix, using sweetened condensed skim-milk and other products. Composition as named above.

Products	Total number of gallons ice cream mix desired							
	Lbs. 150	Lbs. 200	Lbs. 250	Lbs. 300	Lbs. 350	Lbs. 400	Lbs. 450	Lbs. 500
Whole milk	384	513	640	768	896	1025	1153	1280
Butter	107	142	178	214	249	285	320	356
Sweetened condensed skim-milk	428	560	713	856	1000	1140	1283	1426
Gelatin	6.7	9	11.2	13.5	15.7	18	20.2	22.5
Water	408	544	680	816	952	1090	1223	1360
Skim-milk powder	15	20	25	30	35	40	45	50

In case cream is to be made from other materials than butter and 3.50 per cent milk, figure 36.5 pounds of 20.7 per cent cream per 100 pounds of mix wanted.

TABLE 64.

Formulas for making various gallonages of ice cream mix using sweetened condensed skim-milk and other products. Composition as named above.

Products	Total number gallons ice cream mix desired							
	150	200	250	300	350	400	450	500
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Whole milk	220	294	367	440	514	587	660	734
Butter	112	150	187	224	262	299	337	374
Sweetened condensed skim-milk	428	560	713	856	1000	1140	1283	1426
Gelatin	6.7	9	11.2	13.5	15.7	18	20.2	22.5
Skim-milk powder	30	40	50	60	70	80	90	100
Water	550	733	917	1100	1284	1466	1650	1832

When cream is to be made from other material than butter and 3.5 per cent milk, figure 24.7 pounds of 30.5 per cent cream per 100 pounds of mix wanted. All of the above mixes have given very satisfactory results, and if properly made and homogenized, any of them will produce 100 per cent overrun, and make a good, smooth and well flavored product.

HOW TO STANDARDIZE ICE CREAM MIX BY MEANS OF TABLES BASED UPON USING BUTTER, WATER AND SKIM-MILK POWDER.

To J. A. Cross belongs the credit for having developed a simple table method based upon using butter, water and skim-milk powder to effect standardization of ice cream mix. This method can be applied only when these products, and also a homogenizer, or a viscolizer are available. Similar tables could be made covering other dairy products provided these would be of uniform composition. Butter and skim-milk powder of good quality are nearly constant in composition, readily available and can be conveniently carried in stock. For these reasons they have been selected as the most conveneint standardizing materials. In all of the tables the composition assumed is as follows: Butter 83.00 per cent fat and 1.5 per cent S. N. F.; skim-milk powder 2.00 per cent fat, and 95.00 per cent S. N. F. Any small variations from these tests will not materially affect the accuracy of the tables.

Composition of Mix for Which Tables are Given.—Tables of the above nature can be prepared for any composition of mix. Inasmuch as such a wide range of composition is possible it would be obviously impossible to give within the compass of this book tables to cover all possible compositions. The compositions given are those that have been found under actual use to yield the most satisfactory products, and cover a sufficiently wide range to suit all classes of trade. These are given in Table 65.

TABLE 65.

Composition of ice cream mix for which standardizing tables are given.

No. of Mix.	Table No.	Pages Where Found	Per Cent				
			Fat	M. S. N. F.	Sugar	Gelatin	T. S.
1	67	367–372	8.00	11.50	13.00	.50	33.00
2	68	373–378	8.00	12.50	13.00	.50	34.00
4	69	379–384	9.00	11.50	13.00	.50	34.00
5	70	385–390	10.00	10.50	14.00	.50	35.00
6	71	391–396	12.00	8.50	14.00	.50	35.00
7	72	397–402	12.00	9.50	14.00	.50	36.00
8	73	403–408	16.00	7.50	14.00	.50	38.00
9	74	409–414	18.00	7.50	14.00	.50	40.00

Description of the Tables.—The tables given which are each in turn calculated upon the basis of the compositions given in Table 65 have a range in fat and S. N. F. as given in Table 66.

The fat tests will be found upon the top and bottom lines of the tables. The S. N. F. tests upon the vertical line both to the right and to the left of the tables. At the intersection of the fat and S. N. F. columns corresponding to the tests of mix to be standardized, will be found the pounds of powder, water and butter necessary to standardize 1000 pounds of mix of that test. There are three spaces in each square and the figures indicating the pounds of butter, water and powder are in the following order:—

Top figure—Butter (Assumed to test 83.00 per cent fat and 1.50 per cent S. N. F.).

Center figure—Water.

Bottom figure—Skim-milk powder (Assumed to test 2.00 per cent fat and 95.00 per cent S. N. F.)

The absence of figures in any space indicates that none of the omitted product is required.

TABLE 66.

Range of fat and S. N. F. in tables covering mixes of eight different compositions.

No. of Mix.	Table No.	Pages Where Found	Per Cent			Range of Fat		Range of S. N. F.	
			Fat	S. N. F.	T. S.	From	To	From	To
1	67	367–372	8.00	25.00	33.00	6.00	10.00	22.00	28.00
2	68	373–378	8.00	26.00	34.00	6.00	10.00	22.76	29.25
4	69	379–384	9.00	25.00	34.00	7.00	11.00	22.56	27.45
5	70	385–390	10.00	25.00	35.00	8.00	12.00	22.80	27.20
6	71	391–396	12.00	23.00	35.00	10.00	14.00	21.50	24.50
7	72	397–402	12.00	24.00	36.00	10.00	14.00	22.33	25.66
8	73	403–408	16.00	20.00	38.00	14.00	18.00	21.00	23.00
9	74	409–414	18.00	20.00	38.00	16.00	20.00	21.11	22.89

It is assumed that a definite percentage of sugar is always present in the mix that is to be standardized. In order to keep this percentage the same after standardizing, a definite percentage of sugar must be added to the batch along with the standardizing materials. The pounds of sugar to add is ascertained by the following formula:—

$$C^1 = \frac{B^1}{A^1 - B^1} \text{ where}$$

A^1=100.00, or total percentages in mix

B^1=Percentage sugar desired.

C^1=The percentage of sugar to be added to the standardizing materials.

Solving the above formulas in the case of mixes containing 13.00 and 14.00 per cent of sugar respectively we have.

$$C^1=\frac{13.00}{100.00-13.00}=14.94,$$ or the percentage of sugar to be added to standardizing materials when mix with 13.00 per cent of sugar is desired.

$$C^1=\frac{14.00}{100-14.00}=16.28,$$ or the percentage of sugar to be added to standardizing materials when mix with 14.00 per cent of sugar is desired.

To obtain a mix after standardizing that contains the desired percentage of sugar, the total pounds of butter, water and skim-milk powder (or any one or more of these) must be multiplied by the factor C^1, and the product, which will be the pounds of sugar required, must be added.

Example:—Added in standardizing:—

10.00 pounds butter.
75.00 pounds water.
15.00 pounds skim-milk powder.
100.00 pounds total.

The per cent of sugar desired is 14.0.
100.00×.1628 per cent=16.28, pounds sugar desired.
16.28÷(100+16.28)=14.00, per cent sugar desired after standardization.

These tables are all based upon adding, when compounding the mix, the exact percentage of sugar called for in each of the compositions.

How the Tables are Derived.—The successive steps involved in compiling the tables are the same regardless of the composition of

mix desired. The various steps together with the principles of calculations involved are as follows:—

(1). Determine the exact composition of mix desired.

Example:—

8.00 per cent fat.
13.00 per cent sugar.....
11.50 per cent M. S. N. F.
.50 per cent gelatin....

These three constituents are added together and called T. S. N. F.

(2). Fill in percentages of fat progressively by .10 per cent from the lowest to the highest range desired. These should be placed in the horizontal spaces both at the top and at the bottom of the table.

Calculate by ratio the percentages T. S. N. F. corresponding to the above two percentages of fat. Example:—

8 : 12=6 : X. X=9.00, the per cent M. S. N. F. and gelatin in proportion with 6.00 per cent fat.

9.00+13.00=22.00, the minimum per cent of T. S. N. F.

Locate upon Table 67 at A

and 8 : 12=10 : X. X=15.00, the per cent M. S. N. F. and gelatin in proportion with 10.00 per cent fat.

15.00+13.00=28.00, the maximum per cent of T. S. N. F.

Locate upon Table 67 at B

Interpolate the T. S. N. F. in the vertical column from A to B. Each of the eight compositions of mix were compiled upon one large table. These in turn were divided into six sub-tables, each sub-table requiring one page. The letters referred to herewith appear only upon Table 67.

(3). Determination of the composition of the products that are to be used in standardizing. Example:—

Butter 83.00 per cent fat; and 1.50 per cent S. N. F.

Skim-milk powder 2.00 per cent fat, and 95.00 per cent S. N. F.

Sugar 100.00 per cent T. S.

(4). Calculate the percentage composition required upon each constituent used in standardizing in order that the resulting mixture after adding the sugar will be properly standardized.

Example:—

$\frac{13.00}{100-13}$=14.94, the per cent of sugar to add to the other standardizing materials in standardizing to produce a mix containing 13.00 per cent of sugar.

$\frac{12.00}{87.00}$=13.79, the per cent of M. S. N. F. (including the gelatin) required in the standardizing mixture before adding the sugar.

$\frac{8.00}{87.00}$=9.20, the per cent of fat required in the standardizing mixture before adding the sugar.

(5). Calculate the available fat in theoretical mixture No. 1, and the available S. N. F. in theoretical mixture No. 2 using the methods of calculation given in problem 33 of this chapter.

Example:—Theoretical mixture No. 1.

Butter.....1.50 81.21—Butter units

13.79

Skim-milk powder 95.00 12.19—Skim-milk powder units.

12.29+81.21=93.50, the sum of above units.

81.21÷.9350=86.86, parts butter.

12.29÷.9350=13.14, parts skim-milk powder.

86.86 parts butter=72.09 parts fat and 1.30 parts M. S. N. F.

13.14 parts skim-milk powder=.26 parts fat and 12.49 parts M. S. N. F.

100.00 parts mixture No. 1=72.35 parts fat and 13.79 parts M. S. N. F.

72.35—9.20=63.15, the per cent of fat in mixture No. 1 available for standardizing.

Example theoretical mixture No. 2.

Butter.....83.00 7.20 Butter units.

9.20

Skim-milk powder 2.00 73.80 skim-milk powder units.

73.80+7.20=81.00, sum of units.

7.20÷.81=8.90, parts butter.

73.80÷.81=91.10, parts skim-milk powder.

8.90 parts butter=7.38 parts fat and .13 parts M. S. N. F.

91.10 parts skim-milk powder=1.82 parts fat and 86.55 parts M. S. N. F.

100.00 parts mixture No. 2=9.20 parts fat and 86.68 parts M. S. N. F.

86.68—13.79=72.89, per cent S. N. F. in mixture No. 2 available for standardizing.

(6). Block off the square CDEF which includes that part of the table when the range is from the minimum under standard to standard in fat and likewise in T. S. N. F.

Example: 6.00 to 8.00 per cent in fat and 22.80 to 25.00 in T. S. N. F. At the intersection C, both the fat and the T. S. N. F. are standard.

Calculate the pounds of the two mixtures to use.

Example:

$$\frac{(.08—.06)\times 1000}{.6315}=31.7$$ or pounds mixture No. 1 required.

.8686×31.7=27.5, pounds of butter required.

.1314×31.7=4.2, pounds skim-milk powder required.

Insert these values at E in table.

$$\frac{(25.00—22.00)\times 1000}{72.89}=41.2$$ or pounds mixture No. 2 required.

.0890×41.2=3.7, pounds butter required.

.9110×41.2=37.5, pounds skim-milk powder required.

Insert these values at D in the table.

To obtain value of F, add together E and D.

Interpolate, either vertically or horizontally in the above square.

(7.) Calculate the pounds of water required at the point G in the table. Example:

$$\frac{(.10—.08)\times 1000}{.08}=250$$

250—(250×.1300)=218

(8). Calculate the pounds of butter and water to use at the point H in the table. Example:—

8 : 12=X : 1.50. X=1.00, the per cent of fat required to equalize the S. N. F. in the butter.

83.00—1.00=82.00, the per cent of fat in the butter available for standardizing.

$\frac{(.1000—.0600)\times1000}{.82}$=48.8, the pounds of butter to use at H.

$\frac{48.8\times.015}{.1379}$+(218—48.8)=175, the pounds of water to use at H.

(9). Calculate the pounds of water and powder to use at the point I in the table. Example:—

8 : 12=2 : X. X=3.00, the per cent of S. N. F. required to equalize the fat in the skim-milk powder.

95.00—3.00=92.00, the per cent of S. N. F. available for standardizing.

$\frac{(.28—.22)\times1000}{.92}$=65.2, the pounds of skim-milk powder to use at point I.

$218+\frac{(65.2\times.02)}{.092}$—65.2=166, the pounds of water to use at I.

(10). Calculate the pounds of water and skim-milk powder to use at Point J in the table.

Example:—

8 : 12=8.3 : X. X=12.45, the per cent of S. N. F. required to equalize the percentage of fat at J.

$\frac{(.1245—.0920)\times1000}{.92}$=37.5, the pounds of skim-milk powder to use at J.

$\frac{1000\times.003}{.092}$=33, pounds of water to standardize 8.3 per cent fat.

$33+\frac{(37.5\times.02)}{.1163}$—37.5=2, pounds of water to use at J.

(11). Calculate the pounds of water and butter to use at point K in the table. Example:—

8 : 12=X : 11.33. X=8.3, the per cent of fat required to equalize the S. N. F. at K.

$$\frac{(.083-.06)\times 10000}{.82}=27.1,$$ the pounds of butter to use at K

$$27.1-\frac{(27.1\times .015)}{.1379}+\frac{(11.33\times .11)}{.1379}=14.0,$$ the pounds of water to use at K.

(12). Interpolate from I to G.

Interpolate from E to K and K to H.
Interpolate from D to J and J to I.
Interpolate from H to G and G to I and complete the interpolation of entire table.

Proof of the Accuracy of Tables.

The tables have been all proved at the points corresponding to the above letters. Tables of any given composition derived as above described, and in which the interpolations have been properly made should prove out at all points, and be correct for any combination of fat and T. S.

How to apply the standardization tables in practice.

1. About a half hour before a batch is to be homogenized, turn on the electric current upon the Mojonnier Tester, adjust the fat and solids ovens to the current temperatures, heat, cool and weigh a fat and a T. S. dish, and have everything in readiness for a rapid test.

2. Before starting to homogenize the batch, see that all milk powder, butter, sugar, and gelatin are thoroughly dissolved, and that everything that is to be incorporated into the batch is in and mixed thoroughly. The accuracy of the entire system depends upon the accuracy of the first sample, and it must be a representative sample of the entire batch

3. A few minutes after the homogenizer is started, obtain a sample from the cooling coils, and analyze for fat and T. S. If everything is in readiness, and the most efficient routine followed, this test may be completed in 30 minutes or less. (Record time 22 minutes.)

4. Subtract the percentage of fat from the percentage of T. S. The result will be the percentage of T. S. N. F.

5. Locate the most nearly corresponding fat and S. N. F. tests in the table based upon the composition desired. At the intersection will be found the pounds of butter, water or sugar necessary to add to 1000 pounds of mix of that test. Top space is for butter, center space for water, and lower space for skim-milk powder.

6. Multiply the amounts indicated by the number of thousands of pounds of mix to be standardized. Example: If a batch of 2345 pounds is to be standardized, multiply in turn the amounts necessary for 1000 pounds by 2.345. The results will be the pounds of butter, water or skim-milk powder respectively necessary for the entire batch.

7. Add together the total number of pounds of butter, water or sugar and multiply by the percentage of sugar required to produce a mix containing the desired percentage of sugar. Example: Mix desired to contain 13.00 per cent of sugar. Therefore add here sugar to the extent of 14.94 per cent of the total pounds of other products required for standardizing.

The above tests and calculations are made while the batch is being homogenized, and can usually be completed before the entire batch has been run through. The standardizing materials can then be added to the last part of the batch, which has not yet been homogenized. When all has been run through and mixed in the holding tank, the fat and T. S. test should be standard. If skim-milk powder is necessary, it is usually advisable to stop the homogenizer until it is thoroughly dissolved. Butter, sugar and water in small amounts can usually be mixed without stopping the machine. It is sometimes possible to mix the powder and the sugar with the water which is to be added if it is sufficient in amount, and it is a good practice to keep out about 10 gallons of the water until the batch has run through and then dump this in to wash out the mix remaining in the pipes.

8. Obtain a sample of the standardized batch and analyze for fat and T. S. as a check upon the accuracy of the work. It should be accurate, within .1 of 1.00 per cent upon the fat, and within .20 of 1.00 per cent upon the T. S., of the standard desired.

These margins are liberal, and in practice as many as 50 consecutive batches have been run out with variation within .07 per cent upon the fat, and within .2 per cent upon the T. S.

9. It is always simpler to standardize with butter and water only. These are easier to mix and to dissolve with the batch. By compounding the mix with an excess of M. S. N. F., the use of skim-milk powder can be reduced to a minimum, or entirely avoided.

EXAMPLE AND PROOF OF ACCURACY OF STANDARDIZING TABLES.

Example 39, taken from Table 67 showing quantity before standardizing materials added in standardizing, and proof.

Products		Pounds				Per Cent			
		Fat	M.S.N.F. including Gelatin	Sugar	T. S.	Fat	M.S.N.F.	Sugar	T. S.
Mix before standardzing	1000.0	73.0	111.0	130.0	314.0	7.30	11.10	13.00	31.40
Butter	10.7	8.9	.1	.....	9.0	83.00	1.50	.....	84.50
Water	.....	.....	.....	.....	.....	.....	.....	.....	.....
Skim-milk powder	12.7	.3	12.1	.....	12.4	2.00	95.00	.....	97.00
Sugar	3.5	.....	.....	3.5	3.5	.....	.....	100.00	100.00
Total mix after standardizing	1026.9	82.2	123.2	133.5	338.9	8.00	12.00	13.00	33.00

Example 40, taken from Table 67 showing quantity before standardizing; and materials added in standardizing, and proof.

Products		Pounds				Per Cent			
		Fat	M.S.N.F. including Gelatin	Sugar	T. S.	Fat	M.S.N.F.	Sugar	T. S.
Mix before standardizing	1000.0	91.0	144.0	130.0	365.0	9.10	14.40	13.00	36.50
Butter	6.1	5.1	.1	.....	5.2	83.00	1.50	.....	84.50
Water	170.0	.....	.....	.....	.....	.....	.....	.....	.....
Skim-milk powder	.....	.....	.....	.....	.....	2.00	95.00	.....	97.00
Sugar	26.3	.....	.....	26.3	26.3	.....	.....	100.00	100.00
Total mix after standardizing	1202.4	96.1	144.1	156.3	396.5	8.00	12.00	13.00	33.00

TABLE 67.

Standardizing table for ice cream mix No. 1 testing:

8.00% Fat
11.50% M. S. N. F.
13.00% Sugar
.50% Gelatin
33.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: Pounds butter.
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.3	
A	31.2	29.9	28.4	27.1	25.7	24.3	22.9	21.6	20.2	18.8	17.5	16.1	14.7	13.3	
22.00	F 41.7	41.5	41.3	41.1	40.9	40.6	40.4	40.2	40.0	39.8	39.6	39.4	39.2	39.0	22.00
22.15	31.0	29.7	28.2	26.9	25.5	24.1	22.7	21.4	20.0	18.6	17.3	15.9	14.5	13.1	
	39.8	39.6	39.4	39.2	39.0	38.8	38.6	38.3	38.1	37.9	37.7	37.6	37.4	37.2	22.15
22.30	30.8	29.5	28.0	26.7	25.3	24.0	22.5	21.2	19.9	18.4	17.1	15.7	14.3	12.4	
	37.9	37.7	37.5	37.3	37.1	37.0	36.7	36.5	36.3	36.1	35.9	35.7	35.5	35.3	22.30
22.45	30.6	29.3	27.8	26.5	25.1	23.8	22.3	21.0	19.7	18.2	16.7	15.5	14.2	12.7	
	36.1	35.9	35.7	35.5	35.3	35.1	34.9	34.7	34.4	34.2	34.0	33.8	33.6	33.4	22.45
22.60	30.4	29.1	27.6	26.3	24.9	23.6	22.1	20.8	19.5	18.0	16.5	15.3	14.0	12.5	
	34.2	34.0	33.8	33.6	33.4	33.2	33.0	32.7	32.5	32.3	32.1	31.9	31.7	31.4	22.60
22.75	30.2	28.9	27.4	26.1	24.7	23.4	21.9	20.6	19.3	17.9	16.3	15.1	13.8	12.3	
	32.3	32.1	31.9	31.7	31.5	31.3	31.1	30.9	30.7	30.5	30.2	29.9	29.7	29.5	22.75
22.90	30.1	28.7	27.3	26.0	24.5	23.2	21.7	20.4	19.1	17.9	16.1	14.9	13.6	12.1	
	30.4	30.2	30.0	29.8	29.6	29.4	29.2	29.0	28.8	28.6	28.4	28.2	28.0	27.7	22.90
23.05	29.9	28.6	27.1	25.8	24.3	22.9	21.5	20.2	18.9	17.7	16.0	14.7	13.4	12.0	
	28.5	28.3	28.1	27.9	27.7	27.5	27.3	27.1	26.9	26.7	26.5	26.3	26.0	25.8	23.05
23.20	29.7	28.4	26.9	25.6	24.2	22.7	21.4	20.0	18.7	17.5	15.8	14.5	13.1	11.8	
	26.7	26.5	26.3	26.1	25.9	25.7	25.5	25.2	25.0	24.8	24.6	24.4	24.2	23.9	23.20
23.35	29.5	28.2	26.7	25.4	24.0	22.5	21.2	19.8	18.6	17.3	15.6	14.4	12.9	11.6	
	24.8	24.6	24.4	24.2	24.0	23.8	23.6	23.3	23.1	22.9	22.7	22.5	22.3	22.1	23.35
23.50	29.4	28.0	26.5	25.2	23.8	22.5	21.0	19.7	18.4	17.1	15.5	14.2	12.8	11.4	
	22.9	22.7	22.5	22.3	22.1	21.9	21.7	21.5	21.2	21.0	20.8	20.6	20.4	20.2	23.50
23.65	29.2	27.9	26.3	25.1	23.6	22.3	20.9	19.5	18.2	17.0	15.3	14.0	12.6	11.3	
	21.0	20.8	20.6	20.4	20.2	20.0	19.8	19.6	19.4	19.2	18.0	18.8	18.6	18.4	23.65
23.80	29.0	27.7	26.1	24.9	23.4	22.1	20.7	19.3	18.0	16.8	15.1	13.8	12.5	11.1	
	19.1	18.9	18.7	18.5	18.3	18.1	17.9	17.7	17.5	17.3	17.1	16.9	16.7	16.5	23.80
23.95	28.8	27.5	26.0	24.7	23.2	21.9	20.5	19.1	17.8	16.4	15.0	13.7	12.3	10.9	
	17.3	17.1	16.9	16.7	16.5	16.3	16.1	15.8	15.6	15.4	15.2	15.0	14.8	14.6	23.95
24.10	28.6	27.3	25.9	24.6	23.0	21.7	20.3	18.9	17.7	16.2	14.8	13.5	12.1	10.7	
	15.4	15.2	15.0	14.8	14.6	14.4	14.2	14.0	13.8	13.6	13.4	13.2	12.9	12.7	24.10
24.25	28.4	27.1	25.7	24.4	22.9	21.5	20.1	18.8	17.5	16.0	14.6	13.3	12.0	10.5	
	13.5	13.3	13.1	12.9	12.6	12.4	12.2	12.0	11.8	11.6	11.4	11.2	11.0	10.8	24.25
24.40	28 3	27.0	25.5	24.2	22.7	21.3	20.0	18.6	17.3	15.8	14.5	13.1	11.8	10.3	
	11.6	11.4	11.2	11.0	10.8	10.6	10.3	10.1	9.9	9.7	9.5	9.3	9.1	8.9	24.40
24.55	28.1	26.8	25.4	24.0	22.5	21.1	19.8	18.4	17.1	15.6	14.3	12.9	11.6	10.1	
	9.8	9.6	9.4	9.2	9.0	8.8	8.6	8.4	8.2	8.0	7.7	7.5	7.3	7.0	24.55
24.70	27.9	26.6	25.2	23.8	22.3	21.0	19.6	18.2	16.9	15.5	14.1	12.7	11.4	9.9	
	7.9	7.7	7.5	7.3	7.1	6.9	6.6	6.4	6.2	6.0	5.8	5.6	5.4	5.2	24.70
24.85	27.7	26.4	25.0	23.6	22.2	20.8	19.4	18.0	16.7	15.3	13.9	12.6	11.2	9.8	
	6.0	5.8	5.6	5.4	5.2	5.0	4.7	4.5	4.3	4.1	3.9	3.7	3.5	3.3	24.85
	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.3	

TABLE 67 (Continued).

Standardizing table for ice cream mix No. 1 testing:

8.00% Fat
11.50% M. S. N. F.
13.00% Sugar
.50% Gelatin
33.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: Pounds butter.
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.3	
25.00	27.5 E 4.2	26.2 4.0	24.8 3.8	23.4 3.6	22.0 3.4	20.6 3.2	19.2 2.9	17.8 2.7	16.5 2.5	15.1 2.3	13.7 2.1	12.4 1.9	11.0 1.7	9.6 1.5	25.00
25.15	27.3 2.2	26.0 2.0	24.6 1.8	23.2 1.6	21.8 1.4	20.4 1.2	19.0 1.0	17.6 .8	16.3 .6	14.9 .4	13.5 .2	12.2 1	10.9 2	9.7 3	25.15
25.30	27.1 K .3	25.8 .1	24.4 1	23.2 3	22.0 4	20.7 5	19.5 6	18.3 7	17.1 8	15.9 9	14.6 10	13.4 11	12.2 12	10.9 13	25.30
25.45	28.1 8	26.8 9	25.6 10	24.4 11	23.2 12	22.0 14	20.7 16	19.5 17	18.3 18	17.1 19	15.9 20	14.6 21	13.4 22	12.2 23	25.45
25.60	29.3 18	28.1 19	26.8 20	25.6 21	24.4 22	23.2 23	22.0 24	20.7 25	19.5 26	18.3 27	17.1 29	15.9 31	14.6 32	13.4 33	25.60
25.75	30.5 28	29.3 29	28.1 30	26.8 31	25.6 32	24.4 33	23.2 34	22.0 35	20.7 36	19.5 37	18.3 38	17.1 40	15.9 41	14.6 43	25.75
25.90	31.7 38	30.5 39	29.3 40	28.1 41	26.8 42	25.6 43	24.4 44	23.2 45	22.0 46	20.7 47	19.5 49	18.3 50	17.1 51	15.9 52	25.90
26.05	32.9 48	31.7 49	30.5 50	29.3 51	28.1 52	26.8 53	25.6 54	24.4 55	23.2 56	22.0 57	20.7 58	19.5 59	18.3 61	17.1 62	26.05
26.20	34.2 58	32.9 59	31.7 60	30.5 61	29.3 62	28.1 63	26.8 64	25.6 65	24.4 66	23.2 67	22.0 68	20.7 69	19.5 70	18.3 71	26.20
26.35	35.4 68	34.2 69	32.9 70	31.7 71	30.5 72	29.3 73	28.1 74	26.8 75	25.6 76	24.4 77	23.2 78	22.0 79	20.7 80	19.5 82	26.35
26.50	36.6 78	35.4 79	34.2 80	32.9 81	31.7 82	30.5 83	29.3 85	28.1 86	26.8 87	25.6 88	24.4 89	23.2 90	22.0 91	20.7 92	26.50
26.65	37.8 88	36.6 89	35.4 90	34.2 91	32.9 92	31.7 93	30.5 94	29.3 95	28.1 96	26.8 97	25.6 98	24.4 100	23.2 101	22.0 102	26.65
26.80	39.1 98	37.8 99	36.6 100	35.4 101	34.2 102	32.9 103	31.7 104	30.5 105	29.3 106	28.1 107	26.8 108	25.6 109	24.4 111	23.2 112	26.80
26.95	40.3 108	39.1 109	37.8 110	36.6 111	35.4 112	34.2 113	32.9 114	31.7 115	30.5 116	29.3 117	28.1 118	26.8 119	25.6 120	24.4 121	26.95
27.10	41.5 118	40.3 119	39.1 120	37.8 121	36.6 122	35.4 123	34.2 124	32.9 125	31.7 126	30.5 127	29.3 128	28.1 129	26.8 131	25.6 132	27.10
27.25	42.7 128	41.5 129	40.3 130	39.1 131	37.8 132	36.6 133	35.4 134	34.2 135	32.9 136	31.7 137	30.5 138	29.3 139	28.1 140	26.8 142	27.25
27.40	43.9 138	42.7 139	41.5 140	40.3 141	39.1 142	37.8 143	36.6 144	35.4 145	34.2 146	32.9 147	31.7 148	30.5 149	29.3 151	28.1 152	27.40
27.55	45.2 148	43.9 149	42.7 150	41.5 151	40.3 152	39.1 153	37.8 154	36.6 155	35.4 156	34.2 157	32.9 158	31.7 159	30.5 160	29.3 161	27.55
27.70	46.4 158	45.2 159	43.9 160	42.7 161	41.5 162	40.3 163	39.1 164	37.8 165	36.6 166	35.4 167	34.2 168	32.9 169	31.7 170	30.5 171	27.70
27.85	47.6 168	46.4 169	45.2 170	43.9 171	42.7 172	41.5 173	40.3 174	39.1 175	37.8 176	36.6 177	35.4 178	34.2 179	32.9 180	31.7 181	27.85
B 28.00	48.8 175 H	47.6 176	46.4 177	45.2 178	43.9 179	42.7 180	41.5 181	40.3 182	39.1 183	37.8 184	36.6 185	35.4 186	34.2 188	32.9 189	28.00
	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.3	

TABLE 67 (Continued).

Standardizing table for ice cream mix No. 1 testing:

8.00% Fat
11.50% M. S. N. F.
13.00% Sugar
.50% Gelatin
33.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: Pounds butter.
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	
22.0	11.9	10.4	9.2	7.8	6.5	5.1	3.7	2.3	.9	J					22.0
	38.8	38.5	38.3	38.1	37.9	37.7	D 37.5	37.3	37.1	2 37.5	12 39.1	22 40.7	31 42.4	41 44.0	
22.15	11.7	10.2	9.0	7.6	6.3	4.9	3.5	2.1	.7						22.15
	37.0	36.7	36.5	36.3	36.1	35.9	35.7	35.5	35.3	4 35.8	13 37.5	23 39.1	32 40.7	42 42.4	
22.30	11.5	10.0	8.8	7.4	6.1	4.7	3.3	1.9	.5						22.30
	35.0	34.8	34.6	34.4	34.2	34.0	33.8	33.6	33.4	5 34.2	14 35.8	24 37.5	33 39.1	43 40.7	
22.45	11.3	10.0	8.6	7.2	5.9	4.6	3.1	1.7	.3						22.45
	33.2	32.9	32.7	32.5	32.3	32.1	31.9	31.7	31.5	7 32.6	16 34.2	26 35.8	35 37.5	45 39.1	
22.60	11.1	9.9	8.4	7.0	5.7	4.5	2.9	1.5	.1						22.60
	31.2	31.0	30.8	30.6	30.4	30.2	30.0	29.8	29.6	8 30.9	17 32.6	27 34.2	36 35.8	46 37.5	
22.75	11.0	9.7	8.2	6.8	5.5	4.2	2.8	1.4	.0						22.75
	29.3	29.1	28.9	28.7	28.5	28.3	28.1	27.9	27.7	9 29.3	18 30.9	28 32.6	37 34.2	47 35.8	
22.90	10.8	9.5	8.0	6.7	5.3	4.0	2.6	1.2							22.90
	27.5	27.3	27.1	26.9	26.7	26.5	26.3	26.1	26.1	10 27.7	18 29.3	29 30.9	38 32.6	48 34.2	
23.05	10.6	9.3	7.8	6.5	5.1	3.8	2.4	1.0							23.05
	25.6	25.4	25.2	25.0	24.8	24.6	24.4	24.2	24.4	11 26.1	19 27.7	30 29.3	39 30.9	49 32.6	
23.20	10.5	9.1	7.7	6.3	5.0	3.6	2.2	.8							23.20
	23.7	23.5	23.3	23.1	22.9	22.7	22.5	22.3	22.8	13 29.4	21 26.1	32 27.7	41 29.3	51 30.9	
23.35	10.3	8.9	7.5	6.1	4.8	3.5	2.1	.7							23.35
	21.9	21.6	21.4	21.2	21.0	20.8	20.6	20.4	21.2	14 22.8	22 24.4	33 26.1	42 27.7	52 29.3	
23.50	10.1	8.7	7.3	6.0	4.6	3.3	1.9	.5							23.50
	20.0	19.8	19.6	19.4	19.2	19.0	18.8	18.6	19.5	15 21.2	23 22.8	34 24.4	43 26.1	53 27.7	
23.65	9.8	8.6	7.1	5.8	4.4	3.1	1.7	.3							23.65
	18.2	17.9	17.7	17.5	17.3	17.1	16.9	16.7	17.9	16 19.5	24 21.2	35 22.8	44 24.4	54 26.1	
23.80	9.7	8.4	7.0	5.6	4.3	2.9	1.5	.1							23.80
	16.2	16.0	15.8	15.6	15.4	15.2	15.0	14.8	16.3	18 17.9	26 19.5	37 21.2	46 22.8	56 24.4	
23.95	9.5	8.2	6.8	5.4	4.1	2.7	1.3								23.95
	14.3	14.1	13.9	13.7	13.5	13.3	13.1	13.0	14.7	19 16.3	27 17.9	38 19.5	47 21.2	57 22.8	
24.10	9.3	8.0	6.6	5.2	3.9	2.5	1.1								24.10
	12.5	12.3	12.1	11.9	11.7	11.5	11.3	11.4	13.0	20 14.7	28 16.3	39 17.9	48 19.5	58 21.2	
24.25	9.1	7.8	6.5	5.0	3.7	2.4	1.0								24.25
	10.6	10.4	10.2	10.0	9.8	9.6	9.4	9.8	11.4	22 13.0	30 14.7	41 16.3	50 17.9	60 19.5	
24.40	9.0	7.7	6.3	4.8	3.5	2.2	.8								24.40
	8.7	8.5	8.3	8.1	7.9	7.7	7.5	8.2	9.8	23 11.4	31 13.0	42 14.7	51 16.3	61 17.9	
24.55	8.8	7.5	6.1	4.7	3.3	2.0	.6								24.55
	6.8	6.6	6.4	6.2	6.0	5.8	5.6	6.5	8.2	25 9.8	33 11.4	44 13.0	53 14.7	63 16.3	
24.70	8.6	7.3	5.9	4.5	3.2	1.8	.4								24.70
	5.0	4.8	4.6	4.4	4.2	4.0	3.8	4.9	6.5	26 8.2	35 9.8	46 11.4	54 13.0	64 14.7	
24.85	8.4	7.1	5.7	4.3	3.0	1.6	.2								24.85
	3.1	2.9	2.7	2.5	2.3	2.1	1.9	3.2	4.9	28 6.5	37 8.2	47 9.8	55 11.4	65 13.0	
	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	

TABLE 67 (Continued).

Standardizing table for ice cream mix No. 1 testing: 8.00% Fat, 11.50% M. S. N. F., 13.00% Sugar, .50% Gelatin — 33.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: Pounds butter.
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	
25.00	8.2 1.3	6.9 1.0	5.5 .8	4.1 .6	2.8 .4	1.4 .2	Std. C	10 1.6	20 3.2	29 4.9	39 6.5	49 8.2	57 9.8	66 11.4	**25.00**
25.15	8.5 4	7.3 5	6.1 6	4.8 7	3.6 8	2.4 9	1.2 10	11	21 1.6	31 3.2	40 4.9	51 6.5	59 8.2	68 9.8	**25.15**
25.30	9.7 14	8.5 15	7.3 16	6.1 17	4.8 18	3.6 19	2.4 20	1.2 21	22	32 1.6	42 3.2	52 4.9	61 6.5	61 8.2	**25.30**
25.45	10.9 24	9.7 25	8.5 26	7.3 27	6.1 28	4.8 29	3.6 30	2.4 31	1.2 32	33	43 1.6	53 3.2	62 4.9	71 6.5	**25.45**
25.60	12.2 34	10.9 35	9.7 36	8.5 37	7.3 38	6.1 39	4.8 40	3.6 41	2.4 42	1.2 43	44	54 1.6	64 3.2	72 4.9	**25.60**
25.75	13.4 44	12.2 45	10.9 46	9.7 47	8.5 48	7.3 49	6.1 50	4.8 51	3.6 52	2.4 53	1.2 54	55	65 1.6	74 3.2	**25.75**
25.90	14.6 53	13.4 54	12.2 55	10.9 57	9.7 58	8.5 59	7.3 60	6.1 61	4.8 62	3.6 63	2.4 64	1.2 65	66	75 1.6	**25.90**
26.05	15.9 63	14.6 64	13.4 65	12.2 66	10.9 67	9.7 68	8.5 69	7.3 70	6.1 71	4.8 72	3.6 73	2.4 74	1.2 75	76	**26.05**
26.20	17.1 72	15.9 73	14.6 74	13.4 75	12.2 76	10.9 77	9.7 78	8.5 80	7.3 81	6.1 82	4.8 83	3.6 84	2.4 85	1.2 86	**26.20**
26.35	18.3 83	17.1 84	15.9 85	14.6 86	13.4 87	12.2 88	10.9 89	9.7 90	8.5 91	7.3 92	6.1 93	4.8 94	3.6 95	2.4 96	**26.35**
26.50	19.5 93	18.3 94	17.1 95	15.9 96	14.6 97	13.4 98	12.2 99	10.9 100	9.7 101	8.5 102	7.3 103	6.1 104	4.8 105	3.6 106	**26.50**
26.65	20.7 103	19.5 104	18.3 105	17.1 106	15.9 107	14.6 108	13.4 109	12.2 110	10.9 111	9.7 112	8.5 113	7.3 114	6.1 115	4.8 116	**26.65**
26.80	22.0 113	20.7 114	19.5 115	18.3 116	17.1 117	15.9 118	14.6 119	13.4 120	12.2 121	10.9 122	9.7 123	8.5 124	7.3 125	6.1 126	**26.80**
26.95	23.2 122	22.0 123	20.7 124	19.5 125	18.3 126	17.1 127	15.9 128	14.6 129	13.4 130	12.2 131	10.9 132	9.7 134	8.5 135	7.3 136	**26.95**
27.10	24.4 133	23.2 134	22.0 135	20.7 136	19.5 137	18.3 138	17.1 139	15.9 140	14.6 141	13.4 142	12.2 143	10.9 144	9.7 145	8.5 146	**27.10**
27.25	25.6 143	24.4 144	23.2 145	22.0 146	20.7 147	19.5 148	18.3 149	17.1 150	15.9 151	14.6 152	13.4 153	12.2 154	10.9 155	9.7 156	**27.25**
27.40	26.8 153	25.6 154	24.4 155	23.2 156	22.0 157	20.7 158	19.5 159	18.3 160	17.1 161	15.9 162	14.6 163	13.4 164	12.2 165	10.9 166	**27.40**
27.55	28.1 162	26.8 163	25.6 164	24.4 165	23.2 166	22.0 167	20.7 168	19.5 169	18.3 170	17.1 171	15.9 172	14.6 173	13.4 174	12.2 175	**27.55**
27.70	29.3 172	28.1 173	26.8 174	25.6 175	24.4 176	23.2 177	22.0 178	20.7 179	19.5 180	18.3 181	17.1 182	15.9 183	14.6 184	13.4 185	**27.70**
27.85	30.5 182	29.3 183	28.1 184	26.8 185	25.6 186	24.4 187	23.2 188	22.0 189	20.7 190	19.5 191	18.3 192	17.1 193	15.9 194	14.6 195	**27.85**
28.00	31.7 190	30.5 191	29.3 192	28.1 193	26.8 194	25.6 195	24.4 196	23.2 197	22.0 198	20.7 200	19.5 201	18.3 202	17.1 203	15.9 204	**28.00**
	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	

TABLE 67 (Continued).

Standardizing table for ice cream mix No. 1 testing:

8.00% Fat
11.50% M. S. N. F.
13.00% Sugar
.50% Gelatin
33.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: Pounds butter.
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

	8.8	8.9	9.0	9.1	9.2	9.3	9.4	9.5	9.6	9.7	9.8	9.9	10.0	
22.0	50 45.6	60 47.3	70 48.9	79 50.2	89 52.1	99 53.8	108 55.4	118 57.0	127 58.6	137 60.2	147 61.9	157 63.6	I 166 65.2	22.0
22.15	51 44.0	61 45.6	71 47.3	80 48.9	90 50.2	100 52.1	109 53.8	119 55.4	128 57.0	138 58.6	148 60.2	158 61.9	167 63.6	22.15
22.30	52 42.4	62 44.0	72 45.6	81 47.3	91 48.9	101 50.2	110 52.1	120 53.8	129 55.4	139 57.0	149 58.6	159 60.2	168 61.9	22.30
22.45	54 40.7	64 42.4	74 44.0	83 45.6	93 47.3	103 48.9	112 50.2	122 52.1	131 53.8	141 55.4	151 57.0	161 58.6	170 60.2	22.45
22.60	55 39.1	65 40.7	75 42.4	84 44.0	94 45.6	104 47.3	113 48.9	123 50.2	132 52.1	142 53.8	152 55.4	162 57.0	171 58.6	22.60
22.75	56 37.5	66 39.1	76 40.7	85 42.4	95 44.0	105 45.6	114 47.3	124 48.9	133 50.2	143 52.1	153 53.8	163 55.4	172 57.	22.75
22.90	57 35.8	67 37.5	77 39.1	86 40.7	96 42.4	106 44.0	115 45.6	125 47.3	134 48.9	144 50.2	154 52.1	164 53.8	173 55.4	22.90
23.05	58 34.2	68 35.8	79 32.5	88 39.1	98 40.7	108 42.4	117 44.0	127 45.6	136 47.3	146 48.9	156 50.2	166 52.1	175 53.8	23.05
23.20	60 32.6	70 34.2	80 35.8	89 37.5	99 39.1	109 40.7	118 42.4	128 44.0	137 45.6	147 47.3	157 48.9	167 50.2	176 52.1	23.20
23.35	61 30.9	71 32.6	81 34.2	90 35.8	100 37.5	110 39.1	119 40.7	129 42.4	138 44.0	148 45.6	158 47.3	168 48.9	178 50.2	23.35
23.50	62 29.3	72 30.9	82 32.6	91 34.2	101 35.8	111 37.5	120 39.1	130 40.7	139 42.4	149 44.0	159 45.6	169 47.3	178 48.9	23.50
23.65	63 27.7	73 29.3	83 30.9	92 32.6	102 34.2	112 35.8	121 37.5	131 39.1	140 40.7	150 42.4	160 44.0	170 45.6	180 47.3	23.65
23.80	65 26.1	75 27.7	85 29.3	94 30.9	104 32.6	114 34.2	123 35.8	132 37.5	142 39.1	152 40.7	162 42.4	172 44.0	182 45.6	23.80
23.95	66 24.4	76 26.1	86 27.7	95 29.3	105 30.9	115 32.6	124 34.2	133 35.8	143 37.5	153 39.1	163 40.7	173 42.4	183 44.0	23.95
24.10	67 22.8	77 24.4	87 26.1	96 27.7	106 29.3	116 30.9	125 32.6	134 34.2	144 35.8	153 37.5	164 39.1	174 40.7	184 42.4	24.10
24.25	69 21.2	79 22.8	89 24.4	98 26.1	108 27.7	118 29.3	127 30.9	136 32.6	146 34.2	155 35.8	166 37.5	176 39.1	186 40.7	24.25
24.40	70 19.5	80 21.2	90 22.8	99 24.4	109 26.1	119 27.7	128 29.3	137 30.9	147 32.6	156 34.2	167 35.8	177 37.5	187 39.1	24.40
24.55	72 17.9	82 19.5	92 21.2	101 22.8	111 24.4	121 26.1	130 27.7	139 29.3	149 30.9	158 32.6	169 34.2	179 35.8	189 37.5	24.55
24.70	73 16.3	83 17.9	93 19.5	103 21.2	112 22.8	121 24.4	131 26.1	140 27.7	150 29.3	159 30.9	170 32.6	180 34.2	190 35.8	24.70
24.85	74 14.7	85 16.3	94 17.9	104 19.5	113 21.2	122 22.8	133 24.4	141 26.1	151 27.7	160 29.3	171 30.9	181 32.6	192 34.2	24.85
	8.8	8.9	9.0	9.1	9.2	9.3	9.4	9.5	9.6	9.7	9.8	9.9	10.0	

TABLE 67 (Continued).

Standardizing table for ice cream mix No. 1 testing:

8.00% Fat
11.50% M. S. N. F.
13.00% Sugar
.50% Gelatin
33.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: Pounds butter.
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

	8.8	8.9	9.0	9.1	9.2	9.3	9.4	9.5	9.6	9.7	9.8	9.9	10.0	
25.00	76 13.0	86 14.7	95 16.3	105 17.9	114 19.5	122 21.2	134 22.8	143 24.4	152 26.1	161 27.7	173 29.3	183 30.9	193 32.6	25.00
25.15	77 11.4	88 13.0	97 14.7	106 16.3	116 17.9	123 19.5	136 21.2	144 22.8	153 24.4	162 26.1	175 27.7	185 29.3	194 30.9	25.15
25.30	79 9.8	89 11.4	98 13.0	108 14.7	117 16.3	125 17.9	137 19.5	145 21.2	154 22.8	163 24.4	176 26.1	186 27.7	196 29.3	25.30
25.45	80 8.2	90 9.8	100 11.4	109 13.0	119 14.7	127 16.3	138 17.9	147 19.5	155 21.2	165 22.8	178 24.4	188 26.1	197 27.7	25.45
25.60	82 6.5	92 8.2	101 9.8	111 11.4	120 13.0	128 14.7	140 16.3	149 17.9	157 19.5	167 21.2	180 22.8	189 24.4	198 26.1	25.60
25.75	83 4.9	94 6.5	103 8.2	113 9.8	122 11.4	130 13.0	142 14.7	150 16.3	159 17.9	168 19.5	181 21.2	189 22.8	199 24.4	25.75
25.90	85 3.2	95 4.9	104 6.5	114 8.2	123 9.8	131 11.4	143 13.0	151 14.7	160 16.3	169 17.9	182 19.5	189 21.2	200 22.8	25.90
26.05	86 1.6	96 3.2	105 4.9	115 6.5	125 8.2	133 9.8	144 11.4	153 13.0	162 14.7	170 16.3	184 17.9	190 19.5	201 21.2	26.05
26.20	87	97 1.6	107 3.2	116 4.9	126 6.5	135 8.2	145 9.8	154 11.4	164 13.0	172 14.7	186 16.3	192 17.9	203 19.5	26.20
26.35	1.2 97	98	108 1.6	118 3.2	128 4.9	136 6.5	146 8.2	156 9.8	166 11.4	173 13.0	187 14.7	193 16.3	204 17.9	26.35
26.50	2.4 107	1.2 108	109	119 1.6	129 3.2	138 4.9	148 6.5	157 8.2	167 9.8	175 11.4	188 13.0	195 14.7	205 16.3	26.50
26.65	3.6 117	2.4 118	1.2 119	120	130 1.6	139 3.2	149 4.9	159 6.5	168 8.2	176 9.8	189 11.4	196 13.0	207 14.7	26.65
26.80	4.8 127	3.6 128	2.4 129	1.2 130	131	141 1.6	151 3.2	160 4.9	170 6.5	179 8.2	190 9.8	198 11.4	208 13.0	26.80
26.95	6.1 137	4.8 138	3.6 139	2.4 140	1.2 141	142	152 1.6	161 3.2	171 4.9	180 6.5	191 8.2	199 9.8	209 11.4	26.95
27.10	7.3 147	6.1 148	4.8 149	3.6 150	2.4 151	1.2 152	153	162 1.6	173 3.2	181 4.9	192 6.5	201 8.2	211 9.8	27.10
27.25	8.5 157	7.3 158	6.1 159	4.8 160	3.6 161	2.4 162	1.2 163	164	174 1.6	183 3.2	193 4.9	202 6.5	212 8.2	27.25
27.40	9.7 167	8.5 168	7.3 169	6.1 170	4.8 171	3.6 172	2.4 173	1.2 174	175	184 1.6	194 3.2	204 4.9	213 6.5	27.40
27.55	10.9 176	9.7 177	8.5 178	7.3 179	6.1 180	4.8 181	3.6 182	2.4 183	1.2 184	185	195 1.6	205 3.2	214 4.9	27.55
27.70	12.2 186	10.9 187	9.7 188	8.5 189	7.3 190	6.1 191	4.8 192	3.6 193	2.4 194	1.2 195	196	206 1.6	216 3.2	27.70
27.85	13.4 196	12.2 197	10.9 198	9.7 199	8.5 200	7.3 201	6.1 202	4.8 203	3.6 204	2.4 205	1.2 206	207	217 1.6	27.85
28.00	14.6 205	13.4 206	12.2 207	10.9 208	9.7 209	8.5 210	7.3 212	6.1 213	4.8 214	3.6 215	2.4 216	1.2 217	G 218	28.00
	8.8	8.9	9.0	9.1	9.2	9.3	9.4	9.5	9.6	9.7	9.8	9.9	10.0	

TABLE 68.

Standardizing table for ice cream mix No. 2 testing: 8.00% Fat, 12.50% M. S. N. F., 13.00% Sugar, .50% Gelatin — 34.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: Pounds butter.
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

% T.S.N.F.	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.3	
22.76	31.6	30.2	28.8	27.4	26.1	24.7	23.3	21.9	20.6	19.2	17.8	16.4	15.0	13.7	22.76
	45.8	45.6	45.4	45.1	44.9	44.7	44.3	44.1	43.9	43.6	43.4	43.2	43.0	42.7	
22.92	31.4	30.0	28.7	27.3	25.9	24.5	23.1	21.8	20.4	19.0	17.6	16.2	14.8	13.5	22.92
	43.7	43.5	43.3	43.1	42.9	42.7	42.4	42.2	41.9	41.7	41.5	41.2	40.9	40.7	
23.08	31.2	29.8	28.5	27.1	25.7	24.3	22.9	21.6	20.2	18.8	17.4	16.2	14.6	13.3	23.08
	41.7	41.5	41.3	41.0	40.8	40.5	40.3	40.0	39.8	39.5	39.3	39.1	38.9	38.6	
23.24	31.0	29.6	28.3	26.9	25.5	24.1	22.7	21.4	20.0	18.6	17.2	16.0	14.4	13.1	23.24
	39.6	39.3	39.1	38.9	38.7	38.5	38.2	37.9	37.7	37.5	37.2	37.0	36.8	36.6	
23.41	30.8	29.4	28.1	26.7	25.3	23.9	22.5	21.2	19.8	18.4	17.0	15.8	14.2	12.9	23.41
	37.6	37.4	37.1	36.9	36.7	36.5	36.3	36.1	35.8	35.6	35.4	35.1	34.8	34.6	
23.57	30.6	29.2	27.9	26.5	25.1	23.7	22.3	21.0	19.6	18.2	16.8	15.6	14.0	12.7	23.57
	35.5	35.2	35.0	34.8	34.6	34.4	34.1	33.9	33.7	33.3	33.1	32.9	32.6	32.4	
23.73	30.4	29.0	27.7	26.3	24.9	23.5	22.1	20.8	19.4	18.0	16.6	15.4	13.8	12.5	23.73
	33.4	33.2	33.0	32.7	32.5	32.3	32.0	31.7	31.5	31.3	31.1	30.9	30.7	30.5	
23.89	30.2	28.8	27.5	26.1	24.7	23.3	21.9	20.6	19.2	17.8	16.4	15.2	13.6	12.3	23.89
	31.3	31.1	30.9	30.7	30.5	30.3	30.1	29.7	29.5	29.1	28.9	28.7	28.5	28.3	
24.06	30.0	28.6	27.3	25.9	24.5	23.1	21.7	20.4	19.0	17.6	16.2	15.0	13.4	12.1	24.06
	29.3	29.0	28.7	28.5	28.3	28.0	27.8	27.6	27.4	27.2	26.9	26.7	26.5	26.3	
24.22	29.8	28.4	27.1	25.7	24.3	22.9	21.5	20.2	18.8	17.4	16.0	14.8	13.2	11.9	24.22
	27.2	27.0	26.8	26.5	26.3	26.0	25.8	25.6	25.3	25.1	24.9	24.6	24.4	24.2	
24.38	29.6	28.2	26.9	25.5	24.1	22.7	21.3	20.0	18.6	17.2	15.8	14.6	13.0	11.7	24.38
	25.2	25.0	24.7	24.5	24.3	24.0	23.8	23.6	23.3	23.1	22.9	22.6	22.4	22.2	
24.54	29.4	28.0	26.7	25.3	23.9	22.5	21.1	19.8	18.4	17.0	15.6	14.2	12.8	11.5	24.54
	23.1	22.9	22.7	22.5	22.2	22.0	21.7	21.5	21.2	21.0	20.7	20.5	20.3	20.1	
24.70	29.2	27.8	26.5	25.1	23.7	22.3	20.9	19.6	18.2	16.8	15.4	14.0	12.6	11.3	24.70
	21.0	20.8	20.6	20.4	20.2	20.0	19.8	19.5	19.3	19.1	18.9	18.6	18.4	18.2	
24.86	29.0	27.6	26.3	24.9	23.5	22.1	20.7	19.4	18.0	16.6	15.2	13.8	12.4	11.1	24.86
	19.0	18.8	18.5	18.3	18.1	17.8	17.6	17.4	17.1	16.9	16.7	16.4	16.2	15.9	
25.03	28.8	27.4	26.1	24.7	23.3	21.9	20.5	19.2	17.8	16.4	15.0	13.6	12.2	10.9	25.03
	16.9	16.7	16.5	16.3	16.1	15.8	15.6	15.4	15.1	14.9	14.7	14.5	14.3	14.0	
25.19	28.6	27.2	25.9	24.5	23.1	21.7	20.3	19.0	17.6	16.2	14.8	13.4	12.0	10.7	25.19
	14.8	14.6	14.4	14.1	13.9	13.7	13.4	13.2	13.0	12.7	12.5	12.2	12.0	11.8	
25.35	28.4	27.0	25.7	24.3	22.9	21.5	20.1	18.8	17.4	16.0	14.6	13.2	11.8	10.5	25.35
	12.8	12.6	12.4	12.1	11.9	11.7	11.4	11.2	11.0	10.7	10.5	10.2	10.0	9.8	
25.51	28.2	26.8	25.5	24.1	22.7	21.3	19.9	18.6	17.2	15.8	14.4	13.0	11.6	10.3	25.51
	10.8	10.6	10.4	10.1	9.8	9.5	9.3	9.1	8.8	8.6	8.4	8.1	7.9	7.7	
25.68	28.0	26.6	25.3	23.9	22.5	21.1	19.7	18.4	17.0	15.6	14.2	12.8	11.4	10.1	25.68
	8.7	8.5	8.3	8.1	7.8	7.5	7.3	7.1	6.9	6.7	6.4	6.2	5.9	5.7	
25.84	27.8	26.4	25.1	23.7	22.3	20.9	19.5	18.2	16.8	15.4	14.0	12.6	11.2	9.9	25.84
	6.6	6.4	6.2	5.9	5.7	5.5	5.3	5.0	4.8	4.5	4.3	4.1	3.8	3.6	
26.00	27.6	26.2	24.9	23.5	22.1	20.7	19.3	18.0	16.6	15.2	13.8	12.4	11.0	9.7	26.00
	4.6	4.4	4.2	3.9	3.7	3.5	3.3	3.0	2.8	2.5	2.3	2.1	1.8	1.6	
	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.3	

TABLE 68 (Continued).

Standardizing table for ice cream mix No. 2 testing:
8.00% Fat
12.50% M. S. N. F.
13.00% Sugar
.50% Gelatin
34.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: Pounds butter.
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.3	
26.16	27.4 2.5	26.0 2.3	24.7 2.1	23.3 1.8	21.9 1.6	20.5 1.4	19.1 1.2	17.8 .9	16.4 .7	15.0 .5	13.6 .3	12.2 .1	10.8 1	9.7 2	26.16
26.32	27.2 .4	25.8 .2	24.4 1	23.1 2	21.9 3	20.7 4	19.5 5	18.3 6	17.1 7	15.8 8	14.6 9	13.4 10	12.2 12	11.0 13	26.32
26.49	28.0 7	26.8 8	25.6 9	24.4 10	23.1 11	21.9 12	20.7 13	19.5 14	18.3 15	17.1 16	15.8 18	14.6 19	13.4 20	12.2 21	26.49
26.66	29.2 17	28.0 18	26.8 19	25.6 20	24.4 21	23.1 22	21.9 23	20.7 24	19.5 25	18.3 28	17.1 29	15.8 30	14.6 31	13.4 32	26.66
26.82	30.5 27	29.2 28	28.0 29	26.8 30	25.6 31	24.4 32	23.1 33	21.9 34	20.7 35	19.5 36	18.3 37	17.1 39	15.8 40	14.6 41	26.82
26.98	31.7 37	30.5 38	29.2 39	28.0 40	26.8 41	25.6 42	24.4 44	23.1 45	21.9 46	20.7 47	19.5 48	18.3 49	17.1 50	15.8 51	26.98
27.14	32.8 46	31.7 47	30.5 48	29.2 49	28.0 50	26.8 51	25.6 52	24.4 53	23.1 54	21.9 55	20.7 56	19.5 58	18.3 60	17.1 61	27.14
27.30	34.1 56	32.8 57	31.7 58	30.5 59	29.2 61	28.0 62	26.8 63	25.6 64	24.4 65	23.1 66	21.9 67	20.7 68	19.5 69	18.3 71	27.30
27.47	35.3 66	34.1 67	32.8 68	31.7 69	30.5 70	29.2 71	28.0 72	26.8 73	25.6 75	24.4 76	23.1 77	21.9 78	20.7 79	19.5 80	27.47
27.62	36.5 76	35.3 77	34.1 78	32.8 79	31.7 80	30.5 81	29.2 83	28.0 84	26.8 85	25.6 86	24.4 87	23.1 88	21.9 89	20.7 90	27.62
27.78	37.8 85	36.5 86	35.3 87	34.1 88	32.8 89	31.7 90	30.5 91	29.2 92	28.0 93	26.8 95	25.6 97	24.4 98	23.1 99	21.9 100	27.78
27.94	39.0 95	37.8 96	36.5 97	35.3 98	34.1 99	32.8 100	31.7 101	30.5 102	29.2 103	28.0 105	26.8 106	25.6 107	24.4 108	23.1 110	27.94
28.10	40.2 105	39.0 106	37.8 107	36.5 108	35.3 109	34.1 111	32.8 112	31.7 114	30.5 115	29.2 116	28.0 117	26.8 118	25.6 119	24.4 120	28.10
28.27	41.4 115	40.2 116	39.0 117	37.8 118	36.5 119	35.3 120	34.1 121	32.8 122	31.7 123	30.5 124	29.2 126	28.0 127	26.8 128	25.6 129	28.27
28.43	42.6 125	41.4 126	40.2 127	39.0 128	37.8 129	36.5 130	35.3 131	34.1 132	32.8 133	31.7 134	30.5 136	29.2 137	28.0 138	26.8 139	28.43
28.60	43.8 135	42.6 136	41.4 137	40.2 138	39.0 139	37.8 140	36.5 141	35.3 142	34.1 143	32.8 144	31.7 145	30.5 146	29.2 147	28.0 148	28.60
28.76	45.1 145	43.8 146	42.6 147	41.4 148	40.2 149	39.0 150	37.8 151	36.5 152	35.3 154	34.1 155	32.8 156	31.7 157	30.5 158	29.2 159	28.76
28.93	46.3 154	45.1 155	43.8 156	42.6 157	41.4 158	40.2 159	39.0 160	37.8 161	36.5 162	35.3 163	34.1 164	32.8 165	31.7 166	30.5 167	28.93
29.09	47.5 164	46.3 165	45.1 166	43.8 167	42.6 168	41.4 169	40.2 170	39.0 172	37.8 173	36.5 174	35.3 175	34.1 176	32.8 177	31.7 178	29.09
29.25	48.7 174	47.5 175	46.3 176	45.1 177	43.8 178	42.6 179	41.4 180	40.2 181	39.0 182	37.8 183	36.5 185	35.3 186	34.1 187	32.8 188	29.25
	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.3	

TABLE 68 (Continued).

Standardizing table for ice cream mix No. 2 testing: 8.00% Fat, 12.50% M. S. N. F., 13.00% Sugar, .50% Gelatin, 34.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: Pounds butter.
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	
22.76	12.3	10.9	9.5	8.1	6.7	5.4	4.0	2.6	1.2						22.76
	42.5	42.3	42.1	41.9	41.6	41.4	41.2	41.0	39.8	1 40.7	10 42.5	20 44.3	29 46.0	39 47.8	
22.92	12.1	10.7	9.3	7.9	6.5	5.2	3.8	2.4	1.0						22.92
	40.5	40.2	40.0	39.8	39.5	39.3	39.1	38.9	38.7	2 38.9	11 40.7	21 42.5	30 44.3	40 46.0	
23.08	11.9	10.5	9.1	7.7	6.3	5.0	3.6	2.2	.8						23.08
	38.4	38.2	37.9	37.7	37.5	37.3	37.1	36.9	36.7	4 37.2	13 38.9	23 40.7	32 42.5	42 44.3	
23.24	11.7	10.3	8.9	7.5	6.1	4.8	3.4	2.0	.6						23.24
	36.4	36.2	36.0	35.7	35.4	35.2	35.0	34.8	34.5	5 35.4	14 37.2	24 38.9	33 40.7	43 42.5	
23.41	11.5	10.1	8.7	7.3	5.9	4.6	3.2	1.8	.4						23.41
	34.4	34.2	33.9	33.7	33.5	33.2	33.0	32.8	32.6	7 33.6	16 35.4	26 37.2	35 38.9	45 40.7	
23.57	11.3	9.9	8.5	7.1	5.7	4.4	3.0	1.6	.2						23.57
	32.1	31.9	31.7	31.5	31.3	31.1	30.9	30.7	30.5	8 31.9	17 33.6	27 35.4	36 37.2	46 38.9	
23.73	11.1	9.7	8.3	6.9	5.5	4.2	2.8	1.4	.0						23.73
	30.3	30.0	29.7	29.5	29.3	29.1	28.9	28.7	28.5	9 30.1	18 31.9	28 33.6	37 35.4	47 37.2	
23.89	10.9	9.5	8.1	6.7	5.3	4.0	2.6	1.2							23.89
	28.1	27.9	27.7	27.5	27.2	27.0	26.8	26.6	26.4	1 28.3	11 30.1	20 31.9	30 33.6	39 35.4	49
24.06	10.7	9.3	7.9	6.5	5.1	3.8	2.4	1.0							24.06
	26.0	25.8	25.6	25.3	25.1	24.9	24.7	24.5	24.8	2 26.6	12 28.3	21 30.1	31 31.9	40 33.6	50
24.22	10.5	9.1	7.7	6.3	4.9	3.6	2.2	.8							24.22
	24.0	23.7	23.5	23.3	23.1	22.9	22.7	22.5	23.0	4 24.8	14 26.6	23 28.3	33 30.1	42 31.9	52
24.38	10.3	8.9	7.5	6.1	4.7	3.4	2.0	.6							24.38
	21.9	21.7	21.5	21.3	21.1	20.8	20.6	20.4	21.2	5 23.0	15 24.8	24 26.6	34 28.3	43 30.1	53
24.54	10.1	8.7	7.3	5.9	4.5	3.2	1.8	.4							24.54
	19.8	19.6	19.4	19.2	18.9	18.7	18.5	18.3	19.5	6 21.2	16 23.0	25 24.8	35 26.6	44 28.3	54
24.70	9.9	8.5	7.1	5.7	4.3	3.0	1.6	.2							24.70
	17.9	17.7	17.4	17.2	17.0	16.7	16.5	16.3	17.7	8 19.5	18 21.2	27 23.0	37 24.8	46 26.6	56
24.86	9.7	8.3	6.9	5.5	4.1	2.8	1.4	.0							24.86
	15.7	15.5	15.3	15.1	14.8	14.6	14.4	14.2	15.9	9 17.7	19 19.5	28 21.2	38 23.0	47 24.8	57
25.03	9.5	8.1	6.7	5.3	3.9	2.6	1.2								25.03
	13.8	13.5	13.3	13.1	12.8	12.6	12.4	12.4	14.2	11 15.9	21 17.7	30 19.5	40 21.2	49 23.0	59
25.19	9.3	7.9	6.5	5.1	3.7	2.4	1.0								25.19
	11.6	11.3	11.1	10.9	10.6	10.4	10.2	10.6	12.4	12 14.2	22 15.9	31 17.7	41 19.5	50 21.2	60
25.35	9.1	7.7	6.3	4.9	3.5	2.2	.8								25.35
	9.6	9.3	9.1	8.9	8.6	8.4	8.2	8.9	10.6	13 12.4	23 14.2	32 15.9	42 17.7	51 19.5	61
25.51	8.9	7.5	6.1	4.7	3.3	2.0	.6								25.51
	7.5	7.2	7.0	6.8	6.5	6.3	6.1	7.1	8.9	15 10.6	25 12.4	34 14.2	44 15.9	53 17.7	63
25.68	8.7	7.3	5.9	4.5	3.1	1.6	.4								25.68
	5.5	5.2	5.0	4.8	4.5	4.3	4.0	5.3	7.1	16 8.9	26 10.6	35 12.4	45 14.2	54 15.9	64
25.84	8.5	7.1	5.7	4.3	2.9	1.6	.2								25.84
	3.4	3.1	2.9	2.6	2.4	2.2	2.0	3.5	5.3	18 7.1	28 8.9	37 10.6	47 12.4	56 14.2	66
26.00	8.3	6.9	5.5	4.1	2.7	1.3									26.00
	1.4	1.1	.9	.6	.4	.2	Stop	10 1.8	19 3.5	29 5.3	38 7.1	48 8.9	57 10.6	67 12.4	
	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	

TABLE 68 (Continued).

Standardizing table for ice cream mix No. 2 testing: 8.00% Fat; 12.50% M. S. N. F.; 13.00% Sugar; .50% Gelatin; 34.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: Pounds butter.
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	
26.16	8.5 3	7.3 5	6.1 6	4.9 7	3.7 8	2.4 9	1.2 10	11	20 1.8	30 3.5	39 5.3	49 7.1	58 8.9	68 10.6	**26.16**
26.32	9.7 14	8.5 15	7.3 16	6.1 17	4.9 18	3.7 19	2.4 20	1.2 21	22	32 1.8	41 3.5	51 5.3	60 7.1	70 8.9	**26.32**
26.49	11.0 22	9.7 25	8.5 26	7.3 27	6.1 28	4.9 29	3.7 30	2.4 31	1.2 32	33	42 1.8	52 3.5	61 5.3	71 7.1	**26.49**
26.66	12.2 33	11.0 34	9.7 35	8.5 37	7.3 38	6.1 39	4.9 40	3.7 41	2.4 42	1.2 43	44	54 1.8	63 3.5	73 5.3	**26.66**
26.82	13.4 42	12.2 44	11.0 45	9.7 46	8.5 48	7.3 49	6.1 50	4.9 51	3.7 52	2.4 53	1.2 54	55	64 1.8	74 3.5	**26.82**
26.98	14.6 52	13.4 54	12.2 55	11.0 56	9.7 57	8.5 58	7.3 59	6.1 60	4.9 61	3.7 62	2.4 63	1.2 64	65	75 1.8	**26.98**
27.14	15.8 62	14.6 63	13.4 64	12.2 66	11.0 67	9.7 68	8.5 69	7.3 70	6.1 71	4.9 72	3.7 73	2.4 74	1.2 75	76	**27.14**
27.30	17.1 72	15.8 73	14.6 74	13.4 75	12.2 77	11.0 78	9.7 79	8.5 80	7.3 81	6.1 82	4.9 83	3.7 84	2.4 85	1.2 86	**27.30**
27.47	18.3 82	17.1 83	15.8 84	14.6 85	13.4 86	12.2 87	11.0 88	9.7 89	8.5 90	7.3 91	6.1 93	4.9 94	3.7 95	2.4 96	**27.47**
27.62	19.5 92	18.3 93	17.1 94	15.8 95	14.6 96	13.4 97	12.2 98	11.0 99	9.7 101	8.5 102	7.3 103	6.1 104	4.9 105	3.7 106	**27.62**
27.78	20.7 101	19.5 102	18.3 103	17.1 104	15.8 105	14.6 106	13.4 108	12.2 109	11.0 110	9.7 111	8.5 112	7.3 113	6.1 114	4.9 115	**27.78**
27.94	21.9 112	20.7 113	19.5 114	18.3 115	17.1 116	15.8 117	14.6 118	13.4 119	12.2 120	11.0 122	9.7 123	8.5 124	7.3 125	6.1 126	**27.94**
28.10	23.1 121	21.9 122	20.7 124	19.5 125	18.3 126	17.1 127	15.8 128	14.6 129	13.4 131	12.2 132	11.0 133	9.7 134	8.5 135	7.3 136	**28.10**
28.27	24.4 130	23.1 131	21.9 132	20.7 134	19.5 135	18.3 136	17.1 137	15.8 138	14.6 140	13.4 141	12.2 142	11.0 145	9.7 145	8.5 146	**28.27**
28.43	25.6 140	24.4 141	23.1 142	21.9 143	20.7 144	19.5 146	18.3 147	17.1 148	15.8 149	14.6 150	13.4 151	12.2 152	11.0 153	9.7 154	**28.43**
28.60	26.8 150	25.6 151	24.4 153	23.1 154	21.9 155	20.7 156	19.5 157	18.3 158	17.1 159	15.8 160	14.6 162	13.4 163	12.2 164	11.0 165	**28.60**
28.76	28.0 160	26.8 161	25.6 162	24.4 164	23.1 165	21.9 166	20.7 167	19.5 168	18.3 169	17.1 170	15.8 171	14.6 172	13.4 174	12.2 175	**28.76**
28.93	29.2 168	28.6 169	26.8 170	25.6 171	24.4 173	23.1 174	21.9 175	20.7 176	19.5 177	18.3 179	17.1 180	15.8 181	14.6 182	13.4 183	**28.93**
29.09	30.5 179	29.2 180	28.0 181	26.8 183	25.6 184	24.4 185	23.1 186	21.9 187	20.7 188	19.5 189	18.3 190	17.1 191	15.8 192	14.6 194	**29.09**
29.25	31.7 189	30.5 190	29.2 191	28.0 192	26.8 193	25.6 194	24.4 195	23.1 197	21.9 198	20.7 199	19.5 200	18.3 201	17.1 202	15.8 203	**29.25**
	7.4	**7.5**	**7.6**	**7.7**	**7.8**	**7.9**	**8.0**	**8.1**	**8.2**	**8.3**	**8.4**	**8.5**	**8.6**	**8.7**	

TABLE 68 (Continued).

Standardizing table for ice cream mix No. 2 testing:

8.00% Fat
12.50% M. S. N. F.
13.00% Sugar
.50% Gelatin
34.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: Pounds butter.
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

	8.8	8.9	9.0	9.1	9.2	9.3	9.4	9.5	9.6	9.7	9.8	9.9	10.0	
22.76	48 49.6	58 51.3	67 53.1	77 54.9	86 56.7	96 58.4	105 60.2	115 62.0	124 63.7	134 65.5	143 67.3	153 69.0	162 70.8	22.76
22.92	49 47.8	59 49.6	68 51.3	78 53.1	87 54.9	97 56.7	106 58.4	116 60.2	125 62.0	135 63.7	144 65.5	154 67.3	163 69.0	22.92
23.08	51 46.0	61 47.8	70 49.6	80 51.3	89 53.1	99 54.9	108 56.7	118 58.4	127 60.2	137 62.0	146 63.7	156 65.5	165 67.3	23.08
23.24	52 44.3	62 46.0	71 47.6	81 49.6	90 51.3	100 53.1	109 54.9	119 56.7	128 58.4	138 60.2	147 62.0	157 63.7	166 65.5	23.24
23.41	54 42.5	64 44.3	73 46.0	83 47.8	92 49.6	102 51.3	111 53.1	121 54.9	130 56.7	140 58.4	149 60.2	159 62.0	168 63.7	23.41
23.57	55 40.7	65 42.5	74 44.3	84 46.0	93 47.8	103 49.6	112 51.3	122 53.1	131 54.9	141 56.7	150 58.4	160 60.2	169 62.0	23.57
23.73	56 38.9	66 40.7	75 42.5	85 44.3	94 46.0	104 47.8	113 49.6	123 51.3	132 53.1	142 54.9	151 56.7	161 58.4	170 60.2	23.73
23.89	58 37.2	68 38.9	77 40.7	87 42.5	96 44.3	106 46.0	115 47.8	125 49.6	134 51.3	144 53.1	153 54.9	163 56.7	172 58.4	23.89
24.06	59 35.4	69 37.2	78 38.9	88 40.7	97 42.5	107 44.3	116 46.0	126 47.6	135 49.6	145 51.3	154 53.1	164 54.9	173 56.7	24.06
24.22	61 33.6	71 35.4	80 37.2	90 38.9	99 40.7	109 42.5	118 44.3	128 46.0	137 47.8	147 49.6	156 51.3	166 53.1	175 54.9	24.22
24.38	62 31.9	72 33.6	81 35.4	91 37.2	100 38.9	110 40.7	119 42.5	129 44.3	138 46.0	148 47.8	157 49.6	167 51.3	176 53.1	24.38
24.54	63 30.1	73 31.9	82 33.6	92 35.4	101 37.2	111 38.9	120 40.7	130 42.5	139 44.3	149 46.0	158 47.8	168 49.6	177 51.3	24.54
24.70	65 28.3	75 30.1	84 31.9	94 33.6	103 35.4	113 37.2	122 38.9	132 40.7	141 42.5	151 44.3	160 46.0	170 47.8	179 49.6	24.70
24.86	66 26.6	76 28.3	85 30.1	95 31.9	104 33.6	114 35.4	123 37.2	133 38.9	142 40.7	152 42.5	161 44.3	171 46.0	180 47.8	24.86
25.03	68 24.8	78 26.6	87 28.3	97 30.1	106 31.9	116 33.6	125 35.4	135 37.2	144 38.9	154 40.7	163 42.5	173 44.3	182 46.0	25.03
25.19	69 23.0	79 24.8	88 26.6	98 28.3	107 30.1	117 31.9	126 33.6	136 35.4	145 37.2	155 38.9	164 40.7	174 42.5	183 44.3	25.19
25.35	70 21.2	80 23.0	89 24.8	99 26.6	108 28.3	118 30.1	127 31.9	137 33.6	146 35.4	156 37.2	165 38.9	175 40.7	184 42.5	25.35
25.51	72 19.5	82 21.2	91 23.0	101 24.8	110 26.6	120 28.3	129 30.1	139 31.9	148 33.6	158 35.4	167 37.2	177 38.9	186 40.7	25.51
25.68	73 17.7	83 19.5	92 21.2	102 23.0	111 24.8	121 26.6	130 28.3	140 30.1	149 31.9	159 33.6	168 35.4	178 37.2	187 38.9	25.68
25.84	75 15.9	85 17.7	94 19.5	104 21.2	113 23.0	123 24.8	132 26.6	142 28.3	151 30.1	161 31.9	170 33.6	180 35.4	189 37.2	25.84
26.00	76 14.2	86 15.9	95 17.7	105 19.5	114 21.2	124 23.0	133 24.8	143 26.6	152 28.3	162 30.1	171 31.9	181 33.6	190 35.4	26.00
	8.8	8.9	9.0	9.1	9.2	9.3	9.4	9.5	9.6	9.7	9.8	9.9	10.0	

TABLE 68 (Continued).

Standardizing table for ice cream mix, No. 2 testing:

8.00% Fat
12.50% M. S. N. F.
13.00% Sugar
.50% Gelatin
34.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: Pounds butter.
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

	8.8	8.9	9.0	9.1	9.2	9.3	9.4	9.5	9.6	9.7	9.8	9.9	10.0	
26.16	77 12.4	87 14.2	96 15.9	106 17.7	115 19.5	125 21.2	134 23.0	144 24.8	153 26.6	163 28.3	172 30.1	182 31.9	191 33.6	26.16
26.32	79 10.6	89 12.4	98 14.2	108 15.9	117 17.7	127 19.5	136 21.2	146 23.0	155 24.8	165 26.6	174 28.3	184 30.1	193 31.9	26.32
26.49	80 8.9	90 10.6	99 12.4	109 14.2	118 15.9	128 17.7	137 19.5	147 21.2	156 23.0	166 24.8	175 26.6	185 28.3	194 30.1	26.49
26.66	82 7.1	92 8.9	101 10.6	111 12.4	120 14.2	130 15.9	139 17.7	149 19.5	158 21.2	168 23.0	177 24.8	187 26.6	196 28.3	26.66
26.82	83 5.3	93 7.1	102 8.9	112 10.6	121 12.4	131 14.2	140 15.9	150 17.7	159 19.5	169 21.2	178 23.0	188 24.8	197 26.6	26.82
26.98	84 3.5	94 5.3	103 7.1	113 8.9	122 10.6	132 12.4	141 14.2	151 15.9	160 17.7	170 19.5	179 21.2	189 23.0	198 24.8	26.98
27.14	86 1.8	96 3.5	105 5.3	115 7.1	124 8.9	134 10.6	143 12.4	153 14.2	162 15.9	172 17.7	181 19.5	191 21.2	200 23.0	27.14
27.30	87	97 1.8	106 3.5	116 5.3	125 7.1	135 8.9	144 10.6	154 12.4	163 14.2	173 15.9	182 17.7	192 19.5	201 21.2	27.30
27.47	1.2 97	98	108 1.8	118 3.5	127 5.3	137 7.1	146 8.9	156 10.6	165 12.4	175 14.2	184 15.9	194 17.7	203 19.5	27.47
27.62	2.4 107	1.2 108	109	119 1.8	128 3.5	138 5.3	147 7.1	157 8.9	166 10.6	176 12.4	185 14.2	195 15.9	204 17.7	27.62
27.78	3.7 116	2.4 118	1.2 119	120	130 1.8	139 3.5	148 5.3	158 7.1	167 8.9	177 10.6	186 12.4	196 14.2	205 15.9	27.78
27.94	4.9 127	3.7 128	2.4 129	1.2 130	131	141 1.8	150 3.5	160 5.3	169 7.1	179 8.9	188 10.6	198 12.4	207 14.2	27.94
28.10	6.1 137	4.9 138	3.7 139	2.4 140	1.2 141	142	152 1.8	161 3.5	170 5.3	180 7.1	189 8.9	199 10.6	208 12.4	28.10
28.27	7.3 147	6.1 148	4.9 149	3.7 150	2.4 151	1.2 152	153	163 1.8	172 3.5	182 5.3	191 7.1	201 8.9	210 10.6	28.27
28.43	8.5 156	7.3 157	6.1 158	4.9 160	3.7 161	2.4 162	1.2 163	164	173 1.8	183 3.5	192 5.3	202 7.1	211 8.9	28.43
28.60	9.7 166	8.5 167	7.3 168	6.1 169	4.9 170	3.7 171	2.4 172	1.2 173	174	184 1.8	193 3.5	203 5.3	212 7.1	28.60
28.76	11.0 176	9.7 177	8.5 178	7.3 179	6.1 180	4.9 181	3.7 182	2.4 183	1.2 184	185	195 1.8	205 3.5	214 5.3	28.76
28.93	12.2 184	11.0 186	9.7 188	8.5 189	7.3 190	6.1 191	4.9 192	3.7 193	2.4 194	1.2 195	196	206 1.8	215 3.5	28.93
29.09	13.4 195	12.2 196	11.0 197	9.7 198	8.5 200	7.3 201	6.1 202	4.9 203	3.7 204	2.4 205	1.2 206	207	217 1.8	29.09
29.25	14.6 204	13.4 206	12.2 207	11.0 208	9.7 209	8.5 210	7.3 211	6.1 212	4.9 213	3.7 215	2.4 216	1.2 217	218	29.25
	8.8	8.9	9.0	9.1	9.2	9.3	9.4	9.5	9.6	9.7	9.8	9.9	10.0	

TABLE 69.

Standardizing table for ice cream mix No. 4 testing: 9.00% Fat, 11.50% M. S. N. F., 13.00% Sugar, .50% Gelatin, 34.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: Pounds butter.
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

	7.0	7.1	7.2	7.3	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.2	8.3	
22.56	31.6	30.2	38.8	27.4	26.0	24.6	23.2	21.8	20.4	19.0	17.6	16.1	14.7	13.3	22.56
	33.6	33.4	33.2	33.0	32.8	32.6	32.4	32.3	32.1	31.9	31.7	31.5	31.4	31.2	
22.68	31.4	30.0	28.6	27.1	25.9	24.4	23.0	21.7	20.3	18.7	17.3	15.9	14.5	13.1	22.68
	32.1	31.9	31.7	31.5	31.3	30.9	30.8	30.6	30.4	30.2	30.0	29.9	29.9	29.7	
22.81	31.2	29.8	28.4	27.0	25.7	24.2	22.9	21.5	20.1	18.5	17.1	15.7	14.3	12.9	22.81
	30.6	30.4	30.2	30.0	29.8	29.5	29.4	29.2	29.0	28.9	28.7	28.5	28.3	28.1	
22.93	31.1	29.6	28.2	26.8	25.5	24.0	22.7	21.3	19.9	18.3	16.9	15.5	14.1	12.7	22.93
	30.1	29.0	28.8	28.6	28.4	28.2	28.0	27.8	27.7	27.5	27.3	27.1	27.0	26.8	
23.05	30.9	29.5	28.1	26.7	25.3	23.8	22.6	21.1	19.8	18.1	16.8	15.3	13.9	12.6	23.05
	27.6	27.4	27.2	27.0	26.9	26.7	26.5	26.3	26.2	26.0	25.8	25.6	25.4	25.3	
23.17	30.7	29.4	27.9	26.5	25.1	23.7	22.4	21.0	19.6	18.0	16.5	15.1	13.8	12.5	23.17
	26.1	26.0	25.8	25.6	25.4	25.2	25.1	24.9	24.7	24.5	24.3	24.1	23.9	23.8	
23.29	30.6	29.2	27.7	26.3	24.9	23.6	22.2	20.8	19.4	17.8	16.3	14.9	13.6	12.3	23.29
	24.7	24.5	24.3	24.1	23.9	23.7	23.5	23.4	23.2	23.0	22.8	22.6	22.4	22.2	
23.42	30.4	29.0	27.6	26.2	24.8	23.3	22.0	20.6	19.2	17.6	16.1	14.8	13.5	12.1	23.42
	23.2	23.0	22.8	22.6	22.4	22.2	22.1	21.9	21.7	21.6	21.4	21.2	21.0	20.9	
23.54	30.2	28.8	27.4	26.0	24.7	23.1	21.8	20.5	19.0	17.5	16.0	14.7	13.3	11.9	23.54
	21.7	21.5	21.3	21.1	20.9	20.8	20.6	20.4	20.2	20.0	19.9	19.7	19.5	19.3	
23.66	30.0	29.7	27.2	25.8	24.5	22.9	21.6	20.3	18.8	17.3	15.9	14.5	13.1	11.7	23.66
	20.2	20.0	19.8	19.6	19.4	19.3	19.1	18.9	18.8	18.6	18.4	18.2	18.0	17.8	
23.78	29.8	28.5	27.1	25.7	24.3	22.8	21.5	20.1	18.7	17.2	15.7	14.4	12.9	11.6	23.78
	18.7	18.5	18.4	18.3	18.1	17.9	17.7	17.5	17.3	17.1	16.9	16.7	16.5	16.3	
23.91	29.7	28.3	26.9	25.5	24.1	22.7	21.3	19.9	18.5	17.0	15.6	14.2	12.7	11.4	23.91
	17.3	17.1	16.9	16.7	16.5	16.3	16.1	16.0	15.8	15.6	15.4	15.2	15.0	14.8	
24.03	29.5	28.1	26.7	25.3	23.9	22.5	21.1	19.7	18.3	16.8	15.4	14.0	12.6	11.2	24.03
	15.8	15.6	15.4	15.2	15.0	14.8	14.6	14.4	14.3	14.1	13.9	13.7	13.5	13.3	
24.15	29.3	28.0	26.5	25.1	23.7	22.4	20.9	19.6	18.2	16.6	15.2	13.9	12.5	11.1	24.15
	14.3	14.1	13.9	13.7	13.5	13.2	13.1	12.9	12.8	12.6	12.4	12.2	12.0	11.8	
24.27	29.1	27.9	26.4	24.0	23.6	22.2	20.7	19.4	18.0	16.5	15.0	13.7	12.3	10.9	24.27
	12.8	12.6	12.4	12.2	12.0	11.8	11.6	11.4	11.2	11.1	10.9	10.7	10.5	10.3	
24.39	29.0	27.6	26.2	24.8	23.4	22.0	20.6	19.2	17.8	16.3	14.8	13.5	12.1	10.7	24.39
	11.3	11.1	10.9	10.7	10.5	10.3	10.2	10.0	9.8	9.6	9.4	9.2	9.0	8.8	
24.52	28.8	27.4	26.0	24.6	23.2	21.8	20.4	19.0	17.6	16.1	14.7	13.3	11.9	10.6	24.52
	9.8	9.6	9.4	9.2	9.0	8.8	8.6	8.4	8.2	8.0	7.9	7.7	7.5	7.3	
24.64	28.6	27.3	25.9	24.5	23.1	21.7	20.2	18.9	17.5	15.9	14.5	13.1	11.8	10.4	24.64
	8.3	8.1	7.9	7.7	7.5	7.3	7.1	6.9	6.8	6.6	6.4	6.2	6.0	5.8	
24.76	28.4	27.1	25.7	24.3	22.9	21.5	20.1	18.7	17.3	15.8	14.3	12.9	11.6	10.2	24.76
	6.8	6.6	6.4	6.2	6.0	5.8	5.6	5.4	5.3	5.1	4.9	4.7	4.5	4.3	
24.88	28.3	26.9	25.3	24.1	22.7	21.3	19.9	18.5	17.1	15.6	14.2	12.8	11.4	10.0	24.88
	5.3	5.1	4.9	4.7	4.5	4.3	4.1	3.9	3.8	3.6	3.4	3.2	3.0	2.8	
25.00	28.1	26.7	25.3	23.9	22.6	21.1	19.7	18.3	16.9	15.4	14.0	12.6	11.2	9.8	25.00
	3.8	3.6	3.4	3.2	3.0	2.8	2.6	2.4	2.2	2.1	1.9	1.7	1.5	1.3	
	7.0	7.1	7.2	7.3	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.2	8.3	

TABLE 69 (Continued).

Standardizing table for ice cream mix No. 4 testing:

9.00% Fat
11.50% M. S. N. F.
13.00% Sugar
.50% Gelatin
34.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: Pounds butter.
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

	7.0	7.1	7.2	7.3	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.2	8.3	
25.12	27.9 2.3	26.5 2.1	25.1 1.9	23.7 1.7	22.3 1.5	20.9 1.3	19.5 1.1	18.1 .9	16.7 .8	15.2 .6	13.8 .4	12.4 .2	11.0 1	9.8 2	25.12
25.24	27.7 .8	26.3 .6	24.9 .4	23.5 .2	22.1	20.8 1	19.6 2	18.4 3	17.2 4	15.9 5	14.7 6	13.5 7	12.3 8	11.0 9	25.24
25.37	28.2 4	27.0 5	25.8 6	24.5 7	23.3 8	22.1 9	20.8 10	19.6 11	18.4 12	17.2 13	15.9 14	14.7 15	13.5 16	12.3 17	25.37
25.49	29.4 12	28.3 13	27.0 14	25.8 15	24.5 16	23.3 17	22.1 18	20.8 19	19.6 20	18.4 22	17.2 23	15.9 24	14.7 25	13.5 26	25.49
25.61	30.7 21	29.4 22	28.2 23	27.0 24	25.8 25	24.5 26	23.3 27	22.1 28	20.8 30	19.6 31	18.4 32	17.2 33	15.9 34	14.7 35	25.61
25.73	31.9 29	30.7 30	29.4 31	28.2 32	27.0 33	25.8 34	24.5 35	23.3 36	22.1 37	20.8 38	19.6 40	18.4 41	17.2 42	15.9 43	25.73
25.86	33.1 38	31.9 39	30.7 40	29.4 41	28.2 42	27.0 43	25.8 44	24.5 45	23.3 46	22.1 48	20.8 49	19.6 50	18.4 51	17.2 52	25.86
25.98	34.3 47	33.1 48	31.9 49	30.7 50	29.4 51	28.2 52	27.0 53	25.8 54	24.5 55	23.3 57	22.1 58	20.8 59	19.6 60	18.4 61	25.98
26.10	35.5 55	34.3 56	33.1 57	31.9 58	30.7 59	29.4 60	28.2 61	27.0 62	25.8 63	24.5 65	23.3 66	22.1 67	20.8 68	19.6 69	26.10
26.22	36.8 64	35.5 65	34.3 66	33.1 67	31.9 68	30.7 69	29.4 70	28.2 71	27.0 72	25.8 74	24.5 75	23.3 76	22.1 77	20.8 78	26.22
26.35	38.0 73	36.8 74	35.5 75	34.3 76	33.1 77	31.9 78	30.7 79	29.4 80	28.2 82	27.0 83	25.8 84	24.5 85	23.3 86	22.1 87	26.35
26.47	39.2 81	38.0 82	36.8 83	35.5 84	34.3 85	33.1 86	31.9 87	30.7 88	29.4 90	28.2 91	27.0 92	25.8 93	24.5 94	23.3 95	26.47
26.59	40.5 90	39.2 91	38.0 92	36.8 93	35.5 94	34.3 95	33.1 96	31.9 97	30.7 98	29.4 99	28.2 101	27.0 102	25.8 103	24.5 104	26.59
26.71	41.7 98	40.5 99	39.2 100	38.0 101	36.8 102	35.5 103	34.3 104	33.1 105	31.9 106	30.7 107	29.4 109	28.2 110	27.0 111	25.8 112	26.71
26.84	42.9 107	41.7 108	40.5 109	39.2 110	38.0 111	36.8 112	35.5 113	34.3 114	33.1 115	31.9 116	30.7 118	29.4 119	28.2 120	27.0 121	26.84
26.96	44.2 115	42.9 116	41.7 117	40.5 118	39.2 119	38.0 120	36.8 122	35.5 123	34.3 124	33.1 125	31.9 126	30.7 127	29.4 128	28.2 129	26.96
27.08	45.4 124	44.2 125	42.9 126	41.7 127	40.5 128	39.2 129	38.0 130	36.8 131	35.5 132	34.3 133	33.1 134	31.9 135	30.7 136	29.4 137	27.08
27.21	46.6 133	45.4 134	44.2 135	42.9 136	41.7 137	40.5 138	39.2 139	38.0 140	36.8 141	35.5 143	34.3 144	33.1 145	31.9 146	30.7 147	27.21
27.32	47.8 141	46.6 142	45.4 143	44.0 144	42.9 145	41.7 146	40.5 148	39.2 149	38.0 150	36.8 151	35.5 152	34.3 153	33.1 154	31.9 155	27.32
27.45	49.0 150	47.8 151	46.6 152	45.4 153	44.0 154	42.9 155	41.7 156	40.5 157	39.2 158	33.0 159	36.8 160	35.5 161	34.3 162	33.1 163	27.45
	7.0	7.1	7.2	7.3	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.2	8.3	

TABLE 69 (Continued).

Standardizing table for ice cream mix No. 4 testing:

9.00% Fat
11.50% M. S. N. F.
13.00% Sugar
.50% Gelatin
34.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: Pounds butter.
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

	8.4	8.5	8.6	8.7	8.8	8.9	9.0	9.1	9.2	9.3	9.4	9.5	9.6	9.7	
22.56	11.9	10.5	9.1	7.7	6.3	4.9	3.5	2.1	.7	.4					22.56
	31.0	30.8	30.6	30.4	30.2	30.0	29.9	29.7	29.5	30.5	31.8	33.1	34.4	35.8	
22.68	11.8	10.3	8.9	7.5	6.1	4.7	3.3	1.9	.5						22.68
	29.6	29.4	29.2	29.0	28.8	28.6	28.4	28.2	28.0	29.1	30.5	31.8	33.1	34.4	
22.81	11.6	10.2	8.7	7.4	5.9	4.6	3.1	1.7	.3						22.81
	28.0	27.8	27.6	27.4	27.2	27.0	26.9	26.7	26.5	27.8	29.1	30.5	31.8	33.1	
22.93	11.5	9.9	8.5	7.2	5.7	4.4	2.9	1.5	.1						22.93
	26.6	26.4	26.2	26.0	25.8	25.6	25.4	25.2	25.0	26.5	27.8	29.1	30.5	31.8	
23.05	11.3	8.7	8.4	7.0	5.5	4.2	2.7	1.3							23.05
	25.1	24.9	24.7	24.5	24.3	24.1	23.9	23.7	23.8	25.2	26.5	27.8	29.1	30.5	
23.17	11.1	9.6	8.2	6.8	5.4	4.1	2.6	1.2							23.17
	23.6	23.4	23.2	23.0	22.8	22.6	22.4	22.2	22.5	23.8	25.2	26.5	27.8	29.1	
23.29	10.9	9.4	8.0	6.6	5.2	3.9	2.4	1.0							23.29
	22.0	21.9	21.7	21.5	21.3	21.1	20.9	20.7	21.2	22.5	23.8	25.2	26.5	27.8	
23.42	10.7	9.2	7.8	6.4	5.0	3.7	2.2	.8							23.42
	20.7	20.5	20.3	20.1	19.9	19.7	19.5	19.3	19.0	21.2	22.5	23.8	25.2	26.5	
23.54	10.6	9.1	7.7	6.2	4.9	3.5	2.0	.6							23.54
	19.2	19.0	18.8	18.6	18.4	18.2	18.0	17.8	18.5	19.9	21.2	22.5	23.8	25.2	
23.66	10.4	8.9	7.5	6.1	4.7	3.3	1.9	.5							23.66
	17.7	17.5	17.3	17.1	16.9	16.7	16.5	16.3	17.2	18.5	19.9	21.2	22.5	23.8	
23.78	10.2	8.7	7.3	6.0	4.5	3.1	1.7	.3							23.78
	16.2	16.0	15.8	15.6	15.4	15.2	15.0	14.8	15.9	17.2	18.5	19.9	21.2	22.5	
23.91	10.0	8.6	7.1	5.8	4.4	3.8	1.5								23.91
	14.7	14.5	14.3	14.1	13.9	13.7	13.5	13.3	14.6	15.9	17.2	18.5	19.9	21.2	
24.03	9.8	8.4	7.0	5.8	4.2	2.8	1.4								24.03
	13.2	13.0	12.8	12.6	12.4	12.2	12.0	11.8	13.3	14.6	15.9	17.2	18.5	19.9	
24.15	9.6	8.2	6.9	5.4	4.0	2.6	1.2								24.15
	11.7	11.5	11.3	11.1	10.9	10.7	10.5	10.6	11.8	13.3	14.6	15.9	17.2	18.5	
24.27	9.5	8.1	6.7	5.2	3.9	2.5	1.0								24.27
	10.2	10.0	9.8	9.6	9.4	9.3	9.0	9.3	10.6	11.8	13.3	14.6	15.9	17.2	
24.39	9.3	7.9	6.5	5.1	3.7	2.3	.9								24.39
	8.7	8.5	8.3	8.1	7.9	7.7	7.5	7.9	9.3	10.6	11.8	13.3	14.6	15.9	
24.52	9.1	7.8	6.3	4.9	3.5	2.1	.7								24.52
	7.2	7.0	6.8	6.6	6.4	6.2	6.0	6.6	7.9	9.3	10.6	11.8	13.3	14.6	
24.64	8.9	7.6	6.2	4.7	3.3	2.0	.5								24.64
	5.7	5.5	5.3	5.1	4.9	4.7	4.5	5.3	6.6	7.9	8.3	10.6	11.8	13.3	
24.76	8.8	7.4	6.0	4.6	3.2	1.8	.4								24.76
	4.2	4.0	3.8	3.6	3.4	3.2	3.0	4.0	5.3	6.6	7.9	8.3	10.6	11.8	
24.88	8.6	7.2	5.8	4.4	3.0	1.6	1.4								24.88
	2.7	2.5	2.3	2.1	1.9	1.7	1.5	2.7	4.0	5.3	6.6	7.9	8.3	10.6	
25.00	8.4	7.0	5.6	4.2	2.8	1.4									25.00
	1.2	1.0	.8	.6	.4	.2		1.3	2.7	4.0	5.3	6.6	7.9	8.3	
	8.4	8.5	8.6	8.7	8.8	8.9	9.0	9.1	9.2	9.3	9.4	9.5	9.6	9.7	

TABLE 69 (Continued).

Standardizing table for ice cream mix No. 4 testing:

9.00% Fat
11.50% M. S. N. F.
13.00% Sugar
.50% Gelatin
34.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: Pounds butter.
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

	8.4	8.5	8.6	8.7	8.8	8.9	9.0	9.1	9.2	9.3	9.4	9.5	9.6	9.7	
25.12	8.6 3	7.4 4	6.1 5	4.9 6	3.7 7	2.4 8	1.2 9	 10	 18 1.3	 26 2.7	 35 4.0	 44 5.3	 52 6.6	 61 7.9	**25.12**
25.24	9.8 11	8.6 12	7.4 13	6.1 14	4.9 15	3.7 16	2.4 17	1.2 18	 19	 27 1.3	 36 2.7	 45 4.0	 53 5.3	 62 6.6	**25.24**
25.37	11.0 19	9.8 20	8.6 21	7.4 22	6.1 23	4.9 24	3.7 25	2.4 26	1.2 27	 28	 37 1.3	 46 2.7	 54 4.0	 63 5.3	**25.37**
25.49	12.3 28	11.0 29	9.8 30	8.6 31	7.4 32	6.1 33	4.9 34	3.7 35	2.4 36	1.2 37	 38	 47 1.3	 55 2.7	 64 4.0	**25.49**
25.61	13.5 37	12.3 38	11.0 39	9.8 40	8.6 41	7.4 42	6.1 43	4.9 44	3.7 45	2.4 46	1.2 47	 48	 56 1.3	 65 2.7	**25.61**
25.73	14.7 45	13.5 46	12.3 47	11.0 48	9.8 49	8.6 50	7.4 51	6.1 52	4.9 53	3.7 54	2.4 55	1.2 56	 57	 66 1.3	**25.73**
25.86	15.9 54	14.7 55	13.5 56	12.3 57	11.0 58	9.8 59	8.6 60	7.4 61	6.1 62	4.9 63	3.7 64	2.4 65	1.2 66	 67	**25.86**
25.98	17.2 62	15.9 63	14.7 64	13.5 65	12.3 66	11.0 67	9.8 68	8.7 69	7.4 70	6.1 71	4.9 72	3.7 73	2.4 74	1.2 75	**25.98**
26.10	18.4 70	17.2 71	15.9 72	14.7 73	13.5 74	12.3 75	11.0 76	9.8 77	8.7 78	7.4 79	6.1 80	4.9 81	3.7 82	2.4 83	**26.10**
26.22	19.6 79	18.4 80	17.2 81	15.9 82	14.7 83	13.5 84	12.3 85	11.0 86	9.8 87	8.7 88	7.4 89	6.1 90	4.9 91	3.7 92	**26.22**
26.35	20.8 88	19.6 89	18.4 90	17.2 91	15.9 92	14.7 93	13.5 94	12.3 95	11.0 96	9.8 97	8.6 98	7.4 99	6.1 100	4.9 101	**26.35**
26.47	22.1 96	20.8 97	19.6 98	18.4 99	17.2 100	15.9 101	14.7 102	13.5 103	12.3 104	11.0 105	9.8 106	8.6 107	7.4 108	6.1 109	**26.47**
26.59	23.3 105	22.1 106	20.8 107	19.6 108	18.4 109	17.2 110	15.9 111	14.7 112	13.5 113	12.3 114	11.0 115	9.8 116	8.6 117	7.4 118	**26.59**
26.71	24.5 113	23.3 114	22.1 115	20.8 116	19.6 117	18.4 118	17.2 119	15.9 120	14.7 121	13.5 122	12.3 123	11.0 124	9.8 125	8.6 126	**26.71**
26.84	25.8 122	24.5 123	23.3 124	22.1 125	20.8 126	19.6 127	18.4 128	17.2 129	15.9 130	14.7 131	13.5 132	12.3 133	11.0 134	9.8 135	**26.84**
26.96	27.0 130	25.8 131	24.5 132	23.3 133	22.1 134	20.8 135	19.6 136	18.4 137	17.2 138	15.9 139	14.7 140	13.5 141	12.3 142	11.0 143	**26.96**
27.08	28.2 138	27.0 139	25.8 140	24.5 141	23.3 142	22.1 143	20.8 144	19.6 145	18.4 146	17.2 147	15.9 148	14.7 149	13.5 150	12.3 151	**27.08**
27.21	29.4 147	28.2 148	27.0 149	25.8 150	24.5 151	23.3 152	22.1 153	20.8 154	19.6 155	18.4 156	17.2 157	15.9 158	14.7 159	13.5 160	**27.21**
27.33	30.7 156	29.4 157	28.2 158	27.0 159	25.8 160	24.5 161	23.3 162	22.1 163	20.8 164	19.6 165	18.4 166	17.2 167	15.9 168	14.7 169	**27.33**
27.45	31.9 168	30.7 169	29.4 170	28.2 171	27.0 172	25.8 173	24.5 174	23.3 175	22.1 176	20.8 177	19.6 178	18.4 179	17.2 180	15.9 181	**27.45**
	8.4	8.5	8.6	8.7	8.8	8.9	9.0	9.1	9.2	9.3	9.4	9.5	9.6	9.7	

TABLE 69 (Continued).

Standardizing table for ice cream mix No. 4 testing:

9.00% Fat
11.50% M. S. N. F.
13.00% Sugar
.50% Gelatin
34.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: Pounds butter.
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

	9.8	9.9	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.8	10.9	11.0	
22.56	47 37.1	55 38.4	63 39.7	72 41.1	80 42.4	89 43.7	97 45.0	106 46.4	114 47.7	122 49.0	131 50.4	139 51.6	148 52.9	22.56
22.68	48 35.8	56 37.1	64 38.4	72 39.7	81 41.1	90 42.4	98 43.7	107 45.0	115 46.4	123 47.7	132 49.0	140 50.4	149 51.6	22.68
22.81	49 34.4	57 35.8	65 37.1	72 38.4	82 39.7	91 41.1	99 42.4	108 43.7	116 45.0	124 46.4	133 47.7	141 49.0	150 50.4	22.81
22.93	50 33.1	58 34.4	66 35.8	74 37.1	83 38.4	92 39.7	100 41.1	109 42.4	117 43.7	125 45.0	134 46.4	142 47.7	151 49.0	22.93
23.05	51 31.8	59 33.1	67 34.4	75 35.8	84 37.1	93 38.4	102 39.7	110 41.1	118 42.4	125 43.7	135 45.0	143 46.4	152 47.7	23.05
23.17	52 30.5	60 31.8	68 33.1	76 34.4	85 35.8	94 37.1	102 38.4	111 39.7	119 41.1	127 42.4	136 43.7	144 45.0	153 46.4	23.17
23.29	53 29.1	61 30.5	69 31.8	78 33.1	86 34.4	95 35.8	103 37.1	112 38.4	120 39.7	128 41.1	137 42.4	145 43.7	154 45.0	23.29
23.42	54 27.8	62 29.1	70 30.5	79 31.8	87 33.1	96 34.4	104 35.8	113 37.1	121 38.4	129 39.7	138 41.1	146 42.4	155 43.7	23.42
23.54	55 26.5	63 27.8	71 29.1	80 30.5	88 31.8	97 33.1	105 34.4	115 35.8	122 37.1	130 38.4	139 39.7	147 41.1	156 42.4	23.54
23.66	57 25.2	64 26.5	72 27.8	81 29.1	89 30.5	99 31.8	107 33.1	116 34.4	124 35.8	131 37.1	140 38.4	144 39.7	157 41.1	23.66
23.78	58 23.8	65 25.2	73 26.5	82 27.8	90 29.1	100 30.5	108 31.8	117 33.1	125 34.4	132 35.8	141 37.1	145 38.4	158 39.7	23.78
23.91	59 22.5	66 23.8	74 25.2	84 26.5	92 27.8	101 29.1	109 30.5	118 31.8	128 33.1	134 34.4	143 35.8	151 37.1	160 38.4	23.91
24.03	60 21.2	68 22.5	76 23.8	85 25.2	93 26.5	102 27.8	110 29.1	119 30.5	127 31.8	135 33.1	144 34.4	152 35.8	161 37.1	24.03
24.15	61 19.9	69 21.2	77 22.5	86 23.8	94 25.2	103 26.5	111 27.8	120 29.1	128 30.5	136 31.8	145 33.1	153 34.4	162 35.8	24.15
24.27	62 18.5	70 19.9	78 21.2	87 22.5	95 23.8	104 25.2	112 26.5	121 27.8	129 29.1	137 30.5	146 31.8	154 33.1	163 34.4	24.27
24.39	63 17.2	71 18.5	79 19.9	88 21.2	96 22.5	105 23.8	113 25.2	122 26.5	130 27.8	138 29.1	147 30.5	155 31.8	164 33.1	24.39
24.52	64 15.9	72 17.2	80 18.5	89 19.9	97 21.2	106 22.5	114 23.8	123 25.2	131 26.5	139 27.8	148 29.1	156 30.5	165 31.8	24.52
24.64	65 14.6	73 15.9	81 17.2	90 18.5	98 19.9	107 21.2	115 22.5	124 23.8	132 25.2	140 26.5	149 27.8	157 29.1	166 30.5	24.64
24.76	66 13.3	74 14.6	82 15.9	91 17.2	99 18.5	108 19.9	116 21.2	125 22.5	133 23.8	141 25.2	150 26.5	159 27.8	168 29.1	24.76
24.88	67 11.9	75 13.3	84 14.6	93 15.9	101 17.2	109 18.5	117 19.9	126 21.2	135 22.5	143 23.8	152 25.2	159 26.5	168 27.8	24.88
25.00	68 10.6	76 11.9	85 13.3	94 14.6	102 15.9	110 17.2	118 18.5	127 19.9	136 21.2	144 22.5	153 23.8	161 25.2	169 26.5	25.00
	9.8	9.9	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.8	10.9	11.0	

TABLE 69 (Continued).

Standardizing table for ice cream mix No. 4 testing: 9.00% Fat; 11.50% M. S. N. F.; 13.00% Sugar; .50% Gelatin; 34.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: Pounds butter.
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

	9.8	9.9	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.8	10.9	11.0	
25.12	69 9.3	78 10.6	86 11.9	95 13.3	103 14.6	111 15.9	119 17.2	128 18.5	138 19.9	145 21.2	154 22.5	162 23.8	171 25.2	25.12
25.24	70 7.9	79 9.3	87 10.6	96 11.9	104 13.3	113 14.6	120 15.9	129 17.2	138 18.5	146 19.9	155 21.2	163 22.5	172 23.8	25.24
25.37	71 6.6	80 7.9	88 9.3	97 10.6	105 11.9	114 13.3	122 14.6	130 15.9	139 17.2	147 18.5	156 19.9	164 21.2	173 22.5	25.37
25.49	72 5.3	81 6.6	89 7.9	98 9.3	106 10.6	115 11.9	123 13.3	131 14.6	140 15.9	148 17.2	157 18.5	165 19.9	174 21.2	25.49
25.61	73 4.0	82 5.3	90 6.6	99 7.9	107 9.3	116 10.6	124 11.9	132 13.3	141 14.6	149 15.9	158 17.2	166 18.5	175 19.9	25.61
25.73	74 2.7	83 4.0	91 5.3	100 6.6	108 7.9	117 9.3	125 10.6	133 11.9	142 13.3	150 14.6	159 15.9	167 17.2	176 18.5	25.73
25.86	75 1.3	84 2.7	92 4.0	101 5.3	109 6.6	118 7.9	126 9.3	134 10.6	143 11.9	151 13.3	160 14.6	168 15.9	177 17.2	25.86
25.98	76	85 1.3	93 2.7	102 4.0	110 5.3	119 6.6	127 7.9	135 9.3	144 10.6	152 11.9	161 13.3	169 14.6	179 15.9	25.98
26.10	1.2 85	86	94 1.3	103 2.7	111 4.0	120 5.3	128 6.6	136 7.9	145 9.3	154 10.6	162 11.9	171 13.3	180 14.6	26.10
26.22	2.4 93	1.2 94	95	104 1.3	112 2.7	121 4.0	129 5.3	137 6.6	146 7.9	155 9.3	163 10.6	172 11.9	181 13.3	26.22
26.35	3.7 102	2.4 103	1.2 104	105	113 1.3	122 2.7	130 4.0	138 5.3	146 6.6	156 7.9	164 9.3	173 10.6	182 11.9	26.35
26.47	4.9 110	3.7 111	2.4 112	1.2 113	114	123 1.3	131 2.7	140 4.0	149 5.3	157 6.6	166 7.9	174 9.3	183 10.6	26.47
26.59	6.1 119	4.9 120	3.7 121	2.4 122	1.2 123	124	132 1.3	141 2.7	150 4.0	158 5.3	167 6.6	175 7.9	184 9.3	26.59
26.71	7.4 127	6.1 128	4.9 129	3.7 130	2.4 131	1.2 132	133	144 1.3	151 2.7	159 4.0	168 5.3	176 6.6	185 7.9	26.71
26.84	8.6 136	7.4 137	6.1 138	4.9 139	3.7 140	2.4 141	1.2 142	143	152 1.3	160 2.7	169 4.0	177 5.3	186 6.6	26.84
26.96	9.8 145	8.6 146	7.4 147	6.1 148	4.9 149	3.7 150	2.4 151	1.2 152	153	161 1.3	170 2.7	178 4.0	187 5.3	26.96
27.08	11.0 153	9.8 154	8.6 155	7.4 156	6.1 157	4.9 158	3.7 159	2.4 160	1.2 161	162	171 1.3	179 2.7	188 4.0	27.08
27.21	12.3 162	11.0 163	9.8 164	8.6 165	7.4 166	6.1 167	4.9 168	3.7 169	2.4 170	1.2 171	172	180 1.3	189 2.7	27.21
27.33	13.5 170	12.3 171	11.0 172	9.8 173	8.6 174	7.4 175	6.1 176	4.9 177	3.7 178	2.4 179	1.2 180	181	190 1.3	27.33
27.45	14.7 179	13.5 180	12.3 181	11.0 182	9.8 183	8.6 184	7.4 185	6.1 186	4.9 187	3.7 188	2.4 189	1.2 190	191	27.45
	9.8	9.9	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.8	10.9	11.0	

TABLE 70.

Standardizing table for ice cream mix No. 5 testing: 10.00% Fat, 10.50% M. S. N. F., 14.00% Sugar, .50% Gelatin — 34.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: Pounds butter.
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	8.9	9.0	9.1	9.2	9.3	
22.80	32.2	30.8	29.3	27.9	26.5	25.1	23.6	22.2	20.8	19.3	17.9	16.5	15.0	13.6	22.80
	31.1	30.9	30.7	30.5	30.3	30.1	29.9	29.7	29.6	29.4	29.2	29.0	28.8	28.6	
22.91	32.2	30.6	29.1	27.7	26.3	24.9	23.4	22.0	20.6	19.1	17.7	16.3	14.8	13.4	22.91
	29.7	29.5	29.3	29.1	28.9	28.7	28.5	28.3	28.1	28.0	27.8	27.6	27.4	27.2	
23.02	32.0	30.4	28.9	27.5	26.2	24.7	23.2	21.8	20.5	18.9	17.5	16.1	14.6	13.2	23.02
	28.4	28.2	28.0	27.8	27.6	27.4	27.2	27.0	26.8	26.6	26.5	26.3	26.1	25.9	
23.13	31.8	30.2	28.7	27.3	26.0	24.5	23.0	21.6	20.3	18.7	17.3	16.0	14.4	13.0	23.13
	27.0	26.8	26.6	26.4	26.2	26.0	25.8	25.6	25.4	25.2	25.1	24.9	24.7	24.5	
23.24	31.6	30.0	28.5	27.1	25.8	24.3	22.8	21.4	20.2	18.5	17.1	15.8	14.2	12.8	23.24
	25.7	25.5	25.3	25.1	24.9	24.7	24.5	24.3	24.1	24.0	23.8	23.6	23.4	23.2	
23.35	31.5	29.9	28.4	27.0	25.6	24.1	22.7	21.2	20.0	18.3	17.0	15.6	14.1	12.7	23.35
	24.3	24.1	23.9	23.7	23.5	23.3	23.1	22.9	22.7	22.5	22.4	22.2	22.0	21.8	
23.46	31.3	29.8	28.2	26.8	25.4	24.0	22.5	21.1	19.8	18.1	16.8	15.4	13.9	12.5	23.46
	22.9	22.7	22.5	22.3	22.1	21.9	21.7	21.5	21.3	21.1	20.9	20.8	20.6	20.4	
23.57	31.1	29.6	28.0	26.6	25.2	23.8	22.3	20.9	19.6	18.0	16.6	15.2	13.7	12.3	23.57
	21.6	21.4	21.2	21.0	20.8	20.6	20.4	20.2	20.0	19.8	19.6	19.5	19.3	19.1	
23.68	30.9	29.4	27.9	26.4	25.0	23.6	22.2	20.7	19.4	17.8	16.4	15.0	13.5	12.1	23.68
	20.2	20.0	19.8	19.6	19.4	19.2	19.0	18.8	18.6	18.4	18.3	18.1	17.9	17.7	
23.79	30.8	29.2	27.7	26.3	24.9	23.4	22.0	20.5	19.2	17.6	16.2	14.8	13.3	11.9	23.79
	18.9	18.7	18.5	18.3	18.1	17.9	17.7	17.5	17.3	17.1	17.0	16.8	16.6	16.4	
23.90	30.6	29.0	27.5	26.1	24.8	23.2	21.8	20.3	19.1	17.4	16.0	14.6	13.1	11.8	23.90
	17.5	17.3	17.1	16.9	16.7	16.5	16.3	16.1	16.0	15.8	15.6	15.4	15.2	15.0	
24.01	30.4	28.9	27.3	26.0	24.6	23.0	21.7	20.1	18.9	17.2	15.9	14.4	12.9	11.6	24.01
	16.1	15.9	15.7	15.5	15.3	15.1	14.9	14.7	14.5	14.3	14.2	14.0	13.8	13.6	
24.12	30.2	28.7	27.2	25.8	24.4	22.8	21.5	20.0	18.7	17.0	15.7	14.2	12.8	11.4	24.12
	14.8	14.6	14.4	14.2	14.0	13.8	13.6	13.4	13.2	13.0	12.9	12.7	12.5	12.3	
24.23	30.0	28.5	27.0	25.6	24.2	22.6	21.3	19.8	18.5	16.8	15.5	14.0	12.6	11.2	24.23
	13.4	13.2	13.0	12.8	12.6	12.4	12.2	12.0	11.8	11.7	11.5	11.3	11.1	10.9	
24.34	29.7	28.3	26.9	25.4	24.0	22.5	21.1	19.6	18.3	16.6	15.4	13.9	12.4	11.0	24.34
	12.1	11.9	11.7	11.5	11.3	11.1	10.9	10.7	10.5	10.4	10.2	10.0	9.8	9.6	
24.45	29.5	28.1	26.7	25.2	23.9	22.3	21.0	19.4	18.1	16.4	15.2	13.7	12.2	10.9	24.45
	10.7	10.5	10.3	10.1	9.9	9.7	9.5	9.3	9.2	9.0	8.8	8.6	8.4	8.2	
24.56	29.3	27.9	26.5	25.0	23.7	22.1	20.8	19.3	18.0	16.3	15.0	13.5	12.0	10.7	24.56
	9.3	9.1	8.9	8.7	8.5	8.3	8.1	8.0	7.8	7.6	7.4	7.2	7.0	6.8	
24.67	29.1	27.8	26.3	24.8	23.5	21.9	20.6	19.1	17.8	16.1	14.9	13.3	11.9	10.5	24.67
	8.0	7.8	7.6	7.4	7.2	7.0	6.8	6.6	6.4	6.2	6.1	5.9	5.7	5.5	
24.78	28.9	27.6	26.1	24.6	23.3	21.7	20.4	19.0	17.6	15.9	14.7	13.1	11.8	10.4	24.78
	6.6	6.4	6.2	6.0	5.8	5.6	5.4	5.2	5.0	4.9	4.7	4.5	4.3	4.1	
24.89	28.8	27.4	25.9	24.5	23.1	21.5	20.2	18.8	17.4	15.7	14.5	13.0	11.6	10.2	24.89
	5.3	5.1	4.9	4.7	4.5	4.3	4.1	3.9	3.7	3.6	3.4	3.2	3.0	2.8	
25.00	28.6	27.2	25.7	24.3	22.9	21.5	20.0	18.6	17.2	15.7	14.3	12.9	11.4	10.0	25.00
	3.9	3.7	3.5	3.3	3.1	2.9	2.7	2.5	2.3	2.1	2.0	1.8	1.6	1.4	
	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	8.9	9.0	9.1	9.2	9.3	

TABLE 70 (Continued).

Standardizing table for ice cream mix No. 5 testing:

10.00% Fat
10.50% M. S. N. F.
14.00% Sugar
.50% Gelatin
34.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: Pounds butter.
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	8.9	9.0	9.1	9.2	9.3	
25.11	28.4 2.5	27.0 2.3	25.5 2.1	24.1 1.9	22.7 1.7	21.3 1.5	19.8 1.3	18.4 1.1	17.0 .9	15.5 .7	14.1 .6	12.7 .4	11.2 .2	9.8 .0	25.11
25.22	28.2 1.2	26.8 1.0	25.3 .8	23.9 .7	22.5 .5	21.1 .3	19.6 .1	18.4 1	17.2 2	15.9 3	14.7 4	13.5 6	12.3 7	11.0 8	25.22
25.33	28.2 1	27.0 2	25.7 3	24.5 4	23.3 5	22.1 6	20.8 7	19.6 8	18.4 10	17.2 11	15.9 12	14.7 13	13.5 14	12.3 16	25.33
25.44	29.4 9	28.2 10	27.0 11	25.7 12	24.5 13	23.3 14	22.1 15	20.8 16	19.6 17	18.4 19	17.2 20	15.9 21	14.7 22	13.5 23	25.44
25.55	30.6 16	29.4 17	28.2 18	27.0 19	25.7 20	24.5 21	23.3 22	22.1 23	20.8 24	19.6 25	18.4 26	17.2 27	15.9 28	14.7 30	25.55
25.66	31.9 24	30.6 25	29.4 26	28.2 27	27.0 28	25.7 29	24.5 31	23.3 32	22.1 33	20.8 34	19.6 35	18.4 36	17.2 37	15.9 38	25.66
25.77	33.1 31	31.9 32	30.6 33	29.4 34	28.2 35	27.0 36	25.7 37	24.5 39	23.3 40	22.1 41	20.8 42	19.6 43	18.4 44	17.2 45	25.77
25.88	34.3 39	33.1 40	31.9 41	30.6 42	29.4 43	28.2 44	27.0 45	25.7 46	24.5 47	23.3 48	22.1 49	20.8 51	19.6 52	18.4 53	25.88
25.99	35.5 46	34.3 47	33.1 48	31.9 49	30.6 50	29.4 52	28.2 53	27.0 54	25.7 55	24.5 56	23.3 57	22.1 58	20.8 59	19.6 60	25.99
26.10	36.8 54	35.5 55	34.3 56	33.1 57	31.9 58	30.6 59	29.4 60	28.2 62	27.0 63	25.7 64	24.5 65	23.3 66	22.1 67	20.8 68	26.10
26.21	38.0 61	36.8 62	35.5 63	34.3 65	33.1 66	31.9 67	30.6 68	29.4 69	28.2 71	27.0 72	25.7 73	24.5 74	23.3 75	22.1 76	26.21
26.32	39.2 69	38.0 70	36.8 71	35.5 72	34.3 73	33.1 74	31.9 75	30.6 76	29.4 77	28.2 78	27.0 80	25.7 81	24.5 82	23.3 83	26.32
26.43	40.4 76	39.2 77	38.0 78	36.8 79	35.5 80	34.3 81	33.1 82	31.9 83	30.6 84	29.4 85	28.2 86	27.0 88	25.7 89	24.5 91	26.43
26.54	41.7 84	40.4 85	39.2 86	38.0 87	36.8 88	35.5 89	34.3 90	33.1 91	31.9 92	30.6 93	29.4 94	28.2 95	27.0 97	25.7 98	26.54
26.65	42.9 91	41.7 92	40.4 93	39.2 94	38.0 95	36.8 96	35.5 97	34.3 98	33.1 99	31.9 100	30.6 101	29.4 102	28.2 103	27.0 104	26.65
26.76	44.1 99	42.9 100	41.7 101	40.4 102	39.2 103	38.0 104	36.8 105	35.5 106	34.3 107	33.1 108	31.9 109	30.6 110	29.4 112	28.2 113	26.76
26.87	45.3 106	44.1 107	42.9 108	41.7 109	40.4 110	39.2 111	38.0 113	36.8 114	35.5 115	34.3 116	33.1 117	31.9 118	30.6 119	29.4 120	26.87
26.98	46.6 114	45.3 115	44.1 116	42.9 117	41.7 118	40.4 119	39.2 120	38.0 122	36.8 124	35.5 125	34.3 126	33.1 127	31.9 128	30.6 129	26.98
27.09	47.8 121	46.6 122	45.3 123	44.1 124	42.9 125	41.7 126	40.4 127	39.2 128	38.0 129	36.8 130	35.5 131	34.3 132	33.1 134	31.9 135	27.09
27.20	49. 129	47.8 130	46.6 131	45.3 132	44.1 133	42.9 134	41.7 135	40.4 136	39.2 138	38.0 139	36.8 140	35.5 141	34.3 142	33.1 143	27.20
	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	8.9	9.0	9.1	9.2	9.3	

TABLE 70 (Continued).

Standardizing table for ice cream mix No. 5 testing: 10.00% Fat; 10.50% M. S. N. F.; 14.00% Sugar; .50% Gelatin; 34.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: Pounds butter.
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

	9.4	9.5	9.6	9.7	9.8	9.9	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	
22.80	12.2	10.7	9.3	7.9	6.5	5.0	3.6	2.2	.7						22.80
	28.4	28.2	28.0	27.8	27.6	27.4	27.2	27.0	26.8	27.2	28.4	29.6	30.7	31.9	
										3	11	18	26	34	
22.91	12.0	10.6	9.1	7.7	6.3	4.8	3.4	2.0	.5						22.91
	27.0	26.8	26.6	26.4	26.2	26.0	25.8	25.6	25.4	26.0	27.2	28.4	29.6	30.7	
										4	12	19	27	35	
23.02	11.8	10.4	8.9	7.5	6.1	4.6	3.2	1.8	.3						23.02
	25.7	25.5	25.3	25.1	24.9	24.7	24.5	24.3	24.1	24.8	26.0	27.2	28.4	29.6	
										5	13	20	28	36	
23.13	11.7	10.3	8.8	7.3	5.9	4.5	3.1	1.7	.2						23.13
	24.3	24.1	23.9	23.7	23.5	23.3	23.1	22.9	22.7	23.7	24.8	26.0	27.2	28.4	
										6	14	21	29	37	
23.24	11.5	10.1	8.6	7.2	5.7	4.3	2.9	1.5	.0						23.24
	23.0	22.8	22.6	22.4	22.2	22.0	21.8	21.6	21.3	22.5	23.7	24.8	26.0	27.2	
										7	15	22	30	38	
23.35	11.4	10.0	8.5	7.0	5.5	4.1	2.7	1.3							23.35
	21.6	21.4	21.2	21.0	20.8	20.6	20.4	20.2	20.1	21.3	22.5	23.7	24.8	26.0	
									1	8	15	23	31	39	
23.46	11.2	9.8	8.3	6.8	5.3	3.9	2.5	1.1							23.46
	20.2	20.0	19.8	19.6	19.4	19.2	19.0	18.8	18.9	20.1	21.3	22.5	23.7	24.8	
									2	9	16	24	32	40	
23.57	11.0	9.6	8.1	6.6	5.1	3.7	2.3	.9							23.57
	18.9	18.7	18.5	18.3	18.1	17.9	17.7	17.5	17.7	18.9	20.1	21.3	22.5	23.7	
									3	10	17	25	33	41	
23.68	10.9	9.4	7.9	6.4	5.0	3.6	2.2	.8							23.68
	17.5	17.3	17.1	16.9	16.7	16.5	16.3	16.1	16.6	17.7	18.9	20.1	21.3	22.5	
									4	11	18	26	34	42	
23.79	10.7	9.2	7.7	6.2	4.8	3.4	2.0	.6							23.79
	16.2	16.0	15.8	15.6	15.4	15.2	15.0	14.8	15.4	16.6	17.7	18.9	20.1	21.3	
									5	12	19	27	35	43	
23.90	10.5	9.0	7.5	6.1	4.6	3.2	1.8	.4							23.90
	14.8	14.6	14.4	14.2	14.0	13.8	13.6	13.4	14.2	15.4	16.6	17.7	18.9	20.1	
									6	13	20	28	36	44	
24.01	10.4	8.9	7.3	5.9	4.4	3.0	1.6	.2							24.01
	13.4	13.2	13.0	12.8	12.6	12.4	12.2	12.0	13.0	14.2	15.4	16.6	17.7	18.9	
									7	14	21	29	37	45	
24.12	10.2	8.7	7.1	5.7	4.2	2.8	1.4	.0							24.12
	12.1	11.9	11.7	11.5	11.3	11.1	10.9	10.7	11.8	13.0	14.2	15.4	16.6	17.7	
									8	15	22	30	38	46	
24.23	10.0	8.5	6.9	5.5	4.1	2.7	1.3								24.23
	10.7	10.5	10.3	10.1	9.9	9.7	9.5	9.5	10.6	11.8	13.0	14.2	15.4	16.6	
								1	9	16	23	31	39	47	
24.34	9.8	8.3	6.7	5.3	3.9	2.5	1.1								24.34
	9.4	9.2	9.0	8.8	8.6	8.4	8.2	8.3	9.5	10.6	11.8	13.0	14.2	15.4	
								2	10	17	24	32	40	48	
24.45	9.6	8.1	6.6	5.2	3.7	2.3	.9								24.45
	8.0	7.8	7.6	7.4	7.2	7.0	6.8	7.1	8.3	9.5	10.6	11.8	13.0	14.2	
								3	11	18	25	33	41	49	
24.56	9.4	8.0	6.4	5.0	3.6	2.1	.7								24.56
	6.6	6.4	6.2	6.0	5.8	5.6	5.4	5.9	7.1	8.3	9.5	10.6	11.8	13.0	
								4	12	19	26	34	42	50	
24.67	9.2	7.8	6.2	4.9	3.4	1.9	.5								24.67
	5.3	5.1	4.9	4.7	4.5	4.3	4.1	4.7	5.9	7.1	8.3	9.5	10.6	11.8	
								5	12	20	27	35	43	50	
24.78	9.0	7.6	6.1	4.7	3.3	1.8	.4								24.78
	3.9	3.7	3.5	3.3	3.1	2.9	2.7	3.5	4.7	5.9	7.1	8.3	9.5	10.6	
								6	13	21	28	36	44	51	
24.89	8.8	7.4	5.9	4.5	3.1	1.6	.2								24.89
	2.6	2.4	2.2	2.0	1.8	1.6	1.4	2.4	3.5	4.7	5.9	7.1	8.3	9.5	
								7	14	22	29	37	45	52	
25.00	8.6	7.2	5.7	4.3	2.9	1.4									25.00
	1.2	1.0	.8	.6	.4	.2		1.2	2.4	3.5	4.7	5.9	7.1	8.3	
								8	15	23	30	38	46	53	
	9.4	9.5	9.6	9.7	9.8	9.9	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	

TABLE 70 (Continued).

Standardizing table for ice cream mix No. 5 testing:

10.00% Fat
10.50% M. S. N. F.
14.00% Sugar
.50% Gelatin
34.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: Pounds butter.
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

	9.4	9.5	9.6	9.7	9.8	9.9	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	
25.11	8.6 1	7.4 2	6.1 3	4.9 5	3.7 6	2.4 7	1.2 8	9	16 1.2	24 2.4	31 3.5	39 4.7	47 5.9	54 7.1	25.11
25.22	9.8 9	8.6 10	7.4 11	6.1 12	4.9 13	3.7 14	2.4 15	1.2 16	17	25 1.2	32 2.4	40 3.5	48 4.7	55 5.9	25.22
25.33	11.0 17	9.8 18	8.6 19	7.4 20	6.1 21	4.9 22	3.7 23	2.4 24	1.2 25	26	33 1.2	41 2.4	49 3.5	56 4.7	25.33
25.44	12.3 24	10.0 25	9.8 26	8.6 27	7.4 28	6.1 29	4.9 30	3.7 31	2.4 32	1.2 33	34	42 1.2	50 2.4	57 3.5	25.44
25.55	13.5 31	12.3 32	11.0 33	9.8 34	8.6 35	7.4 37	6.1 38	4.9 39	3.7 40	2.4 41	1.2 42	43	51 1.2	58 2.4	25.55
25.66	14.7 39	13.5 40	12.3 41	11.0 42	9.8 44	8.6 45	7.4 46	6.1 47	4.9 48	3.7 49	3.4 50	1.2 51	52	59 1.2	25.66
25.77	15.9 46	14.7 47	13.5 49	12.3 50	11.0 51	9.8 52	8.6 53	7.4 54	6.1 55	4.9 56	3.7 57	3.4 58	1.2 59	60	25.77
25.88	17.2 54	15.9 55	14.7 56	13.5 57	12.3 58	11.0 60	9.8 61	8.6 62	7.4 63	6.1 64	4.9 65	3.7 66	3.4 67	1.2 68	25.88
25.99	18.4 61	17.2 62	15.9 63	14.7 64	13.5 65	12.3 66	11.0 67	9.8 68	8.6 70	7.4 71	6.1 72	4.9 73	3.7 74	3.4 75	25.99
26.10	19.6 69	18.4 70	17.2 71	15.9 72	14.7 73	13.5 74	12.3 75	11.0 76	9.8 78	8.6 79	7.4 80	6.1 81	4.9 82	3.7 83	26.10
26.21	20.8 77	19.6 78	18.4 80	17.2 81	15.9 82	14.7 83	13.5 84	12.3 85	11.0 86	9.8 87	8.6 88	7.4 89	6.1 90	4.9 91	26.21
26.32	22.1 84	20.8 85	19.6 86	18.4 87	17.2 88	15.9 89	14.7 90	13.5 91	12.3 93	11.0 94	9.8 95	8.6 96	7.4 97	6.1 98	26.32
26.43	23.3 92	22.1 93	20.8 94	19.6 95	18.4 96	17.2 97	15.9 98	14.7 100	13.5 101	12.3 102	11.0 103	9.8 104	8.6 105	7.4 106	26.43
26.54	24.5 99	23.3 100	22.1 101	20.8 102	19.6 103	18.4 104	17.2 106	15.9 107	14.7 108	13.5 109	12.3 110	11.0 111	9.8 112	8.6 113	26.54
26.65	25.7 106	24.5 107	23.3 108	22.1 109	20.8 110	19.6 112	18.4 113	17.2 114	15.9 116	14.7 117	13.5 118	12.3 119	11.0 120	9.8 121	26.65
26.76	27.0 114	25.7 115	24.5 116	23.3 117	22.1 118	20.8 119	19.6 120	18.4 121	17.2 122	15.9 123	14.7 124	13.5 126	12.3 127	11.0 128	26.76
26.87	28.2 121	27.0 122	25.7 123	24.5 125	23.3 126	22.1 127	20.8 128	19.6 129	18.4 130	17.2 131	15.9 132	14.7 133	13.5 134	12.3 135	26.87
26.98	29.4 130	28.2 131	27.0 132	25.7 133	24.5 134	23.3 136	22.1 137	20.8 138	19.6 139	18.4 140	17.2 141	15.9 142	14.7 143	13.5 144	26.98
27.09	30.6 136	29.4 137	28.2 138	27.0 140	25.7 141	24.6 142	23.3 143	22.1 145	20.8 146	19.6 147	18.4 148	17.2 149	15.9 150	14.7 151	27.09
27.20	31.9 144	30.6 145	29.4 146	28.2 147	27.0 148	25.7 150	24.5 151	23.3 152	22.1 153	20.8 154	19.6 155	18.4 156	17.2 157	15.9 158	27.20
	9.4	9.5	9.6	9.7	9.8	9.9	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	

TABLE 70 (Continued).

Standardizing table for ice cream mix No. 5 testing: 10.00% Fat; 10.50% M. S. N. F.; 14.00% Sugar; .50% Gelatin; 34.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: Pounds butter.
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

	10.8	10.9	11.0	11.1	11.2	11.3	11.4	11.5	11.6	11.7	11.8	11.9	12.0	
22.80	41 33.1	49 34.3	57 35.5	64 36.7	72 37.8	79 39.0	87 40.2	95 41.4	102 42.6	110 43.8	118 44.9	125 46.1	133 47.3	22.80
22.91	42 31.9	50 33.1	58 34.3	65 35.5	73 36.7	80 37.8	88 39.0	96 40.2	103 41.4	111 42.6	119 43.8	126 44.9	134 46.1	22.91
23.02	43 30.7	51 31.9	59 33.1	66 34.3	74 35.5	81 36.7	89 37.8	97 39.0	104 40.2	112 41.4	120 42.6	127 43.8	135 44.9	23.02
23.13	44 29.6	52 30.7	60 31.9	67 33.1	75 34.3	82 35.5	90 36.7	98 37.8	105 39.0	113 40.2	121 41.4	128 42.6	136 43.8	23.13
23.24	45 28.4	53 29.6	61 30.7	68 31.9	76 33.1	83 34.3	91 35.5	99 36.7	106 37.8	114 39.0	122 40.2	129 41.4	137 42.6	23.24
23.35	46 27.2	54 28.4	62 29.6	69 30.7	77 31.9	84 33.1	92 34.3	100 35.5	107 36.7	115 37.8	123 39.0	130 40.2	138 41.4	23.35
23.46	47 26.0	55 27.2	63 28.4	70 29.6	78 30.7	85 31.9	93 33.1	101 34.3	108 35.5	116 36.7	124 37.8	131 39.0	139 40.2	23.46
23.57	48 24.8	56 26.0	64 27.2	71 28.4	79 29.6	86 30.7	94 31.9	102 33.1	109 34.3	117 35.5	125 36.7	132 37.8	140 39.0	23.57
23.68	49 23.7	57 24.8	65 26.0	72 27.2	80 28.4	87 29.6	95 30.7	103 31.9	110 33.1	118 34.3	126 35.5	133 36.7	141 37.8	23.68
23.79	50 22.5	58 23.7	66 24.8	73 26.0	81 27.2	88 28.4	96 29.6	104 30.7	111 31.9	119 33.1	127 34.3	134 35.5	142 36.7	23.79
23.90	51 21.3	59 22.5	67 23.7	74 24.8	82 26.0	89 27.2	97 28.4	105 29.6	112 30.7	120 31.9	128 33.1	135 34.3	143 35.5	23.90
24.01	52 20.1	60 21.3	68 22.5	75 23.7	83 24.8	90 26.0	98 27.2	106 28.4	113 29.6	121 30.7	129 31.9	136 33.1	144 34.3	24.01
24.12	53 18.9	61 20.1	69 21.3	76 22.5	84 23.7	91 24.8	99 26.0	107 27.2	114 28.4	122 29.6	130 30.7	137 31.9	145 33.1	24.12
24.23	54 17.7	62 18.9	70 20.1	77 21.3	85 22.5	92 23.7	100 24.8	108 26.0	115 27.2	123 28.4	131 29.6	138 30.7	146 31.9	24.23
24.34	55 16.6	63 17.7	71 18.9	78 20.1	86 21.3	93 22.5	100 23.7	109 24.8	116 26.0	124 27.2	132 28.4	139 29.6	147 30.7	24.34
24.45	56 15.4	64 16.6	72 17.7	79 18.9	86 20.1	94 21.3	101 22.5	110 23.7	117 24.8	125 26.0	133 27.2	140 28.4	148 29.6	24.45
24.56	57 14.2	65 15.4	72 16.6	80 17.7	87 18.9	95 20.1	102 21.3	111 22.5	118 23.7	126 24.8	134 26.0	141 27.2	149 28.4	24.56
24.67	58 13.0	65 14.2	73 15.4	81 16.6	88 17.7	96 18.9	103 20.1	111 21.3	119 22.5	127 23.7	135 24.8	142 26.0	150 27.2	24.67
24.78	59 11.8	66 13.0	74 14.2	82 15.4	89 16.6	97 17.7	104 18.9	112 20.1	120 21.3	128 22.5	136 23.7	143 24.8	151 26.0	24.78
24.89	60 10.6	67 11.8	75 13.0	83 14.2	90 15.4	98 16.6	105 17.7	113 18.9	121 20.1	129 21.3	137 22.5	144 23.7	152 24.8	24.89
25.00	61 9.5	68 10.6	76 11.8	84 13.0	91 14.2	99 15.4	106 16.6	114 17.7	122 18.9	130 20.1	137 21.3	145 22.5	153 23.7	25.00
	10.8	10.9	11.0	11.1	11.2	11.3	11.4	11.5	11.6	11.7	11.8	11.9	12.0	

TABLE 70 (Continued).

Standardizing table for ice cream mix No. 5 testing:

10.00% Fat
10.50% M. S. N. F.
14.00% Sugar
.50% Gelatin
34.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: Pounds butter.
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

	10.8	10.9	11.0	11.1	11.2	11.3	11.4	11.5	11.6	11.7	11.8	11.9	12.00	
25.11	62 8.3	69 9.5	77 10.6	85 11.8	92 13.0	100 14.2	107 15.4	115 16.6	123 17.7	131 18.9	138 20.1	146 21.3	154 22.5	25.11
25.22	63 7.1	70 8.3	78 9.5	86 10.6	93 11.8	101 13.0	108 14.2	116 15.4	124 16.6	132 17.7	139 18.9	147 20.1	155 21.3	25.22
25.33	64 5.9	71 7.1	79 8.3	87 9.5	94 10.6	102 11.8	109 13.0	117 14.2	125 15.4	133 16.6	140 17.7	148 18.9	156 20.1	25.33
25.44	65 4.7	72 5.9	80 7.1	88 8.3	95 9.5	103 10.6	110 11.8	118 13.0	126 14.2	133 15.4	141 16.6	148 17.7	157 18.9	25.44
25.55	66 3.5	73 4.7	81 5.9	89 7.1	96 8.3	104 9.5	111 10.6	119 11.8	127 13.0	134 14.2	142 15.4	149 16.6	158 17.7	25.55
25.66	67 2.4	74 3.5	82 4.7	90 5.9	97 7.1	105 8.3	112 9.5	120 10.6	128 11.8	135 13.0	143 14.2	150 15.4	158 16.6	25.66
25.77	68 1.2	75 2.4	83 3.5	91 4.7	98 5.9	106 7.1	113 8.3	121 9.5	129 10.6	136 11.8	144 13.0	151 14.2	159 15.4	25.77
25.88	69	76 1.2	84 2.4	92 3.5	99 4.7	107 5.9	114 7.1	122 8.3	130 9.5	137 10.6	145 11.8	152 13.0	160 14.2	25.88
25.99	1.2 76	77	85 1.2	93 2.4	100 3.5	108 4.7	115 5.9	123 7.1	131 8.3	138 9.5	146 10.6	153 11.8	161 13.0	25.99
26.10	3.4 84	1.2 85	86	94 1.2	101 2.4	109 3.5	116 4.7	124 5.9	132 7.1	139 8.3	147 9.5	154 10.6	162 11.8	26.10
26.21	3.7 92	3.4 93	1.2 94	95	102 1.2	110 2.4	117 3.5	125 4.7	133 5.9	140 7.1	148 8.3	155 9.5	163 10.6	26.21
26.32	4.9 99	3.7 100	3.4 101	1.2 102	103	111 1.2	118 2.4	126 3.5	134 4.7	141 5.9	149 7.1	156 8.3	164 9.5	26.32
26.43	6.1 107	4.9 108	3.7 109	3.4 110	1.2 111	112	119 1.2	127 2.4	135 3.5	142 4.7	150 5.9	157 7.1	165 8.3	26.43
26.54	7.4 114	6.1 115	4.9 116	3.7 117	3.4 118	1.2 119	120	128 1.2	136 2.4	143 3.5	151 4.7	158 5.9	166 7.1	26.54
26.65	8.6 122	7.4 123	6.1 124	4.9 125	3.7 126	3.4 127	1.2 128	129	137 1.2	144 2.4	152 3.5	159 4.7	167 5.9	26.65
26.76	9.8 130	8.6 131	7.4 132	6.1 133	4.9 134	3.7 135	3.4 136	1.2 137	138	145 1.2	153 2.4	160 3.5	168 4.7	26.76
26.87	11.0 136	9.8 137	8.6 138	7.4 140	6.1 141	4.9 142	3.7 143	3.4 144	1.2 145	146	154 1.2	161 2.4	169 3.5	26.87
26.98	12.3 145	11.0 146	9.8 147	8.6 148	7.4 149	6.1 150	4.9 151	3.7 152	3.4 153	1.2 154	155	162 1.2	170 2.4	26.98
27.09	13.5 152	12.3 153	11.0 154	9.8 155	8.6 156	7.4 157	6.1 158	4.9 159	3.7 160	3.4 161	1.2 162	163	171 1.2	27.09
27.20	14.7 160	13.5 161	12.3 162	11.0 163	9.8 164	8.6 165	7.4 166	6.1 167	4.9 168	3.7 169	2.4 170	1.2 171	172	27.20
	10.8	10.9	11.0	11.1	11.2	11.3	11.4	11.5	11.6	11.7	11.8	11.9	12.00	

TABLE 71.

Standardizing table for ice cream mix No. 6 testing:

12.00% Fat
8.50% M. S. N. F.
14.00% Sugar
.50% Gelatin
35.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: Pounds butter.
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.8	10.9	11.0	11.1	11.2	
(A) 21.50	32.6	31.1	29.7	28.2	26.7	25.2	23.8	22.3	20.8	19.3	17.9	16.4	14.9	21.50
(F)	21.2	21.0	19.9	19.8	20.6	20.4	20.3	20.1	19.9	19.8	19.7	19.5	19.3	
21.57	32.4	30.9	29.5	28.0	26.5	25.0	23.6	22.1	20.6	19.1	17.7	16.2	14.7	21.57
	20.7	20.5	20.3	20.2	20.1	20.0	19.8	19.6	19.4	19.2	19.1	18.9	18.7	
21.65	32.3	30.8	29.3	27.9	26.4	24.9	23.4	22.0	20.5	19.0	17.5	16.1	14.6	21.65
	19.8	19.6	19.5	19.4	19.3	19.1	19.0	18.8	18.6	18.5	18.3	18.1	17.9	
21.72	32.2	30.6	29.1	27.7	26.2	24.7	23.3	21.8	20.4	18.9	17.3	15.9	14.4	21.72
	18.8	18.6	18.5	18.3	18.1	18.0	17.9	17.8	17.6	17.5	17.3	17.1	17.0	
21.80	32.0	30.5	29.0	27.6	26.1	24.6	23.2	21.7	20.3	18.7	17.2	15.8	14.3	21.80
	17.9	17.7	17.6	17.4	17.3	17.1	17.0	16.8	16.7	16.5	16.3	16.2	16.0	
21.87	31.8	30.3	28.9	27.5	25.9	24.5	23.0	21.5	20.1	18.6	17.0	15.6	14.1	21.87
	17.0	16.8	16.7	16.5	16.4	16.3	16.1	15.9	15.8	15.6	15.5	15.3	15.1	
21.95	31.6	30.2	28.8	27.3	25.8	24.3	22.9	21.4	20.0	18.5	16.9	15.5	13.9	21.95
	16.1	16.0	15.8	15.6	15.4	15.3	15.1	15.0	14.8	14.7	14.5	14.4	14.2	
22.02	31.5	30.0	28.6	27.2	25.6	24.2	22.7	21.2	19.8	18.3	16.7	15.3	13.7	22.02
	15.1	15.0	14.8	14.7	14.5	14.4	14.3	14.1	14.0	13.8	13.7	13.5	13.3	
22.10	31.3	29.9	28.5	27.0	25.5	24.1	22.6	21.1	19.7	18.2	16.5	15.2	13.6	22.10
	14.2	14.0	13.9	13.7	13.6	13.4	13.3	13.1	13.0	12.8	12.7	12.5	12.4	
22.17	31.1	29.8	28.3	26.9	25.3	24.0	22.5	20.9	19.6	18.0	16.4	15.0	13.5	22.17
	13.3	13.2	13.0	12.8	12.6	12.5	12.3	12.1	11.9	11.8	11.6	11.5	11.3	
22.25	31.0	29.6	28.2	26.8	25.2	23.8	22.3	20.8	19.4	17.8	16.4	14.9	13.3	22.25
	12.4	12.2	12.1	11.9	11.8	11.6	11.4	11.3	11.1	11.0	10.8	10.6	10.5	
22.32	30.9	29.5	28.0	26.6	25.0	23.7	22.2	20.6	19.3	17.7	16.2	14.8	13.2	22.32
	11.4	11.3	11.2	11.0	10.9	10.7	10.5	10.3	10.1	10.0	9.9	9.7	9.5	
22.40	30.7	29.3	27.9	26.5	24.8	23.5	22.0	20.5	19.1	17.5	16.0	14.6	13.0	22.40
	10.5	10.3	10.2	10.0	9.8	9.6	9.5	9.3	9.1	9.0	8.9	8.7	8.6	
22.47	30.6	29.1	27.7	26.3	24.6	23.3	21.7	20.3	19.0	17.3	15.9	14.5	12.9	22.47
	9.6	9.4	9.3	9.1	9.0	8.9	8.7	8.6	8.4	8.2	8.1	7.9	7.8	
22.55	30.4	29.0	27.6	26.2	24.5	23.1	21.5	20.2	18.8	17.2	15.8	14.3	12.7	22.55
	8.7	8.5	8.4	8.2	8.0	7.9	7.7	7.6	7.4	7.2	7.1	6.9	6.8	
22.62	30.3	28.9	27.4	26.0	24.3	23.0	21.4	20.0	18.6	17.0	15.6	14.2	12.5	22.62
	7.7	7.5	7.3	7.1	7.0	6.9	6.7	6.5	6.4	6.2	6.0	5.9	5.8	
22.70	30.1	28.7	27.3	25.8	24.2	22.8	21.2	19.8	18.4	16.9	15.4	14.0	12.4	22.70
	6.8	6.6	6.5	6.4	6.2	6.0	5.9	5.7	5.5	5.4	5.3	5.1	5.0	
22.77	30.0	28.5	27.1	25.7	24.0	22.6	21.0	19.7	18.2	16.7	15.3	13.8	12.3	22.77
	5.9	5.7	5.5	5.4	5.2	5.1	4.9	4.7	4.6	4.5	4.3	4.2	4.0	
22.85	29.8	28.3	26.9	25.5	23.9	22.5	20.9	19.5	18.0	16.6	15.2	13.7	12.2	22.85
	5.0	4.8	4.7	4.5	4.3	4.1	4.0	3.9	3.7	3.5	3.4	3.2	3.1	
22.92	29.7	28.2	26.8	25.3	23.7	22.3	20.7	19.4	17.9	16.4	15.0	13.5	12.0	22.92
	4.0	3.8	3.6	3.5	3.4	3.2	3.1	2.9	2.8	2.6	2.5	2.3	2.1	
23.00	29.5	28.0	26.6	25.1	23.6	22.1	20.6	19.2	17.7	16.2	14.8	13.3	11.8	23.00
(E)	3.1	2.9	2.8	2.6	2.5	2.3	2.2	2.0	1.9	1.7	1.6	1.4	1.2	
	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.8	10.9	11.0	11.1	11.2	

TABLE 71 (Continued).

Standardizing table for ice cream mix No. 6 testing:

12.00% Fat
8.50% M. S. N. F.
14.00% Sugar
.50% Gelatin
35.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: Pounds butter.
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.8	10.9	11.0	11.1	11.2	
23.07	29.3 2.2	27.9 2.0	26.4 1.9	25.0 1.7	23.5 1.6	22.0 1.4	20.4 1.3	19.0 1.1	17.5 1.0	16.0 .8	16.6 .7	13.1 .5	1.9 .3	23.07
23.15	29.2 1.2	27.7 1.0	26.3 .9	24.8 .7	23.3 .6	21.8 .4	20.3 .3	18.8 .1	17.3 .0	16.1 1	14.8 2	13.6 3	12.4 4	23.15
23.22	29.0 .3	27.6 .2	26.1 .0	24.7 1	23.5 2	22.2 3	21.0 4	19.8 5	18.5 6	17.3 7	16.1 8	14.8 9	13.6 10	23.22
23.30	29.6 3 (K)	28.4 4	27.2 5	25.9 6	24.7 7	23.5 8	22.2 9	21.0 10	19.8 11	18.5 12	17.3 13	16.1 14	14.8 15	23.30
23.37	30.9 9	29.6 10	28.4 11	27.2 12	25.9 13	24.7 14	23.5 15	22.2 17	21.0 18	19.8 19	18.5 20	17.3 21	16.1 22	23.37
23.45	32.1 15	30.9 16	29.6 17	28.4 18	27.2 19	25.9 20	24.7 21	23.5 22	22.2 24	21.0 25	19.8 26	18.5 27	17.3 28	23.45
23.52	33.3 21	32.1 22	30.9 23	29.6 24	28.4 25	27.2 26	25.9 27	24.7 28	23.5 29	22.2 30	21.0 32	19.8 33	18.5 34	23.52
23.60	34.6 28	33.3 29	32.1 30	30.9 31	29.6 32	28.4 32	27.2 33	25.9 34	24.7 35	23.5 36	22.2 37	21.0 38	19.8 40	23.60
23.67	35.8 34	34.6 35	33.3 36	32.1 37	30.9 38	29.6 39	28.4 40	27.2 41	25.9 42	24.7 43	23.5 44	22.2 45	21.0 46	23.67
23.75	37.1 40	35.8 41	34.6 42	33.3 43	32.1 44	30.9 45	29.6 46	28.4 47	27.2 48	25.9 49	24.7 50	23.5 51	22.2 52	23.75
23.82	38.3 46	37.1 47	35.8 48	34.6 49	33.3 50	32.1 51	30.9 52	29.6 53	28.4 54	27.2 55	25.9 57	24.7 58	23.5 59	23.82
23.90	39.5 52	38.3 53	37.1 54	35.8 55	34.6 56	33.3 57	32.1 58	30.9 59	29.6 60	28.4 61	27.2 62	25.9 64	24.7 65	23.90
23.97	40.8 58	39.5 59	38.3 60	37.1 61	35.8 62	34.6 63	33.3 64	32.1 65	30.9 66	29.6 67	28.4 68	27.2 70	25.9 71	23.97
24.05	42.0 64	40.8 65	39.5 66	38.3 67	37.1 68	35.8 69	34.6 70	33.3 71	32.1 72	30.9 73	29.6 74	28.4 75	27.2 76	24.05
24.12	43.2 70	42.0 71	40.8 72	39.5 73	38.3 74	37.1 75	35.8 76	34.6 77	33.3 78	32.1 79	30.9 80	29.6 81	28.4 83	24.12
24.20	44.5 77	43.2 78	42.0 79	40.8 80	39.5 81	38.3 82	37.1 83	35.8 84	34.6 85	33.3 86	32.1 87	30.9 88	29.6 89	24.20
24.27	45.7 83	44.5 84	43.2 85	42.0 86	40.8 87	39.5 88	38.3 89	37.1 90	35.8 91	34.6 92	33.3 93	32.1 94	30.9 95	24.27
24.35	46.9 89	45.7 90	44.5 91	43.2 92	42.0 93	40.8 94	39.5 95	38.3 96	37.1 97	35.8 98	34.6 99	33.3 100	32.1 101	24.35
24.42	48.2 95	46.9 96	45.7 97	44.5 98	43.2 99	42.0 100	40.8 101	39.5 102	38.3 103	37.1 104	35.8 106	34.6 107	33.3 108	24.42
24.50	49.4 101	48.2 102	46.9 103	45.7 104	44.5 105	43.2 106	42.0 107	40.8 108	39.5 109	38.3 110	37.1 111	35.8 112	34.6 113	24.50
	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.8	10.9	11.0	11.1	11.2	

TABLE 71 (Continued).

Standardizing table for ice cream mix No. 6 testing:

12.00% Fat
8.50% M. S. N. F.
14.00% Sugar
.50% Gelatin
35.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: Pounds butter.
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

	11.3	11.4	11.5	11.6	11.7	11.8	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	
21.50	13.4	11.9	10.4	9.0	7.5	6.1	4.6	3.1	1.7	.2	(I)				21.50
	19.1	19.0	18.8	18.7	18.5	18.4	18.3	(D) 18.1	17.9	17.8	6 18.4	12 19.3	19 20.0	25 20.9	
21.57	13.2	11.7	10.2	8.9	7.3	5.9	4.4	2.9	1.5	.0					21.57
	18.6	18.4	18.3	18.2	18.0	17.9	17.8	17.6	17.4	17.2	7 17.7	13 18.5	20 19.3	26 20.0	
21.65	13.1	11.5	10.1	8.7	7.2	5.8	4.3	2.8	1.4						21.65
	17.8	17.6	17.5	17.3	17.2	17.0	16.8	16.7	16.5	1 16.1	8 16.9	13 17.7	20 18.5	26 19.3	
21.72	13.0	11.3	10.0	8.6	7.0	5.7	4.1	2.6	1.2						21.72
	16.8	16.7	16.5	16.4	16.2	16.0	15.9	15.7	15.5	2 15.2	8 16.1	14 16.9	21 17.7	26 18.5	
21.80	12.8	11.1	9.8	8.4	6.8	5.5	4.0	2.5	1.1						21.80
	15.9	15.7	15.6	15.5	15.3	15.2	15.0	14.8	14.6	2 14.4	9 15.2	15 16.1	22 16.9	27 17.7	
21.87	12.6	11.0	9.6	8.3	6.7	5.4	3.8	2.3	9.						21.87
	15.0	14.8	14.7	14.5	14.4	14.2	14.1	13.9	13.7	3 13.6	10 14.4	15 15.2	22 16.1	28 16.9	
21.95	12.5	10.9	9.5	8.1	6.6	5.3	3.6	2.2	.8						21.95
	14.0	13.9	13.7	13.6	13.5	13.3	13.2	13.0	12.8	4 12.8	10 13.6	16 14.4	23 15.2	29 16.1	
22.02	12.3	10.7	9.4	7.9	6.4	5.1	3.4	2.0	.6						22.02
	13.1	12.9	12.8	12.6	12.5	12.3	12.2	12.0	11.8	4 12.0	10 12.8	17 13.6	24 14.4	30 15.2	
22.10	12.1	10.5	9.2	7.8	6.3	4.9	3.3	1.9	.5						22.10
	12.2	12.1	11.9	11.8	11.6	11.5	11.3	11.1	10.9	5 11.2	11 12.0	17 12.8	24 13.6	30 14.4	
22.17	12.0	10.4	9.1	7.6	6.1	4.8	3.2	1.7	.3						22.17
	11.2	11.0	10.9	10.8	10.6	10.5	10.3	10.2	10.0	6 10.4	11 11.2	18 12.0	25 12.8	31 13.6	
22.25	11.9	10.2	8.9	7.5	6.0	4.6	3.0	1.6	.1						22.25
	10.3	10.1	10.0	9.9	9.8	9.6	9.5	9.3	9.1	6 9.6	12 10.4	19 11.2	26 12.0	32 12.8	
22.32	11.8	10.1	8.8	7.3	5.8	4.5	2.9	1.4	.0						22.32
	9.4	9.3	9.1	8.9	8.8	8.6	8.5	8.3	8.2	6 8.8	13 9.6	19 10.4	26 11.2	32 12.0	
22.40	11.7	10.0	8.6	7.2	5.6	4.3	2.7	1.2							22.40
	8.4	8.3	8.1	7.9	7.8	7.7	7.6	7.4	1 7.2	7 8.0	14 8.8	20 9.6	27 10.4	33 11.2	
22.47	11.5	9.9	8.4	7.0	5.5	4.2	2.6	1.1							22.47
	7.6	7.5	7.3	7.1	7.0	6.8	6.7	6.5	1 6.4	8 7.2	14 8.0	21 8.8	28 9.6	34 10.4	
22.55	11.3	9.7	8.3	6.9	5.3	4.0	2.4	.9							22.55
	6.6	6.5	6.3	6.2	6.0	5.9	5.8	5.6	2 5.6	8 6.4	15 7.2	21 8.0	28 8.8	34 9.6	
22.62	11.1	9.5	8.2	6.7	5.2	3.7	2.2	.8							22.62
	5.6	5.5	5.3	5.2	5.0	4.9	4.8	4.6	3 4.8	9 5.6	16 6.4	22 7.2	29 8.0	35 8.8	
22.70	11.0	9.4	8.1	6.6	5.0	3.5	2.0	.6							22.70
	4.8	4.7	4.5	4.3	4.2	4.0	3.9	3.7	3 4.0	10 4.8	16 5.6	23 6.4	30 7.2	36 8.0	
22.77	10.8	9.2	7.9	6.5	4.9	3.3	1.9	.5							22.77
	3.8	3.7	3.5	3.4	3.3	3.1	2.9	2.8	4 3.2	10 4.0	17 4.8	23 5.6	30 6.4	36 7.2	
22.85	10.7	9.1	7.7	6.3	4.7	3.2	1.8	.3							22.85
	3.0	2.8	2.6	2.5	2.3	2.1	2.0	1.8	5 2.4	11 3.2	18 4.0	24 4.8	31 5.6	37 6.4	
22.92	10.5	8.9	7.6	6.1	4.6	3.1	1.6	.2							22.92
	2.0	1.8	1.7	1.5	1.4	1.2	1.1	.9	5 1.6	12 2.4	18 3.2	25 4.0	32 4.8	38 5.6	
23.00	10.3	8.8	7.4	5.9	4.4	2.9	1.4								23.00
	1.1	.9	.8	.6	.5	.3	.2	(C)	6 .8	12 1.6	19 2.4	25 3.2	32 4.0	38 4.8	
	11.3	11.4	11.5	11.6	11.7	11.8	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	

TABLE 71 (Continued).

Standardizing table for ice cream mix No. 6 testing:

12.00% Fat
8.50% M. S. N. F.
14.00% Sugar
.50% Gelatin
35.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: Pounds butter.
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

	11.3	11.4	11.5	11.6	11.7	11.8	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	
23.07	9.8 .2	8.6 .0	7.4 1	6.2 2	4.9 3	3.7 4	2.5 5	1.2 6	7	13 .8	20 1.6	26 2.4	33 3.2	39 4.0	23.07
23.15	11.1 5	9.9 6	8.6 7	7.4 8	6.2 9	4.9 10	3.7 11	2.5 12	1.2 13	14	20 .8	27 1.6	34 2.4	40 3.2	23.15
23.22	12.4 11	11.1 12	9.9 13	8.6 14	7.4 15	6.2 16	4.9 17	3.7 18	2.5 19	1.2 20	21	28 .8	34 1.6	41 2.4	23.22
23.30	13.6 17	12.4 19	11.1 20	9.9 21	8.6 22	7.4 23	6.2 24	4.9 25	3.7 26	2.5 27	1.2 28	29	35 1.8	42 1.6	23.30
23.37	14.8 23	13.6 24	12.4 25	11.1 27	9.9 28	8.6 29	7.4 30	6.2 31	4.9 32	3.7 33	2.5 34	1.2 35	36	42 .8	23.37
23.45	16.1 29	14.8 30	13.6 31	12.4 32	11.1 33	9.8 35	8.6 36	7.4 37	6.2 38	4.9 39	3.7 40	2.5 41	1.2 42	43	23.45
23.52	17.3 35	16.1 36	14.8 37	13.6 38	12.4 39	11.1 40	9.9 42	8.6 43	7.4 44	6.2 45	4.9 46	3.7 47	2.5 48	1.2 49	23.52
23.60	18.5 41	17.3 42	16.1 43	14.8 44	13.6 45	12.4 46	11.1 47	9.9 48	8.6 50	7.4 51	6.2 52	4.9 53	3.7 54	2.5 55	23.60
23.67	19.8 47	18.5 48	17.3 49	16.1 51	14.8 52	13.6 53	12.4 54	11.1 55	9.9 56	8.6 57	7.4 58	6.2 59	4.9 60	3.7 61	23.67
23.75	21.0 54	19.8 55	18.5 56	17.3 57	16.1 58	14.8 60	13.6 61	12.4 62	11.1 63	9.9 64	8.6 65	7.4 66	6.2 67	4.9 68	23.75
23.82	22.2 60	21.0 61	19.8 62	18.5 63	17.3 64	16.1 65	14.8 67	13.6 68	12.4 69	11.1 70	9.9 71	8.6 72	7.4 73	6.2 74	23.82
23.90	23.5 66	22.2 67	21.0 68	19.8 69	18.5 70	17.3 71	16.1 72	14.8 73	13.6 75	12.4 76	11.1 77	9.9 78	8.6 79	7.4 80	23.90
23.97	24.7 72	23.5 73	22.2 74	21.0 75	19.8 76	18.5 77	17.3 79	16.1 80	14.8 81	13.6 82	12.4 83	11.1 84	9.9 85	8.6 86	23.97
24.05	25.9 77	24.7 78	23.5 80	22.2 81	21.0 82	19.8 83	18.5 84	17.3 85	16.1 86	14.8 87	13.6 88	12.4 90	11.1 91	9.9 92	24.05
24.12	27.2 84	25.9 85	24.7 86	23.5 87	22.2 88	21.0 89	19.8 91	18.5 92	17.3 93	16.1 94	14.8 95	13.6 96	12.4 97	11.1 98	24.12
24.20	28.4 90	27.2 91	25.9 92	24.7 93	23.5 94	22.2 95	21.0 96	19.8 97	18.5 98	17.3 99	16.1 101	14.8 102	13.6 103	12.4 104	24.20
24.27	29.6 96	28.4 97	27.2 98	25.9 100	24.7 101	23.5 102	22.2 103	21.0 104	19.8 105	18.5 106	17.3 107	16.1 108	14.8 109	13.6 110	24.27
24.35	30.9 102	29.6 103	28.4 104	27.2 105	25.9 106	24.7 107	23.5 108	22.2 109	21.0 111	19.8 112	18.5 113	17.3 114	16.1 116	14.8 117	24.35
24.42	32.1 109	30.9 110	29.6 111	28.4 112	27.2 113	25.9 114	24.7 115	23.5 116	22.2 117	21.0 118	19.8 119	18.5 120	17.3 121	16.1 122	24.42
24.50	33.3 114	32.1 116	30.9 117	29.6 118	28.4 119	27.2 120	25.9 121	24.7 122	23.5 123	22.2 124	21.0 125	19.8 126	18.5 127	17.3 128	24.50
	11.3	11.4	11.5	11.6	11.7	11.8	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	

TABLE 71 (Continued).

Standardizing table for ice cream mix No. 6 testing: 12.00% Fat, 8.50% M. S. N. F., 14.00% Sugar, .50% Gelatin — 35.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: Pounds butter.
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

	12.7	12.8	12.9	13.0	13.1	13.2	13.3	13.4	13.5	13.6	13.7	13.8	13.9	14.0	
21.50	32 21.7	38 22.5	45 23.2	51 24.1	58 24.9	64 25.7	71 26.5	77 27.3	84 28.1	90 28.9	97 29.7	103 30.5	110 31.3	(H) 116 32.1	21.50
21.57	33 20.9	39 21.7	46 22.5	52 23.2	59 24.1	65 24.9	72 25.7	78 26.5	85 27.3	91 28.1	98 28.9	104 29.7	111 30.5	117 31.3	21.57
21.65	33 20.0	39 20.9	46 21.7	52 22.5	59 23.2	65 24.1	72 24.9	78 25.7	85 26.5	91 27.3	98 28.1	104 28.9	111 29.7	117 30.5	21.65
21.72	33 19.3	39 20.0	46 20.9	53 21.7	60 22.5	66 23.2	73 24.1	79 24.9	86 25.7	92 26.5	99 27.3	105 28.1	112 28.9	118 29.7	21.72
21.80	34 18.5	40 19.3	47 20.0	54 20.9	61 21.7	67 22.5	74 23.2	80 24.1	87 24.9	93 25.7	100 26.5	106 27.3	113 28.1	119 28.9	21.80
21.87	35 17.7	41 18.5	48 19.3	54 20.0	61 20.9	67 21.7	74 22.5	80 23.2	87 24.1	93 24.9	100 25.7	106 26.5	113 27.3	119 28.1	21.87
21.95	36 16.9	42 17.7	49 18.5	55 19.3	62 20.0	68 20.9	75 21.7	81 22.5	88 23.2	94 24.1	101 24.9	107 25.7	114 26.5	120 27.3	21.95
22.02	37 16.1	43 16.9	50 17.7	56 18.5	63 19.3	69 20.0	76 20.9	82 21.7	89 22.5	95 23.2	102 24.1	108 24.9	115 25.7	121 26.5	22.02
22.10	37 15.2	43 16.1	50 16.9	56 17.7	63 18.5	69 19.3	76 20.0	82 20.9	89 21.7	95 22.5	102 23.2	108 24.1	115 24.9	121 25.7	22.10
22.17	38 14.4	44 15.2	51 16.1	57 16.9	64 17.7	70 18.5	77 19.3	83 20.0	90 20.9	96 21.7	103 22.5	109 23.2	116 24.1	122 24.9	22.17
22.25	39 13.6	45 14.4	52 15.2	58 16.1	65 16.9	71 17.7	78 18.5	84 19.3	91 20.0	97 20.9	104 21.7	110 22.5	117 23.2	123 24.1	22.25
22.32	39 12.8	45 13.6	52 14.4	58 15.2	65 16.1	71 16.9	78 17.7	84 18.5	91 19.3	97 20.0	104 20.9	110 21.7	117 22.5	123 23.2	22.32
22.40	40 12.0	46 12.8	53 13.6	59 14.4	66 15.2	72 16.1	79 16.9	85 17.7	92 18.5	98 19.3	105 20.0	111 20.9	118 21.7	124 22.5	22.40
22.47	41 11.2	47 12.0	54 12.8	60 13.6	67 14.4	73 15.2	80 16.1	86 16.9	93 17.7	99 18.5	106 19.3	112 20.0	119 20.9	125 21.7	22.47
22.55	41 10.4	47 11.2	54 12.0	60 12.8	67 13.6	73 14.4	80 15.2	86 16.1	93 16.9	99 17.7	106 18.5	112 19.3	119 20.0	125 20.9	22.55
22.62	42 9.6	48 10.4	55 11.2	61 12.0	68 12.8	74 13.6	81 14.4	87 15.2	94 16.1	100 16.9	107 17.7	113 18.5	120 19.3	126 20.0	22.62
22.70	43 8.8	49 9.6	56 10.4	62 11.2	69 12.0	75 12.8	82 13.6	88 14.4	95 15.2	101 16.1	108 16.9	114 17.7	121 18.5	127 19.3	22.70
22.77	43 8.0	49 8.8	56 9.6	62 10.4	69 11.2	75 12.0	82 12.8	88 13.6	95 14.4	101 15.2	108 16.1	114 16.9	121 17.7	127 18.5	22.77
22.85	44 7.2	50 8.0	57 8.8	63 9.6	70 10.4	76 11.2	83 12.0	89 12.8	96 13.6	102 14.4	109 15.2	115 16.1	122 16.9	128 17.7	22.85
22.92	45 6.4	51 7.2	58 8.0	64 8.8	71 9.6	77 10.4	84 11.2	90 12.0	97 12.8	103 13.6	110 14.4	116 15.2	123 16.1	129 16.9	22.92
23.00	45 5.6	51 6.4	58 7.2	64 8.0	71 8.8	77 9.6	84 10.4	90 11.2	97 12.0	103 12.8	110 13.6	116 14.4	123 15.2	129 16.1	23.00
	12.7	12.8	12.9	13.0	13.1	13.2	13.3	13.4	13.5	13.6	13.7	13.8	13.9	14.0	

TABLE 71 (Continued).

Standardizing table for ice cream mix No. 6 testing:

12.00% Fat
8.50% M. S. N. F.
14.00% Sugar
.50% Gelatin
35.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: Pounds butter.
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

	12.7	12.8	12.9	13.0	13.1	13.2	13.3	13.4	13.5	13.6	13.7	13.8	13.9	14.0	
23.07	46 4.8	52 5.6	59 6.4	65 7.2	72 8.0	79 8.8	85 9.6	91 10.4	98 11.2	104 12.0	111 12.8	117 13.6	124 14.4	130 15.2	23.07
23.15	47 4.0	53 4.8	60 5.6	66 6.4	73 7.2	80 8.0	86 8.8	92 9.6	99 10.4	105 11.2	112 12.0	118 12.8	125 13.6	131 14.4	23.15
23.22	47 3.2	53 4.0	60 4.8	67 5.6	74 6.4	81 7.2	87 8.0	93 8.8	100 9.6	106 10.4	113 11.2	119 12.0	126 12.8	132 13.6	23.22
23.30	47 2.4	54 3.2	61 4.0	67 4.8	74 5.6	81 6.4	87 7.2	93 8.0	100 8.8	106 9.6	113 10.4	119 11.2	126 12.0	132 12.8	23.30
23.37	48 1.6	55 2.4	61 3.2	68 4.0	74 4.8	82 5.6	88 6.4	94 7.2	101 8.0	107 8.8	114 9.6	120 10.4	127 11.2	133 12.0	23.37
23.45	49 1.8	56 1.6	62 2.4	69 3.2	75 4.0	82 4.8	89 5.6	95 6.4	102 7.2	108 8.0	115 8.8	121 9.6	128 10.4	134 11.2	23.45
23.52	50	56 .8	63 1.6	69 2.4	75 3.2	83 4.0	89 4.8	96 5.6	103 6.4	109 7.2	116 8.0	122 8.8	128 9.6	134 10.4	23.52
23.62	1.2 56	57	63 .8	70 1.6	76 2.4	83 3.2	90 4.0	96 4.8	103 5.6	109 6.4	117 7.2	123 8.0	129 8.8	135 9.6	23.62
23.67	2.5 62	1.2 63	64	71 .8	77 1.6	81 2.4	90 3.2	97 4.0	104 4.8	110 5.6	117 6.4	123 7.2	129 8.0	136 8.8	23.67
23.75	3.7 69	2.5 70	1.2 71	72	78 .8	85 1.6	91 2.4	97 3.2	104 4.0	111 4.8	118 5.6	124 6.4	130 7.2	136 8.0	23.75
23.82	4.9 75	3.7 76	2.5 77	1.2 78	79	85 .8	91 1.6	98 2.4	105 3.2	111 4.0	118 4.8	125 5.6	131 6.4	137 7.2	23.82
23.90	6.2 81	4.9 82	3.7 83	2.5 84	1.2 85	86	92 .8	98 1.6	105 2.4	112 3.2	119 4.0	125 4.8	131 5.6	138 6.4	23.90
23.97	7.4 87	6.2 88	4.9 89	3.7 90	2.5 91	1.2 92	93	99 .8	106 1.6	112 2.4	120 3.2	126 4.0	132 4.8	138 5.6	23.97
24.05	8.6 93	7.4 94	6.2 95	4.9 96	3.7 97	2.5 98	1.2 99	100	106 .8	113 1.6	121 2.4	126 3.2	133 4.0	139 4.8	24.05
24.12	9.9 99	8.6 100	7.4 101	6.2 102	4.9 103	3.7 104	2.5 105	1.2 106	107	113 .8	121 1.6	127 2.4	134 3.2	140 4.0	24.12
24.20	1.1 105	9.9 106	8.6 107	7.4 108	6.2 109	4.9 110	3.7 111	2.5 112	1.2 113	114	122 .8	127 1.6	134 2.4	140 3.2	24.20
24.27	12.4 111	11.1 112	9.9 113	8.6 115	7.4 116	6.2 117	4.9 118	3.7 119	2.5 120	1.2 121	122	128 .8	135 1.6	141 2.4	24.27
24.35	13.6 118	12.4 119	11.1 120	9.9 121	8.6 122	7.4 123	6.2 124	4.9 125	3.7 126	2.5 127	1.2 128	129	135 .8	142 1.6	24.35
24.42	14.8 123	13.6 125	12.4 126	11.1 127	9.9 128	8.6 129	7.4 130	6.2 131	4.9 132	3.7 133	2.5 134	1.2 135	136	142 .8	24.42
24.50	16.1 130	14.8 131	13.6 132	12.4 133	11.1 134	9.9 135	8.6 136	7.4 137	6.2 138	4.9 139	3.7 140	2.5 141	1.2 142	(G) 143	24.50
	12.7	12.8	12.9	13.0	13.1	13.2	13.3	13.4	13.5	13.6	13.7	13.8	13.9	14.0	

TABLE 72.

Standardizing table for ice cream mix No. 7 testing:

12.00% Fat
9.50% M. S. N. F.
14.00% Sugar
.50% Gelatin
36.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: Pounds butter.
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.8	10.9	11.0	11.1	11.2	
22.33	33.1	31.5	30.1	28.6	27.2	25.7	24.2	22.7	21.2	19.7	18.3	16.8	15.3	22.33
	24.1	23.9	23.7	23.6	23.4	23.2	23.0	22.9	22.7	22.5	22.3	22.1	22.0	
22.41	32.9	31.3	30.0	28.4	27.0	25.5	24.0	22.5	21.0	19.5	18.1	16.6	15.1	22.41
	23.1	22.9	22.7	22.5	22.3	22.2	22.0	21.9	21.7	21.5	21.3	21.1	21.0	
22.50	32.8	31.1	29.8	28.2	26.8	25.3	23.8	22.3	20.8	19.3	18.0	16.5	14.9	22.50
	22.1	22.0	21.8	21.6	21.4	21.2	21.0	20.9	20.7	20.5	20.3	20.2	20.0	
22.58	32.6	31.0	29.6	28.0	26.7	25.1	23.6	22.1	20.7	19.1	17.8	16.3	14.7	22.58
	21.1	20.9	20.7	20.5	20.3	20.1	20.0	19.8	19.6	19.4	19.2	19.1	18.9	
22.66	32.5	30.8	29.4	27.8	26.5	25.0	23.4	22.0	20.5	19.0	17.6	16.1	14.5	22.66
	20.1	19.9	19.7	19.5	19.3	19.1	19.0	18.8	18.6	18.4	18.2	18.1	17.9	
22.75	32.3	30.6	29.2	27.7	26.3	24.8	23.2	21.9	20.3	18.8	17.4	15.9	14.3	22.75
	19.0	18.8	18.6	18.4	18.2	18.0	17.8	17.7	17.5	17.3	17.2	17.1	16.9	
22.83	32.1	30.5	29.0	27.5	26.1	24.6	23.0	21.8	20.1	18.6	17.2	15.7	14.1	22.83
	18.0	17.8	17.6	17.4	17.2	17.0	16.9	16.7	16.5	16.3	16.1	16.0	15.8	
22.91	32.0	30.3	28.9	27.3	26.0	24.4	22.9	21.6	19.9	18.4	17.0	15.5	14.0	22.91
	17.0	16.8	16.6	16.4	16.3	16.1	15.9	15.7	15.5	15.3	15.1	15.0	14.8	
23.00	31.8	30.1	28.7	27.1	25.9	24.2	22.7	21.4	19.8	18.2	16.9	15.4	13.8	23.00
	15.9	15.7	15.5	15.3	15.1	15.0	14.8	14.6	14.4	14.2	14.1	13.9	13.7	
23.08	31.6	30.0	28.5	27.0	25.7	24.0	22.5	21.2	19.6	18.0	16.7	15.3	13.6	23.08
	14.9	14.7	14.5	14.4	14.2	14.1	13.9	13.7	13.5	13.3	13.1	12.9	12.8	
23.16	31.4	29.8	28.4	26.8	25.5	23.9	22.3	21.0	19.4	17.9	16.5	15.2	13.4	23.16
	13.9	13.7	13.5	13.3	13.1	13.0	12.8	12.6	12.4	12.2	12.1	11.9	11.7	
23.25	31.2	29.6	28.3	26.6	25.4	23.7	22.1	20.9	19.2	17.7	16.3	15.0	13.2	23.28
	12.8	12.7	12.5	12.3	12.2	12.0	11.8	11.6	11.4	11.2	11.0	10.9	10.7	
23.33	31.0	29.4	28.1	26.4	25.2	23.5	22.0	20.8	19.0	17.5	16.2	14.9	13.0	23.33
	11.8	11.6	11.4	11.2	11.0	10.9	10.7	10.5	10.3	10.1	10.0	9.9	9.7	
23.41	30.9	29.2	27.9	26.2	25.0	23.3	21.8	20.6	18.9	17.3	16.0	14.7	12.9	23.41
	10.8	10.6	10.5	10.3	10.1	9.9	9.8	9.6	9.4	9.2	9.0	8.9	8.7	
23.49	30.7	29.0	27.7	26.0	24.9	23.1	21.6	20.4	18.7	17.2	15.8	14.5	12.7	23.49
	9.7	9.5	9.3	9.1	9.0	8.8	8.6	8.4	8.2	8.0	7.9	7.7	7.5	
23.58	30.5	28.9	27.5	25.9	24.7	23.0	21.4	20.2	18.5	17.0	15.6	14.3	12.5	23.58
	8.7	8.5	8.3	8.1	7.9	7.7	7.6	7.4	7.2	7.0	6.9	6.7	6.5	
23.66	30.3	28.7	27.3	25.7	24.5	22.9	21.3	20.0	18.3	16.8	15.4	14.1	12.3	23.66
	7.7	7.5	7.3	7.1	6.9	6.7	6.6	6.4	6.2	6.0	5.9	5.7	5.5	
23.75	30.2	28.5	27.2	25.5	24.3	22.8	21.1	19.9	18.2	16.6	15.2	14.0	12.2	23.75
	6.6	6.5	6.3	6.2	6.0	5.9	5.7	5.5	5.3	5.2	5.0	4.8	4.6	
23.83	30.0	28.4	27.0	25.4	24.1	22.6	21.0	19.7	18.0	16.5	15.0	13.8	12.1	23.83
	5.6	5.4	5.2	5.0	4.8	4.6	4.4	4.3	4.1	4.0	3.8	3.6	3.4	
23.91	29.8	28.2	26.9	25.3	23.9	22.4	20.9	19.5	17.9	16.4	14.8	13.6	12.0	23.91
	4.6	4.4	4.2	4.0	3.8	3.7	3.5	3.3	3.1	3.0	2.8	2.6	2.4	
24.00	29.6	28.1	26.7	25.2	23.7	22.2	20.7	19.3	17.8	16.3	14.8	13.4	11.9	24.00
	3.6	3.4	3.2	3.0	2.8	2.6	2.4	2.2	2.1	2.0	1.8	1.7	1.5	
	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.8	10.9	11.0	11.1	11.2	

TABLE 72 (Continued).

Standardizing table for ice cream mix No. 7 testing:

12.00% Fat
9.50% M. S. N. F.
14.00% Sugar
.50% Gelatin
36.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: Pounds butter.
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.8	10.9	11.0	11.1	11.2	
24.08	29.4 2.6	27.9 2.4	26.5 2.2	25.0 2.0	23.5 1.8	22.0 1.6	20.5 1.4	19.1 1.2	17.6 1.1	16.1 1.0	14.6 .8	13.2 .7	11.7 .5	24.08
24.16	29.2 1.6	27.7 1.4	26.3 1.2	24.8 1.0	23.3 .8	21.8 .6	20.3 .4	18.9 .2	17.4 .1	15.9 .0	14.8 1	13.5 2	12.3 3	24.16
24.24	29.0 .5	27.5 .3	26.1 .1	24.7 .0	23.4 1	22.2 2	21.0 3	19.7 4	18.5 5	17.3 6	16.0 7	14.8 8	13.5 9	24.24
24.33	29.6 3	28.4 4	27.1 5	25.9 6	24.7 7	23.4 8	22.2 10	21.0 11	19.7 12	18.5 13	17.3 14	16.0 15	14.8 16	24.33
24.41	30.8 9	29.6 10	28.4 11	27.1 12	25.9 13	24.7 14	23.4 15	22.2 17	21.0 18	19.7 19	18.5 20	17.3 21	16.0 22	24.41
24.49	32.1 15	30.8 16	29.6 17	28.4 18	27.1 19	25.9 20	24.7 21	23.4 22	22.2 24	21.0 25	19.7 26	18.5 27	17.3 28	24.49
24.58	33.3 21	32.1 22	30.8 23	29.6 24	28.4 25	27.1 26	25.9 27	24.7 28	23.4 29	22.2 31	21.0 32	19.7 33	18.5 34	24.58
24.66	34.5 27	33.3 28	32.1 29	30.8 30	29.6 31	28.4 32	27.1 33	25.9 34	24.7 35	23.4 36	22.2 38	21.0 39	19.7 40	24.66
24.74	35.7 33	34.5 34	33.3 35	32.1 36	30.8 37	29.6 38	28.4 39	27.1 40	25.9 41	24.7 42	23.4 43	22.2 45	21.0 46	24.74
24.83	37.0 39	35.7 40	34.5 41	33.3 42	32.1 43	30.8 44	29.6 45	28.4 47	27.1 48	25.9 49	24.7 51	23.4 52	22.2 53	24.83
24.91	38.2 46	37.0 47	35.7 48	34.5 49	33.3 50	32.1 51	30.8 52	29.6 53	28.4 54	27.1 55	25.9 56	24.7 57	23.4 58	24.91
24.99	39.4 52	38.2 53	37.0 54	35.7 55	34.5 56	33.3 57	32.1 58	30.8 59	29.6 60	28.4 61	27.1 62	25.9 63	24.7 64	24.99
25.07	40.7 58	39.4 59	38.2 60	37.0 61	35.7 62	34.5 63	38.3 64	32.1 65	30.8 66	29.6 67	28.4 68	27.1 69	25.9 70	25.07
25.16	41.9 64	40.7 65	39.4 66	38.2 67	37.0 68	35.7 69	34.5 70	33.3 71	32.1 72	30.8 73	29.6 74	28.4 75	27.1 76	25.16
25.24	43.2 70	41.9 71	40.7 72	39.4 73	38.2 74	37.0 75	35.7 76	34.5 77	33.3 78	32.1 79	30.8 80	29.6 81	28.4 82	25.24
25.33	44.4 76	43.2 77	41.9 78	40.7 79	39.4 80	38.2 81	37.0 82	35.7 83	34.5 84	33.3 86	32.1 87	30.8 88	29.6 89	25.33
25.41	45.6 82	44.4 83	43.2 84	41.9 85	40.7 86	39.4 87	38.2 88	37.0 89	35.7 90	34.5 92	33.3 93	32.1 94	30.8 95	25.41
25.49	46.8 88	45.6 89	44.4 90	43.2 91	41.9 92	40.7 93	39.4 94	38.2 95	37.0 96	35.7 97	34.5 98	33.3 10	32.1 101	25.49
25.58	48.1 94	46.8 95	45.6 96	44.4 97	43.2 98	41.9 99	40.7 100	39.4 101	38.2 102	37.0 103	35.7 104	34.5 106	33.3 107	25.58
25.66	49.3 100	48.1 101	46.8 102	45.6 103	44.4 104	43.2 105	41.9 106	40.7 107	39.4 108	38.2 109	37.0 110	35.7 111	34.5 112	25.66
	10.0	10.1	10.2	10.3	10.4	10.5	10 6	10.7	10.8	10.9	11.0	11.1	11.2	

TABLE 72 (Continued).

Standardizing table for ice cream mix No. 7 testing:

12.00% Fat
9.50% M. S. N. F.
14.00% Sugar
.50% Gelatin
36.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: Pounds butter.
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

	11.3	11.	11.5	11.6	11.7	11.8	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6.	
22.33	13.9	12.4	10.9	9.4	7.9	6.4	5.0	3.5	2.0	.5					
	21.8	21.6	21.4	21.2	21.1	20.9	20.7	(C) 20.5	20.3	20.1	3 20.6	9 21.4	16 22.3	22 23.2	22.33
22.41	13.7	12.2	10.7	9.2	7.7	6.2	4.8	3.3	1.8	.3					
	20.8	20.6	20.4	20.2	20.0	19.9	19.7	19.5	19.3	19.1	4 19.7	10 20.6	17 21.4	23 22.3	22.41
22.50	13.5	12.0	10.5	9.0	7.5	6.0	4.7	3.1	1.6	.1					
	19.8	19.6	19.4	19.2	19.1	18.9	18.7	18.5	18.3	18.1	5 18.8	11 19.7	18 20.6	24 21.4	22.50
22.58	13.3	11.8	10.3	8.9	7.3	5.8	4.5	3.0	1.5	.0					
	18.7	18.5	18.3	18.2	18.0	17.9	17.7	17.5	17.3	17.0	5 17.9	12 18.8	19 19.7	24 20.6	22.58
22.66	13.1	11.6	10.1	8.7	7.2	5.7	4.4	2.8	1.3						
	17.7	17.5	17.3	17.2	17.0	16.8	16.6	16.4	16.2	1 16.1	6 17.0	13 17.9	19 18.8	25 19.7	22.66
22.75	13.0	11.4	10.0	8.5	7.0	5.5	4.2	2.7	1.2						
	16.7	16.6	16.4	16.2	16.0	15.8	15.6	15.4	15.2	2 15.2	7 16.1	14 17.0	20 17.9	26 18.8	22.75
22.83	12.8	11.2	9.9	8.3	6.8	5.3	4.0	2.5	1.0						
	15.6	15.4	15.2	15.0	14.9	14.7	14.5	14.3	14.1	3 14.3	8 15.2	15 16.1	20 17.0	27 17.9	22.83
22.91	12.6	11.0	9.7	8.1	6.6	5.1	3.9	2.4	.8						
	14.6	14.4	14.2	14.0	13.9	13.7	13.5	13.3	13.1	3 13.4	8 14.3	16 15.2	21 16.1	27 17.0	22.91
23.00	12.4	10.9	9.5	8.0	6.4	5.0	3.7	2.2	.7						
	13.6	13.4	13.2	13.0	12.9	12.7	12.5	12.3	12.1	4 13.5	9 13.4	16 14.3	22 15.2	28 16.1	23.00
23.08	12.2	10.7	9.3	7.8	6.2	4.8	3.5	2.0	.5						
	12.6	12.4	12.2	12.0	11.9	11.7	11.5	11.3	11.1	5 11.6	10 12.5	17 13.4	23 14.3	29 15.2	23.08
23.16	12.0	10.5	9.1	7.6	6.0	4.6	3.3	1.9	.3						
	11.5	11.3	11.1	10.9	10.8	10.6	10.4	10.2	10.0	5 10.7	11 11.6	18 12.5	23 13.4	30 14.3	23.16
23.25	11.9	10.3	9.0	7.4	5.9	4.5	3.1	1.7	.1						
	10.5	10.3	10.1	10.0	9.8	9.6	9.4	9.2	9.0	6 9.8	12 10.7	19 11.6	24 12.5	31 13.4	23.25
23.33	11.7	10.1	8.8	7.2	5.7	4.3	3.0	1.5	.0						
	9.5	9.3	9.1	8.9	8.8	8.6	8.4	8.2	8.0	7 8.9	12 9.8	20 10.7	25 11.6	31 12.5	23.33
23.41	11.5	10.0	8.6	7.0	5.5	4.2	2.8	1.3							
	8.5	8.3	8.1	8.0	7.8	7.6	7.4	7.2	7.1	7 8.0	13 8.9	20 9.8	26 10.7	32 11.6	23.41
23.49	11.3	9.8	8.4	6.9	5.3	4.0	2.6	1.1							
	7.3	7.1	7.0	6.8	6.6	6.4	6.2	6.1	6.3	8 7.1	14 8.0	21 8.9	27 9.8	33 10.7	23.49
23.58	11.2	9.6	8.2	6.7	5.2	3.8	2.4	.9							
	6.3	6.2	6.0	5.9	5.7	5.5	5.3	5.1	5.4	8 6.3	15 7.1	22 8.0	28 8.9	34 9.8	23.58
23.66	11.0	9.5	8.0	6.6	5.0	3.7	2.2	.8							
	5.3	5.1	5.0	4.9	4.7	4.5	4.3	4.1	4.5	9 5.4	16 6.3	23 7.1	29 8.0	35 8.9	23.66
23.75	10.9	9.3	7.9	6.5	4.9	3.5	2.0	.6							
	4.4	4.2	4.0	3.9	3.7	3.5	3.3	3.1	3.6	10 4.5	16 5.4	24 6.3	30 7.1	36 8.0	23.75
23.83	10.8	9.1	7.7	6.3	4.8	3.4	1.9	.4							
	3.2	3.0	2.9	2.7	2.6	2.4	2.2	2.0	2.7	11 3.6	17 4.5	24 5.4	31 6.3	37 7.1	23.83
23.91	10.6	9.0	7.6	6.1	4.7	3.2	1.7	0.2							
	2 2	2.0	1.9	1.8	1.6	1.4	1.2	1.0	1.8	11 2.7	18 3.6	25 4.5	31 5.4	38 6.3	23.91
24.00	10.4	8.9	7.4	5.9	4.5	3.0	1.5								
	1.3	1.1	.9	.8	.6	.4	.2	0	6 .9	12 1.8	18 2.7	26 3.6	32 4.5	38 5.4	24.00
	11.3	11.4	11.5	11.6	11.7	11.8	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	

TABLE 72 (Continued).

Standardizing table for ice cream mix No. 7 testing:

12.00% Fat
9.50% M. S. N. F.
14.00% Sugar
.50% Gelatin
36.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: Pounds butter.
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

	11.3	11.4	11.5	11.6	11.7	11.8	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	
24.08	10.2 .3	8.7 .1	7.4 1	6.2 2	4.9 3	3.7 4	2.5 5	1.2 6	7	13 .9	19 1.8	26 2.7	33 3.6	39 4.5	24.08
24.16	11.1 4	9.9 5	8.6 6	7.4 7	6.2 8	4.9 9	3.7 10	2.5 12	1.2 13	14	20 .9	27 1.8	33 2.7	40 3.6	24.16
24.24	12.3 10	11.1 12	9.9 13	8.6 14	7.4 15	6.2 16	4.9 17	3.7 18	2.5 19	1.2 20	21	28 .9	34 1.8	40 2.7	24.24
24.33	13.5 18	12.3 19	11.1 20	9.9 21	8.6 22	7.4 23	6.2 24	4.9 25	3.7 26	2.5 27	1.2 28	29	35 .9	41 1.8	24.33
24.41	14.8 23	13.5 24	12.3 26	11.1 27	9.9 28	8.6 29	7.4 30	6.2 31	4.9 32	3.7 33	2.5 34	1.2 35	36	42 .9	24.41
24.49	16.0 29	14.8 30	13.5 31	12.3 33	11.1 34	9.9 35	8.6 36	7.4 37	6.2 38	4.9 39	3.7 40	2.5 41	1.2 42	43	24.49
24.58	17.3 35	16.0 36	14.8 37	13.5 38	12.3 40	11.1 42	9.9 43	8.6 44	7.4 45	6.2 46	4.9 47	3.7 47	2.5 48	1.2 49	24.58
24.66	18.5 41	17.3 42	16.0 43	14.8 44	13.5 45	12.3 47	11.1 48	9.9 49	8.6 50	7.4 51	6.2 52	4.9 53	3.7 54	2.5 55	24.66
24.74	19.7 47	18.5 48	17.3 49	16.0 50	14.8 51	13.5 52	12.3 54	11.1 56	9.9 57	8.6 58	7.4 59	6.2 60	4.9 61	3.7 62	24.74
24.83	21.0 54	19.7 55	18.5 56	17.3 57	16.0 58	14.8 59	13.5 61	12.3 62	11.1 63	9.9 64	8.6 65	7.4 66	6.2 67	4.9 68	24.83
24.91	22.2 59	21.0 61	19.7 62	18.5 63	17.3 64	16.0 65	14.8 66	13.5 67	12.3 68	11.1 70	9.9 71	8.6 72	7.4 73	6.2 74	24.91
24.99	23.4 65	22.2 67	21.0 68	19.7 69	18.5 70	17.3 71	16.0 72	14.8 73	13.5 74	12.3 76	11.1 77	9.9 78	8.6 79	7.4 80	24.99
25.07	24.7 71	23.4 72	22.2 74	21.0 75	19.7 76	18.5 77	17.3 78	16.0 79	14.8 80	13.5 81	12.3 83	11.1 84	9.9 85	8.6 86	25.07
25.16	25.9 77	24.7 78	23.4 79	22.2 81	21.0 82	19.7 83	18.5 84	17.3 85	16.0 86	14.8 87	13.5 88	12.3 90	11.1 91	9.9 92	25.16
25.24	27.1 83	25.9 84	24.7 85	23.4 87	22.2 88	21.0 89	19.7 90	18.5 91	17.3 92	16.0 93	14.8 94	13.5 96	12.3 97	11.1 98	25.24
25.33	28.4 90	27.1 91	25.9 92	24.7 93	23.4 94	22.2 96	21.0 97	19.7 98	18.5 99	17.3 100	16.0 101	14.8 102	13.5 103	12.3 105	25.33
25.41	29.6 96	28.4 97	27.1 98	25.9 99	24.7 100	23.4 101	22.2 102	21.0 103	19.7 104	18.5 105	17.3 106	16.0 107	14.8 109	13.5 110	25.41
25.49	30.8 102	29.6 103	28.4 104	27.1 105	25.9 106	24.7 107	23.4 109	22.2 110	21.0 111	19.7 112	18.5 113	17.3 114	16.0 115	14.8 116	25.49
25.58	32.1 108	30.8 109	29.6 110	28.4 111	27.1 112	25.9 113	24.7 114	23.4 116	22.2 117	21.0 118	19.7 119	18.5 120	17.3 121	16.0 122	25.58
25.66	33.3 114	32.1 115	30.8 116	29.6 117	28.4 118	27.1 119	25.9 120	24.7 121	23.4 122	22.2 124	21.0 125	19.7 126	18.5 127	17.3 128	25.66
	11.3	11.4	11.5	11.6	11.7	11.8	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	

TABLE 72 (Continued).

Standardizing table for ice cream mix No. 7 testing: 12.00% Fat, 9.50% M. S. N. F., 14.00% Sugar, .50% Gelatin, 36.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: Pounds butter.
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

	12.7	12.8	12.9	13.0	13.1	13.2	13.3	13.4	13.5	13.6	13.7	13.8	13.9	14.0	
22.33	29 24.1	35 25.0	42 25.9	48 26.8	54 27.7	61 28.6	67 29.5	74 30.4	80 31.3	86 32.2	93 33.1	99 33.9	106 34.5	112 35.7	22.33
22.41	30 23.2	36 24.1	43 25.0	49 25.9	55 26.8	62 27.7	68 28.6	75 29.5	81 30.4	87 31.3	94 32.2	100 33.1	107 33.9	113 34.8	22.41
22.50	31 22.3	37 23.2	44 24.1	50 25.0	56 25.9	63 26.8	69 27.7	76 28.6	82 29.5	88 30.4	95 31.3	101 32.2	108 33.1	114 33.9	22.50
22.58	31 21.4	37 22.3	44 23.2	50 24.1	56 25.0	63 25.9	69 26.8	76 27.7	82 28.6	88 29.5	95 30.4	101 31.3	108 32.2	115 33.1	22.58
22.66	32 20.6	38 21.4	45 22.3	51 23.2	57 24.1	64 25.0	70 25.9	77 26.8	83 27.7	89 28.6	96 29.5	102 30.4	109 31.3	115 32.2	22.66
22.75	33 19.7	39 20.6	46 21.4	52 22.3	58 23.2	65 24.1	71 25.0	78 25.9	84 26.8	90 27.7	97 28.6	103 29.5	110 30.4	116 31.3	22.75
22.83	34 18.8	40 19.7	47 20.6	53 21.4	59 22.3	66 23.2	72 24.1	79 25.0	85 25.9	91 26.8	98 27.7	104 28.6	111 29.5	117 30.4	22.83
22.91	34 17.9	40 18.8	47 19.7	53 20.6	59 21.4	66 22.3	72 23.2	79 24.1	85 25.0	91 25.9	98 26.8	104 27.7	111 28.6	118 29.5	22.91
23.00	35 17.0	41 17.9	48 18.8	54 19.7	60 20.6	67 21.4	73 22.3	80 23.2	86 24.1	92 25.0	99 25.9	105 26.8	112 27.7	119 28.6	23.00
23.08	36 16.1	42 17.0	49 17.9	55 18.8	61 19.7	68 20.6	74 21.4	81 22.3	87 23.2	93 24.1	100 25.0	106 25.9	113 26.8	119 27.7	23.08
23.16	37 15.2	43 16.1	50 17.0	56 17.9	62 18.8	69 19.7	75 20.6	82 21.4	88 22.3	94 23.2	101 24.1	107 25.0	114 25.9	120 26.8	23.16
23.25	38 14.3	44 15.2	51 16.1	57 17.0	63 17.9	70 18.8	76 19.7	83 20.6	89 21.4	95 22.3	102 23.2	108 24.1	115 25.0	121 25.9	23.25
23.33	38 13.4	44 14.3	51 15.2	57 16.1	63 17.0	70 17.9	76 18.8	83 19.7	89 20.6	95 21.4	102 22.3	108 23.2	115 24.1	122 25.0	23.33
23.41	39 12.5	45 13.4	52 14.3	58 15.2	64 16.1	71 17.0	77 17.9	84 18.8	90 19.7	96 20.6	103 21.4	109 22.3	116 23.2	123 24.1	23.41
23.49	40 11.6	46 12.5	53 13.4	59 14.3	65 15.2	72 16.1	78 17.0	85 17.9	91 18.8	97 19.7	104 20.6	110 21.4	117 22.3	123 23.2	23.49
23.58	41 10.7	47 11.6	54 12.5	60 13.4	66 14.3	73 15.2	79 16.1	86 17.0	92 17.9	98 18.8	105 19.7	111 20.6	118 21.4	124 22.3	23.58
23.66	41 9.8	48 10.7	54 11.6	60 12.5	67 13.4	74 14.3	79 15.2	87 16.1	93 17.0	99 17.9	106 18.8	112 19.7	119 20.6	125 21.4	23.66
23.75	42 8.9	48 9.8	55 10.7	61 11.6	68 12.5	75 13.4	80 14.3	87 15.2	93 16.1	99 17.0	106 17.9	112 18.8	119 19.7	126 20.6	23.75
23.83	43 8.0	49 8.9	55 9.8	62 10.7	69 11.6	75 12.5	81 13.4	88 14.3	94 15.2	100 16.1	107 17.0	113 17.9	120 18.8	127 19.7	23.83
23.91	44 7.1	50 8.0	56 8.9	63 9.8	70 10.7	76 11.6	82 12.5	89 13.4	95 14.3	101 15.2	108 16.1	114 17.0	121 17.9	128 18.8	23.91
24.00	45 6.3	51 7.1	57 8.0	64 8.9	70 9.8	77 10.7	82 11.6	89 12.5	96 13.4	101 14.3	108 15.2	114 16.1	121 17.0	128 17.9	24.00
	12.7	12.8	12.9	13.0	13.1	13.2	13.3	13.4	13.5	13.6	13.7	13.8	13.9	14.0	

TABLE 72 (Continued).

Standardizing table for ice cream mix No. 7 testing:

12.00% Fat
9.50% M. S. N. F.
14.00% Sugar
.50% Gelatin
36.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: Pounds butter.
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

	12.7	12.8	12.9	13.0	13.1	13.2	13.3	13.4	13.5	13.6	13.7	13.8	13.9	14.0	
24.08	45 5.4	52 6.3	58 7.1	65 8.0	71 8.9	77 9.8	83 10.7	90 11.6	97 12.5	103 13.4	109 14.3	115 15.2	122 16.1	129 17.0	24.08
24.16	46 4.5	52 5.4	59 6.3	66 7.1	72 8.0	78 8.9	84 9.8	91 10.7	98 11.6	104 12.5	110 13.4	116 14.3	123 15.2	130 16.1	24.16
24.24	47 3.6	53 4.5	59 5.4	67 6.3	73 7.1	79 8.0	85 8.9	91 9.8	99 10.7	105 11.6	111 12.5	117 13.4	123 14.3	131 15.2	24.24
24.33	47 2.7	54 3.6	60 4.5	67 5.4	74 6.3	80 7.1	86 8.0	92 8.9	99 9.8	106 10.7	112 11.6	118 12.5	124 13.4	132 14.3	24.33
24.41	48 1.8	54 2.7	61 3.6	68 4.5	74 5.4	81 6.3	87 7.1	93 8.0	100 8.9	106 9.8	113 10.7	119 11.6	124 12.5	133 13.4	24.41
24.49	49 .9	55 1.8	61 2.7	69 3.6	75 4.5	81 5.4	88 6.3	94 7.1	101 8.0	107 8.9	113 9.8	120 10.7	125 11.6	133 12.5	24.49
24.58	50	56 .9	62 1.8	69 2.7	76 3.6	82 4.5	88 5.4	95 6.3	102 7.1	108 8.0	114 8.9	120 9.8	126 10.7	134 11.6	24.58
24.66	1.2 56	57	63 .9	70 1.8	76 2.7	83 3.6	89 4.5	95 5.4	103 6.3	109 7.1	115 8.0	121 8.9	127 9.8	134 10.7	24.66
24.74	2.5 62	1.2 63	64	71 .9	77 1.8	83 2.7	90 3.6	96 4.5	103 5.4	110 6.3	116 7.1	122 8.0	128 8.9	135 9.8	24.74
24.83	3.7 69	2.5 70	1.2 71	72	78 .9	84 1.8	90 2.7	97 3.6	104 4.5	110 5.4	117 6.3	123 7.1	129 8.0	135 8.9	24.83
24.91	4.9 75	3.7 76	2.5 77	1.2 78	79	85 .9	91 1.8	97 2.7	105 3.6	111 4.5	117 5.4	124 6.3	130 7.1	136 8.0	24.91
24.99	6.2 81	4.9 82	3.7 83	2.5 84	1.2 85	86	92 .9	98 1.8	105 2.7	112 3.6	118 4.5	124 5.4	131 6.3	136 7.1	24.99
25.07	7.4 87	6.2 88	4.9 89	3.7 90	2.5 91	1.2 92	93	99 .9	106 1.8	112 2.7	119 3.6	125 4.5	131 5.4	137 6.3	25.07
25.16	8.6 93	7.4 94	6.2 95	4.9 96	3.7 97	2.5 98	1.2 99	100	107 .9	113 1.8	119 2.7	126 3.6	132 4.5	138 5.4	25.16
25.24	9.9 99	8.6 100	7.4 101	6.2 102	4.9 103	3.7 104	2.5 105	1.2 107	108	114 .9	120 1.8	126 2.7	133 3.6	139 4.5	25.24
25.33	11.1 106	9.9 107	8.6 108	7.4 109	6.2 110	4.9 111	3.7 112	2.5 113	1.2 114	115	121 .9	127 1.8	133 2.7	140 3.6	25.33
25.41	12.3 111	11.1 113	9.9 114	8.6 115	7.4 116	6.2 117	4.9 118	3.7 119	2.5 120	1.2 121	122	128 .9	134 1.8	140 2.7	25.41
25.49	13.5 118	12.3 119	11.1 120	9.9 121	8.6 122	7.4 123	6.2 124	4.9 125	3.7 126	2.5 127	1.2 128	129	135 .9	141 1.8	25.49
25.58	14.8 123	13.5 124	12.3 126	11.1 127	9.9 128	8.6 129	7.4 130	6.2 131	4.9 132	3.7 133	2.5 134	1.2 135	136	142 .9	25.58
25.66	16.0 129	14.8 130	13.5 131	12.3 132	11.1 133	9.9 134	8.6 136	7.4 137	6.2 138	4.9 139	3.7 140	2.5 141	1.2 142	143	25.66
	12.7	12.8	12.9	13.0	13.1	13.2	13.3	13.4	13.5	13.6	13.7	13.8	13.9	14.0	

TABLE 73.

Standardizing table for ice cream mix No. 8 testing:

16.00% Fat
7.50% M. S. N. F.
14.00% Sugar
.50% Gelatin
38.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: Pounds butter.
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

	14.0	14.1	14.2	14.3	14.4	14.5	14.6	14.7	14.8	14.9	15.0	15.1	15.2	15.3	
21.00	35.0	33.4	31.8	30.2	28.6	27.0	25.4	23.8	22.2	20.6	19.0	17.5	15.9	14.3	21.00
	15.1	14.9	14.7	14.6	14.4	14.3	14.1	14.0	13.9	13.7	13.6	13.4	13.3	13.1	
21.05	34.8	33.2	31.7	30.1	28.1	26.9	25.3	23.7	22.0	20.5	18.9	17.4	15.8	14.1	21.05
	14.5	14.4	14.2	14.1	13.9	13.8	13.6	13.5	13.3	13.2	13.0	12.9	12.7	12.6	
21.10	34.6	33.1	31.5	29.9	28.3	26.8	25.1	23.5	21.9	20.3	18.7	17.2	15.7	13.9	21.10
	13.9	13.7	13.6	13.4	13.3	13.1	13.0	12.8	12.6	12.5	12.3	12.2	12.1	11.9	
21.15	34.5	32.9	31.3	29.8	28.1	26.7	25.0	23.4	21.7	20.1	18.6	17.0	15.6	13.8	21.15
	13.3	13.1	13.0	12.8	12.7	12.5	12.4	12.2	12.1	11.9	11.8	11.6	11.5	11.3	
21.20	34.4	32.8	31.2	29.7	28.0	26.5	24.9	23.2	21.6	20.0	18.5	16.8	15.4	13.6	21.20
	12.7	12.6	12.4	12.3	12.1	12.0	11.8	11.7	11.5	11.4	11.2	11.1	10.9	10.8	
21.25	34.2	32.6	31.0	29.5	27.9	26.3	24.7	23.1	21.4	19.8	18.3	16.7	15.3	13.5	21.25
	12.1	12.0	11.8	11.7	11.5	11.4	11.2	11.1	10.9	10.8	10.6	10.5	10.3	10.2	
21.30	34.0	32.4	30.9	29.3	27.7	26.1	24.6	22.9	21.3	19.7	18.1	16.5	15.1	13.5	21.30
	11.5	11.3	11.2	11.0	10.9	10.7	10.6	10.4	10.3	10.1	10.0	9.8	9.7	9.5	
21.35	33.9	32.3	30.8	29.1	27.6	25.9	24.4	22.8	21.1	19.5	18.0	16.4	15.0	13.1	21.35
	10.9	10.8	10.6	10.4	10.3	10.1	10.0	9.8	9.7	9.5	9.4	9.2	9.1	8.9	
21.40	33.7	36.1	30.6	29.0	27.4	25.7	24.2	22.6	21.0	19.4	17.8	16.2	14.8	13.0	21.40
	10.3	10.1	9.9	9.7	9.6	9.4	9.3	9.1	9.0	8.8	8.7	8.6	8.5	8.3	
21.45	33.6	32.0	30.5	28.8	27.3	25.6	24.1	22.5	20.9	19.2	17.6	16.1	14.6	12.8	21.45
	9.7	9.6	9.4	9.3	9.1	9.0	8.8	8.7	8.5	8.4	8.2	8.1	7.9	7.8	
21.50	33.4	31.8	30.3	28.7	27.1	25.4	23.9	22.3	20.7	19.1	17.5	16.0	14.5	12.7	21.50
	9.0	8.9	8.9	8.8	8.6	8.5	8.3	8.1	7.9	7.8	7.6	7.5	7.3	7.2	
21.55	33.3	31.7	30.2	28.5	26.9	25.3	23.7	22.1	20.6	18.9	17.3	15.8	14.3	12.6	21.55
	8.4	8.3	8.2	8.1	7.9	7.8	7.6	7.5	7.3	7.2	7.0	6.9	6.7	6.5	
21.60	33.1	31.5	30.0	28.3	26.8	25.1	23.5	21.9	20.4	18.8	17.1	15.7	14.1	12.4	21.60
	7.8	7.6	7.5	7.3	7.2	7.0	6.9	6.7	6.6	6.4	6.3	6.1	6.0	5.8	
21.65	32.9	31.4	29.9	28.2	26.6	25.0	23.3	21.7	20.3	18.7	17.0	15.6	14.0	12.3	21.65
	7.2	7.0	6.8	6.7	6.5	6.4	6.2	6.1	5.9	5.8	5.6	5.5	5.3	5.2	
21.70	32.8	31.2	29.7	28.0	26.4	24.8	23.2	21.6	20.1	18.5	16.9	15.5	13.9	12.1	21.70
	6.6	6.4	6.3	6.1	6.0	5.8	5.7	5.5	5.4	5.2	5.1	4.9	4.8	4.6	
21.75	32.6	31.1	29.6	27.9	26.3	24.6	23.0	21.5	20.0	18.4	16.7	15.3	13.7	12.0	21.75
	6.0	5.9	5.8	5.6	5.5	5.3	5.1	4.9	4.8	4.6	4.5	4.3	4.2	4.0	
21.80	32.5	30.9	29.4	27.7	26.1	24.5	22.8	21.3	19.8	18.2	16.6	15.1	13.5	11.8	21.80
	5.4	5.3	5.1	4.9	4.8	4.6	4.5	4.3	4.2	4.0	3.9	3.7	3.6	3.4	
21.85	32.4	30.7	29.3	27.5	26.0	24.3	22.7	21.2	19.6	18.1	16.5	15.0	13.3	11.7	21.85
	4.8	4.7	4.6	4.5	4.3	4.1	3.9	3.8	3.6	3.5	3.3	3.1	3.0	2.8	
21.90	32.2	30.6	29.1	27.4	25.8	24.2	22.6	21.0	19.5	17.9	16.3	14.8	13.1	11.5	21.90
	4.2	4.0	3.9	3.7	3.6	3.4	3.3	3.1	3.0	2.8	2.7	2.5	2.4	2.2	
21.95	32.5	30.4	28.9	27.2	25.6	24.0	22.4	20.9	19.3	17.7	16.1	14.6	13.0	11.3	21.95
	3.6	3.5	3.3	3.2	3.0	2.9	2.7	2.5	2.3	2.2	2.0	1.8	1.7	1.6	
22.00	31.9	30.3	28.7	27.1	25.5	23.9	22.3	20.7	19.1	17.5	15.9	14.4	12.8	11.2	22.00
	3.0	2.9	2.7	2.6	2.4	2.3	2.1	2.0	1.8	1.7	1.5	1.4	1.2	1.1	
	14.0	14.1	14.2	14.3	14.4	14.5	14.6	14.7	14.8	14.9	15.0	15.1	15.2	15.3	

TABLE 73 (Continued).

Standardizing table for ice cream mix No. 8 testing:

16.00% Fat
7.50% M. S. N. F.
14.00% Sugar
.50% Gelatin
38.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: Pounds butter.
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

	14.0	14.1	14.2	14.3	14.4	14.5	14.6	14.7	14.8	14.9	15.0	15.1	15.2	15.3	
22.05	31.7 2.4	30.2 2.3	28.6 2.1	27.0 2.0	25.4 1.8	23.8 1.7	22.2 1.5	20.6 1.4	19.0 1.2	17.4 1.1	15.8 .9	14.3 .8	12.6 .6	11.1 .5	22.05
22.10	31.6 1.8	30.0 1.7	28.4 1.5	26.8 1.4	25.2 1.2	23.6 1.1	22.0 .9	20.4 .8	18.9 .6	17.2 .5	15.6 .3	14.1 .2	12.5 .0	11.3 1	22.10
22.15	31.5 1.2	29.9 1.1	28.3 .9	26.7 .8	25.1 .6	23.5 .5	21.9 .3	20.3 .2	18.8 .0	17.5 1	16.3 2	15.0 3	13.8 5	12.5 6	22.15
22.20	31.4 .6	29.7 .5	28.1 .3	26.5 .2	25.0 .0	23.8 1	22.5 2	21.3 3	20.0 4	18.8 5	17.5 6	16.3 8	15.0 9	13.8 10	22.20
22.25	31.3 0	30.0 1	28.8 2	27.5 3	26.3 4	25.0 5	23.8 6	22.5 7	21.3 8	20.0 9	18.8 10	17.5 11	16.3 13	15.0 14	22.25
22.30	32.5 6	31.3 7	30.0 8	28.8 9	27.5 10	26.3 11	25.0 12	23.8 13	22.5 14	21.3 15	20.0 16	18.8 18	17.5 19	16.3 20	22.30
22.35	33.8 10	32.5 11	31.3 12	30.0 13	28.8 14	27.5 15	26.3 16	25.0 17	23.8 18	22.5 19	21.3 20	20.0 21	18.8 22	17.5 23	22.35
22.40	35.0 14	33.8 15	32.5 16	31.3 17	30.0 18	28.8 19	27.5 20	26.3 21	25.0 22	23.8 23	22.5 24	21.3 25	20.0 26	18.8 27	22.40
22.45	36.3 18	35.0 19	33.8 20	32.5 21	31.3 22	30.0 23	28.8 24	27.5 25	26.3 26	25.0 27	23.8 28	22.5 29	21.3 30	20.0 31	22.45
22.50	37.5 23	36.3 24	35.0 25	33.8 26	32.5 27	31.3 28	30.0 29	28.8 30	27.5 31	26.3 32	25.0 33	23.8 34	22.5 35	21.3 36	22.50
22.55	38.8 27	37.5 28	36.3 29	35.0 30	33.8 31	32.5 32	31.3 33	30.0 34	28.8 35	27.5 36	26.3 37	25.0 38	23.8 39	22.5 40	22.55
22.60	40.0 31	38.8 32	37.5 33	36.3 34	35.0 35	33.8 36	32.5 37	31.3 38	30.0 39	28.8 40	27.5 41	26.3 42	25.0 43	23.8 44	22.60
22.65	41.3 36	40.0 37	38.8 38	37.5 39	36.3 40	35.0 41	33.8 42	32.5 43	31.3 44	30.0 45	38.8 46	27.5 47	26.3 48	25.0 49	22.65
22.70	42.5 40	41.3 41	40.0 42	38.8 43	37.5 44	36.3 45	35.0 46	33.8 47	32.5 48	31.3 49	30.0 50	28.8 51	27.5 52	26.3 53	22.70
22.75	43.8 44	42.5 45	41.3 46	40.0 47	38.8 48	37.5 49	36.3 50	35.0 51	33.8 52	32.5 53	31.3 54	30.0 55	28.8 56	27.5 57	22.75
22.80	45.0 48	43.8 49	42.5 50	41.3 51	40.0 52	38.8 53	37.5 54	36.3 55	35.0 56	33.8 57	32.5 58	31.3 59	30.0 60	28.8 61	22.80
22.85	46.3 53	45.0 54	43.8 55	42.5 56	41.3 57	40.0 58	38.8 59	37.5 60	36.3 61	35.0 62	33.8 63	32.5 64	31.3 65	30.0 66	22.85
22.90	47.5 57	46.3 58	45.0 59	43.8 60	42.5 61	41.3 62	40.0 63	38.8 64	37.5 65	36.3 66	35.0 67	33.8 68	32.5 69	31.3 70	22.90
22.95	48.8 61	47.5 62	46.3 63	45.0 64	43.8 65	42.5 66	41.3 67	40.0 68	38.8 69	37.5 70	36.3 71	35.0 72	33.8 73	32.5 74	22.95
23.00	50.0 65	48.8 66	47.5 67	46.3 68	45.0 69	43.8 70	42.5 71	41.3 72	40.0 73	38.8 74	37.5 75	36.3 76	35.0 77	33.8 78	23.00
	14.0	14.1	14.2	14.3	14.4	14.5	14.6	14.7	14.8	14.9	15.0	15.1	15.2	15.3	

TABLE 73 (Continued).

Standardizing table for ice cream mix No. 8 testing:

16.00% Fat
7.50% M. S. N. F.
14.00% Sugar
.50% Gelatin
38.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: Pounds butter.
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

	15.4	15.5	15.6	15.7	15.8	15.9	16.0	16.1	16.2	16.3	16.4	16.5	16.6	16.7	
21.00	12.7	11.1	9.5	7.9	6.3	4.7	3.1	1.5							
	13.0	12.8	12.7	12.5	12.4	12.2	12.1	12.0	11.9	12.5	13.0	13.6	14.1	14.7	21.00
21.05	12.6	10.9	9.3	7.8	6.1	4.6	3.0	1.4							
	12.4	12.2	12.1	11.9	11.8	11.6	11.5	11.4	11.4	11.9	12.5	13.0	13.6	14.1	21.05
21.10	12.4	10.7	9.1	7.6	6.0	4.4	2.8	1.2							
	11.8	11.6	11.5	11.3	11.2	11.0	10.9	10.8	10.9	11.4	11.9	12.5	13.0	13.6	21.10
21.15	12.3	10.6	9.0	7.5	5.8	4.3	2.7	1.1							
	11.2	11.0	10.9	10.7	10.6	10.4	10.3	10.2	10.3	10.9	11.4	11.9	12.5	13.0	21.15
21.20	12.1	10.4	8.9	7.3	5.6	4.1	2.5	.9							
	10.6	10.5	10.3	10.2	10.0	9.8	9.7	9.6	9.8	10.3	10.9	11.4	11.9	12.5	21.20
21.25	12.0	10.3	8.7	7.1	5.3	4.0	2.4	.8							
	10.0	9.9	9.7	9.6	9.4	9.2	9.1	9.0	9.2	9.8	10.3	10.9	11.4	11.9	21.25
21.30	11.8	10.1	8.5	7.0	5.3	3.8	2.2	.6							
	9.4	9.2	9.1	8.9	8.8	8.6	8.5	8.4	8.7	9.2	9.8	10.3	10.9	11.4	21.30
21.35	11.7	10.0	8.4	6.8	5.2	3.7	2.1	.5							
	8.8	8.6	8.5	8.3	8.2	8.0	7.9	7.8	8.1	8.7	9.2	9.8	10.3	10.9	21.35
21.40	11.6	9.8	8.3	6.7	5.0	3.5	1.9	.3							
	8.2	8.0	7.9	7.7	7.6	7.4	7.3	7.2	7.6	8.1	8.7	9.2	9.8	10.3	21.40
21.45	11.4	9.7	8.1	6.6	4.9	3.4	1.8	.2							
	7.6	7.5	7.3	7.2	7.0	6.8	6.7	6.6	7.1	7.6	8.1	8.7	9.2	9.8	21.45
21.50	11.3	9.5	7.9	6.4	4.7	3.2	1.6	.0							
	7.0	6.9	6.7	6.5	6.3	6.2	6.0	5.9	6.5	7.1	7.6	8.1	8.7	9.2	21.50
21.55	11.2	9.4	7.7	6.3	4.5	3.0	1.4								
	6.3	6.2	6.0	5.9	5.7	5.6	5.4	5.4	6.0	6.5	7.1	7.6	8.1	8.7	21.55
21.60	11.1	9.2	7.6	6.1	4.4	2.8	1.2								
	5.7	5.5	5.4	5.2	5.1	4.9	4.8	4.9	5.4	6.0	6.5	7.1	7.6	8.1	21.60
21.65	11.0	9.1	7.5	6.0	4.2	2.7	1.1								
	5.0	4.9	4.7	4.6	4.4	4.3	4.2	4.3	4.9	5.4	6.0	6.5	7.1	7.6	21.65
21.70	10.8	8.9	7.3	5.8	4.1	2.5	.9								
	4.5	4.3	4.2	4.0	3.9	3.7	3.6	3.8	4.3	4.9	5.4	6.0	6.5	7.1	21.70
21.75	10.6	8.8	7.2	5.7	3.9	2.4	.8								
	3.9	3.7	3.6	3.4	3.3	3.1	3.0	3.3	3.8	4.3	4.9	5.4	6.0	6.5	21.75
21.80	10.4	8.6	7.0	5.5	3.8	2.2	.6								
	3.3	3.1	3.0	2.8	2.7	2.5	2.4	2.7	3.3	3.8	4.3	4.9	5.4	6.0	21.80
21.85	10.2	8.5	6.8	5.4	3.6	2.1	.5								
	2.7	2.5	2.4	2.2	2.1	1.9	1.8	2.2	2.7	3.3	3.8	4.3	4.9	5.4	21.85
21.90	10.0	8.3	6.7	5.2	3.5	1.9	.3								
	2.1	1.9	1.8	1.6	1.5	1.3	1.2	1.6	2.2	2.7	3.3	3.8	4.3	4.9	21.90
21.95	9.8	8.2	6.6	5.0	3.3	1.8	.2								
	1.4	1.3	1.2	1.0	.9	.7	.6	1.1	1.6	2.2	2.7	3.3	3.8	4.3	21.95
22.00	9.6	8.0	6.4	4.8	3.2	1.6	0								
	.9	.8	.6	.5	.3	.2		.5	1.1	1.6	2.2	2.7	3.3	3.8	22.00
	15.4	15.5	15.6	15.7	15.8	15.9	16.0	16.1	16.2	16.3	16.4	16.5	16.6	16.7	

TABLE 73 (Continued).

Standardizing table for ice cream mix No. 8 testing:

16.00% Fat
7.50% M. S. N. F.
14.00% Sugar
.50% Gelatin
38.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: Pounds butter.
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

	15.4	15.5	15.6	15.7	15.8	15.9	16.0	16.1	16.2	16.3	16.4	16.5	16.6	16.7	
22.05	9.5 .3	7.9 .2	6.3 .0	5.0 1	3.8 2	2.5 3	1.3 4	5	11 .5	15 1.1	20 1.6	25 2.2	29 2.7	35 3.3	22.05
22.10	10.0 2	8.8 3	7.5 4	6.3 5	5.0 7	3.8 8	2.5 9	1.3 10	11	16 .5	20 1.1	26 1.6	30 2.2	35 2.7	22.10
22.15	11.3 7	10.0 8	8.8 9	7.5 10	6.3 11	5.0 12	3.8 13	2.5 14	1.3 15	16	21 .5	26 1.1	30 1.6	36 2.2	22.15
22.20	12.5 11	11.3 12	10.0 13	8.8 14	7.5 15	6.3 16	5.0 17	3.8 18	2.5 19	1.3 20	21	27 .5	31 1.1	36 1.6	22.20
22.25	13.8 15	12.5 16	11.3 17	10.0 19	8.8 20	7.5 21	6.3 22	5.0 23	3.8 24	2.5 25	1.3 26	27	31 .5	37 1.1	22.25
22.30	15.0 21	13.8 22	12.5 23	11.3 24	10.0 25	8.8 26	7.5 27	6.3 28	5.0 29	3.8 29	2.5 30	1.3 31	32	37 .5	22.30
22.35	16.3 24	15.0 25	13.8 26	12.5 27	11.3 28	10.0 29	8.8 30	7.5 31	6.3 32	5.0 33	3.8 34	2.5 35	1.3 36	37	22.35
22.40	17.5 28	16.3 29	15.0 30	13.8 31	12.5 32	11.3 33	10.0 34	8.8 35	7.5 36	6.3 38	5.0 39	3.8 40	2.5 41	1.3 42	22.40
22.45	18.8 32	17.5 33	16.3 34	15.0 35	13.8 36	12.5 37	11.3 39	10.0 40	8.8 41	7.5 42	6.3 43	5.0 44	3.8 45	2.5 46	22.45
22.50	20.0 37	18.8 38	17.5 39	16.3 40	15.0 41	13.8 42	12.5 43	11.3 44	10.0 45	8.8 46	7.5 47	6.3 48	5.0 49	3.8 50	22.50
22.55	21.3 41	20.0 42	18.8 43	17.5 44	16.3 45	15.0 46	13.8 47	12.5 49	11.3 50	10.0 51	8.8 52	7.5 53	6.3 54	5.0 55	22.55
22.60	22.5 45	21.3 46	20.0 47	18.8 48	17.5 49	16.3 50	15.0 51	13.8 52	12.5 53	11.3 55	10.0 56	8.8 57	7.5 58	6.3 59	22.60
22.65	23.8 50	22.5 51	21.3 52	20.0 53	18.8 54	17.5 55	16.3 56	15.0 57	13.8 58	12.5 59	11.3 60	10.0 61	8.8 62	7.5 63	22.65
22.70	25.0 54	23.8 55	22.5 56	21.3 57	20.0 58	18.8 59	17.5 60	16.3 62	15.0 63	13.8 64	12.5 65	11.3 66	10.0 67	8.8 68	22.70
22.75	26.3 58	25.0 59	23.8 60	22.5 61	21.3 62	20.0 63	18.8 64	17.5 65	16.3 67	15.0 68	13.8 69	12.5 70	11.3 71	10.0 72	22.75
22.80	27.5 62	26.3 63	25.0 64	23.8 65	22.5 66	21.3 67	20.0 68	18.8 70	17.5 71	16.3 72	15.0 73	13.8 74	12.5 75	11.3 76	22.80
22.85	28.8 67	27.5 68	26.3 69	25.0 70	23.8 71	22.5 72	21.3 73	20.0 74	18.8 75	17.5 76	16.3 77	15.0 79	13.8 80	12.5 81	22.85
22.90	30.0 71	28.8 72	27.5 73	26.3 74	25.0 75	23.8 76	22.5 77	21.3 78	20.0 80	18.8 81	17.5 82	16.3 83	15.0 84	13.8 85	22.90
22.95	31.3 75	30.3 77	28.8 78	27.5 79	26.3 80	25.0 81	23.8 82	22.5 83	21.3 84	20.0 85	18.8 86	17.5 87	16.3 88	15.0 89	22.95
23.00	32.5 79	31.3 80	30.0 82	28.8 83	27.5 84	26.3 85	25.0 86	23.8 87	22.5 88	21.3 89	20.0 90	18.8 92	17.5 93	16.3 94	23.00
	15.4	15.5	15.6	15.7	15.8	15.9	16.0	16.1	16.2	16.3	16.4	16.5	16.6	16.7	

TABLE 73 (Continued).

Standardizing table for ice cream mix No. 8 testing:

16.00% Fat
7.50% M. S. N. F.
14.00% Sugar
.50% Gelatin
38.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: Pounds butter.
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

	16.8	16.9	17.0	17.1	17.2	17.3	17.4	17.5	17.6	17.7	17.8	17.9	18.0	
21.00	29 15.2	34 15.8	39 16.3	43 16.8	48 17.4	53 17.9	58 18.5	63 19.0	68 19.5	72 20.1	77 20.6	82 21.2	87 21.7	21.00
21.05	29 14.7	34 15.2	39 15.8	43 16.3	48 16.8	54 17.4	58 17.9	63 18.5	69 19.0	72 19.5	77 20.1	82 20.6	87 21.2	21.05
21.10	30 14.1	35 14.7	40 15.2	44 15.8	49 16.3	54 16.8	59 17.4	64 17.9	69 18.5	73 19.0	78 19.5	83 20.1	88 20.6	21.10
21.15	30 13.6	35 14.1	40 14.7	44 15.2	49 15.8	55 16.3	59 16.8	64 17.4	70 17.9	73 18.5	78 19.0	83 19.5	88 20.1	21.15
21.20	31 13.0	36 13.6	41 14.1	45 14.7	50 15.2	55 15.8	60 16.3	65 16.8	70 17.4	74 17.9	79 18.5	84 19.0	89 19.5	21.20
21.25	31 12.5	36 13.0	41 13.6	45 14.1	50 14.7	56 15.2	60 15.8	65 16.3	71 16.8	74 17.4	79 17.9	84 18.5	89 19.0	21.25
21.30	32 11.9	37 12.5	42 13.0	46 13.6	51 14.1	56 14.7	61 15.2	66 15.8	71 16.3	75 16.8	80 17.4	85 17.9	90 18.5	21.30
21.35	32 11.4	37 11.9	42 12.5	46 13.0	51 13.6	57 14.1	61 14.7	66 15.2	72 15.8	75 16.3	80 16.8	85 17.4	90 17.9	21.35
21.40	33 10.9	38 11.4	43 11.9	47 12.5	52 13.0	57 13.6	62 14.1	67 14.7	72 15.2	76 15.8	81 16.3	86 16.8	91 17.4	21.40
1.45	33 10.3	38 10.9	43 11.4	47 11.9	52 12.5	58 13.0	62 13.6	67 14.1	73 14.7	76 15.2	81 15.8	86 16.3	91 16.8	21.45
21.50	34 9.8	39 10.3	44 10.9	48 11.4	53 11.9	58 12.5	63 13.0	68 13.6	73 14.1	77 14.7	82 15.2	87 15.8	92 16.3	21.50
21.55	34 9.2	39 9.8	44 10.3	48 10.9	53 11.4	59 11.9	63 12.5	68 13.0	74 13.6	77 14.1	82 14.7	87 15.2	92 15.8	21.55
21.60	35 8.7	40 9.2	45 9.8	49 10.3	54 10.9	59 11.4	64 11.9	69 12.5	74 13.0	78 13.6	83 14.1	88 14.7	93 15.2	21.60
21.65	35 8.1	40 8.7	45 9.2	49 9.8	54 10.3	60 10.9	64 11.4	69 11.9	75 12.5	78 13.0	83 13.6	88 14.1	93 14.7	21.65
21.70	36 7.6	41 8.1	46 8.7	50 9.2	55 9.8	60 10.3	65 10.9	70 11.4	75 11.9	79 12.5	84 13.0	89 13.6	94 14.1	21.70
21.75	36 7.1	41 7.6	46 8.1	50 8.7	55 9.2	61 9.8	65 10.3	70 10.9	76 11.4	79 11.9	84 12.5	89 13.0	94 13.6	21.75
21.80	37 6.5	42 7.1	47 7.6	51 8.1	56 8.7	61 9.2	66 9.8	71 10.3	76 10.9	80 11.4	85 11.9	90 12.5	95 13.0	21.80
21.85	37 6.0	42 6.5	47 7.1	51 7.6	56 8.1	62 8.7	66 9.2	71 9.8	77 10.3	80 10.9	85 11.4	90 11.9	95 12.5	21.85
21.90	38 5.4	43 6.0	48 6.5	52 7.1	57 7.6	62 8.1	67 8.7	72 9.2	77 9.8	81 10.3	86 10.9	91 11.4	96 11.9	21.90
21.95	38 4.9	43 5.4	48 6.0	52 6.5	57 7.1	63 7.6	67 8.1	72 8.7	78 9.2	81 9.8	86 10.3	91 10.9	96 11.4	21.95
22.00	39 4.3	44 4.9	49 5.4	53 6.0	58 6.5	63 7.1	68 7.6	73 8.1	78 8.7	82 9.2	87 9.8	92 10.3	97 10.9	22.00
	16.8	16.9	17.0	17.1	17.2	17.3	17.4	17.5	17.6	17.7	17.8	17.9	18.0	

TABLE 73 (Continued).

Standardizing table for ice cream mix No. 8 testing:

16.00% Fat
7.50% M. S. N. F.
14.00% Sugar
.50% Gelatin
38.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: Pounds butter.
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

	16.8	16.9	17.0	17.1	17.2	17.3	17.4	17.5	17.6	17.7	17.8	17.9	18.0	
22.05	39 3.8	44 4.3	49 4.9	53 5.4	58 6.0	64 6.5	68 7.1	73 7.6	79 8.1	82 8.7	87 9.2	92 9.8	97 10.3	22.05
22.10	40 3.3	45 3.8	50 4.3	54 4.9	59 5.4	64 6.0	69 6.5	74 7.1	79 7.6	83 8.1	88 8.7	93 9.2	98 9.8	22.10
22.15	40 2.7	45 3.3	50 3.8	54 4.3	59 4.9	65 5.4	69 6.0	74 6.5	80 7.1	83 7.6	88 8.1	93 8.7	99 9.2	22.15
22.20	41 2.2	46 2.7	51 3.3	55 3.8	60 4.3	65 4.9	70 5.4	75 6.0	80 6.5	84 7.1	89 7.6	94 8.1	99 8.7	22.20
22.25	41 1.6	46 2.2	51 2.7	55 3.3	60 3.8	66 4.3	70 4.9	75 5.4	81 6.0	84 6.5	89 7.1	94 7.6	100 8.1	22.25
22.30	42 1.1	47 1.6	52 2.2	56 2.7	61 3.3	66 3.8	71 4.3	76 4.9	81 5.4	85 6.0	90 6.5	95 7.1	100 7.6	22.30
22.35	42 .5	47 1.1	52 1.6	56 2.2	61 2.7	67 3.3	71 3.8	76 4.3	82 4.9	85 5.4	90 6.0	95 6.5	101 7.1	22.35
22.40	43	48 .5	53 1.1	57 1.6	62 2.2	67 2.7	72 3.3	77 3.8	82 4.3	86 4.9	91 5.4	96 6.0	101 6.5	22.40
22.45	1.3 47	48	53 .5	57 1.1	62 1.6	68 2.2	72 2.7	77 3.3	83 3.8	86 4.3	91 4.9	96 5.4	102 6.0	22.45
22.50	2.5 51	1.3 52	53	58 .5	63 1.1	68 1.6	73 2.2	78 2.7	83 3.3	87 3.8	92 4.3	97 4.9	102 5.4	22.50
22.55	3.8 56	2.5 57	1.3 58	59	63 .5	69 1.1	73 1.6	78 2.2	84 2.7	87 3.3	92 3.8	97 4.3	103 4.9	22.55
22.60	5.0 60	3.8 61	2.5 62	1.3 63	64	69 .5	74 1.1	79 1.6	84 2.2	88 2.7	93 3.3	98 3.8	103 4.3	22.60
22.65	6.3 64	5.0 65	3.8 66	2.5 67	1.3 68	69	74 .5	79 1.1	85 1.6	88 2.2	93 2.7	98 3.3	104 3.8	22.65
22.70	7.5 69	6.3 70	5.0 71	3.8 72	2.5 73	1.3 74	75	80 .5	85 1.1	89 1.6	94 2.2	99 2.7	104 3.3	22.70
22.75	8.8 73	7.5 74	6.3 75	5.0 76	3.8 77	2.5 78	1.3 79	80	85 .5	89 1.1	94 1.6	99 2.2	105 2.7	22.75
22.80	10.0 77	8.8 78	7.5 79	6.3 80	5.0 81	3.8 82	2.5 83	1.3 84	85	90 .5	95 1.1	100 1.6	105 2.2	22.80
22.85	11.3 82	10.0 83	8.8 84	7.5 85	6.3 86	5.0 87	3.8 88	2.5 89	1.3 90	91	95 .5	101 1.1	106 1.6	22.85
22.90	12.5 86	11.3 87	10.0 88	8.8 89	7.5 90	6.3 91	5.0 92	3.8 93	2.5 94	1.3 95	96	101 .5	106 1.1	22.90
22.95	13.8 90	12.5 92	11.3 93	10.0 94	8.8 95	7.5 96	6.3 97	5.0 98	3.8 99	2.5 100	1.3 101	102	107 .5	22.95
23.00	15.0 95	13.8 96	12.5 97	11.3 98	10.0 99	8.8 100	7.5 101	6.3 102	5.0 103	3.8 104	2.5 105	1.3 106	107	23.00
	16.8	16.9	17.0	17.1	17.2	17.3	17.4	17.5	17.6	17.7	17.8	17.9	18.0	

TABLE 74.

Standardizing table for ice cream mix No. 9 testing:

18.00% Fat
7.50% M. S. N. F.
14.00% Sugar
.50% Gelatin
40.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: Pounds butter.
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

	16.0	16.1	16.2	16.3	16.4	16.5	16.6	16.7	16.8	16.9	17.0	17.1	17.2	17.3	
21.11	37.1	35.4	33.8	32.1	30.4	28.7	27.0	25.3	23.6	21.9	20.2	18.5	16.8	15.1	21.11
	14.1	14.0	13.8	13.6	13.5	13.3	13.1	12.9	12.7	12.6	12.4	12.3	12.1	12.0	
21.16	36.9	35.2	33.6	31.9	30.2	28.5	26.8	25.1	23.4	21.7	20.0	18.3	16.6	14.9	21.16
	13.5	13.4	13.2	13.0	12.9	12.7	12.5	12.3	12.1	12.0	11.8	11.7	11.5	11.4	
21.20	36.7	35.0	33.4	31.7	30.0	28.3	26.6	24.9	23.2	21.5	19.8	18.1	16.4	14.7	21.20
	13.0	12.8	12.7	12.5	12.4	12.2	12.0	11.8	11.7	11.5	11.3	11.1	10.9	10.7	
21.24	36.6	34.9	33.3	31.6	29.9	28.2	26.5	24.8	23.1	21.4	19.7	18.0	16.3	14.6	21.24
	12.4	12.2	12.0	11.9	11.8	11.6	11.5	11.3	11.1	10.9	10.8	10.7	10.5	10.4	
21.29	36.4	34.7	33.1	31.4	29.7	28.0	26.3	24.6	22.9	21.2	19.5	17.8	16.1	14.4	21.29
	11.8	11.6	11.5	11.4	11.2	11.0	10.8	10.7	10.6	10.4	10.3	10.1	9.9	9.7	
21.33	36.3	34.6	32.0	31.3	29.6	27.9	26.2	24.5	22.8	21.1	19.4	17.7	16.0	14.3	21.33
	11.4	11.2	11.0	10.9	10.7	10.6	10.4	10.3	10.1	10.0	9.9	9.7	9.5	9.3	
21.38	36.1	34.4	32.8	31.1	29.4	27.7	26.2	24.3	22.6	20.9	19.2	17.5	15.8	14.1	21.38
	10.9	10.8	10.6	10.4	10.3	10.1	10.0	9.9	9.7	9.5	9.4	9.2	9.0	8.9	
21.42	36.0	34.3	32.7	31.0	29.3	27.6	26.1	24.2	22.5	20.8	19.1	17.4	15.7	14.0	21.42
	10.3	10.1	10.0	9.8	9.6	9.5	9.3	9.2	9.0	8.8	8.6	8.5	8.3	8.2	
21.47	35.8	34.1	32.5	30.8	29.1	27.4	25.9	24.0	22.3	20.6	18.9	17.2	15.5	13.8	21.47
	9.7	9.6	9.4	9.3	9.1	8.9	8.8	8.6	8.5	8.3	8.1	7.9	7.8	7.6	
21.51	35.6	33.9	32.3	30.6	28.9	27.3	25.7	23.8	22.1	20.4	18.7	17.0	15.3	13.6	21.51
	9.2	9.0	8.9	8.8	8.6	8.5	8.3	8.2	8.0	7.8	7.6	7.4	7.3	7.1	
21.56	35.5	33.8	32.3	30.6	28.8	27.1	25.5	23.7	22.1	20.3	18.7	17.0	15.2	13.6	21.56
	8.6	8.4	8.3	8.1	8.0	7.8	7.6	7.4	7.3	8.1	7.0	6.8	6.6	6.4	
21.60	35.3	33.6	32.1	30.4	28.6	26.9	25.3	23.5	21.9	20.1	18.5	16.8	15.1	13.4	21.60
	8.1	7.9	7.8	7.7	7.5	7.4	7.2	7.0	6.9	6.7	6.5	6.4	6.2	6.1	
21.64	35.2	33.5	32.0	30.3	28.5	26.8	25.2	23.4	21.8	20.0	18.4	16.7	15.0	13.3	21.64
	7.5	7.3	7.2	7.0	6.9	6.7	6.6	6.4	6.2	6.0	5.9	5.7	5.6	5.4	
21.69	35.0	33.3	31.8	30.1	28.3	26.6	25.0	23.2	21.6	19.8	18.2	16.5	14.8	13.1	21.69
	7.0	6.8	6.7	6.5	6.3	6.1	6.0	5.8	5.6	5.5	5.3	5.1	5.0	4.8	
21.73	34.8	33.1	31.6	29.9	28.1	26.4	24.8	23.0	21.4	19.6	18.0	16.3	14.6	12.9	21.73
	6.4	6.2	6.1	5.9	5.8	5.6	5.5	5.3	5.1	5.0	4.8	4.6	4.5	4.3	
21.78	34.7	33.0	31.5	29.8	28.0	26.3	24.7	22.9	21.3	19.5	17.9	16.2	14.5	12.8	21.78
	5.8	5.6	5.5	5.3	5.1	5.0	4.9	4.7	4.5	4.4	4.2	4.0	3.9	3.7	
21.82	34.5	32.8	31.3	29.6	27.8	26.1	24.5	22.7	21.1	19.3	17.7	16.0	14.3	12.6	21.82
	5.3	5.2	5.0	4.9	4.7	4.6	4.4	4.2	4.1	3.9	3.8	3.6	3.4	3.2	
21.87	34.3	32.6	31.1	29.4	27.6	25.9	24.3	22.5	20.9	19.1	17.5	15.8	14.1	12.4	21 87
	4.8	4.6	4.5	4.3	4.2	4.0	3.9	3.7	3.6	3.4	3.3	3.2	3.0	2.8	
21.91	34.2	32.5	31.0	29.3	27.5	25.8	24.2	22.4	20.8	19.0	17.4	15.7	14.0	12.3	21.91
	4.3	4.2	4.0	3.9	3.7	3.6	3.4	3.3	3.1	2.9	2.8	2.6	2.5	2.3	
21.96	34.0	32.3	30.7	28.0	27.2	25.6	24.0	22.2	20.5	18.8	17.1	15.4	13.7	12.0	21.96
	3.7	3.6	3.4	3.3	3.1	3.0	2.9	2.7	2.5	2.3	2.1	1.9	1.8	1.6	
22.00	33.8	32.1	30.4	28.7	27.0	25.4	23.7	22.0	20.3	18.6	16.9	15.2	13.5	11.8	22.00
	3.2	3.0	2.9	2.7	2.6	2.4	2.2	2.1	1.9	1.8	1.6	1.5	1.3	1.1	
	16.0	16.1	16.2	16.3	16.4	16.5	16.6	16.7	16.8	16.9	17.0	17.1	17.2	17.3	

TABLE 74 (Continued).

Standardizing table for ice cream mix No. 9 testing:

18.00% Fat
7.50% M. S. N. F.
14.00% Sugar
.50% Gelatin
40.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: Pounds butter.
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

	16.0	16.1	16.2	16.3	16.4	16.5	16.6	16.7	16.8	16.9	17.0	17.1	17.2	17.3	
22.04	33.6 2.7	32.0 2.5	30.2 2.4	28.5 2.3	26.8 2.1	25.2 2.0	23.5 1.8	21.8 1.6	20.1 1.4	18.4 1.3	16.7 1.1	15.0 1.0	13.3 .8	11.6 .6	22.04
22.09	33.4 2.2	31.8 2.0	30.1 1.9	28.3 1.7	26.6 1.6	25.0 1.4	23.4 1.2	21.7 1.1	19.9 .9	18.2 .8	16.5 .6	14.8 .5	13.1 .3	11.3 1	22.09
23.13	33.3 1.7	31.6 1.5	29.9 1.4	28.2 1.2	26.4 1.1	24.9 .9	23.2 .7	21.5 .6	19.4 .4	18.0 .2	16.3 1	15.1 2	13.8 3	12.5 4	23.13
22.18	33.1 1.2	31.4 1.0	29.7 .9	28.0 .7	26.3 .6	24.8 .4	22.6 1	21.3 2	20.1 3	18.8 4	17.6 5	16.3 6	15.1 7	13.8 8	22.18
22.22	32.9 .6	31.2 .4	28.4 1	27.6 2	26.4 3	25.1 4	23.8 5	22.6 6	21.3 7	20.1 8	18.8 9	17.6 10	16.3 11	15.1 12	22.22
22.26	32.6 3	31.4 4	30.1 5	28.9 6	27.6 7	26.4 8	25.1 9	23.8 10	22.6 11	21.3 12	20.1 13	18.8 14	17.6 15	16.3 16	22.26
22.31	33.9 7	32.6 8	31.4 9	30.1 10	28.9 11	27.6 12	26.4 13	25.1 14	23.8 15	22.6 16	21.3 17	20.1 18	18.8 19	17.6 20	22.31
22.36	35.1 10	33.9 11	32.6 12	31.4 13	30.1 14	28.9 15	27.6 16	26.4 17	25.1 18	23.8 19	22.6 20	21.3 21	20.1 22	18.8 23	22.36
22.40	36.4 14	35.1 15	33.9 16	32.6 17	31.4 18	30.1 19	28.9 20	27.6 21	26.4 22	25.1 23	23.8 24	22.6 25	21.3 26	20.1 27	22.40
22.44	37.6 17	36.4 18	35.1 19	33.9 20	32.6 21	31.4 22	30.1 23	28.9 24	27.6 25	26.4 26	25.1 27	23.8 28	22.6 30	21.3 31	22.44
22.49	38.9 21	37.6 22	36.4 23	35.1 24	33.9 25	32.6 26	31.4 27	30.1 28	28.9 29	27.6 30	26.4 31	25.1 32	23.8 33	22.6 34	22.49
22.53	40.2 24	38.9 25	37.6 26	36.4 27	35.1 28	33.9 29	32.6 30	31.4 31	30.1 32	28.9 33	27.6 34	26.4 35	25.1 36	23.8 37	22.53
22.58	41.4 28	40.2 29	38.9 30	37.6 31	36.4 32	35.1 33	33.9 34	32.6 35	31.4 36	30.1 37	28.9 38	27.6 39	26.4 40	25.1 41	22.58
22.62	42.7 32	41.4 33	40.2 34	38.9 35	37.6 36	36.4 37	35.1 38	33.9 39	32.6 40	31.4 41	30.1 42	28.9 43	27.6 44	26.4 46	22.62
22.67	43.9 36	42.7 37	41.4 38	40.2 39	38.9 40	37.6 41	36.4 42	35.1 43	33.9 44	32.6 45	31.4 46	30.1 47	28.9 48	27.6 49	22.67
22.71	45.2 39	43.9 40	42.7 41	41.4 42	40.2 43	38.4 44	37.6 45	36.4 46	35.1 47	33.9 48	32.6 49	31.4 50	30.1 51	28.9 52	22.71
22.76	46.4 43	45.2 44	43.9 45	42.7 46	41.4 47	40.2 48	38.9 49	37.6 50	36.4 51	35.1 52	33.9 53	32.6 54	31.4 55	30.1 56	22.76
22.80	47.7 47	46.4 48	45.2 49	43.9 50	42.7 51	41.4 52	40.2 53	38.9 54	37.6 55	36.4 56	35.1 57	33.9 58	32.6 59	31.4 60	22.80
22.85	48.9 51	47.7 52	46.4 53	45.2 54	43.9 55	42.7 56	41.4 57	40.2 58	38.9 59	37.6 60	36.4 61	35.1 62	33.9 63	32.6 64	22.85
22.89	50.2 54	48.9 55	47.7 56	46.4 57	45.2 58	43.9 59	42.7 60	41.4 61	40.2 62	38.9 63	37.6 64	36.4 65	35.1 66	33.9 67	22.89
	16.0	16.1	16.2	16.3	16.4	16.5	16.6	16.7	16.8	16.9	17.0	17.1	17.2	17.3	

TABLE 74 (Continued).

Standardizing table for ice cream mix No. 9 testing: 18.00% Fat, 7.50% M. S. N. F., 14.00% Sugar, .50% Gelatin = 40.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: Pounds butter.
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

	17.4	17.5	17.6	17.7	17.8	17.9	18.0	18.1	18.2	18.3	18.4	18.5	18.6	18.7	
21.11	13.4 11.8	11.7 11.6	10.0 11.5	8.4 11.3	6.7 11.2	5.0 11.0	3.3 10.9	1.6 10.7	.0 10.4	4 10.9	9 11.4	13 11.8	17 12.3	22 12.8	21.11
21.16	13.2 11.2	11.5 11.0	9.8 10.9	8.2 10.7	6.5 10.6	4.8 10.4	3.1 10.3	1.4 10.1	1 9.9	4 10.4	9 10.9	13 11.4	17 11.8	22 12.3	21.16
21.20	13.0 10.5	11.3 10.4	9.6 10.3	8.0 10.2	6.3 10.1	4.6 10.0	2.9 9.8	1.2 9.6	1 9.5	5 9.9	10 10.4	14 10.9	18 11.4	23 11.8	21.20
21.24	12.9 10.2	11.2 10.1	9.5 9.9	7.9 9.7	6.2 9.6	4.5 9.4	2.8 9.3	1.1 9.1	2 9.0	5 9.5	10 9.9	14 10.4	18 10.9	23 11.4	21.24
21.29	12.7 9.6	11.0 9.4	9.3 9.3	7.7 9.1	6.0 9.0	4.3 8.9	2.6 8.7	.9 8.5	2 8.5	6 9.0	11 9.5	15 9.9	18 10.4	24 10.9	21.29
21.33	12.6 9.1	10.9 8.9	9.2 8.8	7.6 8.7	5.9 8.5	4.2 8.3	2.5 8.2	.8 8.0	3 8.0	6 8.5	11 9.0	15 9.5	19 9.9	24 10.4	21.33
21.38	12.4 8.7	10.7 8.6	9.0 8.4	7.4 8.2	5.7 8.0	4.0 7.8	2.3 7.6	.6 7.4	3 7.6	7 8.0	12 8.5	15 9.0	19 9.5	24 9.9	21.38
21.42	12.3 8.0	10.6 7.9	8.9 7.7	7.3 7.6	5.6 7.4	3.8 7.3	2.1 7.1	.4 7.0	4 7.1	7 7.6	12 8.0	16 8.5	20 9.0	25 9.5	21.42
21.47	12.1 7.4	10.4 7.2	8.7 7.1	7.1 6.8	5.4 6.7	3.7 6.6	2.0 6.5	.3 6.3	4 6.7	8 7.1	12 7.6	16 8.0	20 8.5	25 9.0	21.47
21.51	11.9 7.0	10.2 6.8	8.5 6.7	6.9 6.5	5.2 6.4	3.5 6.2	1.8 6.0	.1 5.8	5 6.2	8 6.7	13 7.1	17 7.6	21 8.0	26 8.5	21.51
21.56	11.8 6.2	10.1 6.0	8.4 5.9	6.8 5.7	5.1 5.6	3.4 5.5	1.7 5.4	0 5.2	5 5.7	9 6.2	13 6.7	17 7.1	21 7.6	26 8.0	21.56
21.60	11.6 5.9	9.9 5.7	8.2 5.6	6.6 5.4	4.9 5.2	3.2 5.0	1.5 4.9	1 4.7	6 5.2	9 5.7	14 6.2	17 6.7	21 7.1	26 7.6	21.60
21.64	11.5 5.3	9.8 5.1	8.1 5.0	6.5 4.8	4.8 4.6	3.0 4.5	1.3 4.3	1 4.2	6 4.7	9 5.2	14 5.7	18 6.2	22 6.7	27 7.1	21.64
21.69	11.3 4.6	9.6 4.5	7.9 4.4	6.3 4.3	4.6 4.2	2.9 4.0	1.2 3.8	2 3.8	6 4.2	10 4.7	15 5.2	18 5.7	22 6.2	27 6.7	21.69
21.73	11.1 4.2	9.4 4.0	7.7 3.9	6.1 3.7	4.4 3.6	2.7 3.4	1.0 3.3	2 3.3	7 3.8	10 4.2	15 4.7	19 5.2	23 5.7	28 6.2	21.73
21.78	11.0 3.6	9.3 3.5	7.6 3.3	6.0 3.1	4.3 3.0	2.5 2.9	.8 2.7	3 2.8	7 3.3	11 3.8	15 4.2	19 4.7	23 5.2	28 5.7	21.78
21.82	10.8 3.1	9.1 2.9	7.4 2.8	5.8 2.6	4.1 2.5	2.4 2.4	.7 2.2	3 2.4	8 2.8	11 3.3	16 3.8	19 4.2	23 4.7	28 5.2	21.82
21.87	10.6 2.5	8.9 2.3	7.2 2.1	5.6 2.0	3.9 1.9	2.2 1.8	.5 1.6	4 1.9	8 2.4	11 2.8	16 3.3	20 3.8	24 4.2	29 4.7	21.87
21.91	10.5 2.1	8.8 1.9	7.1 1.7	5.5 1.6	3.8 1.4	2.0 1.3	.3 1.1	4 1.4	9 1.9	12 2.4	17 2.8	20 3.3	24 3.8	29 4.2	21.91
21.96	10.4 1.5	8.6 1.3	7.0 1.1	5.3 1.0	3.6 .8	1.9 .7	.2 .5	4 .9	9 1.4	12 1.9	17 2.4	21 2.8	25 3.3	30 3.8	21.96
22.00	10.2 1.0	8.4 .8	6.8 .6	5.1 .5	3.4 .3	1.7 .2		5 .5	9 .9	13 1.4	17 1.9	21 2.4	25 2.8	30 3.3	22.00
	17.4	17.5	17.6	17.7	17.8	17.9	18.0	18.1	18.2	18.3	18.4	18.5	18.6	18.7	

TABLE 74 (Continued).

Standardizing table for ice cream mix No. 9 testing:

18.00% Fat
7.50% M. S. N. F.
14.00% Sugar
.50% Gelatin
40.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: Pounds butter.
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

	17.4	17.5	17.6	17.7	17.8	17.9	18.0	18.1	18.2	18.3	18.4	18.5	18.6	18.7	
22.04	10.0 .5	8.2 .3	6.6 .1	5.0 1	3.8 2	2.5 3	1.3 4	5	10 .5	13 .9	18 1.4	22 1.9	26 2.4	31 2.8	22.04
22.09	10.0 2	8.8 3	7.5 4	6.3 5	5.0 6	3.8 7	2.5 8	1.3 9	10	14 .5	18 .9	22 1.4	26 1.9	31 2.4	22.09
22.13	11.3 5	10.0 6	8.8 7	7.5 8	6.3 9	5.0 10	3.8 11	2.5 12	1.3 13	14	19 .5	23 .9	27 1.4	32 1.9	22.13
22.18	12.5 9	11.3 10	10.0 11	8.8 12	7.5 13	6.3 14	5.0 15	3.8 16	2.5 17	1.3 18	19	24 .5	28 .9	33 1.4	22.18
22.22	13.8 13	12.5 14	11.3 15	10.0 16	8.8 17	7.5 18	6.3 19	5.0 20	3.8 21	2.5 22	1.3 23	24	28 .5	33 .9	22.22
22.26	15.1 17	13.8 18	12.5 19	11.3 20	10.0 21	8.8 22	7.5 23	6.3 24	5.0 25	3.8 26	2.5 27	1.3 28	29	34 .5	22.26
22.31	16.3 21	15.1 22	13.8 23	12.5 24	11.3 25	10.0 26	8.8 27	7.5 28	6.3 29	5.0 30	3.8 31	2.5 32	1.3 33	34	22.31
22.36	17.6 24	16.3 25	15.1 26	13.8 27	12.5 28	11.3 29	10.0 30	8.8 31	7.5 32	6.3 33	5.0 34	3.8 35	2.5 36	1.3 37	22.36
22.40	18.8 28	17.6 29	16.3 30	15.1 31	13.8 32	12.5 33	11.3 34	10.0 36	8.8 37	7.5 38	6.3 39	5.0 40	3.8 41	2.5 42	22.40
22.44	20.1 32	18.8 33	17.6 34	16.3 35	15.1 36	13.8 37	12.5 38	11.3 39	10.0 40	8.8 41	7.5 42	6.3 43	5.0 44	3.8 45	22.44
22.49	21.3 35	20.1 36	18.8 37	17.6 38	16.3 39	15.1 40	13.8 41	12.5 42	11.3 43	10.0 44	8.8 45	7.5 46	6.3 47	5.0 48	22.49
22.53	22.6 39	21.3 40	20.1 41	18.8 42	17.6 43	16.3 44	15.1 45	13.8 46	12.5 47	11.3 48	10.0 49	8.8 50	7.5 51	6.3 52	22.53
22.58	23.8 42	22.6 43	21.3 44	20.1 45	18.8 46	17.6 47	16.3 48	15.1 49	13.8 51	12.5 52	11.3 53	10.0 54	8.8 55	7.5 56	22.58
22.62	25.1 47	23.8 48	22.6 49	21.3 50	20.1 51	18.8 52	17.6 53	16.3 54	15.1 55	13.8 56	12.5 57	11.3 58	10.0 59	8.8 60	22.62
22.67	26.4 50	25.1 51	23.8 52	22.6 53	21.3 54	20.1 55	18.8 56	17.6 57	16.3 58	15.1 60	13.8 61	12.5 62	11.3 63	10.0 64	22.67
22.71	27.6 53	26.4 54	25.1 55	23.8 56	22.6 60	21.3 61	20.1 62	18.8 63	17.6 64	16.3 65	15.1 66	13.8 67	12.5 68	11.3 69	22.71
22.76	28.9 57	27.6 58	26.4 59	25.1 60	23.8 61	22.6 63	21.3 64	20.1 65	18.8 66	17.6 67	16.3 68	15.1 69	13.8 70	12.5 71	22.76
22.80	30.1 61	28.9 62	27.6 63	26.4 64	25.1 65	23.8 66	22.6 67	21.3 68	20.1 70	18.8 71	17.6 72	16.3 73	15.1 74	13.8 75	22.80
22.85	31.4 65	30.1 66	28.9 67	27.6 68	26.4 70	25.1 71	23.8 72	22.6 73	21.3 74	20.1 75	18.8 76	17.6 77	16.3 78	15.1 79	22.85
22.89	32.6 68	31.4 69	30.1 70	28.9 71	27.6 72	26.4 73	25.1 74	23.8 75	22.6 76	21.3 77	20.1 78	18.8 79	17.6 80	16.3 81	22.89
	17.4	17.5	17.6	17.7	17.8	17.9	18.0	18.1	18.2	18.3	18.4	18.5	18.6	18.7	

TABLE 74 (Continued).

Standardizing Standardizing cream mix No. 9 testing:

18.00% Fat
7.50% M. S. N. F.
14.00% Sugar
.50% Gelatin
40.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: **Pounds butter.**
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

	18.8	18.9	19.0	19.1	19.2	19.3	19.4	19.5	19.6	19.7	19.8	19.9	20.0	
21.11	26 13.2	30 13.8	35 14.2	39 14.7	43 15.1	47 15.6	52 16.1	56 16.5	61 17.0	65 17.5	69 17.9	74 18.4	78.0 18.9	**21.11**
21.16	26 12.8	30 13.2	35 13.8	39 14.2	43 14.7	47 15.1	52 15.6	56 16.1	61 16.5	65 17.0	69 17.5	74 17.9	78.0 18.4	**21.16**
21.20	27 12.3	31 12.8	36 13.2	40 13.8	44 14.2	48 14.7	53 15.1	57 15.6	62 16.1	66 16.5	70 17.0	75 17.5	79 17.9	**21.20**
21.24	27 11.8	31 12.3	36 12.8	40 13.2	44 13.8	48 14.2	53 14.7	57 15.1	62 15.6	66 16.1	70 16.5	75 17.0	79 17.5	**21.24**
21.29	28 11.4	32 11.8	37 12.3	41 12.8	45 13.2	49 13.8	54 14.2	58 14.7	63 15.1	67 15.6	71 16.1	76 16.5	80 17.0	**21.29**
21.33	28 10.9	32 11.4	37 11.8	41 12.3	45 12.8	49 13.2	54 13.8	58 14.2	63 14.7	67 15.1	71 15.6	76 16.1	80 16.5	**21.33**
21.38	28 10.4	32 10.9	37 11.4	41 11.8	45 12.3	49 12.8	54 13.2	58 13.8	63 14.2	68 14.7	72 15.1	77 15.6	80 16.1	**21.38**
21.42	29 9.9	33 10.4	38 10.9	42 11.4	46 11.8	50 12.3	55 12.8	59 13.2	64 13.8	68 14.2	72 14.7	77 15.1	81 15.6	**21.42**
21.47	29 9.5	33 9.9	38 10.4	42 10.9	46 11.4	50 11.8	55 12.3	59 12.8	64 13.2	69 13.8	73 14.2	77 14.7	81 15.1	**21.47**
21.51	30 9.0	34 9.5	39 9.9	43 10.4	47 10.9	51 11.4	56 11.8	60 12.3	65 12.8	69 13.2	73 13.8	78 14.2	82 14.7	**21.51**
21.56	30 8.5	34 9.0	39 9.5	43 9.9	47 10.4	51 10.9	56 11.4	60 11.8	65 12.3	70 12.8	73 13.2	78 13.8	82 14.2	**21.56**
21.60	30 8.0	34 8.5	39 9.0	43 9.5	47 9.9	51 10.4	56 10.9	60 11.4	65 11.8	70 12.3	74 12.8	79 13.2	83 13.8	**21.60**
21.64	31 7.6	35 8.0	40 8.5	44 9.0	48 9.5	52 9.9	57 10.4	61 10.9	66 11.4	70 11.8	74 12.3	79 12.8	83 13.2	**21.64**
21.69	31 7.1	35 7.6	40 8.0	44 8.5	48 9.0	52 9.5	57 9.9	61 10.4	66 10.9	71 11.4	75 11.8	80 12.3	83 12.8	**21.69**
21.73	32 6.7	36 7.1	41 7.6	45 8.0	49 8.5	53 9.0	58 9.5	62 9.9	67 10.4	71 10.9	75 11.4	80 11.8	84 12.3	**21.73**
21.78	32 6.2	36 6.7	41 7.1	45 7.6	49 8.0	53 8.5	58 9.0	62 9.5	67 9.9	71 10.4	76 10.9	81 11.4	84 11.8	**21.78**
21.82	32 5.7	36 6.2	41 6.7	45 7.1	49 7.6	53 8.0	58 8.5	62 9.0	67 9.5	72 9.9	76 10.4	81 10.9	85 11.4	**21.82**
21.87	33 5.2	37 5.7	42 6.2	46 6.7	50 7.1	54 7.6	59 8.0	63 8.5	68 9.0	72 9.5	77 9.9	81 10.4	85 10.9	**21.87**
21.91	33 4.7	37 5.2	42 5.7	46 6.2	50 6.7	54 7.1	59 7.6	63 8.0	68 8.5	73 9.0	77 9.5	82 9.9	85 10.4	**21.91**
21.96	34 4.2	38 4.7	43 5.2	47 5.7	51 6.2	55 6.7	60 7.1	64 7.6	69 8.0	73 8.5	77 9.0	82 9.5	86 9.9	**21.96**
22.00	34 3.8	38 4.2	43 4.7	47 5.2	51 5.7	55 6.2	60 6.7	64 7.1	69 7.6	74 8.0	78 8.5	83 9.0	86 9.5	**22.00**
	18.8	18.9	19.0	19.1	19.2	19.3	19.4	19.5	19.6	19.7	19.8	19.9	20.0	

TABLE 74 (Continued).

Standardizing table for ice cream mix No. 9 testing:

18.00% Fat
7.50% M. S. N. F.
14.00% Sugar
.50% Gelatin
40.00% T. S.

Basis 1000 pounds of mix.
Top and bottom lines: Fat tests.
Side columns: S. N. F. tests.

In each square:
Top figure: Pounds butter.
Center figure: Pounds water.
Bottom figure: Pounds skim-milk powder.
(Blanks indicate none of kind required.)

	18.8	18.9	19.0	19.1	19.2	19.3	19.4	19.5	19.6	19.7	19.8	19.9	20.0	
22.04	35 3.3	39 3.8	44 4.2	48 4.7	52 5.2	56 5.7	61 6.2	65 6.7	70 7.1	74 7.6	78 8.0	83 8.5	87 9.0	22.04
22.09	35 2.8	39 3.3	44 3.8	48 4.2	52 4.7	56 5.2	61 5.7	65 6.2	70 6.7	75 7.1	79 7.6	84 8.0	87 8.5	22.09
22.13	36 2.4	40 2.8	45 3.3	49 3.8	53 4.2	57 4.7	62 5.2	66 5.7	71 6.2	75 6.7	79 7.1	84 7.6	88 8.0	22.13
22.18	37 1.9	41 2.4	46 2.8	50 3.3	54 3.8	58 4.2	63 4.7	67 5.2	72 5.7	76 6.2	80 6.7	84 7.1	88 7.6	22.18
22.22	37 1.4	41 1.9	46 2.4	50 2.8	54 3.3	58 3.8	63 4.2	67 4.7	72 5.2	76 5.7	80 6.2	85 6.7	88 7.1	22.22
22.26	37 .9	42 1.4	46 1.9	51 2.4	55 2.8	59 3.3	64 3.8	68 4.2	73 4.7	77 5.2	80 5.7	85 6.2	89 6.7	22.26
22.31	38 .5	43 .9	47 1.4	51 1.9	55 2.4	59 2.8	64 3.3	68 3.8	73 4.2	77 4.7	81 5.2	86 5.7	89 6.2	22.31
22.36	38	43 .5	47 .9	51 1.4	55 1.9	60 2.4	65 2.8	68 3.3	74 3.8	78 4.2	81 4.7	86 5.2	89 5.7	22.36
22.40	1.3 43	44	48 .5	52 .9	56 1.4	60 1.9	65 2.4	69 2.8	75 3.3	78 3.8	81 4.2	87 4.7	90 5.2	22.40
22.44	2.5 46	1.3 47	48	52 .5	56 .9	61 1.4	66 1.9	69 2.4	75 2.8	79 3.3	82 3.8	87 4.2	90 4.7	22.44
22.49	3.8 49	2.5 50	1.3 51	52	57 .5	61 .9	66 1.4	70 1.9	76 2.4	79 2.8	82 3.3	88 3.8	91 4.2	22.49
22.53	5.0 53	3.8 54	2.5 55	1.3 56	57	62 .5	67 .9	70 1.4	76 1.9	80 2.4	83 2.8	88 3.3	91 3.8	22.53
22.58	6.3 57	5.0 58	3.8 59	2.5 60	1.3 61	62	67 .5	71 .9	77 1.4	80 1.9	83 2.4	89 2.8	92 3.3	22.58
22.62	7.5 61	6.3 62	5.0 63	3.8 64	2.5 65	1.3 66	67	72 .5	77 .9	80 1.4	84 1.9	89 2.4	92 2.8	22.62
22.67	8.8 65	7.5 66	6.3 67	5.0 68	3.8 69	2.5 70	1.3 71	72	78 .5	81 .9	84 1.4	90 1.9	93 2.4	22.67
22.71	10.0 70	8.8 71	7.5 72	6.3 73	5.0 74	3.8 75	2.5 76	1.3 77	78	81 .5	85 .9	90 1.4	93 1.9	22.71
22.76	11.3 72	10.0 73	8.8 74	7.5 75	6.3 76	5.0 77	3.8 78	2.5 79	1.3 80	81	85 .5	91 .9	94 1.4	22.76
22.80	12.5 76	11.3 77	10.0 78	8.8 79	7.5 80	6.3 81	5.0 82	3.8 83	2.5 84	1.3 85	86	91 .5	94 .9	22.80
22.85	13.8 80	12.5 81	11.3 82	10.0 83	8.8 84	7.5 85	6.3 86	5.0 87	3.8 88	2.5 89	1.3 90	91	95 .5	22.85
22.89	15.1 83	13.8 84	12.5 85	11.3 86	10.0 87	8.8 88	7.5 89	6.3 90	5.0 91	3.8 92	2.5 93	1.3 94	95	22.89
	18.8	18.9	19.0	19.1	19.2	19.3	19.4	19.5	19.6	19.7	19.8	19.9	20.0	

TABLES FOR COMPOUNDING, UPON 1000 POUND BASIS, ICE CREAM MIXES OF VARIOUS TESTS AND FROM VARIOUS RAW PRODUCTS.

Tables 75 to 84 inclusive, immediately following give the pounds of various commonly available raw products necessary to mix together, in order to produce ice cream mixes of the compositions indicated. The tables are all made upon the 1000 pound basis. The proportions will of course hold for any quantity desired, either greater or smaller than 1000 pounds. The accuracy of the tests of the various mixes is limited to the accuracy in the composition of the products used, as compared with the composition named in the tables. This method can be depended upon to give only approximate results. It is not recommended when accuracy is desired, nor when the aim is to make a uniformly standardized product.

The heading over each table enumerates the products used. The products used are also given upon the left hand side of the table, together with the composition of the same. The composition of the nine different mixes giving the fat, M. S. N. F., sugar, gelatin and total solids is found in the upper half of the table. The pounds of the various products necessary to use to make 1000 pounds of mix, are given in the lower half of the table.

The various combinations of products used in the several tables are as follows:

Table 75. Mixes of nine compositions; made from 18 per cent cream; evaporated milk testing 8.00 per cent fat and 26.15 per cent total solids; whole milk; sugar; gelatin and water.

Table 76. Cream; plain 8 per cent condensed whole milk; whole milk; sugar and gelatin. Butter necessary in two compositions of mix.

Table 77. Cream; plain 9 per cent condensed whole milk: whole milk; sugar and gelatin. Butter necessary in two compositions of mix.

Table 78. Cream; plain condensed skim-milk; whole milk; sugar and gelatin.

Table 79. Skim-milk powder; butter; sugar; gelatin and water.

Table 80. Sweetened condensed whole milk; cream; skim-milk powder; butter; whole milk; sugar and gelatin.

Table 81. Sweetened condensed skim-milk; cream; butter; whole milk; sugar and gelatin.

Table 82. Skim-milk powder; whole milk; butter; sugar and gelatin.

Table 83. Sweetened condensed skim-milk; cream; sugar; gelatin and water.

Table 84. Sweetened condensed skim-milk; butter; sugar; gelatin and water.

METHOD OF CALCULATION USED IN DERIVING INGREDIENT FORMULAS.

J. A. Cross devised a unique method of calculation that was applied in solving all the problems included in Tables 75 to 81 inclusive. This method can be applied to any combination of substances that it may be desired to use in making up ice cream mix.

The example used to illustrate the method is taken from Table 75 and is as follows:—

Example: Wanted to make 1000 pounds of ice cream mix testing 8.00 per cent fat; 11.50 per cent M. S. N. F.; 13.00 per cent sugar, and .50 per cent water free gelatin. The materials available are cream testing 18.00 per cent fat, and 25.59 per cent T. S.; evaporated milk testing 8.00 per cent fat, and 26.15 per cent T. S.; whole milk testing 3.50 per cent fat and 12.00 per cent T. S., sugar testing 100 per cent T. S.; and gelatin testing 87.00 per cent T. S.

Solution: Each 1000 pounds of mix must contain 130 pounds of sugar and 5 pounds of gelatin. Therefore $1000-(130+5)=$ 865 pounds of milk products. The 865 pounds of milk products must contain 80 pounds of fat and 115.7 pounds of M. S. N .F. (The extra .7 pounds is added to make up for the water contained in the gelatin used. $5-(5\times.87)=.65$.

$80\div865=9.25$, per cent fat required in mixture of milk products.

115.7 ÷ 865 = 13.39, per cent M. S. N. F. in mixture of milk products.

The tests of the cream, evaporated milk and whole milk respectively are plotted upon the basis of their fat and S. N. F. contents, and lines are drawn from the one to the other to form a triangle. The test of the mixture required is then plotted within the triangle. The other lines are then drawn, all being as illustrated under Fig. 89. Accurate measurements are made of each full line that intersects the point of the mixture inside of the triangle, and in turn of the short line which extends from the central point to one of the sides of the triangle. The larger the triangle the more accurate these measurements will be, and when many determinations of this kind require to be made, a drawing board and T square can be used to advantage. By simple ratio the proportion of each ingredient required is calculated as follows:—

$$\frac{A^1D}{A^1A} = \frac{1.046 \text{ cm.}}{4.494 \text{ cm.}} \quad \frac{1.046}{4.494} \text{ of } 865 = 201.3 \text{ pounds cream required.}$$

$$\frac{B^1D}{B^1B} = \frac{.7819 \text{ cm.}}{3.246 \text{ cm.}} \quad \frac{.7819}{3.246} \text{ of } 865 = 208.8 \text{ pounds milk required.}$$

$$\frac{C^1D}{C^1C} = \frac{1.7213 \text{ cm.}}{3.273 \text{ cm.}} \quad \frac{1.7213}{3.273} \text{ of } 865 = 454.9 \text{ pounds evaporated milk required.}$$

1000 lbs. of mix require

130.0 pounds sugar
5.0 pounds gelatin.

Total, 1000.0 pounds mix.

Test { 7.994 per cent fat.
32.99 per cent T. S.

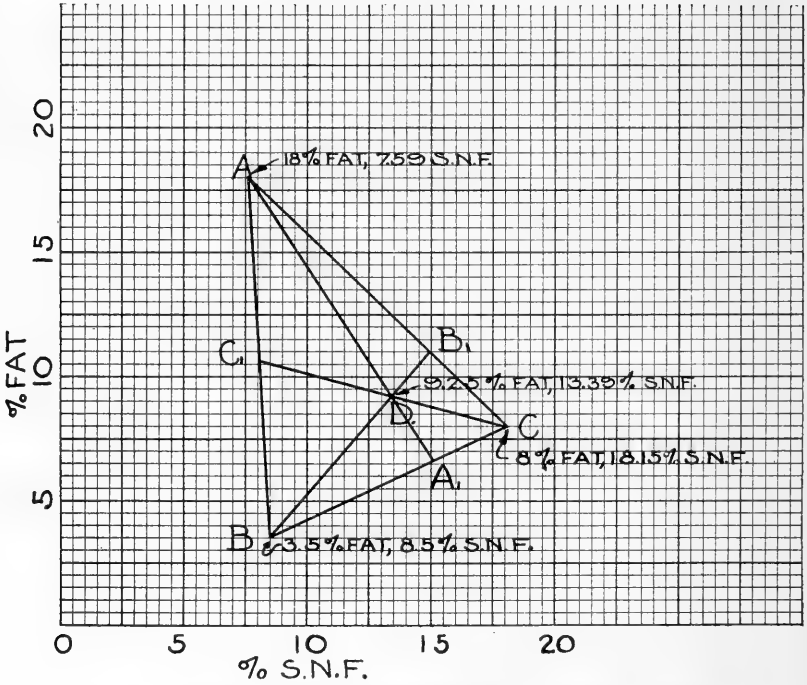


Fig 89. Diagram Showing Graphic Method of Standardization.

In the above diagram point A, representing cream testing 18 per cent fat and 7.59 per cent S. N. F., is plotted as indicated. Point B, representing whole milk testing 3.5 per cent fat and 8.5 per cent S. N. F., and point C, representing evaporated milk, testing 8 per cent fat and 18.15 per cent S. N. F., are plotted in the same way. These three points are then connected to form the triangle ABC. Point D represents the mixture desired, testing 9.25 per cent fat and 13.39 per cent S. N. F. Lines are then drawn through AD, BD and CD to the point where they intersect the side of the triangle. The ratio of A, D to A, A times 865 represents the pounds of cream required. The ratio of B,D to B,B times 865 represents the pounds of whole milk required and the proportion of C,D to C,C times 865 represents the pounds of evaporated milk required. Adding these three amounts, and the sugar and gelatin necesary, the sum will be 1,000 pounds.

TABLE 75

Mixes of Nine Compositions Made from 18 Per Cent Cream, Evaporated Milk, Whole Milk, Sugar, Gelatin and Water.

	No. of mixes		1	2	3	4	5	6	7
	Fat		Per Cent 8.00	Per Cent 8.00	Per Cent 8.50	Per Cent 9.00	Per Cent 10.00	Per Cent 12.00	Per Cent 12.00
Composition of mixes in percentages	M. S. N. F.		11.50	12.50	12.00	11.50	10.50	8.50	9.50
	Sugar		13.00	13.00	13.00	13.00	14.00	14.00	14.00
	Gelatin		.50	.50	.50	.50	.50	.50	.50
	T. S.		33.00	34.00	34.00	34.00	35.00	35.00	36.00
Product	Fat Per Cent	M.S.N.F. Per Cent	T. S. Per Cent	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
Cream	18.00	7.59	25.59	201.3	170.5	220.8	269.4	366.1	562.4	530.0
Evaporated milk	8.00	18.15	26.15	454.9	557.3	509.7	461.3	379.7	186.7	291.0
Whole milk	3.50	8.50	12.00	208.8	137.2	135.5	134.3	109.2	105.9	34.0
Sugar			100.00	130.0	130.0	130.0	130.0	140.0	140.0	140.0
Gelatin			87.00	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Total				1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0

TABLE 76.

Mixes of Nine Compositions. Made from Cream, Plain Condensed Whole Milk, Whole Milk, Sugar, Gelatin and Butter. 1000 Lb. Basis.

	No. of Mix	1	2	3	4	5	6	7	8	9
Composition of mixes in percentages.	Fat	Per Cent 8.00	Per Cent 8.00	Per Cent 8.50	Per Cent 9.00	Per Cent 10.00	Per Cent 12.00	Per Cent 12.00	Per Cent 16.00	Per Cent 18.00
	M. S. N. F.	11.50	12.50	12.00	11.50	10.50	8.50	9.50	7.50	7.50
	Sugar	13.00	13.00	13.00	13.00	14.00	14.00	14.00	14.00	14.00
	Gelatin	.50	.50	.50	.50	.50	.50	.50	.50	.50
	T. S.	33.00	34.00	34.00	34.00	35.00	35.00	36.00	38.00	40.00

	Name	Fat %	M. S. N. F. %	T. S. %	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
Name and tests of products with pounds of each required.	Cream	18.00	7.59	25.59	260.5	242.3	285.2	367.9	415.6	588.	569.8	711.1	730.
	Plain cond. whole milk	8.00	25.00	33.00	266.	325.	297.8	269.8	219.0	107.7	166.7	64.5	73.5
	Whole milk	3.50	8.50	12.00	338.5	297.7	282.0	267.3	220.4	159.3	118.5	.....	.....
	Sugar	.....	.....	100.00	130.	130.	130.	130.	140.	140.	140.	140.	140.
	Gelatin	.....	.....	87.00	5.	5.	5.	5.	5.	5.	5.	5.	5.
	Butter	83.00	1.5	84.5	.....	.....	.....	.....	.....	.....	.....	19.4	51.5
	Total	.....	.....	.....	1000	1000	1000	1000	1000	1000	1000	1000	1000

TABLE 77.

Mixes of Nine Compositions. Made from Plain Condensed Whole Milk, Whole Milk, Sugar, Gelatin and Butter. 1000 Lb. Basis.

Composition of mixes in percentages..	No. of Mix..		1	2	3	4	5	6	7	8	9
	Fat.....		Per Cent 8.00	Per Cent 8.00	Per Cent 8.50	Per Cent 9.00	Per Cent 10.00	Per Cent 12.00	Per Cent 12.00	Per Cent 16.00	Per Cent 18.00
	M. S. N. F....		11.50	12.50	12.00	11.50	10.50	8.50	9.50	7.50	7.50
	Sugar.....		13.00	13.00	13.00	13.00	14.00	14.00	14.00	14.00	14.00
	Gelatin.....		.50	.50	.50	.50	.50	.50	.50	.50	.50
	T. S.....		33.00	34.00	34.00	34.00	35.00	35.00	36.00	38.00	40.00
Name and tests of products with pounds of each required.		Fat %	M. S. N. F. %	T. S. %	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
	Cream.....	18.00	7.59	25.59	253.	232.5	276.9	320.6	409.4	587.8	569.4	786.	738.4
	Plain Cond. whole milk	9.00	27.00	36.00	237.	289.7	265.4	240.2	195.2	95.6	142.7	52.3	67.1
	Whole milk..	3.50	8.50	12.00	375.	342.8	322.7	304.2	250.4	171.6	142.9	.....	.....
	Sugar.....	.....	.....	100.	130.	130.0	130.0	130.0	140.0	140.0	140.0	140.	140.
	Gelatin.....	.....	.....	87.	5.	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
	Butter.....	83.	1.5	84.5	.....	.....	.....	.....	.....	.....	.....	16.7	19.5
	Total.....	.....	.....	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000

TABLE 78.

Mixes of Nine Compositions. Made from Cream, Plain Condensed Skim-milk, Whole Milk, Sugar and Gelatin. 1000 Lb. Basis.

Composition of mixes in percentages..	No. of mix..	1	2	3	4	5	6	7	8	9
	Fat.....	Per Cent 8.00	Per Cent 8.00	Per Cent 8.50	Per Cent 9.00	Per Cent 10.00	Per Cent 12.00	Per Cent 12.00	Per Cent 16.00	Per Cent 18.00
	M. S. N. F....	11.50	12.50	12.00	11.50	10.50	8.50	9.50	7.50	7.50
	Sugar.....	13.00	13.00	13.00	13.00	14.00	14.00	14.00	14.00	14.00
	Gelatin.....	.50	.50	.50	.50	.50	.50	.50	.50	.50
	T. S.....	33.00	34.00	34.00	34.00	35.00	35.00	36.00	38.00	40.00

		Fat	M. S. N. F.	T. S.								
Name and tests of products with pounds of each required.	Cream.....	% 40.00	% 5.50	% 45.50	158.5	163.3	175.1	186.3	210.7	256.6	261.4	363.	418.2
	Plain cond. skim milk.	.50	25.50	26.00	272.5	331.5	305.1	277.5	227.6	118.5	177.8	77.	87.8
	Whole milk..	3.50	8.50	12.00	439.	368.2	384.8	401.2	416.7	479.9	415.8	415.	349.0
	Sugar.....	.....	.....	100.	130.	130.0	130.	130.	140.	140.	140.	140.	140.
	Gelatin.....	.....	.....	87.00	5.	5.	5.	5.	5.	5.	5.	5.	5.
	Total.....	.....	.....	.....	1000	1000	1000	1000	1000	1000	1000	1000	1000

TABLE 79.

Mixes of Nine Compositions. Made from Skim-milk Powder, Butter, Sugar, Gelatin and Water. 1000 Lb. Basis.

				No. of mix..	1	2	3	4	5	6	7	8	9
					Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent
Composition of mixes in percentages..				Fat.....	8.00	8.00	8.50	9.00	10.00	12.00	12.00	16.00	18.00
				M. S. N. F....	11.50	12.50	12.00	11.50	10.50	8.50	9.50	7.50	7.50
				Sugar.....	13.00	13.00	13.00	13.00	14.00	14.00	14.00	14.00	14.00
				Gelatin.....	.50	.50	.50	.50	.50	.50	.50	.50	.50
				Total Solids..	33.00	34.00	34.00	34.00	35.00	35.00	36.00	38.00	40.00
		Fat	M. S. N. F.	T. S.	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
		%	%	%									
Name and tests of products with pounds of each required.	Skim milk powder....	1.00	94.00	95.00	121.9	131.5	126.0	120.6	110.0	88.2	98.8	76.7	76.3
	Butter.....	83.00	1.50	84.50	95.0	94.8	100.8	107.0	119.2	143.5	143.3	192.0	216.0
	Sugar.....	.....	.....	100.00	130.0	130.0	130.0	130.0	140.0	140.0	140.0	140.0	140.0
	Gelatin.....	.....	.....	87.00	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
	Water.....	.....	.....	.....	648.1	638.7	638.2	637.4	625.8	623.3	612.9	586.3	562.7
	Total.....	.....	.....	.....	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0

TABLE 80.

Mixes of Nine Compositions. Made From Cream, Butter, Skim Milk Powder, Whole Milk, Sweetened Condensed Whole Milk, Sugar and Gelatin. 1000 Lb. Basis.

	No. of mix	1	2	3	4	5	6	7	8	9
Composition of mixes in per centages	Fat	Per cent 8.00	Per cent 8.00	Per cent 8.50	Per cent 9.00	Per cent 10.00	Per cent 12.00	Per cent 12.00	Per cent 16.00	Per cent 18.00
	M. S. N. F.	11.50	12.50	12.00	11.50	10.50	8.50	9.50	7.50	7.50
	Sugar	13.00	13.00	13.00	13.00	14.00	14.00	14.00	14.00	14.00
	Gelatin	.50	.50	.50	.50	.50	.50	.50	.50	.50
	Total solids	33.00	34.00	34.00	34.00	35.00	35.00	36.00	38.00	40.00

		Fat	M. S. N. F.	T. S.	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
Name and tests of products	Sw. cond. whole milk	% 8.	% 20.	% 70.	289.0	309.5	309.5	293.2	238.0	115.5	181.1	68.9	83.2
	Cream	18.00	7.59	25.59	224.2	216.6	250.3	291.0	385.5	573.5	546.7	803.0	763.1
	Skim milk powder	1.00	94.00	95.00	.....	7.9	2.1	.....	.....	.....	.....	.....	.....
	Butter	83.00	1.50	84.50	.....	.....	.....	.....	.....	.....	.....	12.1	43.6
	Whole milk	3.50	8.50	12.00	473.2	461.0	433.1	403.9	311.5	214.5	203.3	.....	.....
	Sugar	....	.....	100. 00	8.6	.....	.....	6.9	40.0	91.5	63.9	111.1	105.1
	Gelatin	....	.....	87. 00	5.	5.	5.	5.	5.	5.	5.	5.	5.
	Total	....	.....	.....	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.

TABLE 81.

Mixes of Nine Compositions. Made From Cream, Sweetened Condensed Skim-Milk, Butter, Whole Milk, Sugar and Gelatin. 1000 Lb. Basis.

	No. of mix	1	2	3	4	5	6	7	8	9
Composition of mixes in per centages	Fat	Per cent 8.00	Per cent 8.00	Per cent 8.50	Per cent 9.00	Per cent 10.00	Per cent 12.00	Per cent 12.00	Per cent 16.00	Per cent 18.00
	M. S. N. F.	11.50	12.50	12.00	11.50	10.50	8.50	9.50	7.50	7.50
	Sugar	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	Gelatin	.50	.50	.50	.50	.50	.50	.50	.50	.50
	Total solids	33.00	34.00	34.00	34.00	35.00	35.00	36.00	38.00	40.00

		Fat	M. S. N. F.	T. S.	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
Name and test of products with pounds of each required	Sw. cond. skim milk	% .5	% 27.50	% 70.	198.6	242.8	221.5	201.5	163.9	80.2	124.3	47.8	56.7
	Cream	18.00	7.59	25.59	363.8	368.2	400.9	432.9	500.8	630.0	634.6	811.1	773.1
	Butter	83.	1.5	84.5	.....	.....	.....	.....	.....	.....	.....	16.9	49.0
	Whole milk	3.5	8.5	12.	386.	355.9	335.7	315.3	259.2	178.5	148.3	.....	.....
	Sugar	....	.....	100.	46.6	28.1	36.9	45.3	71.1	106.3	87.8	119.2	116.2
	Gelatin	....	.....	87.	5.	5.	5.	5.	5.	5.	5.	5.	5.
	Total	....	.....	.....	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.

TABLE 82.

Mixes of Nine Compositions. Made from Skim-milk Powder, Whole Milk, Butter, Sugar and Gelatin. Great Care Must be Taken to Use Only Raw Products of Best Quality. 1000 Lb. Basis.

Composition of mixes in percentages..	No. of mix..	1	2	3	4	5	6	7	8	9
		Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent
	Fat.....	8.00	8.00	8.50	9.00	10.00	12.00	12.00	16.00	18.00
	M. S. N. F....	11.50	12.50	12.00	11.50	10.50	8.50	9.50	7.50	7.50
	Sugar.....	13.00	13.00	13.00	13.00	14.00	14.00	14.00	14.00	14.00
	Gelatin.....	.50	.50	.50	.50	.50	.50	.50	.50	.50
	Total Solids..	33.00	34.00	34.00	34.00	35.00	35.00	36.00	38.00	40.00

		Fat	M. S. N. F.	T. S.	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
Name and tests of products with pounds of each required.	Skim-milk powder....	% 1.00	% 94.00	% 95.00	54.6	66.1	60.7	55.4	45.8	24.3	36.1	16.7	16.9
	Whole milk..	3.50	8.50	12.00	746.1	734.3	733.4	732.7	719.6	716.6	704.6	674.3	669.5
	Butter.....	83.00	1.50	84.50	64.3	64.6	70.9	76.9	89.6	114.1	114.3	164.0	188.6
	Sugar.....	.....	.....	100.00	130.0	130.0	130.0	130.0	140.0	140.0	140.0	140.0	140.0
	Gelatin.....	.....	.....	87.00	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
	Total.....	.....	.....	.....	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0

TABLE 83.

Mixes of Six Compositions. Made from Sweetened Condensed Skim-milk, Cream, Sugar, Gelatin and Water. 1000 Lb. Basis.

	No. of mix.....	1	2	3	4	5	6
		Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent
Composition of mixes in percentages.....	Fat.....	8.00	8.50	9.00	10.00	12.00	12.00
	M. S. N. F.....	11.50	12.00	11.50	10.50	8.50	9.50
	Sugar.....	13.00	13.00	13.00	14.00	14.00	14.00
	Gelatin.....	.50	.50	.50	.50	.50	.50
	Total Solids.....	33.00	34.00	34.00	35.00	36.00	36.00

		Fat	M. S. N. F.	T. S.	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
		%	%	%						
Names and tests of products with pounds of each required.....	Sweet. condensed skim-milk.....	.50	27.50	70.00	300.7	309.5	285.0	232.8	128.7	1654.0
	Cream.....	18.00	7.59	25.59	436.1	463.8	491.5	548.8	662.8	662.1
	Sugar.....	.....	.....	100.00	3.7	.3	10.3	42.3	85.9	70.7
	Gelatin.....	.....	.....	87.00	5.0	5.0	5.0	5.0	5.0	5.0
	Water.....	.....	.....	.....	254.5	221.4	208.2	171.1	117.6	96.8
	Total.....	.....	.....	.....	1000	1000	1000	1000	1000	1000

TABLE 84.

Mixes of Three Compositions. Made from Sweetened Condensed Skim-Milk, Butter, Sugar, Gelatin and Water. 1000 lb. Basis.

Composition of Mixes in Percentages	No. of Mix	1	2	3
	Fat	Per Cent 12.00	Per Cent 16.00	Per Cent 18.00
	M. S. N. F.	8.50	7.50	7.50
	Sugar	14.00	14.00	14.00
	Gelatin	.50	.50	.50
	T. S.	35.00	38.00	40.00

Name and tests of products with pounds of each required		Fat	M.S.N.F.	T. S.	Pounds	Pounds	Pounds
		%	%	%			
	Sweet Condensed Skim-milk	.50	27.50	70.00	303.5	264.6	263.6
	Butter	83.00	1.50	84.5	142.8	191.4	215.0
	Sugar	.....	.....	100.	12.5	28.9	29.3
	Gelatin	.....	.....	87.	5.0	5.0	5.0
	Water	.....	.....	.....	536.2	510.1	487.1
	Total	.....	.....	.....	1000	1000	1000

TABLE FOR COMPOUNDING ICE CREAM MIXES IN VACUUM PAN.

Tables 85 to 87 inclusive each in turn give the pounds of three different combinations of raw materials, necessary to produce nine different compositions of ice cream mix. These are all calculated upon basis that will yield 1,000 pounds of finished product, when condensed to the concentration desired; in the vacuum pan, using the Mojonnier method. The proportions given will apply to any size of batch of finished product that may be wanted either larger or smaller than 1,000 pounds.

The arrangement of the tables is similar to that followed in the tables just preceding.

The combination of products used was as follows:

Table 85, Whole milk, butter, sugar and gelatin.

Table 86, Whole milk, butter, sugar and gelatin.

Table 87, Skim-milk, butter, sugar and gelatin.

TABLE 85.

Mixes of Nine Compositions. Made from Whole Milk, Butter, Sugar and Gelatin. All Constituents Condensed in Vacuum Pan to Yield 1000 Lbs. of Finished Product.

		No. of mixes..	1	2	3	4	5	6	7	8	9
			Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent
Composition of mixes in percentages..		Fat.....	8.00	8.00	8.50	9.00	10.00	12.00	12.00	16.00	18.00
		M. S. N. F....	11.50	12.50	12.00	11.50	10.50	8.50	9.50	7.50	7.50
		Sugar.....	13.00	13.00	13.00	13.00	14.00	14.00	14.00	14.00	14.00
		Gelatin.....	.50	.50	.50	.50	.50	.50	.50	.50	.50
		T. S.....	33.00	34.00	34.00	34.00	35.00	35.00	36.00	38.00	40.00
		Fat	M. S. N. F.	T. S.	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
		%	%	%									
Name and tests of products with pounds of each required.	Whole milk..	3.50	8.50	12.00	134.60	1462.0	1347.0	1224.0	983.0	983.0	1100.0	855.0	850.0
	Butter.....	83.00	1.50	84.50	39.7	34.7	43.1	51.7	68.9	103.2	98.3	156.8	181.0
	Sugar.....	.....	.....	100.00	130.0	130.0	130.0	130.0	130.0	140.0	140.0	140.0	140.0
	Gelatin.....	.....	.....	87.00	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7
	Total.....	.....	.....	.....	1521.4	1632.4	1584.8	1534.8	1438.6	1231.9	1344.0	1157.5	1176.7
	Water to be removed...	.....	.....	.....	521.4	632.4	584.8	534.4	438.6	231.9	344.0	157.5	176.7
	Finished mix.....	.....	.....	.....	1000	1000	1000	1000	1000	1000	1000	1000	1000

TABLE 86.

Mixes of Nine Compositions. Made from Whole Milk, Butter, Sugar and Gelatin. All Constituents Condensed in Vacuum Pan to Yield 1000 Lbs. of Finished Product.

	No. of mixes..	1	2	3	4	5	6	7	8	9
		Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent
Composition of mixes in percentages..	Fat.....	8.00	8.00	8.50	9.00	10.00	12.00	12.00	16.00	18.00
	M. S. N. F....	11.50	12.50	12.00	11.50	10.50	8.50	9.50	7.50	7.50
	Sugar.....	13.00	13.00	13.00	13.00	14.00	14.00	14.00	14.00	14.00
	Gelatin.....	.50	.50	.50	.50	.50	.50	.50	.50	.50
	Total Solids..	33.00	34.00	34.00	34.00	35.00	35.00	36.00	38.00	40.00

		Fat	M. S. N. F.	T. S.	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
		%	%	%									
Name and tests of products of each required.	Whole milk..	4.00	8.70	12.70	1315.0	1432.0	1372.0	1315.0	1196.0	960.0	1075.0	835.0	832.0
	Butter.....	83.00	1.50	84.50	33.0	27.4	36.3	45.1	62.9	98.2	92.8	152.6	176.8
	Sugar.....	.....	.....	100.00	130.0	130.0	130.0	130.0	140.0	140.0	140.0	140.0	140.0
	Gelatin.....	.....	.....	87.00	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7
	Total.....	.....	.....	.....	1483.7	1595.1	1544.0	1495.8	1404.6	1203.9	1313.5	1133.3	1154.5
	Water to be removed.....	.....	.....	.....	483.7	595.1	544.0	495.8	404.6	203.9	313.5	133.3	154.5
	Finished mix.	.....	.....	.....	1000	1000	1000	1000	1000	1000	1000	1000	1000

TABLE 87.

Mixes of Nine Compositions. Made from Skim-milk, Butter, Sugar and Gelatin. All Constituents Condensed in Vacuum Pan to Yield 1000 Lbs. of Finished Product.

Composition of mixes in percentages.	No. of Mix				1	2	3	4	5	6	7	8	9
	Fat				Per Cent 8.00	Per Cent 8.00	Per Cent 8.50	Per Cent 9.00	Per Cent 10.00	Per Cent 12.00	Per Cent 12.00	Per Cent 16.00	Per Cent 18.00
	M. S. N. F.				11.50	12.50	12.00	11.50	11.50	8.50	9.50	7.50	7.50
	Sugar				13.00	13.00	13.00	13.00	14.00	14.00	14.00	14.00	14.00
	Gelatin				.50	.50	.50	.50	.50	.50	.50	.50	.50
	Total Solids				33.00	34.00	34.00	34.00	35.00	35.00	36.00	38.00	40.00
Name and tests of products with pounds of each required		Fat	M. S. N. F.	T. S.	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
	Skim Milk	% .20	% 8.8	% 9.00	1290.0	1404.0	1346.0	1290.0	1174.0	943.0	1055.0	822.0	818.0
	Butter	83.00	1.50	84.5	93.4	93.0	99.2	105.4	117.8	142.3	142.1	190.8	215.0
	Sugar	.....	.....	100.	130.0	130.0	130.0	130.0	140.0	140.0	140.0	140.0	140.0
	Gelatin	.....	.....	87.0	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7
	Total	.....	.....	.....	1519.1	1632.7	1580.9	1531.1	1437.5	1231.0	1342.8	1158.5	1178.7
	Water to be removed	.....	.....	.....	519.1	632.7	580.9	531.1	437.5	231.0	342.8	158.5	178.7
	Finished mix	.....	.....	.....	1000	1000	1000	1000	1000	1000	1000	1000	1000

REFERENCES

[1] Richmond, H. D. Dairy Chemistry p. 335.

[2] Hammer, B. W. & Johnson, A. R. The specific heat of milk and milk derivatives. Research Bul. No. 14, Ames, Iowa.

[3] Bogue, R. H. and Skinner, W. W. Relative sweetness of sweet sugar, Jour. Ind. Eng. Chem. Vol. 14, 1922, p. 522.

[5] Cromley, Roy H. Chief Chemist, Stroh Products Co. Article in Ice Cream Trade Journal.

[6] Heller's Guide for Ice Cream makers, B. Heller & Co., Chicago.

[7] Analysis made by Miss Lucy Klein, Research Laboratories, Mojonnier Bros. Co., Chicago, Ill.

[8] Sample received by courtesy of Horine and Bowey Co., Chicago.

[9] Atwater, W. O. and Bryant, A. P. Bul. No. 28, 1906. Office of Exp. Sta., Washington, D. C

[10] Mojonnier, T.

[11] Bothell, F. H. Facts about sandy ice cream. Ice Cream Trade Journal, Feb. 1920.

[12] Bothell, F. H. Sandy Ice Cream and its cause. Creamery & Milk Plant Monthly, June, 1921.

[13] Zoller, H. F. and Williams, O. E. Creamery and Milk Plant Monthly, October, 1921.

[14] Williams, O. E. Progress in studying causes of sandy ice cream. Creamery and Milk Plant Monthly, Nov. 1921.

[15] Groth, P. Chem. Krystallsgraphic. Teil 3, p. 804, 1910. Leipzig.

[16] Dubrunfaut, Compt. Rend. Vol. 42, p. 228, 1856.

[17] Hudson, C. S. Jour. Amer. Chem. Soc. 1904, Vol. 26, p. 1065 and 1908, Vol. 30, p. 1767.

[18] Solliard, E. Chemie et Industrie, Sept. 1919.

[19] Mack, Edw. and Liedel, H. J. Thesis—The solubility of milk sugar. H. J. Liedel, Ohio State University, 1920.

[20] Travis, R. P. The final solubility of lactose in a representative ice cream mix, and in a fourteen per cent solution of pure sucrose. Thesis for M. S. degree, Graduate School, Cornell University, Ithaca, N. Y., 1922.

[21] Hall, Thos. Ice Cream Trade Journal, New York, N. Y., Nov. 1921, p. 72.

[22] Mojonnier, T. and Mojonnier, J. J.

[23] Peterson, R. W. and Tracy, D. H. The Condensation Process of Preparing an Ice Cream Mix, Jour. Dairy Science, Vol. V, 1922, p. 273.

CHAPTER XIV

THE STANDARDIZATION OF MISCELLANEOUS DAIRY PRODUCTS

In addition to the products described in the preceding chapters, there are numerous others of great commercial and economic importance that require the most exact control possible in their manufacture, if these are to be marketed of uniform chemical and physical properties. The standardization of the most important of these products will be discussed in this chapter.

THE STANDARDIZATION OF UNSWEETENED CONDENSED MILK.

Besides evaporated milk described in Chapter XI, there are several other unsweetened condensed milk products of great commercial importance, the same being made both of skim and whole milk. There are two main varieties of concentrated skim-milk. One variety is controlled by a Federal Standard of 20.00 per cent T. S., and is canned largely in one gallon cans, and sterilized like evaporated milk.

The second variety is manufactured largely under a trade standard of 25.50 per cent T. S., and is usually superheated in the vacuum pan. This is marketed largely in eight or ten-gallon milk shipping cans, the same being an unsterilized product, and intended for prompt consumption.

The fat content in these products is frequently disregarded but under careful management the same should be determined, otherwise preventable losses may occur. The standardization is usually based upon the T. S. content only.

Evaporated skim-milk of 20 per cent T. S. test is condensed in the vacuum pan in a manner similar to evaporated whole milk. The condensation is continued sufficiently to provide an excess

of T. S. in the condensed product. This is then tested for T. S. using the Mojonnier Tester, and water is added to bring the product back to the test desired.

Plain condensed skim-milk testing 25.50 per cent T. S. is usually condensed beyond the point desired before superheating. The overcondensed product is diluted back with water to the point desired as in the case of the evaporated skim-milk.

If the skim-milk used is properly sampled and tested the yield can be calculated as indicated by the following example: The batch contains 10000 pounds skim-milk testing 8.80 per cent T. S. It is desired to make evaporated skim-milk testing 20.00 per cent T. S. The product obtained from the pan weighed 4200 pounds.

$10000 \times .088 = 880$, pounds T. S. in the entire batch.

$880 \div .20 = 4400$, the pounds of evaporated skim-milk possible to make.

$4400 - 4200 = 200$, or the pounds of water necessary to add.

If the standardizing is to be done after condensing, the calculation is indicated by the following example:

The product from the pan weighs 3200 pounds, and tests 26.87 per cent T. S.

The test desired is 25.50 per cent T. S.

$32.00 : X = 25.50 : 26.87.$

$X = 3451$, the total pounds that the batch should contain.

$3451 - 3200 = 251$, the pounds of water necessary to add.

Plain condensed whole milk is manufactured under many different trade standards, as regards both fat and T. S. The two most common standards are 6.00 per cent fat and 28.00 per cent T. S. and 8.00 per cent fat and 30.00 per cent T. S. The methods of calculation for standardizing these products are the same as in the case of evaporated milk given under Chapter XI, to which the reader is referred.

RELATION OF COMPOSITION, TEMPERATURE AND SPECIFIC GRAVITY IN SEVERAL UNSWEETENED CONDENSED MILK PRODUCTS.

It is pointed out in the chapter on evaporated milk that a proper knowledge of the relation between temperature, specific gravity and composition is of value in determining the point at which to strike the batch. A knowledge of this relation may also

be used to advantage in determining the striking point of other concentrated milk products. With the object in view of providing this useful information, the specific gravity at various temperatures and compositions was carefully determined in the case of three of the most common unsweetened condensed milk products. Fig. 90 shows this relation in the case of unsweetened condensed whole milk in which the fat and M. S. N. F. are in the ration of 8: 22. Fig. 91 applies to plain condensed skim-milk ranging from 20.00 per cent to 40.00 per cent T. S. Fig. 92 applies to condensed buttermilk testing from 13.50 per cent to 32.00 per cent T. S. All tests were made by J. A. Cross and H. J. Liedel.

THE STANDARDIZATION OF MILK POWDERS.

Milk powders are manufactured of various compositions from skim-milk to cream. In skim-milk powder the per cent of fat is ordinarily disregarded, but sometimes this is considerable—the closeness of the separation of the whole milk being the governing factor. As a matter of precaution in factory control, the fat test of the skim-milk should be daily ascertained both in the fresh skim-milk, and in the finished powder. The water content of skim-milk powder is limited in the Federal standard to 5 per cent.

The test must be closely watched both because of the standard requirements, and because of the close relation between water content and keeping quality.

The following example shows how to calculate the pounds of skim-milk powder possible to make. The batch of skim-milk weighs 10000 pounds and tests 8.80 per cent T. S.

$10000 \times .088 = 880$, pounds T. S. in entire batch.

$880 \div .95 = 927$, pounds skim-milk powder testing 95.00 per cent T. S. that it is possible to make.

The sampling and the testing of the powder itself is fully described in the chapters relating to this subject.

HOW TO STANDARDIZE WHOLE MILK AND CREAM POWDERS.

The principles underlying the standardization of whole milk powder are very similar to those underlying the standardization of evaporated milk. Two general methods are available, namely, (1) standardizing the whole milk in the hot wells before condensing, or (2) standardizing the finished product by adding skim-

KEY TO FIG. 90

Curve	1	2	3	4	5	6	7
Fat, per cent..	5.0	5.50	6.00	6.50	7.00	7.50	8.00
M. S. N. F. per cent..	13.75	15.13	16.50	17.88	19.25	20.63	22.00
T. S., per cent..	18.75	20.63	22.50	24.38	26.25	28.13	30.00

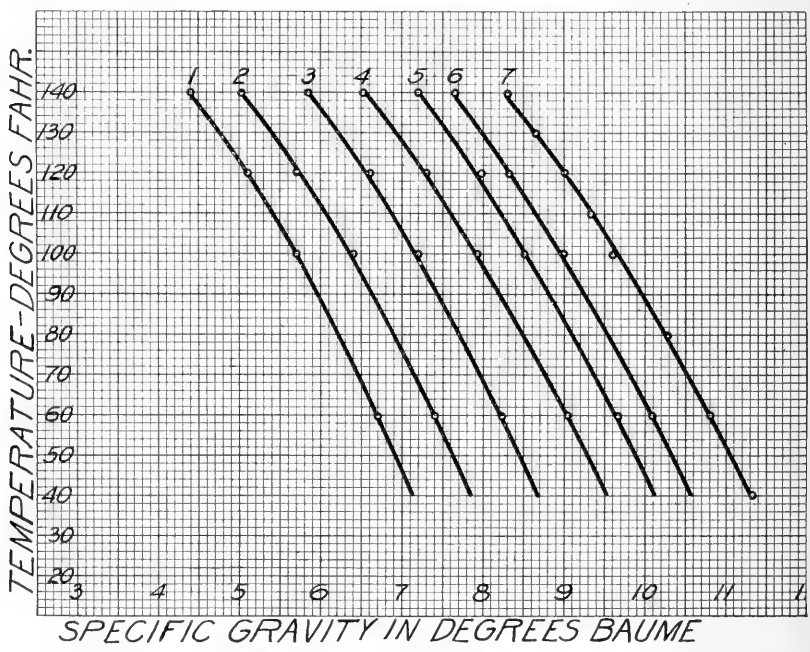


Fig. 90. Relation Between Temperature, Specific Gravity and Composition in the case of unsweetened condensed whole milk in which the Constituents are in the Ratio 8.00 Per Cent Fat to 22.00 Per Cent M. S. N. F.

milk powder or whole milk or cream powder as the case may require. The first named method is usually preferable, for the reasons that the proper products are not always available, and that many plants are not equipped to mix, satisfactorily, various grades of milk powder.

Whole milk powder is marketed under many different compositions. The minimum composition is governed by the Federal ruling which calls for not less than 26.00 per cent fat. 69.00 per

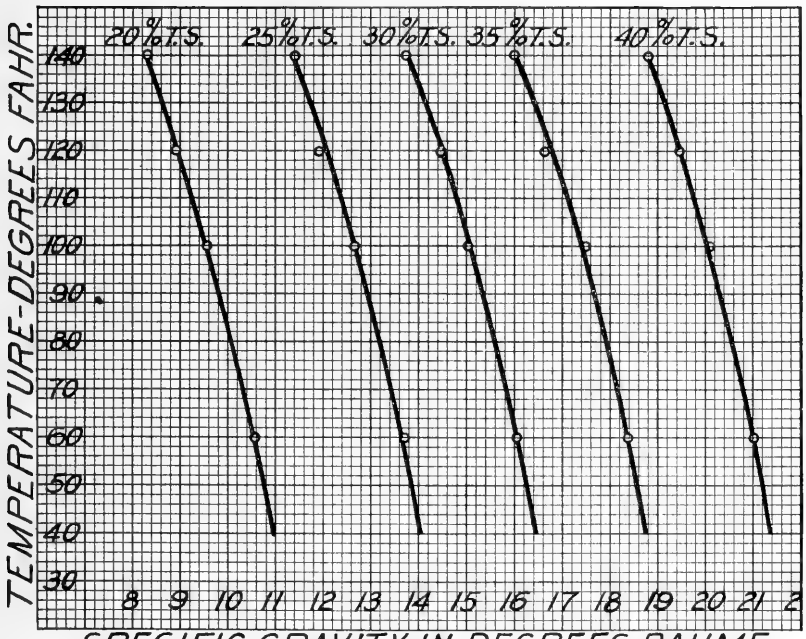


Fig. 91. Relation Between Temperature, Specific Gravity and Composition in the Case of Plain Condensed Skim-milk Ranging from 20.00 Per Cent to 40.00 Per Cent T. S.

cent M. S. N. F., and not more than 5 per cent water. In this product the ratio of M. S. N. F. to fat is 1 : 3768.

When necessary to add skim-milk to the whole milk, when standardizing before condensing, follow method of calculation recommended under Problem 7, Chapter XII.

When necessary to add cream to the whole milk, when standardizing before condensing, follow the method of calculation recommended under Problem 8, Chapter XII.

When desired to standardize whole milk powder with other milk powders, follow methods of calculation recommended under Problems 1 and 2, Chapter X.

In cream powder the per cent of M. S. N. F. and the physical properties of the product will vary with the composition of cream used to make the powder. Table 88 gives the percentage of M. S. N. F. in the T. S. of three samples of cream of different compositions.

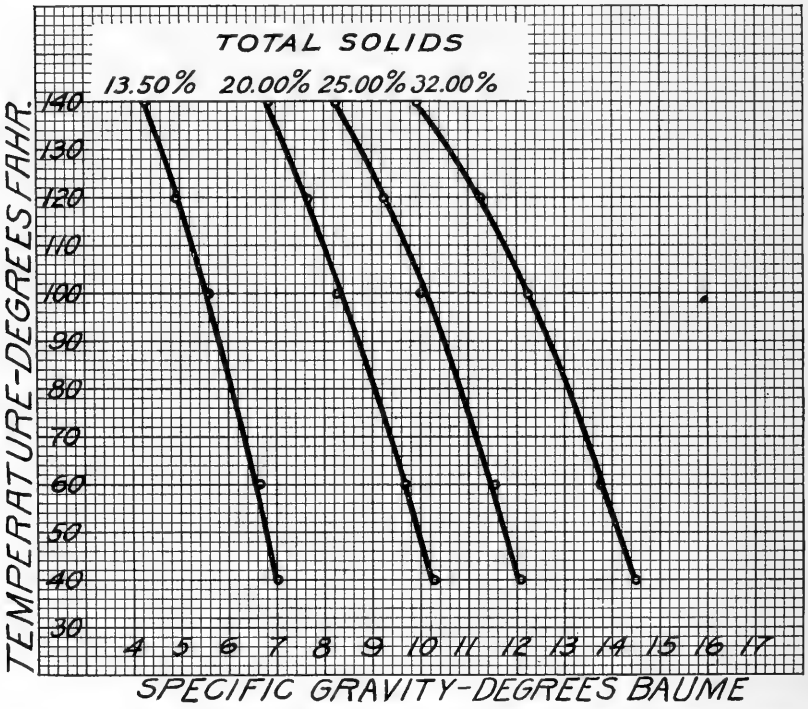


Fig. 92. Relation Between Temperature, Specific Gravity and Composition in the Case of Condensed Buttermilk Ranging from 13.50 Per Cent to 32.00 Per Cent T. S.

TABLE 88.

Per Cent M. S. N. F. in T. S. of Cream of Different Tests.

Composition of Cream in Per Cent			Per Cent M. S. N. F. of T. S.
Fat	M. S. N. F.	T. S.	
15.15	7.85	23.00	34.13
30.02	6.48	36.50	17.75
50.02	4.63	54.65	8.47

It is evident that the composition of cream powder depends entirely upon the composition of the cream from which it is produced. A cream low in fat will produce a cream powder high in S. N. F. and vice versa.

MANUFACTURE, COMPOSITION AND STANDARDIZATION OF CHOCOLATE, COCOA AND MILK CHOCOLATE.

Chocolate and cocoa are made from the seeds of Theobroma

Cacao, a tree that grows in most tropical countries. The seeds are commonly called "cocoa beans."

In the manufacture of chocolate the seeds are separated from the pulp of the fruit in which they grow. Then they are roasted, partially crushed and winnowed to remove the seed shells. The partially crushed seeds after having the shells removed are known as cocoa nibs. In the manufacture of chocolate these are crushed warm between grinding stones, and the freed fat causes the material to flow from the grinding stones in the form of a thin paste. This is allowed to cool in molds and forms commercial unsweetened chocolate. It has practically the same composition as the cocoa nibs from which it is made.

The sweetened chocolate usually contains between 50 and 70 per cent of added sugar, and the percentages of the other constituents are correspondingly lower.

Cocoa is made from the ground cocoa nibs, or unsweetened chocolate by separating part of the fat, usually about one-half. The removal of the fat increases proportionately the percentage of the other constituents remaining in the cocoa.

In the manufacturing process cocoa shells may not be completely separated from the cocoa nibs before they are ground, but any large amount of material from the shells remaining in the chocolate, or in cocoa would be classed as an adulteration.

Winton analyzed cocoa nibs, pure commercial cocoa, and cocoa shells, and his results are given in the following table.

Milk chocolate consists of material from ground cocoa nibs with added sugar, and milk or milk products. The composition of ten samples of milk chocolate is given in the Annual Report of the Conn. Agr. Exp. Sta. for 1911. Each sample was taken from the product placed on the market by a different manufacturer. These analyses are given in Table 89.

A sample of milk chocolate obtained upon the Chicago market was tested by Miss Lucy Klein and found to contain 32.66 per cent fat, and 2.38 per cent water.

The results given in Table 90 indicate the wide differences in composition that were found in milk chocolate. By proper methods of standardization, these differences could be greatly reduced.

TABLE 89

Composition of Cocoa Nibs, Pure Commercial Cocoa and Cocoa Shells.

	Cocoa nibs (hand shelled) Average of 17 analyses. %	Pure commercial cocoa. Average of 26 analyses. %	Cocoa shells (hand shelled) Average of 17 analyses. %
Water	2.72	6.23	4.87
Ash	3.32	5.49	10.43
Theobromin	1.04	1.15	0.49
Caffein	0.40	0.16	0.16
Other nitrogenous substance (Protein)	12.12	18.34	14.46
Crude fiber	2.64	4.48	16.55
Pure starch	8.07	11.14	4.13
Other nitrogen-free substances	19.57	26.32	46.15
Fat	50.12	26.69	2.76
	100.00	100.00	100.00

TABLE 90

Composition of Milk Chocolate.

	In Air-Dry Material								
Sample No.	Ash per cent	Alkalinity of ash c. c. of N/10 acid per gram of chocolate	Fat per cent	Nitrogen per cent	Sucrose per cent	Lactose per cent	Fat Constants		
							Iodine number (Hanus)	Refractive Index at 40° C.	Reichert Meissl No.
1	1.56	1.19	29.95	1.17	48.31	7.28	35.60	1.4566	6.2
2	1.85	1.82	28.69	1.36	45.81	7.75	31.41	1.4567	5.9
3	1.71	2.09	32.13	1.19	43.09	3.57	33.86	1.4567	5.0
4	1.67	1.93	28.77	1.11	49.45	2.25	33.35	1.4569	3.2
5	1.56	1.58	28.85	1.17	49.65	6.87	34.42	1.4562	5.6
6	1.79	2.10	33.23	1.42	39.45	6.24	35.36	1.4566	4.1
7	2.12	2.49	26.84	1.44	44.26	8.46	35.16	1.4576	3.7
8	1.66	1.89	33.31	1.20	42.45	7.39	34.08	1.4569	3.7
9	1.60	1.92	32.67	1.29	42.64	7.81	33.80	1.4562	5.1
10	2.25	1.75	30.63	1.55	39.49	8.17	35.30	1.4563	5.8

TABLE 91.

Composition of Miscellaneous Milk Foods.

	Per Cents					
Malts	Moisture	Fat	Proteids	Ash	Cold Water Extract	Starch, etc., by Difference
Malted milk	3.98	7.70	14.88	3.12		
Malted milk	2.98	8.08	15.18	3.34		
Malted milk	3.55	8.36	15.64	3.52		
Malted milk	2.68	8.17	14.52	3.34		
Malted milk	2.90	7.77	14.96	2.92	75.10	
Malted milk	2.50	8.37	14.57	3.48		
Peptogenic milk powder	0.65	Trace	0.81	1.11	89.93	7.50
Peptogenic milk powder	0.80	Trace	0.52	1.10	89.76	7.82
Allenbury's Milk Food No. 2....	3.92	15.00	9.19	2.60		
Allenbury's Milk Food No. 2....	3.10	16.27	9.56	2.87	67.45	0.75
Allenbury's Milk Food No. 2....	3.37	16.03	10.04	2.61		
Allenbury's Milk Food No. 2....	4.55	15.07	9.30	3.04	69.55	
Allenbury's Milk Food No. 1....	2.72	17.80	10.13	3.45	66.50	
Wampole's Milk Food	5.22	7.87	12.73	2.22	76.55	

Two general methods of standardizing milk chocolate are possible. First, mixing the milk products and the sugar in the proper proportions in the hot well before condensing in the vacuum pan. This mixture is condensed as low as possible in the vacuum pan, and finally reduced to the desired consistency in another operation. In turn this dried mixture of butterfat, milk solids not fat and sugar is mixed and ground with unsweetened chocolate. Maintaining a uniform balance between the various ingredients that compose the finished milk chocolate will do much to insure a uniform product.

Second. The milk products and the sugar are condensed in the vacuum pan to the desired consistency and this condensed product is in turn mixed with the cocoa liquor, in the desired proportions, and the mixture further reduced to the desired consistency.

Table 91 gives the composition of various other milk foods, as reported by McGill.[1]

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[1] McGill, A. Infants' and Invalids' Foods. Inland Revenue Dept., Ottawa, Canada. Bul. 278, 1914.

CHAPTER XV

THE OVERRUN IN ICE CREAM

GENERAL FACTS REGARDING OVERRUN.

In the process of freezing ice cream mix the volume is increased by the expansion of both the solid and liquid constituents comprising the mix, and by the incorporation of innumerable small air bubbles. One of the best theories offered as the cause for this increase in the volume of the ice cream mix is that the walls enclosing the air cells become frozen, and thus prevent the escape of the air in the cells, so long as the ice cream is kept sufficiently cold. When the ice cream is drawn from the freezer it is in a plastic condition, and unless hardened soon after drawing the air will gradually escape, as the cell walls are not sufficiently rigid to retain the enclosed air.

This important subject has received the attention of many investigators, among whom may be especially mentioned Washburn,[1] Baer,[2] and Mortensen.[3]

The true percentage of overrun is calculated by the following formula:

$$\text{Percentage overrun} = \left(\frac{\text{Weight unit volume mix—weight unit volume ice cream}}{\text{Weight unit volume of ice cream}}\right) \times 100$$

Example in calculating overrun. Ice cream mix weighs 9.10 pounds per U. S. gallon. The ice cream made from this mix weighs 4.55 pounds per U. S. gallon. What is the percentage of overrun?

$$\text{Percentage overrun} = \left(\frac{9.10-4.55}{4.55}\right) \times 100 = 100 \text{ per cent overrun.}$$

There is no factor in the manufacture of ice cream that fluctuates more than the percentage of overrun; therefore, its control is of very great importance. Insufficient overrun greatly increases the cost of the ice cream, and yields a product that is immediately detected by its heavy and soggy appearance and to some users by

its unpalatable taste. Too high an overrun produces a fluffy product with a flat taste, that stands up poorly in the cabinet of the dealer, thereby causing many complaints.

The aim should be for the manufacturer to adopt a standard percentage of overrun, unless this is already done by law, and then to control the manufacture of his product, so that this standard can be maintained at all times.

DIFFERENT PHASES IN THE NORMAL FREEZING AND HARDENING OF ICE CREAM.

The normal freezing and hardening period divides itself into four separate and clearly defined phases, as shown in the chart under Fig. 93. The values given upon the chart were obtained from careful experiments made in the plant of the Goodman-American Ice Cream Co., Chicago, Illinois, and the same are being published through their courtesy.

The percentage of overrun and the temperature of the ice cream were determined at the end of minute periods, beginning immediately after the freezing of the mix was started, and continuing until the batch was drawn from the freezer. The temperature of the ice cream was determined at larger intervals as indicated.

The mix was one testing 18.00 per cent of fat, and 38.00 per cent of total solids.

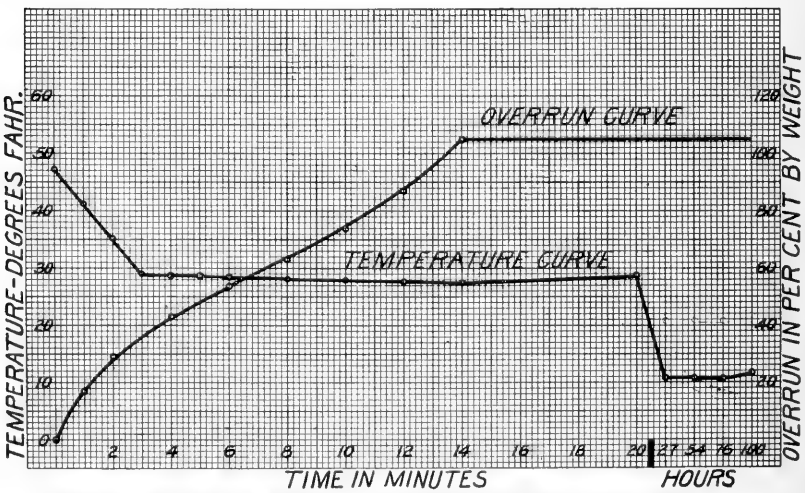


Fig. 93. The Four Phases in the Normal Freezing of Ice Cream.

(1). The specific heat phase, during which the specific heat is removed from the mix, and the temperature is lowered to the freezing point. This phase begins the instant the mix is drawn into the freezer, and ends the instant that the specific heat has been all absorbed, and just before the latent heat begins to be absorbed. The increase in the overrun during this phase is quite appreciable. During this phase the heat to be removed from a mix containing 8.00 per cent fat, 34.00 per cent T. S. and 66.00 per cent water, the initial temperature of which upon entering the freezer is 40° F., and which has a freezing point of 28° F., is about as follows, calculated upon the basis of 100 pounds of the mix:

$40 - 28 = 12$, or the number of F. degrees that the mix is to be lowered. $(12 \times 100) \times .900 = 1080$, or number B. T. U. required to reduce the mix to freezing temperatures.

(Note: By specific heat is meant the amount of heat required to raise or lower one pound of the mix 1° F. or the equivalent of one British thermal unit: = 1 B. T. U.) The above calculation is obviously only an approximation, since the specific heat is calculated upon that of water at 15° C., as shown by the researches of Bartoli and Stracciati. The specific heat of water varies at different temperatures, being 1.000 at 15° C. and 1.00664 at 0° C. The specific heats of milk and other products entering into the composition of ice cream mix are considerably different than that of water, and like water the same vary with the temperature. Hammer and Johnson[4] report extensive investigation relating to the specific heat of milk and other dairy products. The average specific heat of milk testing 3.50 per cent fat between 0° and 15° C. is reported as being 0.939 and of 15.00 per cent cream 0.837. The specific heats of ice cream mix of various composition, calculated from the values reported by Hammer and Johnson, are given in Table 44, Chapter XIII. For a mix of the above composition it is .900.

(2). The latent heat phase.

This phase begins the instant that the latent heat begins to be absorbed and ends the instant that the latent heat is all absorbed, and just before ice crystals begin to form. During this phase the temperature remains practically constant. The viscosity and the overrun both increase rapidly during this phase. It may be completed while the ice cream is still in the freezer or whenever the

freezing operation is continued long enough to remove all the latent heat. When the freezing operation is stopped before the latent heat is all removed, then it is completed after the ice cream is drawn from the freezer, and after the ice cream has stood in the hardening room for the time necessary to complete the removal of the latent heat. The best practice is to complete this phase in the hardening room. As soon as it is passed the ice cream passes from a highly viscous or plastic condition to a brittle condition, due to the freezing of the walls encasing the air. If it is passed while the ice cream is in the freezer, there is danger of losing part of the overrun. The ice cream should be drawn from the freezer near the end of this phase, or as soon as the desired viscosity and overrun have been obtained, inside of it.

During this phase, as pointed out by Cutler[5] the number of heat units removed is governed to quite an extent by the composition of the mix, this being due to the latent heat that is derived from the water content only of the mix. In the case of a mix of the composition just named, the latent heat removed would be as follows:

$100 - 34.00 = 66.00$, or per cent water in mix.

$100 \times .66 = 66$, or pounds water in 100 pounds of mix.

$144 =$ B. T. U. required to convert one pound of water into one pound of ice or vice versa, at 32° F., or the latent heat of ice.

$66 \times 144 = 9504$, or B. T. U. required to remove the latent heat from 100 pounds ice cream mix of above composition.

Each one per cent increase or decrease in T. S. would increase or decrease the above numbers to the extent of 144 B. T. U. upon every 100 pounds of the mix.

(3). The critical point phase.

This phase begins the instant that all the latent heat has been extracted, and ice crystals begin to form. The ice cream should be drawn when the proper viscosity and overrun have been obtained just before reaching this phase. Under good practice this phase should begin after the ice cream has been drawn into the cans, and placed in the hardening room. If passed while the ice cream remains in the freezer, the danger of losing overrun

becomes very large. The temperature will remain nearly constant during this phase.

(4). The hardening phase. This phase begins when the critical point phase has been passed. The ice cream during this entire phase should be kept in the hardening room at a sufficiently low temperature to cause the crystallization of the ice crystals in a minimum of time. If too much time is consumed in passing through this phase, loss of overrun may result as the cell walls may not be sufficiently hard to prevent the escape of the air, and in addition the ice cream will become coarse and grainy.

The temperature will remain nearly constant for several minutes, and then it will gradually fall until it reaches equilibrium at a point near the temperature of the hardening room. The heat absorption during this phase is in about the same proportion to the number of decreased degrees, as in the specific heat phase. The ice cream should remain at the low temperature acquired in this phase, until consumed.

PROPER OVERRUN.

It has been proved by experience that ice cream of proper composition, containing 95 to 100 per cent overrun, makes a most satisfactory product. This does not mean where the general average is as above, but with some of the freezers being drawn at 60 per cent and others at 140 per cent. The overrun upon each single freezer should be controlled, and every freezer drawn when the overrun reaches the standard set. The overrun for ice cream containing crushed fruits is usually set at about 10 per cent under the standard for the plain varieties. Some manufacturers prefer an overrun standard of as low as 70 per cent, and again others desire as much as 110 per cent. This is a matter to be decided by local conditions, trade requirements, and quality of product desired.

The overrun in ice cream is influenced by a number of factors. The principal of these will be discussed in turn, indicating as far as possible under each factor the conditions required for obtaining the best results.

(1). **The Composition of the Mix.**

The influence of the composition of the mix is a most important one as affecting overrun, both in producing and in retaining the

overrun after it has been obtained. A high overrun can be obtained from a mix without fat, or from one low in T. S., but in order to produce a product that is smooth to the taste, and one that will retain its overrun and give satisfaction, a fair amount of both fat and T. S. must be used.

A careful experiment was made to determine the influence of composition upon the freeezing of ice cream. All conditions were the same except the composition of the mix. Several freezings were made from each lot of mix. The average results obtained are given upon the graph in Fig. 94.

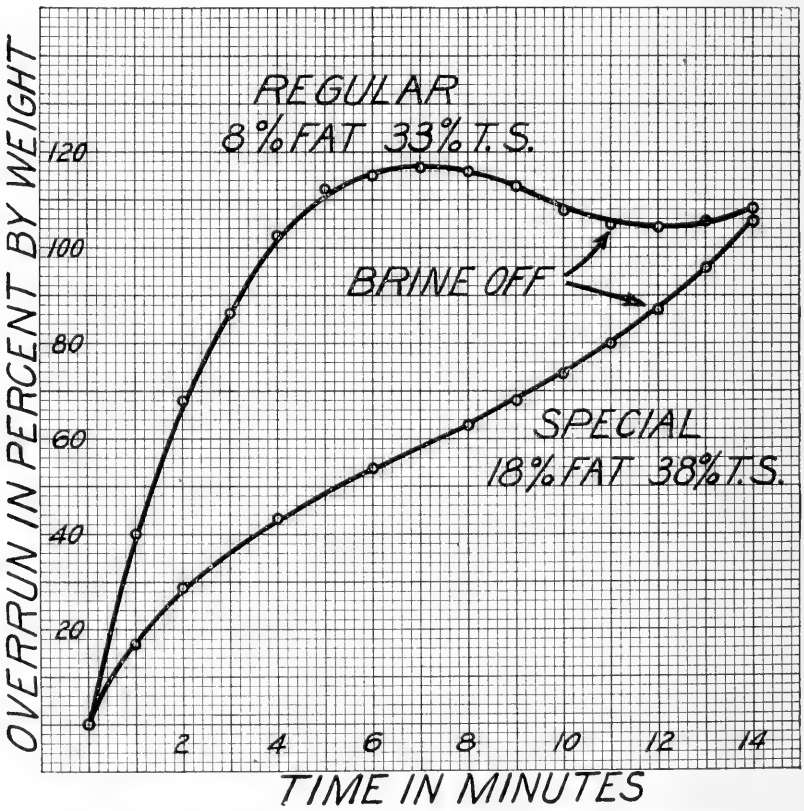


Fig. 94. Influence of Composition Upon the Freezing of Ice Cream.

As indicated by the results upon the above graph, mix high in milk solids not fat and comparatively low in fat, acquired overrun much more rapidly than in the reverse case. The overrun is best controlled and the finished product is the most satisfactory if the fat is maintained between 8 and 18 per cent and the total solids are maintained between 33.00 and 40.00 per cent. The extremes would apply only to exceptional products. Of great importance in its influence upon overrun is the proportions of the various constituents that make up the total solids. Probably of first importance is the amount of milk solids not fat, and more especially the amount of casein and albumen that constitute part of the milk solids not fat.

The maximum allowable percentage of milk solids not fat is limited to the quantity that may cause sandy ice cream, as described under Chapter XIII. Less than nine per cent of milk solids not fat will make it very difficult, if not impossible, to obtain any overrun that may be desired in excess of 75 to 80 per cent. A milk solid not fat content ranging from 9 to 12.50 per cent will help greatly in making it possible to obtain up to 100 per cent overrun with comparative ease. With an ample supply of milk solids not fat, there is no difficulty in obtaining the desired overrun, regardless of what the fat content may be. The fat is, of course, of great importance as affecting other qualities and properties of the ice cream.

From 13.00 to 14.00 per cent of sugar is universally recognized as the most satisfactory. When less than 13.00 per cent sucrose, or its equivalent in sweetening power, is used, the finished product is not sufficiently sweet, and using over 14.00 per cent increases the freezing point and makes it much more difficult both to obtain and to retain the overrun.

The extent to which the sugar content influences the overrun is indicated under Fig. 95, which is reproduced by courtesy of the Telling Belle Vernon Co.

As the results upon the chart indicate, the ability to produce overrun in the ice cream when freshly prepared decreased with an increase in the sugar content.

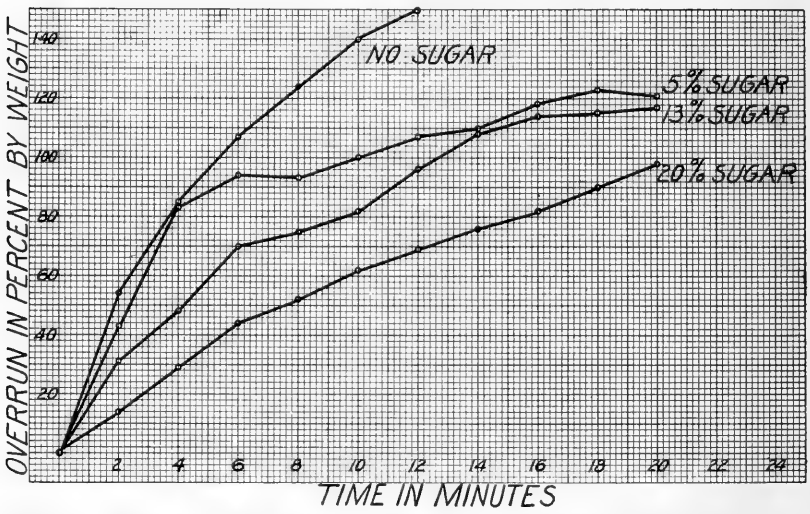


Fig. 95. Influence of the Sugar Content of the Mix Upon the Production of Overrun in Ice Cream. By W. O. Frohring.
Reproduced by Courtesy Telling Belle Vernon Co.

(2). The Aging of the Mix.

The practice of aging the mix by holding it in storage tanks at a temperature of 32 to 40° F. is followed by many manufacturers, but the practice is by no means a universal one. If the mix is properly handled, the necessary overrun can be obtained without aging, although the advantages in favor of aging are sufficient to warrant this practice where possible. This has been found in some cases to be the only method that would make it possible to obtain the overrun desired. Aging increases both the acidity and the viscosity of the mix. The acidity is due to the development of acid as in the case of the souring of any other dairy product, being caused by bacterial growth.

The increase in acidity is very slight if the aging is done at 40° F. or less, and if the mix is not aged in excess of 72 hours.

The gelatin added to the mix exerts probably more influence upon increasing the viscosity in aging than does the acidity developed by bacterial growth. As shown in Chapter XIII, gelatin solutions increase greatly in viscosity upon aging at low temperatures. The hydration of gelatin is a slow process, and the increase in

viscosity which accompanies hydration is favored by low temperatures, such as are used when aging ice cream mix.

The low temperatures used in aging ice cream mix no doubt cause a certain hardening of the constituents, particularly the fat and the protein, and in turn this probably exerts some influence upon the viscosity.

Whatever the cause may be, it remains a well established fact that viscosity increases with aging, and that an increase in viscosity favors the incorporation of air into ice cream.

A careful experiment by W. O. Frohring shows the influence of aging upon the production of overrun, as illustrated upon the graph under Fig. 96.

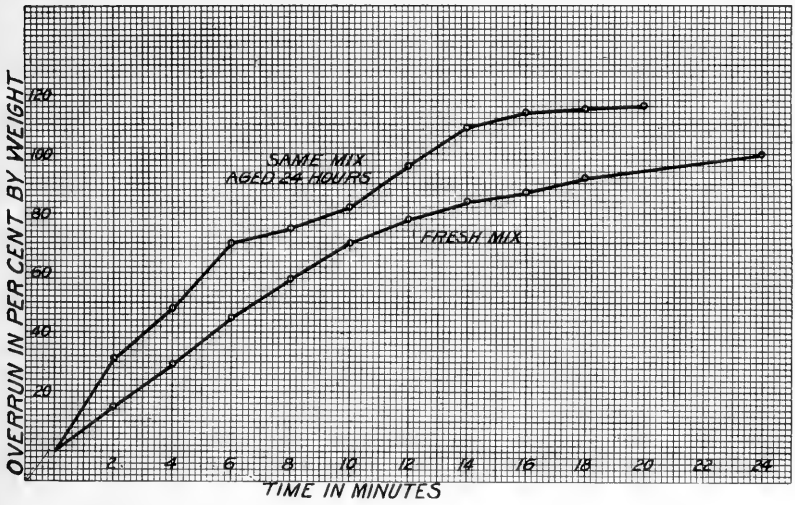


Fig. 96. The Influence of Aging Upon the Production of Overrun in Ice Cream. By W. O. Frohring.
Reproduced by Courtesy Telling Belle Vernon Co.

As indicated by the graph, the same mix yielded 100 per cent of overrun after 24 minutes in the freezer without aging, and after 12 minutes after aging 24 hours.

The aging operation requires careful watching on account of the danger of over-ripening which causes the mix to become sour; and to change from a viscous to a lumpy condition, under which it becomes difficult to retain air in it, in the freezer.

Aging usually causes an increase in the bacteria count, and necessitates increased storage capacity.

(3). **The Acidity of the Mix.**

The acidity is an important factor in obtaining the most desirable flavor and texture in the finished product, and in controlling the overrun. An acidity of between .25 per cent and .30 per cent is considered as giving the best results. The presence of too much acid may cause the mix to curdle, particularly where the same is pasteurized.

The acidity may be immediately increased by adding cultured buttermilk when compounding the mix. This will insure a good sharp flavor; permit of pasteurization thus insuring a low bacteria count, and make it possible to produce a mix of constant and ample viscosity. Possibly the aging period in the case of mix treated in this manner can be shortened or dispensed with. This is a phase of the ice cream industry that is in its infancy, and it opens possibilities for very interesting studies.

(4). **The Viscosity of the Mix.**

This factor has already been discussed under the aging and acidity of the mix, inasmuch as both of the last mentioned factors produce viscosity in the mix. Viscosity is sometimes called the body or stickiness of a substance. This is a physical property that can be measured with great accuracy in ice cream mix by means of the viscosimeter described under Chapter XVII.

The viscosity of ice cream mix is itself influenced by several factors. Any condition that would cause coagulation of the casein, or of the albumen, would cause an increase in the viscosity of the mix. Such conditions would be the presence of acid due either to aging or to the addition of pure lactic buttermilk cultures or to the addition of sucrate of lime, or the addition of some enzymes. Homogenizing under the proper conditions of temperature also causes an increase in the viscosity. This factor will be further discussed under another heading. The matter of temperature is a very important one as affecting viscosity, inasmuch as this influences all the products composing the mix. The two best illustrations of this are the case of fat which is a liquid at the comparatively low temperature of 90° F. and a semi-solid at

about 60° F., and sugar syrups, whose viscosity increases so rapidly with lowering temperatures.

As already pointed out both in this chapter and in Chapter XIII, one of the principal factors affecting viscosity is the gelatin added to the mix.

The viscosity and the acidity of ice cream mixes of different compositions at different temperatures and at different ages are given in Chapter XIII.

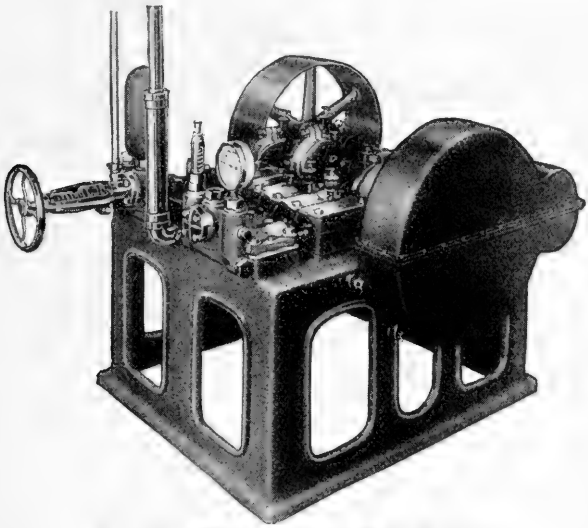


Fig. 97. Manton-Gaulin Homogenizer.
Courtesy Creamery Package Mfg. Co.

Viscosity in ice cream mix can be readily destroyed by agitation both at low and at high temperatures. The possibility of destroying viscosity is especially favored under the violent agitation prevailing in an ice cream freezer. This proves the importance of reaching the whipping point in the freezer before the viscosity of the mix has been reduced. If brine of too high a temperature or of insufficient volume is used, the viscosity may become sufficiently reduced before the whipping point is reached to make it impossible to obtain the desired overrun.

(5). **Homogenizing the Mix.**

The practice of homogenizing the mix is well nigh universally understood by ice cream manufacturers, and the importance of

this operation is being increasingly appreciated. Machines upon the market for performing this operation are known both as homogenizers and viscolizers. These are made in such a large range of sizes (60 gallons to 800 gallons per hour capacity) as to be within the reach of both small and large manufacturers.

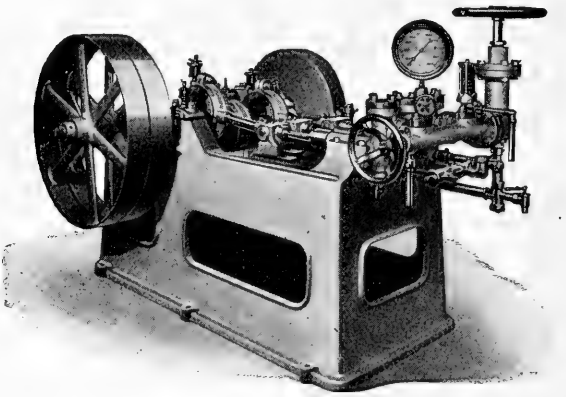


Fig. 98. Progress Homogenizer.
Courtesy Davis-Watkins Dairymens Mfg. Co.

As the term implies, homogenizing the mix makes a product that is uniform throughout its mass, in its physical properties. The large fat globules are broken up into smaller ones, and likewise particles of the other constituents are all reduced to small dimensions. This result is reflected in the finished product, the latter being of smoother texture than where the mix is not homogenized. The three other most important results obtained from homogenizing are (1) the ability to produce ice cream of the desired overrun under nearly all conditions of operation; (2) the production of ice cream that retains its overrun better when once obtained, and (3) decreased danger of churning the fat in the freezers.

The homogenizer further makes it possible for the manufacturer to use many products that could not be otherwise employed for making ice cream. The most important of these are butter

and skimmed milk powder, which can be reconstituted into milk or cream or condensed milk or directly into ice cream mix itself.

The best temperature at which to homogenize ice cream mix is generally accepted as being 140 to 145° F. This is considered the best practice from a bacteriological point of view, and also as pointed out by Morse[6], mix homogenized at this temperature does not become pasty, nor does it so easily acquire excessive viscosity.

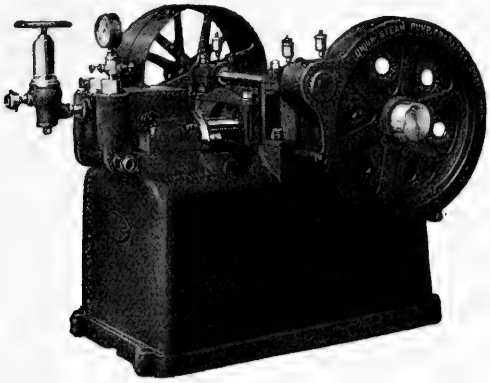


Fig. 99. Viscolizer.
Courtesy Union Steam Pump Co.

According to Hanna[7], "the age, condition and temperature of run entirely governs the pressure the machine should be operated at." Pressures of 2000 to 3000 pounds give all the viscosity usually required, and produce a homogenous product from which the fat is not likely to separate under any of the usual methods used in freezing ice cream.

The use of too low temperatures and of too high pressure will increase the viscosity too much, and in turn this may result in too high overrun. If under the above conditions of operation the mix is too low viscosity, it is an indication that the homogenizer is functioning improperly, and the same should be immedately repaired. The temperature and pressure to use are governed largely by result desired.

The increase in viscosity is frequently accompanied by a large increase in the volume of the mix. This increase may amount to as much as 75 per cent of the total overrun desired. This condition should be carefully taken into consideration, as otherwise misleading results will be obtained in the overrun.

(6). **Amount of Mix Drawn in the Freezer.**

The volume of mix drawn into the freezer is governed in a large measure by the overrun desired. If 100 per cent overrun is desired, a 40-quart freezer should not receive more than 20 quarts of mix. A little less than this amount is better, since space must be allowed for the dasher. The same proportion would govern in the case of freezers of larger capacity.

When too much mix is used, it becomes necessary to draw out some of the ice cream before the full overrun has been obtained. This necessarily causes a product of uneven overrun.

This factor can be closely controlled by fitting the supply tank over each freezer with an overflow pipe so adjusted that a uniform volume of mix will be fed into each freezer, or with a batch weigher.

(7). **Type of Freezer.**

The design and the mechanical construction of the freezer are important factors as affecting overrun. Repeated experiments have shown that it is much more difficult to obtain the desired overrun with freezers of the vertical type as against those of the horizontal type. In some cases it was found to be impossible to increase the overrun in certain vertical freezers beyond 70 per cent with all other conditions under control.

The blades of the freezer should be kept sharp and adjusted so that they scrape evenly against the side of the freezer. If this is neglected a coating forms on the inner wall of the freezer and tends to slow down the freezing operation by preventing the heat in the mix from passing into the brine.

Another source of trouble traceable to the freezer is due to the slipping of the belt, thus causing improper dasher speed. On account of the damp conditions that obtain in the average freezing rooms, freezers that are equipped with direct motor drive are the most likely to prove satisfactory.

(8). **Brine Temperature and Brine Pressure.**

An important relation exists between the brine pressure and the brine temperature. The matter of temperature is more important than that of pressure, the controlling principle being the necessity of having a sufficient volume of brine to insure maintaining the proper temperature inside the freezer. This can be ascertained by noting the difference in the temperature between the incoming and the out-going brine, which should be about 5° F.

The brine pressure determines the volume going through the freezer. The pressure and the volume are in turn both influenced by a number of factors, such as size of the brine pump and of the brine pipes; the number of angles in the pipe lines, and the distance that the brine has to travel between the brine pump and the freezer. Obviously when the above conditions are favorable, the brine pressure may be much lower than when the opposite conditions prevail.

Washburn[1] recommends the following relation between those two factors: "For a temperature of 12° F., use a pressure of 10 pounds; for 10° F., use 9 pounds, and for 8° F. brine use about 7 pounds." Upon the other hand, some very successful manufacturers, using 8° brine operate under a pressure of 45 pounds. The important consideration is to so corelate the brine temperatures and brine pressure, so as to obtain the desired overrun in the required time, under the varied conditions that prevail in ice cream plants.

When the temperature of the brine is below zero it is difficult to get good results. The temperature of the brine should be such that when about 100 per cent of overrun has been obtained, with the brine turned off, the overrun will decrease rapidly upon turning on the brine again. If turning on the brine, after the desired overrun is obtained with the brine off, does not reduce the overrun, it is an indication of improper brine temperature, or of insufficient brine flowing through the freezer. In such a case it is advisable to stop the operation of the freezer until the brine temperature can be reduced to such a point that the freezing can be done efficiently and the overrun can be properly controlled. A brine temperature of 8 to 12° F. is universally recognized as the most desirable brine temperature to use, although the present

tendency is to use even lower temperatures than these. Other conditions being right, the lower the brine temperature, the greater the output that can be obtained from a given number of freezers

When using brine of too high a temperature, there is great danger of churning out the fat in the mix before the whipping temperature is reached. This is especially true if the mix is of a fairly high temperature when the same is introduced into the freezer. Churning may also be caused by insufficient brine, thus prolonging too much the time required to reach the whipping temperature.

It is important to equip both the brine inlet and outlet upon each freezer with thermometers, in order to observe the temperature of the incoming and outgoing brine.

A leaky valve may be the cause of low overrun due to improper brine circulation. These should, therefore, be in good condition, so that when they are turned off there will be no leakage of brine through the freezer.

When several freezers are operating in a row, all of which receive their brine from a common pipe, it is of great importance to so arrange the piping that each freezer in the row will receive the same amount of brine.

(9). **The Speed of Freezer; Time Given to Freezing; Temperture of Incoming Mix and Outgoing Ice Cream.**

All of the above factors are so closely correlated as to merit discussion together.

The proper speed of dasher varies with the size and make of the freezer. Experience has proved as a rule that, with the brine temperature of about 12° F., the best results are obtained where a dasher speed of 200 revolutions per minute is used. The colder the brine the faster the dasher should operate, on account of the shorter time required for freezing. Therefore, in order to obtain the desired overrun, it is necessary to operate the dashers fast enough to incorporate in the mix the same volume of air in the shorter time that would be incorporated into it in the longer time with a lower brine temperature. Washburn states, "If 6 minutes be required with a dasher speed of 225 turns per minute, this will

make a total of 1350 turns, during the given period. Whereas, if the brine is too cool, or flows too rapidly, and the freezing period is passed through in say 4 minutes, there will necessarily be only 900 turns during this period, and there will be considerably less swell than if the full 1350 turns had been given.''

The time given to the freezing will be governed by the brine temperature, the temperature of the incoming mix and the dasher speed.

The correlation of these several factors is indicated in Table 92.

TABLE 92.

Correlation Dasher Speed, Temperatures Incoming Brine and Mix, and Time Required to Freeze.

Dasher speed revolutions per minute.	Temperature incoming brine degrees F.	Temperature incoming mix degrees F.	Minutes required to freeze the batch.
250	0	32	6
240	6	32	8
230	6	38	10
230	12	32	12
225	12	32	12
200	18	38	18
165	8	40	12

The practice of holding the mix at 32 to 35° F. and freezing in from 6 to 8 minutes usually results in the formation of grainy ice cream unless the dasher speed be greatly increased. It is generally conceded that the best results are obtained under the following conditions:

Speed of dasher, 225 revolutions per minute.

Temperature of incoming brine, 8° F.

Brine pressure, 11 pounds.

Temperature incoming mix, 32 to 36° F.

Minutes required to freeze batch, 12 to 15.

The temperature of the outgoing ice cream, or in other words the freezing point of the mix, depends upon its composition and especially upon its content of both milk and cane sugar. The sugar content exerts the most influence upon the freezing point.

A mix with too low a freezing point is not only more difficult to freeze, but the danger from subsequent loss of overrun is correspondingly increased. This is obvious from the fact that the lower the freezing point, the more difficult it becomes to maintain in the holding cabinets the lower temperatures required to keep the product frozen.

HOW TO RETAIN OVERRUN AFTER THE ICE CREAM LEAVES THE FREEZER.

It is one thing to manufacture ice cream with the desired overrun. It is another thing to retain the overrun in the ice cream between the time it leaves the freezer until consumed. Complaints of shrinkage are quite numerous, and causes for such shrinkage are not always under proper control. The principal factors causing loss in overrun are as follows:

(1). Improper Composition of Mix.

The use of too much sugar as already pointed out, lowers the freezing point of the mix. On account of the difficulty of maintaining abnormally low temperatures in ice cream cabinets, loss in overrun results unless the required temperatures can be maintained. Proper control over the composition of the mix will prevent trouble from the above cause.

(2). Too High Temperature in Hardening Room.

The temperature of the ice cream as it leaves the freezer is usually from 26 to 28° F. If kept at this temperature longer than one or two hours, the air will gradually escape. It is therefore necessary to harden the ice cream immediately, and the temperature found to be the best to maintain in the hardening room is 0° F. It is difficult to control properly with one compressor, the above low temperature for the hardening room, and the higher temperature of about 12° F. required at the freezers. Where ammonia compressors are used, with the ammonia entering the compressor at 0° F. the low pressure gauge will register about 16 pounds. This is the condition required for the most satisfactory work at the freezers while for hardening room work the incoming ammonia temperature should be about — 20° F. which will make a gauge pressure of about 4 pounds per square

inch. For these reasons the most satisfactory results are obtained where this may be possible by using a separate compressor for each operation.

Hall[8] recommends the use of one hardening room of about —15° F. which is to be used for hardening the ice cream immediately after it leaves the freezers. After the ice cream has hardened he recommends transferring it into the regular hardening room with temperature around 0° F. Under this condition of handling the ice cream will have smaller water crystals, and therefore it will be smoother to the taste.

(3). **Drawing the Ice Cream From the Freezer While Too Soft or at Too High a Temperature.**

If the overrun is obtained too early during the freezing period, the viscosity is not sufficient, or in other words the walls of the cells are not strong enough to retain the enclosed air. Such ice cream is also almost certain to melt slightly against the side of the cans and later on when hardening, the melted portion will form coarse ice crystals. Under a condition of this kind even if the hardening room has the proper temperature, loss of overrun is very likely to result. The shrinkage is likely to be greater if air hardened, than if hardened in brine, owing to the quicker cooling by the latter method.

The following experiment was made by W. O. Frohring of the Telling Belle Vernon Co., and the results are reported with their permission.

"Out of the same freezer, one can was drawn in the early part of the freezing period with the overrun at 70 per cent. Another can was drawn near the end of the freezing period with an overrun of 120 per cent when the temperature had about reached the critical point. Both cans were placed in the hardening room under a temperature of about 0° F. The following morning the can with 70 per cent overrun had suffered great loss in overrun while that with 120 per cent overrun, had suffered no loss in overrun and the same was normal in all respects."

The above trouble can be entirely prevented by continuing the freezing operation until an overrun is obtained slightly in excess of the standard desired, and then by momentarily turning on the

brine again, beat back the overrun to the point desired. Or it can be avoided by closely controlling all factors involved, and drawing the ice cream as soon as the desired overrun is obtained. This is the better method.

Washburn further points to the importance of precooling the empty cans before running the ice cream into the same.

(4). **Too High Overrun.**

The presence of too much overrun is frequently attributed as being the cause of loss of overrun. Overrun in excess of 100 per cent is seldom if ever desirable, and such excessive overrun may be responsible for many ice cream defects, and should be guarded against. No doubt the presence of too much overrun can aggravate shrinkage troubles, but it is not necessarily in itself the cause of such troubles.

(5). **The Relation of Gelatin to Overrun.**

The value of gelatin in helping to obtain overrun in ice cream is practically universally recognized. Its value in helping to retain the overrun has not been so clearly demonstrated. The quantities of gelatin ordinarily used, are too limited to exert any appreciable effect upon the ability of the ice cream to stand up after freezing.

The two principal physical properties of ice cream are its body and its texture. By body is meant the viscosity—that is, if the product is soft, mellow or hard. By texture is meant the smoothness to the taste of the ice cream. The body is influenced largely by temperature, composition, and the processes of manufacture used. The favorable influence of gelatin upon the texture of ice cream is now universally conceded. This influence becomes more marked after the ice cream has passed 24 to 48 hours of age. This subject is further discussed in Chapter XIII.

Most of the above factors can be kept under the control of the manufacturer provided the plant is equipped with the necessary apparatus for making the tests required. However, conditions sometimes arise under which it is impossible to obtain the desired overrun. The cause for such conditions requires close investigation.

THE MOJONNIER ICE CREAM OVERRUN TESTER.

The fundamental principles that control the percentage of overrun in ice cream are not always well understood by those in charge of the ice cream freezers. In fact, it is only in very recent years that problems connected with the process of controlling the percentage of overrun have received serious attention. Furthermore the use of modern machinery, a variety of new raw materials, with new methods of manufacture have introduced new factors, affecting overrun, not previously encountered.

To J. J. Mojonnier belongs the credit for the invention of the Mojonnier Ice Cream Overrun Tester illustrated under Fig. 100. Patents both pending and obtained in his name cover both the process used, and the mechanical devices for applying the process. The test is based upon the difference in weight between equal volumes of ice cream mix and the frozen product.

The great advantage in the use of the Mojonnier Overrun Tester is that it enables the ice cream maker to make a nearly instantaneous test for the percentage of overrun, at any time during the freezing operation. This enables the operator to change the freezing process so that as a rule any desired percentage of overrun may be finally and readily obtained.

The Mojonnier Ice Cream Overrun Tester has been proved to be absolutely accurate both in principle and in practice. A single test for overrun can be made in about five seconds, and the number of tests that can be made is limited only by this time requirement. It is easy and convenient to operate and can be applied by any one who can read figures. No chemicals or glassware are needed in making the tests.

TWO METHODS FOR APPLYING THE MOJONNIER ICE CREAM OVERRUN TESTER.

First Method: In plants operating less than four, or multiples of four freezers, the tests for overrun are made to the best advantage by the freezer operator. It is recommended that the Mojonnier Overrun Tester be located between the freezers as in-

dicated in Fig. 100. It is designed to be used from both sides.

Under this arrangement the freezer operator can make the tests and control the overrun upon four freezers, which works out very well in practice.

Second Method: In plants operating more than eight freezers a special operator, usually a bright girl can be employed to make overrun tests only, using one operator for each lot of six freezers. The Tester operator instructs the helper to draw off the ice cream after the desired overrun has been obtained. This method gives good results in large plants.

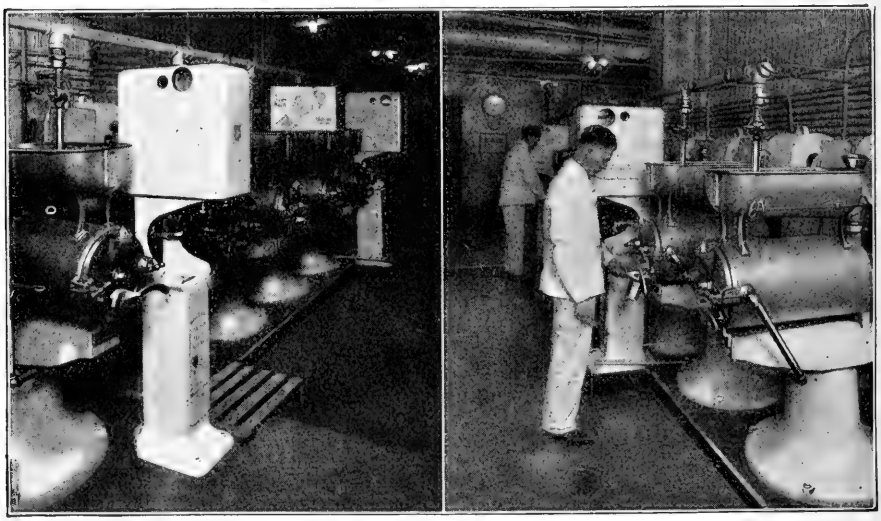


Fig. 100. Suggested Location of Mojonnier Overrun Testers in the Freezer Room.

DIRECTIONS FOR SETTING UP THE MOJONNIER OVERRUN TESTER.

It is very important for intending operators to read these directions carefully before attempting to set up and operate the Mojonnier Overrun Tester. The directions should be kept conveniently at hand and be referred to from time to time, even though the user is quite familiar with the operation and care of the machine. After the Tester is properly installed and adjusted, the operation of the same is very simple.

Uncrating. When uncrating the tester use extra precaution so as not to injure the delicate working parts of the scale, or the white finish.

Accessories: Packed in the case accompanying the Overrun Tester the following accessories should be found.

	Quantity
Aluminum screw base cups with hollow counterpoised handles	2
Broad nickel-plated scraper knives	2
100% Counterpoise	1
0% Counterpoise	1
Spouted dipper for pouring in mix	1
Key for locking door to pedestal cabinet	1
Small bottle of shot for counterpoising cups	1
6 Ft. Electric light extension cord plug and socket	1
110 volt electric light bulbs for lighting scale dial inside of cabinet	2
Bottle of refined dash pot oil	1
Small metal trough for pouring oil into the dash pot	1
Pad of freezer room reports	1
Clip for holding freezer room reports	1
Binder for freezer room reports	1

Leveling and Fastening in Position. Level the base or pedestal carefully as follows:

Place the slotted base of the empty overrun cup over the metal cleat on the horizontal surface just above the pedestal cabinet. Fill the cup to overflowing with water. Scrape off the water with a scraper knife to an even level, and use the filled cup as a level to accurately level the pedestal base on the floor. This will insure absolute accuracy when the cup is adjusted for the mix. When the pedestal is leveled, fasten with lag screws or bolts to the floor, using the same method as is used in fastening the base of freezers to the floor.

Adjusting the Scale. Unscrew the oblong plate upon the side of the scale cabinet which will allow access to the scale, electric light sockets and the scale level. The scale beam is held rigid for shipping with a U-shaped wire encircling it about in the center, and a rod to the right of the beam. Pull both of these out. See Fig. 101.

Level the scale as shown in Fig. 102 by turning the adjusting screw in the rear of the Overrun Tester. This can be done by watching the level in the base of the scale itself.

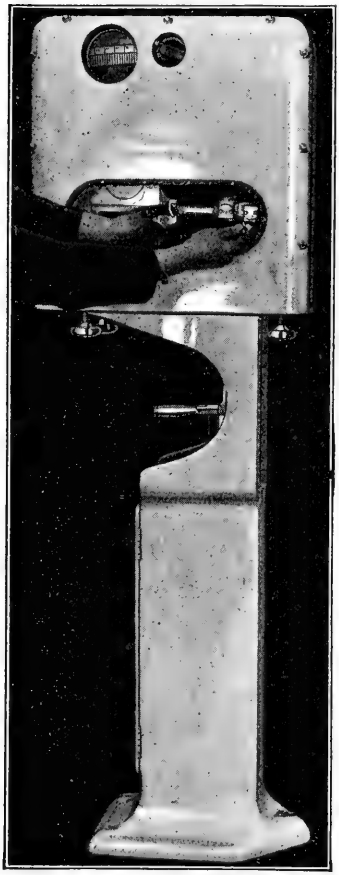


Fig. 101. Removing Wire and Rod from Scale Beam. This allows the scale beam to move freely.

Fig. 102. Leveling Scale.

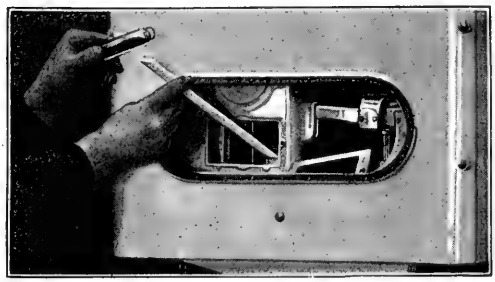


Fig. 103. Filling Dash Pot With Oil.

Filling and Adjusting the Dash Pot.

Remove the screws holding the rectangular glass plate upon the scale, permitting access to the scale dash pot. Unscrew the

dash pot cap and fill the pot with oil by means of small metal trough furnished. See Fig. 103. Pour oil in the dash pot to the BASE LINE shown in Fig. 104 or about two-thirds full. When replacing cap, be careful to avoid crossing the threads. The dash pot construction makes the scale very sensitive and eliminates excessive vibration of dial indicator.

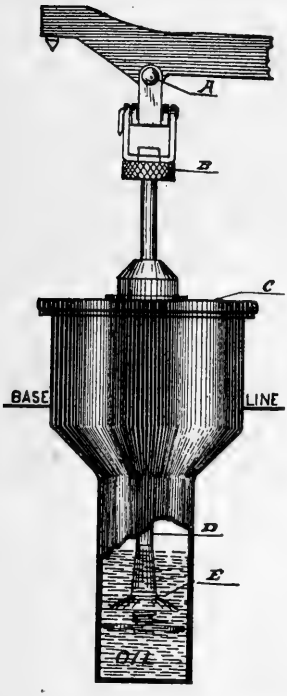


Fig. 104. Dash Pot in Cross Section.

Note: Use in dash pot only such oil as is furnished by the manufacturers as this is a high grade refined oil, and is of the proper consistency for this work. A—Clevis pin. B—Vibration regulating screw. C—Dash pot cap. D—Dash pot plunger. E—Plunger cap.

Regulating Vibration of Dial Indicator.

Place the empty overrun cup on horse shoe shaped, suspended weighing frame. Place 100 per cent weight on form immediately above the cup. The indicator should point to 100 per cent on dial. If indicator points to 96, unscrew the cap in the cup handle and take out shot until the indicator points to 100. If over 100 add necessary shot.

Take off 100 per cent weight and put on 0 per cent weight, and proceed in the same manner.

If the pointer moves too freely or too slowly, or "jiggles", turn the thumb screw B shown in Fig. 104 either to the right or to the left, which adjusts the two discs on the dash pot plunger. By means of this vibration regulating screw, the pointer can be

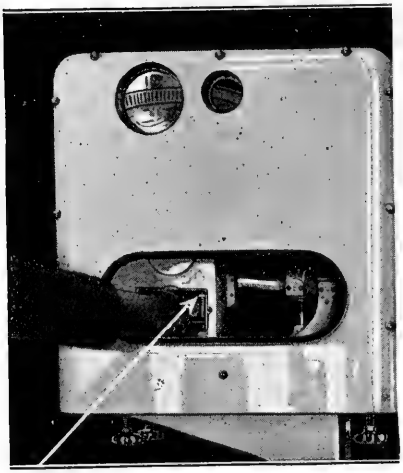


Fig. 105. Adjusting Movement of Pointer By Means of Screw B.

regulated to a nicety, so that it will go to its maximum point quickly, and remain there with practically no vibration. See Fig. 105. Be sure however, not to get the vibration screw too tight, as the action of the plunger may thus be retarded and result in incorrect readings.

When it becomes impossible to regulate the vibration in the manner described above, it indicates that it is necessary to refill the dash pot with oil. When properly adjusted the scale is sensitive to one gram, or about one-twenty-eighth of an ounce. Unnecessary changing or regulating of the scale parts should be avoided. Should there be any trouble in carrying out the above instructions the manufacturers should be notified so that further instructions can be furnished.

When the adjustments are completed replace the glass plate on the scale, and the oblong metal plate on the scale cabinet. The Mojonnier Overrun Tester is then ready to operate.

Adjusting Pointer of Automatic Scale.

In shipping, the adjustment of the automatic scale is sometimes jarred loose, and the pointer then registers inaccurately. If the scale is made to register correctly with the 0 per cent weight in place, and then the 100 per cent weight is substituted, the pointer sometimes indicates either more or less than 100 per cent.

To make the necessary adjustment, first place the cup and the 0 per cent weight on the hanger, and add to, or take lead from "C" until the pointer registers exactly 0 per cent. Next, substitute the 100 per cent weight for the 0 per cent weight, and note exactly what is registered on the dial.

Remove plate "A" and take out the screw in the end of pendulum "B". Attached to the screw will be found lead weights. If less than 100 per cent is registered on the dial, **remove** about .1 gram of lead for each point short. If more than 100 per cent **add** about .1 gram for each point over, and replace the screw in the pendulum. Put on the 0 per cent weight and add to, or remove lead from "C" until the pointer registers 0 per cent again. When the 100 per cent weight is again substituted, the pointer should indicate 100 per cent. If still slightly over or under, the adjustment should be repeated, taking off or adding a very small quantity of lead.

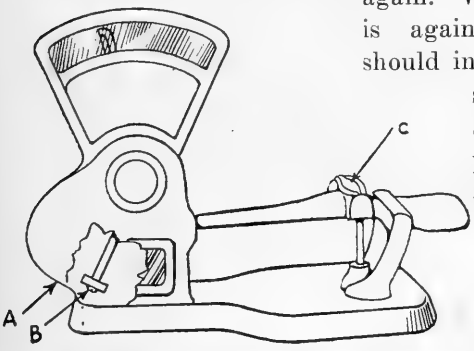


Fig. 106. Phantom View of Scale Showing Where to Make Pointer Adjustments.

The Overrun Cup.

The Overrun Cup is fitted with a telescopic bottom, and it should be adjusted for every batch, except in ice cream plants that carefully standardize the percentage of fat and total solids, in the mix. In such instances, after the cup has been once adjusted, it will require very little, if any adjusting thereafter. For instance, if the mix is standardized to 8 per cent fat and 34 per cent total solids, and kept at this standard by careful testing, no further adjustments of the overrun cup need be made thereafter. In all plants where the mix is standardized an overrun cup can be used, the body of which is made in one piece. In plants where more than one quality of ice cream mixes are made and standardized, overrun cups with solid bodies can be supplied for each quality of mix. This will simplify the problem, and help to prevent errors. Reference to Table 44, Chapter XIII, will show that at equal temperatures the weight of unit volumes of ice cream mix of comparatively wide differences in composition, varies relatively but little. Ice cream mix testing 8.00 per cent fat and 33.00 per cent total solids, at 40° F. weighs 9.19 pounds per U. S. gallon. Ice cream mix testing 18.00 per cent and 40.00 per cent total solids at 40° F. weighs 9.04 pounds per gallon. The

difference is only .15 pounds per gallon or a possible error of 1.66 per cent upon the frozen ice cream.

Daily Care to Give to Overrun Tester.

Each day before freezing the overrun cup should be checked against the 0 per cent counterpoise and the 100 per cent counterpoise to insure accuracy of test. The hollow handled construction of the cup will permit adding to or taking from the cup, the shot used in counterpoising. After the freezing is finished it is absolutely necessary that the overrun cups have the following attention every night:

Fig. 107. Adjusting the Overrun Cup for any Composition of Mix. Remove the Cup of Mix from the Scale, and Place the Slotted Base on the Metal Cleat Under Weighing Frame.

(1). Clean and dry the cups thoroughly.

(2). Remove the telescopic base where this type of overrun cup is used and thoroughly smear all threads and screw connections with vaseline or oil.

Unless the above rules are carefully observed the screw base of the cup will become corroded and may "stick," making it very difficult to adjust.

Adjusting the Overrun Cup Against the Mix.

Carefully study and carry out this operation. The overrun cup is first balanced against the 0 per cent weight. The telescopic base of the overrun cup is unscrewed as far as is necessary to hold 500 grams of the mix. This will amount to a little more than one pint. Place the empty overrun cup in the suspended cup holder. Fill the dipper with the finished mix from

the aging tank and pour the mix into the cup until the dial indicator points to 0 per cent. See Fig. 107. The mix at this time should contain all of the ingredients that enter into the frozen product. As already pointed out, there is always a possibility of a certain amount of air becoming incorporated with the mix during the process of homogenizing. It is of the utmost importance when adjusting the overrun cup, to make the adjustment upon the basis of a mix that is free from air.

Fig. 108. Emptying Overrun Cup Into Freezer Hopper.

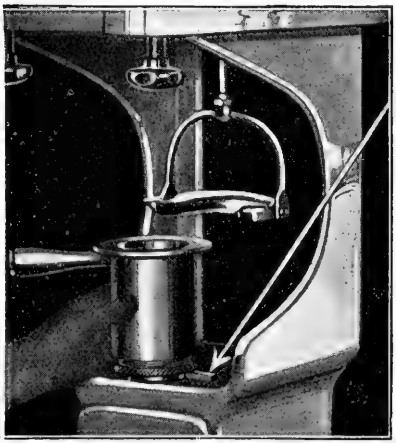


Fig. 109. Adjusting Telescopic Bottom Upon Overrun Cup.

Where to Get the Sample of Mix for Adjusting the Overrun cup.

It is of great importance to obtain the sample of mix from the holding tank, before any air has been incorporated into the mix. If the sample should be obtained after air has been whipped into it, and the overrun cup adjusted upon the basis of such a sample, the overrun consequently obtained will not represent the true overrun, and there may be great danger under such a condition of producing ice cream with excessive overrun.

Adjust the telescopic base by turning the cup around so that the top of the mix comes exactly even with the top of the cup. Carefully lock the base of the cup tight by means of the knurled locking ring.

Empty the mix back into the hopper over the freezer, see Fig. 108. and rinse out the cup in a pail or five gallon can of tepid water, making ready for the overrun determination.

There is now a fixed relation between the capacity, and the weight of the cup, and the markings on the scale dial. The dial will indicate the percentage of overrun nearly instantaneously when the cup, filled with ice cream, is placed upon the suspended weighing frame.

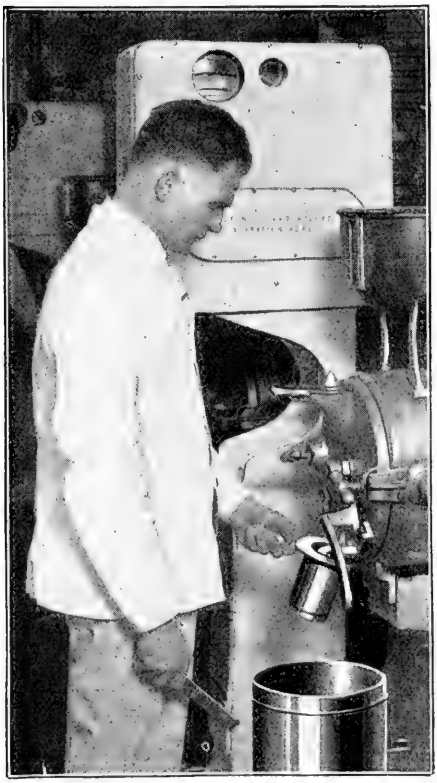


Fig. 110. Filling Overrun Cup With Ice Cream at the Freezer.

Finding the Exact Per Cent of Overrun.

Draw a heaping cup of the frozen ice cream from the freezer, using the broad plated knife scrape off the excess to an even level with the top of the cup. See Figs. 110 and 111. Place the cup in the suspended cup holder. The dial indicator will immediately show the percentage of overrun. If it points to 60, it indicates 60 per cent of overrun. If to 90, it indicates 90 per cent overrun, etc. Two operators may use the same Overrun Tester at the same time if desired, one operating from either side. Repeated use of the Overrun Tester will enable the operator to handle the work with dexterity and speed.

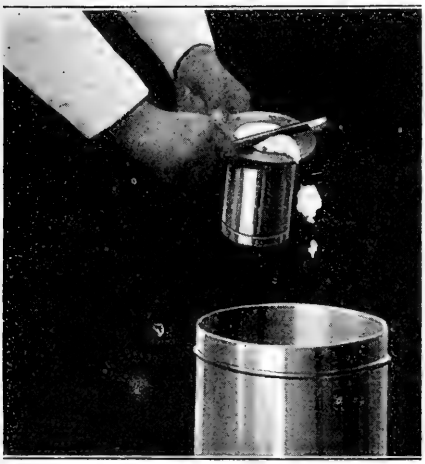


Fig. 111. Scraping Overrun Cup Level Full of Ice Cream.

Fig. 112. Making Reading for Overrun.

HOW TO STANDARDIZE THE OVERRUN.

In standardizing the overrun, the Mojonnier Overrun Tester should be used on every freezer of ice cream drawn. As it takes only five seconds to make the test there is no good reason why this important part of the work should be omitted.

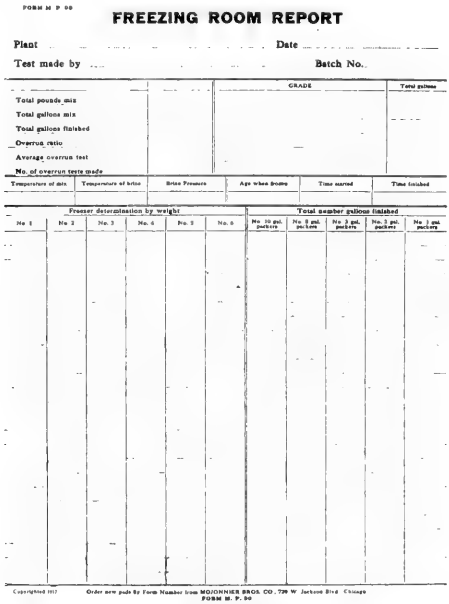
First operation: When starting to freeze a new batch, see that the overrun cup is adjusted as described on page 470.

Second operation: Draw not more than five gallons of mix into the hopper above the freezer when using a ten gallon freezer. If larger freezers are used, draw a volume into the hopper equal, but not to exceed, one-half the rated capacity of the freezer.

Third operation: Run the mix into the freezers as usual, filling all freezers while they are running.

Fourth operation: Turn on the brine and continue whipping.

Fifth operation: Watch the ice cream through the freezer peep hole in front of the freezer during the time of freezing and whipping, and as soon as it becomes sufficiently viscous, make a test for the overrun. This will be when the overrun is between 60 to 80 per cent.



FORM M P 90

FREEZING ROOM REPORT

Plant ..... Date .....

Test made by ..... Batch No. .....

	GRADE	Total gallons
Total pounds mix		
Total gallons mix		
Total gallons finished		
Overrun ratio		
Average overrun test		
No. of overrun tests made		

Temperature of data	Temperature of brine	Brine Pressure	Age when frozen	Time started	Time finished

Freezer determination by weight						Total number gallons finished				
No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 10 gal. packers	No. 5 gal. packers	No. 3 gal. packers	No. 2 gal. packers	No. 1 gal. packers

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Fig. 113. Blank for Recording Overrun Readings.

Sixth operation: If aiming for 100 per cent overrun and the test shows between 95 and 100 per cent, turn off the brine and draw the freezer. Where the overrun is more than 110 per cent, the product is usually unsatisfactory, and the overrun should be brought back to the point desired, by momentarily turning on the brine. If the test shows less than 95 per cent turn off the brine and continue whipping until the desired percentage of overrun is obtained. The frozen ice cream should be sufficiently viscous to retain all of its overrun during the hardening process.

Seventh operation: At this point draw the ice cream into the cans, and record the percentage of overrun in the proper

column of the freezing room record sheet, illustrated under Fig 113.

Ice cream of ideal texture will have the appearance of taffy when it is frozen, and ready to be drawn from the freezer. If of the proper texture it will stand considerable handling, without suffering any bad effects.

The ice cream should be drawn from the freezer as rapidly as possible, inasmuch as the overrun keeps changing upon the part that remains in the freezer while the balance is being drawn out. The change may occur in both directions. If the critical phase has not been reached, the overrun will increase, making the last portion of higher overrun than the first portion. If the critical phase has been passed, the overrun will decrease, making the last portion of lower overrun than the first portion. If the ice cream is drawn rapidly the danger from these fluctuations can be greatly reduced. Proper manipulation of the brine valve may frequently assist in preventing the above changes.

It is important to draw off the ice cream as rapidly as possible when the proper overrun is reached, so that the overrun does not increase during the time of drawing off. A helper may be used to advantage at this time to bring in empty cans, and take away filled cans.

HOW TO DETERMINE OVERRUN IN ICE CREAM CONTAINING CRUSHED FRUITS.

It is recommended that a different standard be set for ice cream containing crushed fruit, than for the plain varieties. For example if the standard for plain variety is 100 per cent, a standard of 90 per cent in the case of ice cream containing crushed fruit will yield a very satisfactory product.

REFERENCES.

[1] Washburn, R. M. "Principles of Ice Cream Making," Vermont Station Bulletin No. 155.

[2] Baer, A. C. "Ice Cream Making," Wisconsin Station Bulletin No. 262.

[3] Mortensen, M. Factors which influence the yield and consistency of Ice Cream. Iowa Station Bulletin No. 180.

[4] Hammer, B. M. and Johnson, A. R. The Specific Heat of Milk and Milk Derivatives. Iowa Station, Research Bulletin No. 14.

[5] Cutler, Thos. H. Ice Cream Trade Journal, 1920.

[6] Morse, James B. Homogenizing the entire mix. Ice Cream Trade Journal, 1920.

[7] Hanna, E. C. The Viscolizer is an important factor in the ice cream industry. Ice Cream Review, 1921.

[8] Hall, Thos. Microscopic and Thermal Analysis of Ice Cream, P. 71, Ice Cream Trade Journal, December, 1921.

CHAPTER XVI

MICROSCOPICAL AND BACTERIOLOGICAL TESTS OF DAIRY PRODUCTS WITH DIRECTIONS FOR THE CARE AND USE OF CULTURES

THE USE OF THE MICROSCOPE IN THE DAIRY INDUSTRY.

The microscope is used to great advantage in dairy control work. It is indispensable in identifying bacteria, and it frequently affords a rapid means of determining the physical condition of milk substances that would require a large amount of time and labor to determine by other methods, or would be altogether impossible. The quality of milk is fixed to a large degree by the number and kind of bacteria that it contains. Also the physical condition of some of the constituents of dairy products influences the process of manufacture, the treatment they must receive, and their market value.

The successful use of the microscope in determining these factors does not always require the services of a highly trained individual. Any resourceful, intelligent young man or woman of limited training can determine the number of bacteria in milk, the size of fat globules, and the presence of milk sugar crystals, when provided with necessary equipment, some instructions at the beginning, and the directions given in this chapter.

These brief directions should enable any skillful person to use the microscope successfully in the simpler operations. If the instrument is to be used to a large degree it would be advisable for the operator to obtain special training, and to consult books devoted especially to the subject.

Care: Some knowledge of the microscope on the part of the operator is necessary in order to work to advantage, and to keep the instrument in good condition. Like all instruments of precision, it should be handled with reasonable care, and kept free

of dust and all corroding elements. When the instrument is not in use it should be kept in a case, and stored in a reasonably dry place. If frequent use makes it impractical to return the instrument to its case, a suitable cover should be placed over it when not in use to protect it from dust. The frequent removal of dust from its polished surfaces is liable to scratch them, and if the dust gets into the bearings and close fittings, they will work harder and cause unnecessary wear.

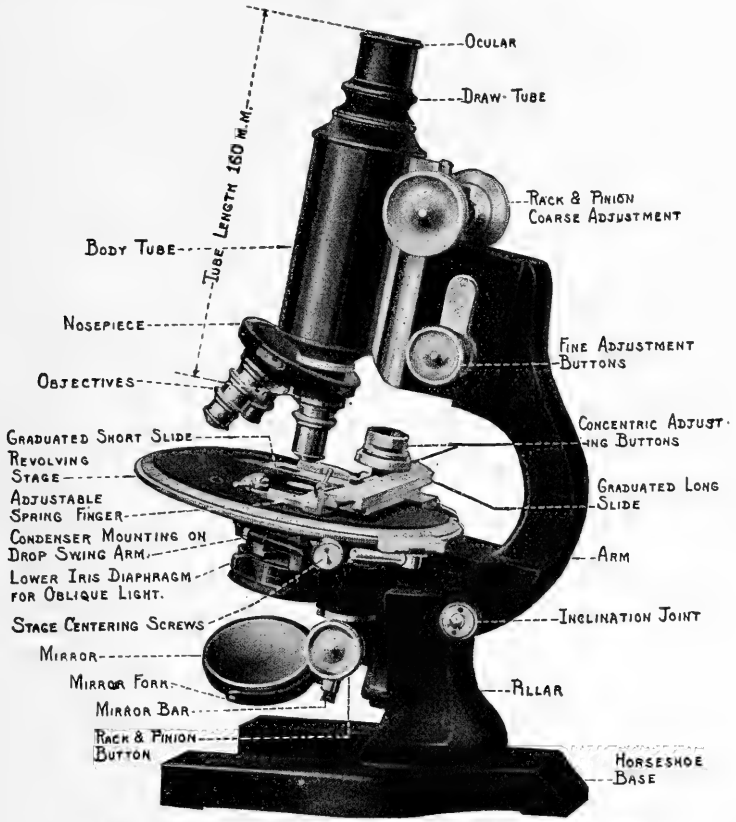


Fig. 114. Microscope with Names of Various Parts.
Courtesy Spencer Lens Company.

Do not leave the microscope exposed to direct sunlight for a long time. Avoid rough handling of the instrument and when it must be removed, grasp the pillar below the stage. The oculars

and objectives should never be allowed to fall. Do not allow acids, alkalies, alcohol, turpentine or chloroform to come in contact with any part of the microscope, as they will dissolve the lacquer. For finger marks or material on the surface, that cannot be removed with a soft cloth or clean chamois skin, use a damp cloth and rub gently. In exceptional cases, it may be necessary to apply a little xylol, ether or chloroform to the substance, and then rub it off gently so as not to remove the lacquer.

Stage: This is the part that supports the slide while a specimen is under examination. Should the stage become soiled with anything which water will not remove, apply a little xylol, or chloroform and rub it off with a clean cloth. If the stage turns to a dull gray color, it may be restored to its original black by rubbing a little of some heavy oil on it. When the black color has been restored wipe the stage free from oil. If any substance falls on the stage it should be removed immediately.

Inclination Joint: This joint, which permits the body of the microscope to be inclined at any desired angle, sometimes wears so loose that it will not support the body properly. The joint may be corrected by tightening the nuts on the end of the inclination axis using a heavy screw driver if the nut is slotted, or a "spanner" if the nut is provided with two small holes. A round nosed pliers may sometimes serve to turn the nut. Do not mar the nut with the tools. The axis pin is slightly conical on most modern instruments. This makes it possible to tighten the joint by turning the nut on the end that will draw the pin tighter into its bearing. The nut on the other end may first have to be slightly loosened, then tightened after the cone is drawn in to give the necessary friction.

Coarse Adjustment: The bearing of this adjustment should work so smoothly that the highest power may be easily focused with it. But it should hold the body of the microscope securely in place. If any foreign matter interferes with the working of the bearings rub a little xylol or chloroform on them to remove it. Oil the bearing with parafin oil or "watch" oil after they are thoroughly cleaned. Keep the teeth of the rack free from foreign substance at all times and use judgment in making necessary repairs to worn parts.

Fine Adjustment: This is much more delicate then the coarse adjustment, and of limited range. The micrometer head is located at the top of the arm in one type while in the other there are two micrometer heads, one on either side of the arm.

The micrometer head should turn easily and smoothly, yet fit snugly, and hold the body of the microscope at all times from slipping down with danger of damaging the objective lens and the object. The range of the fine adjustment has been reached when no change of focus occurs while the micrometer head is being turned. The micrometer head should then be turned in the opposite direction until nearly the middle of the range is reached. If the thread is turned off its bearing, as may happen with some of the older forms of microscopes, take great care to start it on correctly, and not cut the thread. If there appears to be any unusual friction do not force it. When anything exceptional needs repairing it is better to have it done by an experienced mechanic, or by the maker. If the fine adjustment is not so constructed that it ceases to work when the objective rests on the cover glass, great care must be exercised in focusing so as not to crush the specimen or damage the lens.

Draw Tube. This should fit snugly, work easily and smoothly, and be kept clean. Always support the body tube, while pushing the draw tube in, and thus avoid pushing the objective into the slide.

Substage: If the threads on the quick acting screw become gummed, and make it work hard, clean them with xylol or chloroform until they work easily. Clean the leaves of the iris diaphragm with the same substances if they become dirty or rusty. Then oil them and work it over all the parts by opening and closing them several times. If the leaves become bent or misplaced have them repaired by a skilled mechanic or by the maker. When working with the diaphragm nearly closed make certain that no particles of dust or lint have collected in the edge of the opening and interfere with the light.

Nosepiece: This is the part of the instrument that supports the objectives. When the nosepiece supports two or more objectives the latter should be parfocal. That is, they should be made so that when one objective is in focus, the other also will be in fairly good focus if it is swung into the optical axis; and

the center of the field of one lens should fall within the field of the others. To obtain this result each set of objectives are fitted to a particular nose piece, therefore objectives should not be exchanged. If the nosepiece is bent, the lens will be thrown out of center. Use care to avoid swinging the lens into the cover glass when changing from a lower to a higher power. When removing an objective from a nose piece always support it with one hand while screwing it off with the other and exercise every necessary precaution to prevent its injury.

The Optical Parts. The best results cannot be obtained with dirty lenses. In cleaning them remember that glass surfaces are soiled by coming in contact with the fingers. As the glass of the lenses is comparatively soft avoid rubbing it hard or using anything but soft clean cloth or lens paper in wiping it. Chamois skin should never be used for cleaning a lens. Japanese filter paper serves best. It is not expensive, and may be obtained from any dealer in microscopical supplies.

Objective. Dust may be removed from the objective with a camel hair brush, or by wiping it with lens paper. Breathe on clouded lenses before wiping them. Remaining cloudiness may be removed by wiping the lens with a corner of a piece of lens paper, or cloth that has been dipped in alcohol, then wipe dry. For oily substance, dampen the corner of the lens paper or cloth with chloroform, benzine, or xylol before wiping the lens, then wipe it dry. Clean immersion objectives with lens paper immediately after using them. If the immersion oil has dried on, use lens paper or cloth dampened with xylol or chloroform, then wipe dry.

Always keep an eyepiece in the tube to prevent dust from falling through the tube onto the back lens of the objective. Dust may be removed from this lens with a camel hair brush. An objective is too delicate and expensive to be repaired by any one but an experienced mechanic. If anything serious is the matter it should be returned to the maker for repairs.

Oculars: These are cleaned by wiping in the same manner as described for objectives. If a gray film or specks of dust deposit on the inner surfaces of the lenses it will be necessary to remove the lenses from the tube and wipe them clean.

Condenser: It is necessary to have a clean condenser to enable the instrument to do its best work. In cleaning it, follow the directions given for cleaning the oculars.

Mirror: Keep the surface of the mirror clean by applying the methods used in cleaning the lenses.

Operating the Microscope: Location: The microscope should be placed on a firm table that is large enough to hold the necessary material without crowding. The table should be in a roomy place free from distracting influences, and of a height to make the position of the worker comfortable. The use of the inclination joint and a chair, the height of which may be adjusted, will assist in attaining this object. When working on fluids it may be necessary to have the stage in a horizontal position. For this reason, it is advisable to become accustomed to using it in this position for all work.

Practice working with both eyes open and divide the work by using either eye. By doing this, and not working too long in the beginning, several hours' work will not tire the eyes. If the eyes feel fatigued stop work until they are rested. Proper lighting is a great help toward making the work easy for the eyes.

Lighting: North light from windows without cross bars gives the best light. Direct sunlight is to be avoided, and should be toned down by using white shades on the windows if the sunlight strikes the microscope. Wire netting on the windows or branches of trees near them interferes with good work. In order to avoid shadows from the hands while manipulating the mirror or other parts, the operator should face the light, and use a screen to protect the eyes.

Almost any strong artificial light that can be placed reasonably near the microscope will serve well. It has the advantage of constancy, and may be used at all hours. Placing a bull's eye condenser between it and the mirror will assist. When examining opaque objects it may be necessary to have the light shine directly upon the object in place of passing through it. For this work ordinary daylight, or daylight that is condensed upon the object by means of a lens or concave mirror, serves fairly well.

Focusing: Place upon the stage directly under the objective, a semi-transparent specimen having sharp outlines and mounted

on a slide. With the ocular in place first use an objective of low power in focusing. While watching the objective lens from the side with the eye nearly on a level with the stage, turn the coarse adjustment to force the body tube down until the lens of the objective is almost in contact with the cover glass. Adjust the size of the opening in the diaphragm until the lighting effect is good but not too strong. Then examine the field through the microscope while very slowly elevating the tube by means of the coarse adjustment, to bring the specimen into focus. When the specimen is clearly outlined, bring it into a sharp focus by using the fine adjustment. At this point move the mirror into different positions trying both the concave and plane sides, until the best lighting effect is obtained. The fine adjustment will have to be used almost continuously to bring different parts of the specimen into the focal field while moving it around and examining it. Caution must be exercised at all times while focusing to avoid unconsciously forcing the objective through the cover glass on the slide.

If it is necessary to obtain greater detail elevate the tube of the microscope by means of the coarse adjustment, then carefully unscrew the objective and replace it with a higher power. If more than one objective is attached to a nose piece and they are parfocal, the nose piece may be turned without refocusing until the higher power objective is in the optical axis. While turning the nose piece, or while bringing the objective down close to the cover glass, look between the objective and the slide, and move the objective very slowly to avoid contact with the cover glass. If the specimen is not in focus after changing the objective, it will be necessary to refocus as in the first instance.

Two objectives and two oculars should be provided. Their magnifying powers, to order in purchasing, can usually be safely left to the maker of the microscope after explaining the character of the work in which they are to be used.

Special Suggestions: It is a good practice for beginners to look through the microscope and examine the field with the slide removed. If specks or cloudiness are visible it may be due to dust or other material on the lenses. Specks on the ocular will move in the field when the ocular is revolved. Sometimes specks and filaments on the vitreous humor of the eye appear to be lo-

cated in the microscope field. No attention should be given to them. When examining fluids difficulty may be experienced in keeping objects in the field due to motion in the liquid. It should be remembered that specimens of considerable depth may change in form as the focal plane passes up or down. Particles at the bottom of a liquid may come into the focal plane and disappear as the objective and local plane are raised, other particles or crystals coming into view. Liquid used in mounting the specimens sometimes flows out and partly covers the cover glass, thus interfering with a clear field, or being mistaken for the liquid beneath the cover. Air bubbles are frequently found in the liquid mounts. A little experience will usually enable one to distinguish them from other objects. These are only minor troubles, and the remedies for them are obvious.

Objectives mm.	Initial Magnification	OCULARS								Objectives mm.
		4X	5X	6X	8X	10X	12X	15X	20X	
48	2.2	8	11	13	18	22	27	33	44	48
40	2.8	11	14	17	22	28	33	42	56	40
32	4	16	20	24	32	40	48	60	80	22
30–32	2–4.5	4–9	5–12	8–19	10–24	15–35	18–43	20–48	30–70	30–32
25.4	6	24	30	36	48	60	72	90	120	25.4
16	10	40	50	60	80	100	120	150	200	16
12	15	60	75	80	129	150	180	225	300	12
8	20	80	100	120	160	200	240	300	400	8
5	36	144	180	216	288	360	432	540	720	5
4	44	176	220	264	352	440	528	660	880	4
3	60	240	300	360	480	600	720	900	1200	3
1.8	95	380	475	570	760	950	1140	1425	1900	1.8
1.5	109	436	545	654	872	1090	1308	1635	2180	1.5

THE USE OF THE MICROSCOPE IN DAIRY PLANTS.

The microscope can be put to many important uses in dairy plants. These uses include the examination of solid particles found in milk or in its products; the general physical appearance of all kinds of dairy products; the examination of fat globules; the examination of milk sugar crystals, and finally complete bacteriological examination of all dairy products.

The foregoing instructions are sufficiently comprehensive to enable one to operate the instrument for all minor microscopical examinations. Complete bacteriological examinations can be made only by those well versed in the subject.

HOW TO MAKE MICROSCOPICAL EXAMINATIONS OF FAT IN DAIRY PRODUCTS.

In the case of skim-milk, whole milk, and usually in the case of cream, the samples can be examined without being diluted with water. Place a small drop upon the slide, and with the cover glass spread the same uniformly between the slide and the cover glass. Use samples of uniform size.

In the case of evaporated milk, concentrated cream, sweetened condensed milk, and all other fluid condensed products, it is usually desirable to dilute the sample with an equal volume of water. This is best accomplished by placing a small drop of the condensed product upon the slide, and then adding to it a drop of water of equal size, and mixing the two very thoroughly before placing the cover glass over the same. The dilutions can be made in a flask using equal volume of the product to be examined and water.

The best results are obtained by using 10 X ocular and 4 mm objective. This will give a magnification of 440 diameters.

HOW TO MAKE MICROSCOPICAL EXAMINATIONS OF MILK SUGAR IN DAIRY PRODUCTS.

The products that usually contain crystallized milk sugar are principally sweetened condensed whole and skim-milk. Plain and skim condensed milk, if of too great concentration, also sometimes contain milk sugar crystals. The defect in ice cream known as "sandy ice cream", is due to the presence of crystallized milk sugar. All of the above products should be examined without diluting with water, inasmuch as the addition of water might cause many of the crystals to go into solution.

It is usually desirable to examine the crystals under both low and high magnifications. The two combinations most commonly used are 10 X ocular and 16 mm objective giving a magnification of 100 diameters; and 10 X ocular and 4 mm objective, giving a magnification of 440 diameters. By means of the lower magnification, a large field of crystals can be examined, and the uniformity of the crystals carefully studied, while with the higher magnification the individual crystals are better defined, and the same can be subjected to close study.

BACTERIA IN MILK.

When milk is first secreted in the udder of a healthy cow, it is free from living organisms since these do not usually pass through the tissues of the digestive tract, and through those that supply the udder. As the milk descends in the udder it comes in contact with a few bacteria that probably gained entrance through the opening in the teat. Others are introduced later by dust from the air; by dirt from the hands of the milker; by particles of dirt or other material that fall into the milk; or by contact with bacteria on the walls of containers.

Since milk affords a food supply in a condition readily available for their growth, bacteria that gain entrance to it soon increase in numbers by reproduction, unless rigid measures are practiced to check their growth, or to destroy them.

While all bacteria are considered objectionable in fresh milk, and some kinds are decidely harmful, some types are utilized to advantage in the manufacture of butter, cheese, and fermented milk products. For all of these reasons dairy bacteriology has been extensively studied, and methods of sanitary control developed. The application of these methods adds considerably to the labor of handling milk, and to the cost of equipment for preserving it.

The number of bacteria in a sample of milk ordinarily has little significance when the history of the sample is unknown, but where the bacterial count is high, and the sample's history is known, it may indicate that something is wrong, and thus become the basis for starting an investigation. Upon the other hand, a low bacteria count—other factors being considered, is usually an indication of good sanitary quality. The bacteria count and especially the determination of the kind of organisms present, is of unquestioned value to the industry for the purpose of locating and removing sources of contamination, and for measuring the effectiveness of sanitary methods.

Types of Organisms Found in Milk. The organisms found in milk consist of bacteria, and usually a few yeasts and moulds. They comprise the lowest form of life in the vegetable kingdom, and like other plants, they must have suitable food and surroundings in order to grow. As many bacteria are unable to move by

their own effort, and the others have only limited means of movement, all require a very moist, or liquid medium with a readily available food supply. Milk is a fluid of this character, and it meets the requirements of a number of varieties, although some after gaining entrance to it are unable to develop, and soon perish.

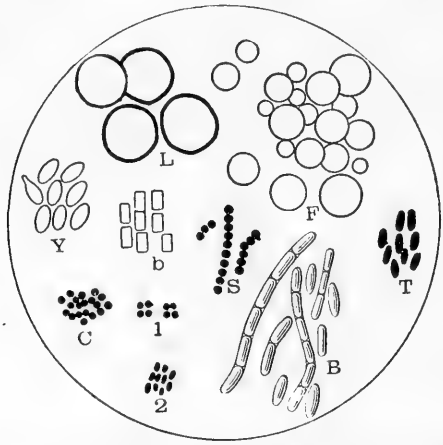


Fig. 115. Microscopic Substances Found in Milk, Showing Relatives Sizes, According to Melick.[1]

The above cut represents a portion of a drop of milk. F, fat globules; L, leucocytes; Y, yeast; and B, b, c, s, t, 1 and 2 seven species of bacteria frequently found in milk. B represents the hay bacillus group; b represents one species of bacillus viscosus which forms slimy milk; c represents a streptococcus; t represents bacillus typhosus; 1 represents tetragenococci, and 2 one of the lactic acid group.

Attempts have been made by a number of investigators to classify bacteria in groups, and describe varieties by their special properties. But many difficulties have arisen because some of the properties of bacteria are transitory or extremely variable. It appears that permanent identifying characteristics, if they exist, are not understood with such clearness that it permits a satisfactory classification at present. The grouping that has been made, however, is used to advantage for the purpose of

separation, study and description. The group name is usually derived from the most pronounced characteristics of the type.

In this way the principal organisms that are nearly always present in milk may be placed in two groups, namely the Bacillus lactis acidi group, and the Bacillus lactis aerogenes group including Bacillus coli communis. The members of the former group vary in their ability to produce lactic acid but do not develop gas. The varieties that produce lactic acid and curdle the casein rather promptly are most universally distributed. Their presence like the presence of all bacteria is very undesirable in all fresh milk, but in the form of pure cultures some are used to advantage in the manufacture of butter, most varieties of cheese, and sour milk beverages. The characteristics of this group of organisms are described under S. lacticus Kruse, p. 490 and B. lactic acidi Leichmann, p. 491.

The members of B. lactis aerogenes, and B. coli communis groups are frequently present in milk. They are very commonly the source of fermentations that cause trouble and loss to the dairy industry. Some of the varieties of these groups are described under Acid Gas Producers, p. 495.

A group of liquefying organisms, characterized by their ability to liquefy gelatin, not uncommonly cause the loss of dairy products. They digest casein and have the power to bring about decidedly putrefactive decomposition. B. Subtilis is a spore-bearing organism of this type. It sometimes causes the decompostion of evaporated milk that has not been properly sterilized. Also, the pronounced bitter taste that sometimes develops in whole milk and in evaporated milk may be due to protein decomposition products developed through the action of the members of this group.

Another group sometimes known as Bacterium caucasicum is of some importance in the dairy industry principally because a few types are used in the production of fermented milk beverages. The better known variety is Bacillus Bulgaricus. When used as a pure culture it yields a buttermilk having a sharp acid flavor and heavy body. Sometimes from 5 to 15 parts of the pure culture is added to 100 parts of a pure culture of Bacillus Lacticus in order to give the resulting buttermilk a more pronounced acid flavor and heavier body. The use of Bacillus

Bulgaricus in the making of commercial cultured buttermilk is on the decline.

Yeasts and torula are occasionally the cause of pronounced fermentation with production of gas in cream, is condensed milk, and in ice cream. In cream it causes foaming and prevents the fat globules from gathering in the churning process. It is liable to appear, with generous production of gas in sweetened condensed milk, and in ice cream when manufactured in unsanitary surroundings or from infected products, and then held for a time.

A few pathogenic organisms can live and develop in milk, and thereby disease may be transmitted to man. For this reason, their study is of importance in dairy bacteriology. The best protection for the public, however, is the practice of pasteurizing, and exercise of every reasonable precaution to keep the milk free from contamination.

Wilcox[2] drawing upon data from numerous sources concisely describes "the morphological characters, biology, and behavior of the pathogenic and saprophatic bacteria that have been found in milk". His description of several of the more important types are reproduced in the following paragraphs:

PATHOGENIC BACTERIA MOST FREQUENTLY FOUND IN MILK.

Bacillus tuberculosis Koch.

Morphology.—Slender, slightly bent, pointed ends, sometimes threads and branched forms, or club forms, longer in milk than in tissues, occurring singly or in twos, three or colonies. Size 1.5—4X .4m. (m = micron). Acid—fast. Gram and Ziehl-Neelsen stains positive. No spores or flagella. Non-motile. Capsule stains. Bouillon.—Growth in 7 or 8 days if glycerine is added. Sometimes pellicle. Glycerine-agar.—Growth begins in 6-12 days. Colonies minute, whitish-yellow, later brown, lichen-like, elevated, sinuate, dry or moist. Potato.—Decided growth in 2 or 3 weeks, best if potato is moist, small crumb-like masses, friable, yellow, dull. Blood serum.—Growth begins in 10-12 days. Serum not liquefied. Colonies light, dry crumb-like coalescing scales. Pathogenic for man and other animals. Aerobe. —Growth from 22° to 42° C., but best at 37° C.

B. typhosus Eberth.

Morphology.—Takes ordinary stains, Gram stain negative. Short, plump, rods, longer in cultures. Size 1-3 × .6—.8m. capsule. Motile, 8-14 long flagella. Occurs in threads. Serpentine movements. Vacuoles in stained and unstained preparations but no spores. Bouillon.—Turbidity, abundant sediment. Gelatine plates and tubes.—Small, yellowish-white, punctiform, raised center, wavy elevations under microscope. In stab cultures granular, grayish-white thread growth. Streaks culture similar, non-liquefying. Agar plates and tubes.—Colonies irregular, round, grayish-white, slightly raised, yellow line extending outward from the center. In stab cultures granular, grayish, thread growth with irregular outline and oily lustre, later yellow. On streak cultures spreading, wavy, smooth edge, shiny. Milk.—Appearance unchanged, not coagulated, slightly acid. Potato.—Variable. Delicate and moist, grayish or rarely brownish. May be readily differentiated from B. coli by the fact that the latter coagulates milk within 48 hours with abundance of acid. B. typhosus grows best as aerobe but also as anerobe and in CO. Produces typhoid fever in man, and a fatal intoxication in animals. Grows best at 37° C. on all ordinary media, less well on non-albuminous media. No pigment nor indol. No gas in lactose.

B. diphtheriae Klebs-Loeffler.

Morphology.—Slightly curved rods usually with one end club-shaped and the other pointed, or may be short wedge shaped, comma shaped, or dumb bell form. Size 1.2-2 × .3-.5m. In groups of 2-4, no long chains. Stained by aniline dyes. Gram, Loeffler and Nicolle. Capsule. No flagella. Non-motile. No spores. Bouillon.—Dust like granules, usually pellicle. Produces indol, acid and nitrites. Gelatine.—Yellowish-white, slightly elevated surface, non-liquefying, non-characteristic. Agar plates and tubes.—In 24 hours circular, round, white elevated colonies with smooth edges and moist. Potato.—Little or no growth if acid, scanty after a few days if alkaline. Milk—Abundant growth, amphoteric reaction, no curdling. Blood serum.—Rapid at 37° C. Characteristic within 12 hours, round, raised, grayish-white colonies, yellowish, translucent if young, moist, margin irregular, center thickened and opaque. Colonies not confluent, may reach

size of 4 or 5mm. Abundant growth on hen's eggs. Grows best at 37° C. Quickly killed at 60° C. Aerobe.

Streptococcus of contagious mammitis.

Morphology.—Long, undulating chains, elements 1m in diameter, shorter in old than in recent cases of mammitis. Aerobe or anaerobe. Takes analine dyes, but Gram stain poorly. Gelatin.—Small, translucent, whitish colony. Pellicle. Potato.—Poor growth. Bouillon.—Growth after 24 hours. Sediment, no turbidity. Milk.—Rapid growth. Curdled in 24-48 hours, strongly acid. Causes mammitis in cows and goats. A smaller form causes gangrenous mammitis in sheep. Possible cause of sterptococcic sore throat in children.

Streptococcus scarlatinae Klein and Gordon.

Morphology.—Polymorphic streptococcus with all transition stages between coccus and bacillus. Coccus forms prevails in bouillon, bacillus on agar. Takes simple stains and Gram. Bouillon.—After 24 hours at 37° C. a single, coherent, white-gray mass appears at base of tube, floating as a flat conglomerage in the fluid medium. Gelatin.—Slow, small, gray, circular, firm edge. No liquefaction. Chain formation conspicuous. Agar.—After 24 hours colonies are gray, granular, irregular, tuberculated; or similar without tubercles; or with a frill of chains around a compact center. Milk.—Rapid curdling, acid. Blood serum.—Good growth of colonies. Aerobe. Found in cases of scarlet fever and sometimes thought to be the cause of the disease. Occurs also in diseased udders of cows. Pathogenic for mice and rabbits.

BACTERIA PRODUCING ACID BUT NO GAS.

Ordinary Types Most Frequently Found in Milk.

S. lactis viscosus Conn.

Morphology.—A streptococcus. Size .8-.9m. Gram stain positive. Gelatin colony.—Shiny, pale, yellow, round or lobate, usually viscous. Gelatin stab.—Needle and surface growth, producing a nail culture. Agar streak.—Lobate, luxuriant, viscous. Fermentation tubes.—Acid in all sugar bouillons and growth in the closed arm but no gas. Bouillon.—Sediment, turbidity and pellicle. Milk.—Acidified, curdled and rendered very

slimy. Potato.—Luxuriant, dull, pasty growth. Grows at 20° and 37° C. Facultative anaerobe. Variety A shows scanty, non-viscous growth on agar and no pellicle on bouillon.

S. lacticus Kruse.

Morphology.—Long or short chains. Size .5-1m. Gram stain positive. Gelatin colony.—Minute, white, rough, dense. In litmus gelatin always acid. Gelatin stab.—Moderate needle growth, but no surface. Agar streak.—Barely visible, faint film. Fermentation tubes.—Acid in all sugars, usually growth in closed arm but no gas. Bouillon.—Almost invisible, slight sediment and turbidity. Milk.—Promptly acidified and curdled. Potato.—Uusually invisible. This species sometimes comprises 99 per cent of all the bacteria in a sample of milk. The type S. lacticus I produces acid in dextrose but not in other sugars. Variety A of this type shows no turbidity but a slight pellicle in bouillon, variety B. turbidity but no pellicle, variety C turbidity and pellicle with negative Gram stain, variety D luxuriant growth on potato. The type S. lacticus II produces acid in lactose and saccharose but not in dextrose. Gram stain negative. S. lacticus III shows pellicle on bouillon and acidifies or curdles milk.

M. lactis Fluorescens Conn.

Morphology.—Size .5 – .6m. Gram stain negative. Gelatin colony.—Round. Moderately thick, smooth, with greenish liquefaction. Gelatin stab.—Stratiform. Agar streak.—Luxuriant, narrow, thick, smooth, white. Fermentation tubes.—Dextrose acid, other sugars alkaline, no gas or growth in closed arm. Bouillon.—Sediment, turbidity, pellicle. Milk.—acidified, curdled, digested. Potato.—Scanty, thin, smooth, white. Grows at 20° and 37° C. Facultative anaerobe.

M. lactis variens Conn.

Yellow coccus, common in milk. Morphology.—Size .4-1.4m. Gram stain positive. Gelatin colony.—Deep and opaque or superficial and white, usually acid in litmus gelatin. Gelatin stab.—Napiform, liquefaction slow or rapid, sometimes a dry pit. Agar streak.—Luxuriant, rough, spreading pale orange. Fermentation tubes.—Acid in all sugars, closed arm growth, no gas. Bouillon.—Flocculent sediment, slight turbidity or pellicle. Milk—Acid, commonly curdled and digested. Potato.—Luxuriant or scanty,

pale orange, frequently dry. Grows better at 37° than at 20° C. Facultative anareobe. Variety A produces acid only in dextrose and does not acidify milk.

Sar. lactis aurantiaca Conn.

Orange, liquefying. Morphology.—Size lm. Gram stain positive. Not motile. Gelatin colony.—Liquefying pit, orange pigment. Gelatin stab.—Slow liquefaction, stratiform. Agar streak. —Filiform, raised, smooth, moist, orange. Fermentation tubes.— No acid, gas or closed arm growth in any sugar. Bouillon.—Pellicle, slight sediment. Milk.—No change in reaction, curdling, digestion. Potato.—Spreading, capitate, luxuriant. Grows at 20° and 37° C. Aerobe.

B. lactis Viscosus Adametz.

Slimy milk bacteria. Morphology.—Size. .5–1.2 x .5 – 2.5m. Filaments 15m long. Gelatin colony.—Flat, lobate, viscous. Gelatine stab.—Needle growth sometimes granular, thin, shiny, gray surface. Agar streak.—Luxuriant, viscous, white. Fermentation tubes.—No acid, gas or closed arm growth. Bouillon.— Sediment, turbidity, pellicle. Milk.—Alkaline, slimy, not curdled. Potato.—Thick, uneven, dirty gray. Grows at 20° and 37° C. Aerobe.

B. lactis acidi Leichmann.

Immensely numerous. Common cause of sour milk. Several varieties differing from type form. Morphology.—Size .7 – 1.2 x .5 – .8m. Sometimes cocci. Gram stain positive. No motility, spores or long chains. Gelatin colony.—Small points, opaque, not characteristic, mostly below surface. Acid on litmus gelatin. Gelatin stab.—Granular or linear needle growth, no surface. Agar streak.—No growth or barely visible, better on milk agar. Fermentation tubes.—Acid in all sugars, commonly closed arm growth, no gas. Bouillon.—Sometimes no growth, commonly slight sediment. Milk.—Acid, promptly curdled without gas, no digestion. Potato.—Thin, transparent or no growth. Grows better at 20° than at 37°. Facultative anaerobe. Variety A has a minute colony. Milk sometimes curdled in 6 hours. Variety B has a dense surface colony. Variety C is more anaerobic. Variety D never curdles milk.

B. lactis burri Conn.

Reddish bitter-milk organism. Morphology.—Size 1.3 x .7m. No chains, spores or Gram stain. Gelatin colony.—Surface in liquefying area 1–3 mm. in diameter. Gelatin stab.—Begins to liquefy in 4 days, infundibuliform. Agar streak.—Luxuriant, smooth, lobed, reddish. Fermentation tubes.—No acid, gas or closed arm growth. Bouillon.—Turbidity, no sediment or pellicle. Milk.—Acid, not curdled or digested. Potato.—No growth. Grows at 20°, not 37°. Aerobe.

B. lactis fluorescens Conn.

Morphology.—Size 1.4. – 1.5 x .8 – .9m. No chains, spores, capsule or Gram stain. Gelatin colony.—Slow, race-like, dense center. Gelatin stab.—Needle growth, stratiform, liquefaction in one day. Agar streak.—Filiform, translucent, smooth, white, green fluorescence. Fermentation tubes.—No gas or closed arm growth, acid in dextrose and saccharose. Bouillon.—Sediment, turbidity, pellicle. Milk.—Alkaline, curdled at 20° C., digestion. Potato.—Filiform, raised, white. Grows at 20°, poorly at 37° C. Aerobe.

P. lactis varians Conn.

Common in milk. Morphology.—Size 1 – 1.4 x 8m. Chains. No spores, capsules or Gram stain. Gelatin colony.—Round, flat or umbilicate, rugose, brownish. Gelatin stab.—Stratiform or infundibuliform, slow. Agar streak.—Filiform, raised, opaque, white. Fermentation tubes.—No gas or closed arm growth, usually acid in dextrose only. Bouillon.—Sediment, turbidity, membranous pellicle. Milk.—slightly acid and curdled at 20° C., not at 37° C. Potato.—Variable, white to brown. Grows better at 20° than at 37° C. Aerobe Variety A. liquefies rapidly. B. acidificans presamigenes casei Gorini and P. fragariae probably belong here.

B. lactis citreus Conn.

No chains or spores. Size .8 x .5m. Gelatin colony.—White, opaque, later yellow. Gelatin stab.—Needle growth, lemon—yellow surface. Agar streak.—Luxuriant, lemon–yellow, smooth. Fermentation tubes.—Probably acid without gas. Bouillon.—Sediment, turbidity, pellicle. Milk.—Acid, curdles. Potato.—

Luxuriant, white, then lemon yellow. Grows at 20° and 37° C. Aerobe.

B. lactis rubifacens Gruber.

Red pigment. Morphology.—Size 2 – 3 x .7m. Spores, no chains, capsule or gram stain. Gelatin colony.—Thick, gyrose, white. Gelatin stab.—Needle growth villous, spreading surface. Agar streak.—Linear, moderate, white. Fermentation tubes.—Acid and closed arm growth, no gas. Bouillon.—Sediment, turbidity, ring pellicle. Milk.—Acid, curdled like jelly. Potato.—Thick, white. Grows better at 20° than at 37° C. Facultative anaerobe.

B. Subtilis.

Very common in milk. Morphology.—Size 1.5 – 4 x .6 – 1.5 mm. Chains, spores, no capsule, Gram stain positive. Gelatin colony.—Rapid liquefaction, irregular granular masses. Gelatin stab.—Liquefies in one day. Crateriform, later stratiform. Agar streak.—Filiform, spreading, cretaceous, wrinkled. Fermentation tubes.—No acid, gas or closed arm growth. Bouillon.—Sediment, turbidity, pellicle. Milk.—Alkaline, curdled, digested. Potato.—spreading, gray, raised, dry or moist. Grows at 20° and 37° C. Aerobe. Varieties with slow liquefaction and negative Gram stain.

This bacillus,—also frequently called "Hay Bacillus," on account of having been first found in hay, as well as other members belonging to the same group to which this one belongs, are among the most important encountered in the dairy industry. Spoilage in the case of improperly sterilized evaporated milk is usually due to the presence of this bacillus.

Fig. 116 and 117 illustrate this bacillus in two forms.

B. lactis gelatinosus Conn.

Produces jelly-like milk. Morphology.—Size .8 x .6 m. No chains, spores, capsule or Gram stain. Gelatin colony.—Round, smooth, white, slow. Gelatin stab.—Slow, crateriform, white. Agar streak.—Filiform, raised, smooth, brownish. Fermentation tubes.—No acid, gas or closed arm growth. Bouillon.—Sediment, turbidity, membranous pellicle. Milk.—Acid, curdled, digested into jelly. Potato.—Moderate, raised, brownish. Grows at 20° and 37° C. Aerobe.

B. mesentericus fuscus Conn.

Morphology. No chains. Size 1.2 – 1.5 x .4 – .6m. Central spores, gram stain positive. Gelatin colony.—Round, convex, entire, brownish-red. Gelatin stab.—Slow, napiform. Agar streak. —Spreading, thin, rugose, gray. Fermentation tubes.—o gass or closed arm growth. Acid in dextrose and saccharose. Bouillon.—

Fig. 116. Bacillus Subtilis.[3] Vegetating Rods from a Very Young Culture of Agar. Bacilli Showing Flagella.

Fig 117. Bacillus Subtilis and Spores.[4] The Spores Have Very Thick Cell Membrane Almost Impenetrable by Heat.

Slight turbidity, no sediment or pellicle. Milk.—Alkaline, curdled, digested. Potato.—Luxuriant, thin, rugose, brownish-red. Grows better at 37° than at 20° C. Aerobe.

ACID GAS PRODUCERS.

Bacterium aerogenes type.

B. lactis aerogenes Esch.

Morphology.—Size 1.4 – 5 x 1 – 1.5m. Sometimes capsule. No chains or spores. Gram stain irregular. Gelatin colony.—Thick, round, smooth, moist, sometimes viscous, 2 mm. in diameter. Gelatine stab.—Needle growth, thick, white surface. Agar streak.—Luxuriant, moist, gray. Fermentation tubes.—Acid, gas and closed arm growth in all sugars. Bouillon.—Sediment, turbidity, usually pellicle. Milk.—Strongly acid, curdles, gas. Potato.—Luxuriant, dirty white. Grows better at 37° than at 20° C. Aerobe. No indol. One variety produces indol, a second a thick colony, and two others bitter milk.

The Coli Communis type.

B. Coli aerogenes Conn.

Flagellate. Morphology.—Size 1 – 3 x 1 – 1.4m. No chains, spores or Gram stain. Gelatin colony.—Prominent, thick, smooth, moist, large. Gelatin stab.—Needle growth, thick white surface. Agar streak.—Filiform, raised, smooth opaque. Fermentation tubes.—Acid, gas and closed arm growth, not much gas. Bouillon.—Sediment, turbidity, usually pellicle. Milk.—Strongly acid, curdles with gas. Potato.—Luxuriant, white or straw color. Grows better at 37° than at 20° C. Aerobe. Indol produced, or sometimes not.

B. coli communis Esch.

Like the last species, but produces a thinner, umbonate colony on gelatin with a granular lobate edge. Indol is produced. B. coli is very common in milk on account of the frequent contamination with feces.

Typical characters. Morphology.—Size 1 – 1.6 x .4 – 1m. No chains, spores, capsule, or Gram stain. Flagella peretrichic. Gelatin colony.—Thin, spreading umbonate, smooth center, lobate. Gelatin stab.—Filiform needle growth, spreading, moderate sur-

face. Agar streak.—Filiform, raised, smooth, white, sometimes lobed. Fermentation tubes.—Acid, gas, and closed arm growth in all sugars. Bouillon.—Turbidity, sediment, ring pellicle. Milk. —Acid, curdling, no digestion. Potato.—Moderate, smooth, gray-white. Grows better at 37° than 20° C. Aerobe. Indol produced. One variety produces gas in dextrose only, and another renders milk slimy.

P. Coli communis Conn.

Gas-producing Pseudomonas. Morphology.—Size 1 – 1.5 x .8 – .9m. No spores, chains, capsule or Gram stain. Gelatin colony. —Round, thick, smooth, auriculate, gray. Gelatin stab.—Filiform, umbonate, bluish surface. Agar Streak.—Moderate, linear, raised, gray. Fermentation tubes.—Acid, gas and closed arm growth. Bouillon.—Sediment, turbidity, flocculent pellicle. Milk. —Acid, curdling, no digestion. Potato.—Moderate, thin, spreading. Grows better at 20° than at 37° C. Facultative anaerobe. Almost identical with B. coli communis except that there is only one flagellum, which is long and characteristic.

Common types of fungi found in milk.

In addition to the bacteria which may occur in milk and cause various changes in it a number of fungi other than bacteria may gain entrance to milk. Of these perhaps Oidium Lactis and Torula amara are most common. Brief descriptions of these fungi may be given in this connection.

Oidium lactis.

This is the conidial form of a mildew belonging to the same genus with the powdery mildew of the grape. It occurs normally in sour milk. Morphology.—Fruiting hyphae simple, erect, colorless, bearing at the tips chains of conidia which germinate to form septate hyphae. Takes ordinary aniline stains. The spores or conidia are short cylinders. Gelatine.—Colonies at first white points, becoming stellate and finally covering the entire surface with a mycelial network. Makes similar growth on agar.

Torula amara Harrison.

Morphology.—Oval cells. 7.5 – 10 m. long, showing vacuolation after a few days, budding at smaller end of cell. Singly or in clumps or chains. No spores. Wort.—Abundant growth at

25° C. No pellicle. Yeast rings form at 37° C. Wort Gelatin.—Pin-point colonies becoming round and grayish white in 4 days. Gelatin stab.—Beaded line becoming dense and spiny. Surface waxy becoming brown at center. Wort Agar.—Rapid, luxuriant. Agar.—Glistening, flat. Potato.—In 3 days slightly raised, yellowish growth. Milk.—Bitter in 5 or 6 hours, curdled in 10 days, much gas, no butyric acid.

QUANTITATIVE DETERMINATION OF ORGANISM IN MILK.

Laboratory and apparatus: The suggestion given in Chapter I should be found helpful in fitting out a small laboratory but much will depend upon the ingenuity of the individual, the space available, and the funds that may be used for purchasing equipment. Where a room is used for a variety of purposes, there is likely to be an excess of dust whereas bacteriological work should be carried on in a place as free from dust as possible. It would therefore be well to partition off a portion of the room where sterile apparatus and the reagents may be kept and the plating and other work may be done. As plenty of light is necessary, the partitions may be made largely of glass.

The autoclave or steam sterilizer should maintain a steam pressure of at least 10 pounds to insure convenient and reasonably quick means for thoroughly sterilizing the media and water. Any kind of an oven that can be maintained at a temperature of 175° C will serve as a sterilizer for glassware. It should be fitted with a thermometer. An incubator, in which the temperature can be accurately controlled is indispensable. It is much better to purchase a good one especially designed for the purpose than to try to use a cheaply built substitute.

Methods: The American Public Health Association published in 1921 Standard Methods for the Bacteriological Examination of Milk.[5] As these methods are representative of the best work in America they are given here.[6]

COLLECTION OF SAMPLES FOR BACTERIOLOGICAL COUNTS.

Although the technique of the plating method is fundamentally different from that involved in microscopic counting, microscopic counts are readily made from the same samples as those used in making agar plates. As the precautions necessary

for securing a fair sample are identical, the method of collecting samples for both methods are described under a single heading.

All collecting apparatus, glassware, pipettes, collecting tubes, bottles, etc., shall be sterilized at a temperature of at least 175° C. for one hour.

Each sample shall consist of at least 10 cc. of milk. Before taking the sample the milk shall be mixed as thoroughly as possible. If the original container can be inverted the mixing of the milk should be done by inverting it several times. If this is impossible, the milk should be stirred wth some sterile stirrer. Any stirrer already in the container may be used. If there is none in the container, the sampling pipette (or any other sterile article) may be used; but it shall be used for one container only until it is again sterilized.

A sample merely poured from a large can is not a fair sample unless the milk in the can is thoroughly stirred. Neither is a sample of mixed milk, taken after it is poured into an unsterilized weighing vat, a fair sample from which to judge the quality of the milk before it was poured into the vat. The sample shall be taken from cans by means of a glass or aluminum tube with straight sides, long enough to reach the bottom of the original container and inserted, not too rapidly, with the top of the tube left open. This will result in the tubes containing a cylindrical section of the milk from top to bottom of the can. The finger then placed on the top of the tube will make it possible to withdraw the tube full of milk and transfer it to the sampling bottle. The sampling bottle should be large enough to hold the entire contents of the tube, all of which must be reserved as the sample. Each tube shall be used for collecting a single sample only, and must be washed and sterilized before it is used again. If the sample is taken from a bottle, the bottle should be first shaken to ensure thorough mixing and the milk may be poured into the sample bottle, although it is better here also to use a sampling tube.

If the temperature of the milk is desired, it should be taken from a different container from that used for the bacteriological sample, or after the bacteriological sample has been withdrawn. All records shall be made immediately after taking the sample. The milk sample shall be placed in a properly labeled bottle. The

most convenient kinds of sample bottles are glass stoppered, or those closed with a cork lined screw cap. Cotton plugs are not satisfactory method of closure. The sample bottles shall be placed at once in a carrying case containing cracked ice, so that the milk is promptly cooled to near the freezing point.

The samples shall be transferred to the laboratory as quickly as possible and shall be plated with as little delay as possible. The samples placed in cracked ice and water may be kept for several hours (12) without an appreciable increase in bacteria. If the plates are not made within four hours from the time of collection, the number of hours that did elapse should be stated in the report. If the milk is kept at 40° C. a slight and somewhat variable increase may be found in twelve to twenty hours. Up to twenty hours this will not be more than 20 per cent in normal cases. The larger increases may be expected in milk which has been stored at low temperatures for some time previous to sampling. Continued shaking of the milk during its transit to the laboratory tends to break up the clumps into smaller masses and so increases slightly the number of colonies.

In the case of samples to be used for direct microscopic examination, icing of the samples may be dispensed with under some conditions where it is possible to add preservatives (formaline 2 to 3 drops of a 40 per cent solution of formaldehyde for each 10 cc. of milk) to the samples as taken. Samples containing preservatives that have been allowed to stand until the cream is compact are not satifactory, and are likely to give a lower count than fresh samples.

(A) MACROSCOPIC COLONY COUNT (PETRI PLATE METHODS).

Composition of medium.

Standard beef extract agar* shall be used for all routine work and shall contain the following ingredients:**

Agar (oven dried).....1.2%

or

*Beef infusion may be substituted for beef extract in those laboratories where past records are based on the use of beef infusion agar; but in the interest of uniformity, it is urged that beef extract be used.

**This medium is essentially the same as that recommended in the last edition of the Standard Methods of Water Analysis except for the reaction preferred.

Agar (market).....1.5%
Beef extract.....0.3%
Peptone 0.5%
Distilled water.....

The beef extract shall be Liebig's where this is obtainable, or some other brand giving comparable results.

Witte peptone, if available, can be used with assurance that the reaction of the medium will be neutral (pH=7.0); other brands—such as Armour's, Digestive Ferments Co.'s, Parke Davis Co.'s,—although more acid can often be used for milk analysis without necessitating change of reaction; and nearly any good commercial peptone may be used with comparable results provided special attention be given to H-ion concentration of the medium.

The agar must be of the best quality. If oven-dried at 105° C. just before using, take 1.2%; if used just as obtained in the market without oven-drying, use 1.5%. Remove salts and any dirt present by soaking, washing and draining. Distilled water is to be used for dissolving the ingredients.

Reaction.

A medium consisting of the above ingredients, including a suitable peptone, ordinarily has a reaction between pH=6.2 and 7.0. If within these limits, the reaction requires no adjustment for milk analysis. The most desirable reaction is about pH=6.5 to 6.6; but any reaction between pH=6.2 and 7.0 is allowable. No change in reaction should be made without carefully determining the H-ion concentration of the finished medium by the method described below.

Inasmuch as the range of H-ion concentration recommended for water analysis[8] is pH=6.8 to 8.4, it is permissible, if desired, to use a single agar for both purposes with a reaction of pH=6.8 to 7.0. If Witte's peptone is used in the above formula, this will ordinarily be the reaction without adjustment.

Each batch of finished medium should be tested before use as to its final reaction after sterilization. This test is to be made as follows:

Put 4 cc. of distilled water at 30 to 40° C. (not warmer) in a test tube. Add 1 cc. of the agar to be tested and then 10 drops

of the indicator, brom thymol blue* (0.04 per cent solution in 95 per cent alcohol). The resulting color should be either a yellowish green or vary to a deeper shade of grass green. To one whose eye is trained this shade of color is sufficient.

These shades may be accurately determined by means of the buffered solution[9] of Sörensen or of Clark and Lubs.

However, they may be approximately determined by comparing the tube of agar containing the indicator with a set of color tubes after the method of Barnett and Chapman.[10]

Select 12 test tubes of even caliber and place in two rows of 6 each. In each tube of one row put 5 cc. of a dilute alkali (as, for example, twentieth normal sodium hydroxide). In each tube of the other row put 5 cc. of very dilute acid (one drop of concentrated sulphuric or hydrochloric to 100 cc. of distilled water is sufficient). Avoid stronger acid.

Add indicator to the tubes as follows:

Acid tubes	Alkali tubes	H-ion concentration
9 drops	1 drop	pH 6.2
8 drops	2 drops	pH 6.4
7 drops	3 drops	pH 6.7
6 drops	4 drops	pH 6.9
5 drops	5 drops	pH 7.1
4 drops	6 drops	pH 7.3

The tubes are to be viewed in pairs of acid and alkali, each pair containing the sum of ten drops of indicator.

If preferred, double these quantities may be used throughout and the indicator measured in fractions of a cubic centimeter instead of drops. That is, two cc. of agar should be taken for testing. This should be added to 8 cc. of distilled water. One cc. of indicator should be used. In comparing with the Barnett and Chapman tubes, use 10 cc. of dilute acid or alkali in each tube, and add the indicator in tenths of a cubic centimeter instead of in drops.

All of the test tubes used in this determination must be of the same diameter and of clear glass.

*Prepared by Hynson, Wescott & Dunning, Baltimore, Md.

Another indicator, brom cresol purple,* (0.04 per cent solution in 95 per cent alcohol) may be used as an alternative for brom thymol blue. Its use is especially desirable if the reaction of the agar is more acid than pH=6.4, because brom thymol blue is not very sensitive at this point. Brom cresol purple, on the other hand, is not sensitive at pH=7.0 and therefore cannot be used if the medium is of neutral reaction.

The pH values corresponding to the color pairs (acid and alkali) prepared by the method of Barnett and Chapman have been worked out by Medalia.[11] The color of brom cresol purple is a good shade of purple at pH=6.8 with increasingly lighter shade to pH=6.2. At pH=6.0 the color is a grayish hue not easily confused with that of pH=6.2.

Adjustment of reaction.

If the correct color of the indicator does not appear in the agar as tested, add dilute NaOH (e. g. N/20) from a burette until the shade is obtained which represents the desired H-ion concentration, that is between pH=6.8 and 7.0. Fifty times the amount of N/20 NaOH added from the burette equals the amount of normal NaOH to be added to one liter of the medium if 1 cc. of the agar is being tested. When testing 2 cc. of agar, multiply by 25 instead of 50.

In this adjustment, it is permissible to use any strength NaOH, but the strength of that added to the medium must be an exact multiple of the strength of NaOH used in titration; if the ratio is not 1:20 proper allowances must be made.

Method of preparing agar.

The important point is to secure an agar of the correct reaction and composition which contains no troublesome precipitates. Methods of cooking and filtering to accomplish this vary with the ingredients used. Those suggested below have been found satisfactory in practical use; but other methods securing the same results are allowed. White of egg, however, must not be used for clarification.

The finished medium may be tubed or bottled, placing 10 cc. in each tube or 55 cc. (enough for five plates) in each bottle.

*Prepared by Hynson, Wescott & Dunning, Baltimore, Md

Sterilization shall be accomplished by heating in the autoclave for 20 minutes after the pressure reaches 15 lbs.; or after the agar is completely melted, heat in flowing steam on three successive days for 20 minutes each day.

All glassware and all apparatus such as kettles, funnels and filtration flasks, must be kept scrupulously clean by running hot water over or through them after use before the agar has had time to harden. There is danger otherwise of dried particles of agar chipping off and giving rise to sediment in future batches of agar which in the poured plates may be mistaken for colonies.

Procedure No. 1. Mix all of the ingredients together cold. Heat in an autoclave at 15 lbs. pressure for 40 to 90 minutes according to the quantity of medium being made in each batch. Allow the autoclave to cool very slowly so as not to disturb the sediment. Decant through a cotton filter taking care not to pour the sediments on the cotton until the bulk of the liquid has passed through.

This simple procedure with certain brands of peptone and grades of agar gives excellent results.

Procedure No. 2. Where large quantities of agar are to be prepared the following procedure has been found useful. Prepare two separate solutions:

Mixture A.—Beef extract 0.3 per cent of total quantity of medium to be made.

Peptone 0.5 per cent of total quantity of medium to be made.

Distilled water 40 per cent of total quantity of medium to be made.

Place in a kettle. Weigh kettle with contents. Heat on stove to boiling, and boil five minutes. If absolutely necessary to adjust reaction (see Reaction) do so at this point and boil again. Make up with hot distilled water that lost by evaporation. Do this by weight. Filter through paper or paper pulp in a Buchner funnel (see below).

Mixture B.—Agar oven dried 1.2 per cent (market 1.5 per cent) of total quantity of medium to be made. Soak and wash under tap in sieve. Weigh before and after soaking to determine quantity of water absorbed. Distilled water 60 per cent of total

quantity of medium to be made, minus that absorbed by the agar during the washing.

Mix A and B (agar not yet melted). Heat mixture over stove, stirring at frequent intervals until agar is entirely melted. Then boil and stir constantly for 20 minutes. Make up by weight water lost by evaporation by adding hot distilled water. Keep kettle of agar in chamber of flowing steam while preparing funnel for filtering.

Filter through cotton until clear. For 10 liter amounts it is suggested that either a Sharples centrifuge or a nine inch Buchner funnel with a suction pump be used. The ordinary filtration pump attached to a water faucet producing about 11 inches of vacuum gives good results.

Prepare paper pulp by soaking scraps of ordinary filter paper for 36 to 48 hours in a large wide-mouthed bottle. The paper and water should be in the ratio of six sheets of soft absorbent filter paper (20 by 20 inches) to 2½ liters of hot water. Moisten the paper and tear it into fragments about ¼ to ½ inches square. Shake vigorously at intervals to make the suspension fine and uniform. When ready to prepare the nine inch funnel, take 400 to 500 cc. of the paper pulp and dilute it with about three liters of very hot water. Cut a piece of surgeon's lint (or cotton flannel) to fit the bottom of the funnel exactly. Rinse the funnel with hot water. Place in it the lint with the fleecy side upermost. Pour in the hot paper pulp suspension carefully so as to cover the lint with an even layer about ⅛ to ¼ inch thick. Over this lay a disk of filter paper. Place a four liter suction flask under the funnel and apply the suction to draw the water into the filtration flask until the pulp is firm, yet somewhat moist. The agar will not go through too dry a filter.

The funnel and the paper pulp must be hot when the agar is poured in carefully and slowly, striking the disk of filter paper which prevents the breaking of the surface of the paper pulp. Discard the first 100 cc. of agar which come through as they contain some of the water from the pulp.

Even in the first filtration the agar should come through very clear. Keep the remainder of the unfiltered agar hot in flowing steam while the first part is running through the filter.

Ordinarily the temperature of the agar in the funnel is 80° to 85° C. but the last portions will come through well as low as 50° to 55° C.

Keep the filtered agar hot in flowing steam while preparing a second funnel in the same way as the first. Then filter as before.

Plating.

For miscellaneous milk samples, the character of which is not known, three dilutions shall be made; 1 : 100, 1 : 1,000 and 1 : 10,000. Where the character of the milk is known, the number of dilutions may be reduced. If the milk is pasteurized, certified or known to be fresh, and of high grade, the 1,000 and 10,000 dilutions may be omitted. If the milk is known to be old and of high bacterial count, the 100 and 1,000 dilutions may be omitted, and dilusions in excess of 10,000 prepared. In no case shall less than two plates be made from each sample. Where two satisfactory plates are obtained it is advisable to count both of them.

The water used for dilutions may be placed in dilution bottles (99 cc., 49.5 and 9 cc. are convenient sizes) are sterilized for one hour in an autoclave at 15 lbs. pressure. The bottles should be marked so that it can be determined that they have neither gained nor lost water during or subsequent to sterilization. Or, the water may be sterilized in bulk, if kept in a properly guarded container, and subsequently measured directly into the dilution bottles with sterilized pipettes.

The dilution bottles should have glass or cork stoppers, or some other type of closing that makes shaking possible. Cotton plugs are a less satisfactory method of closure because a small portion of the dilution water will soak into the cotton.[12]

Straight sided pipettes graduated to deliver 1 cc. are the best. They may be either the two mark or the one mark style. In either case, the errors of measurement are caused more by faulty calibration or by faulty manipulation of the pipettes than by the particular form of pipette used. In using two mark pipettes, great care must be taken to see that the quantities used are exactly 1 cc., while many one mark pipettes in use are calibrated to contain 1 cc. rather than to deliver 1 cc. Breakage of tips of the latter type of pipette also cause errors.

In making dilutions the original sample and each dilution bottle shall be rapidly shaken 25 times, each shake being an up and down excursion of about one foot (entire shaking not to take longer than about seven seconds). After the final dilution fill a pipette to the mark and allow contents to run into an empty petri dish, the end of the pipette touching the dish as the liquid runs out. If the pipettes are of the one mark style be sure that they are so manipulated as to deliver a full cubic centimeter. Use care to raise the cover only as far as necessary to insert the end of the pipette.

Pipette should be placed immediately in water after using to make subsequent cleaning easier.

The flasks (or test tubes) of agar shall be melted in boiling water or steam and after melting shall be cooled to a temperature of between 40 and 45° C. before using.

Pour about 10 cc. of the melted agar in each inoculated petri dish, and by a gentle rotary motion thoroughly mix the agar and the diluted milk. As nearly as possible the same amount of agar should be poured into each petri dish so that the depth of agar will be uniform in all. If desired 10 cc. may be measured out from the flask with a sterile pipette.

It is important that the plating shall be completed as rapidly as possible. The work should be so planned that no more than 15 minutes shall elapse after the dilution of the milk and before the agar is poured into the petri dishes; and in no case shall the interval be allowed to exceed 20 minutes.

After the agar has been thoroughly hardened, place the petri dishes in an incubator. The danger of spreaders may be reduced either by the use of clay tops or by inverting the plates as preferred.

Incubation.

Only one period of incubation, and one temperature is regarded as standard, 48 hours at 37.5° C. Piles of plates should not be packed too closely together and in crowded incubators ventilation should be provided.

Counting Plates.

If among the different dilutions there are plates containing from 30 to 300 colonies these should be counted,[13] and the num-

ber, multiplied by the dilution, be reported as the final count. All colonies on such plates should be counted, and the numbers from the different plates averaged. If there are no plates within these limits, the one that comes the nearest to 300 is to be counted. No plate that contains less than 20 colonies shall be counted, unless it happens that there are no other plates. If the number of colonies on the plates to be counted are in excess of 300 per plate, a part of the plate may be counted and the total number estimated; but such plates are admittedly overcrowded and the counts are less than they should be.

Countings shall be done with a lens, and all recognizable colonies included. A lens magnifying 2½ diameters (or what the opticians call a 3½ x lens) is recommended for general use. In case any particles visible by this method are of doubtful nature they should be examined with a compound microscope to determine whether they are colonies or dirt specks.

Common sources of error in counts.

Agar plate "counts" per cc. are to be regarded as estimates of numbers rather than as exact counts, since only a portion of a cubic centimeter is used in preparing the plates. As such they are (like all estimates) subject to certain well known and recognized errors whose size can be largely controlled by the care taken in the analysis. Among these errors are: (a) Failure of some of the bacteria to grow because the incubation temperature, or the composition reaction of the medium, is not suitable. (b) Inaccuracies in measurement of the quantities used. (c) Mistakes in counting, recording data, computing results and the like. (d) Incomplete sterilization or contamination of the plates, dilution waters, etc. The possible errors caused by these things makes it highly important for all routine laboratories to follow carefully a standard procedure.

Recent investigations make it clear that these largely controllable errors, are not likely to cause serious misconceptions of the accuracy of results as are the errors due to the fact that bacteria in milk usually cling together in groups of from two to many hundreds of individuals. These groups are only partially broken apart by the shaking given in preparing the dilutions so that at best the counts from the agar plates represent the number of isolated individuals and groups of two or more bacteria that

exist in the final dilution water. Thus the colony counts from the plates are always much smaller than the total number of bacteria present. This error would not be troublesome if the groups were of constant average size; but the best information available shows that the groups in ordinary market milk commonly vary in size so that they contain an average of from 2 to 6 individual bacteria. Some samples contain groups of even smaller size than this, while others, such as those bearing long chain streptococci, may show groups containing an average of 25 or even more individual bacteria. The irregularity of this error (whose size is not indicated in any way by the appearance of the plates) should be kept in mind in interpreting the results obtained.

Reports.

Because of the fact that agar plate counts only represent a fraction of the total number of bacteria present, they should not be reported as showing the "number of bacteria per cc." Accurately speaking the counts from agar plates give the estimated number of colonies that would have developed on standard agar per cc. of milk if an entire cubic centimeter of milk had been used for inoculation. Because this statement of fact is cumbersome, and also because a certain ratio exists in each case between the colony count and the total number of bacteria, it has become a common practice to speak of the plate counts as showing the number of bacteria per cc. This is very confusing now that microscopic methods of counting have been developed which permits counts of the actual bacteria to be made. These counts average approximately five times the size of the counts as made by the standard agar plate technique.

It is therefore recommended that all agar plate counts obtained by the standard technique shall not be stated in the form "2,000,000 bacteria per cc." but rather as follows: "official plate count, 2,000,000." This latter form of expression shall be considered an abbreviated method of saying: "a count of 2,000,000 colonies per cc. as obtained by standard methods." Moreover analysts shall be careful to avoid giving a fictitious idea of the accuracy of the official plate count. There is ample justification for thinking them sufficiently accurate to justify drawing conclusions as to the general quality of a given sample of milk, and when a series

of samples from the same source are examined the average result may permit much more specific conclusions to be drawn with confidence.

Specific data showing the actual percentage error in these counts has been difficult to obtain, and has only recently been obtained by means of comparisons made between microscopic and agar plate counts. The conclusions reached by Breed and Stocking are that the margin between two plate counts made from similar samples of marketed milk must be as great as one to five before it becomes a practical certainty that the larger count actually represents the larger number of bacteria.

It is, however, self evident that between any two samples the one having the higher count probably contains the greater number of bacteria, and this probability can be made a practical certainty by the examination of a series of samples. It is therefore required that a series of samples, preferably four or more, be examined before judgment shall be rendered as to the general quality of a given milk supply. Under no conditions is the practice sanctioned of publishing exact counts from individual samples as showing the quality of a given milk supply.

All laboratories conforming to standard procedure will keep a record of the exact number of colonies developed on the plates that are counted; but will render their reports in round numbers only. Never use more than two significant left hand digits in any report, raising the number to the next highest round number in any case; but never lowering it. Those wishing to be still more conservative may use a form of report such as "official plate count less than 10,000," "official plate count between 10,000 and 30,000," and the like.

STANDARD METHODS OF BACTERIAL MILK ANALYSIS.

Plating apparatus.

For plating it is best to have a water bath in which to melt the media and a water jacketed water bath for keeping it at the required temperature; a wire-rack which should fit both the water baths for holding the media tubes; a thermometer for recording the temperature of the water in the water jacketed bath, a sterile

one c. c. pipette, sterile petri dishes and sterile dilution water in measured quantities.

Dilutions.

Ordinary potable water, sterilized may be used for dilutions. Occasionally spore forms are found in such water which resist ordinary autoclave sterilization; in such cases distilled water may be used or the autoclave pressure increased. With dilution water in eight-ounce bottles calibrated for ninety-nine cubic centimeters, all the necessary dilutions may be made.

Short wide mouthed "Blakes" or wide mouthed French square bottles are more easily handled and more economical of space than other forms of bottles or flasks.

Eight ounce bottles are the best, as the required amount of dilution water only about half fills them, leaving room for shaking. Long fibre, non absorbent cotton should be used for plugs. It is well to use care in selecting cotton for this purpose to avoid short fibre or "dusty" cotton, which gives a cloud of lint-like particles on shaking. Bottles and tubes should be filled a little over the 99 c. c. and 9 c. c. marks to allow for loss during sterilization.

The dilutions recommended are 1 – 10, 1 – 100, 1 – 1,000, 1 – 10,000, 1 – 100,000, and 1 – 1,000,000.

For certified milk the 1 – 100 dilution should be used, while 1 – 100 and 1 – 10,000 will usually be found best for market milk.

The 1 – 10 dilution is prepared by shaking the milk sample twenty-five times and then transferring 1 c. c. of the milk to a test tube containing the 9 c. c. of sterile water.

The 1 – 100 dilution is prepared in the same way, except that a bottle with 99 c. c. of sterile water is substituted for the test tube.

The 1 –1,000 dilution is prepared by first making the 1 – 100 dilution, shaking twenty-five times and transferring 1 c. c. of the dilution to a test tube containing 9 c. c. of sterile water.

The 1 – 10,000, 1 – 100,000, and 1,000,000 dilutions are made in the same manner by dilutions of 1 – 100, 1 – 1,000, and 1 – 10,000 dilutions, 1 c. c. to 99 c. c. of sterile water.

It is recommended that that dilution be used which will produce about 200 colonies to a plate, ranging from 40 – 200 where a 1 – 10 dilution exceeds this number the 1 – 100 dilution is more

accurate, etc. The number of bacteria present may if desired, be approximately estimated before dilutions are made by direct microscopic examination of a properly prepared sediment. Otherwise, it is necessary to make a range of dilutions thereafter selecting for record the count obtained on that plate which yields between 40 and 200 colonies.

Plating whole milk is unreliable, whatever quantities be used, since the bacteria are not so well separated as in the dilutions, and often, owing to the crowded conditions, only a portion of the bacteria present will develop into visible colonies. Moreover, if a cubic centimeter of the milk is used, the turbidity of the jelly due to the presence of the milk hides the colonies present from the eye.

Porous earthenware Petri dish covers are recommended as superior to glass since they absorb the excess moisture. They also have the advantage of being cheaper and more durable than glass, they are easily marked with ordinary lead pencil. With long incubation a tendency of plates with these covers to dry out has been observed by some workers; for ordinary routine work, however, they are perfectly satisfactory using 10 c. c. of media to the plate and incubating in a saturated atmosphere. These covers should never be washed but always thoroughly dry sterilized before use.

Another method of preventing spreaders is by inverting the dishes and placing in the glass cover of each a strip of sterile filter paper moistened with one large drop of glycerine. Plates so treated do not dry out as quickly as with the porous tops and the glassware does not become scratched.

Pipettes.

Straight sides 1 c. c. pipettes are more easily handled than those with bulbs; they may be made from ordinary 3-16 inch glass tubing and should be about 10 inches in length.

Plating Technique.

The agar after melting should be kept in the water jacketed water bath between 40 degrees C. for at least fifteen minutes before using to make sure that the agar itself has reached the temperature of the surrounding water. If used too warm the heat may destroy some of the bacteria or retard their growth.

For routine work in cities in order to bring down the actual number of colonies in a plate to about the standard of two hundred, it is well to use a dilution of 1 – 10,000. To make this dilution use two bottles of sterile water each containing 99 c. c.

Shake the first dilution twenty-five times, then with a fresh sterile pipette transfer 1 c. c. to the second dilution water, rinsing the pipette to the mark as before; this gives a dilution of 1 – 10,000. Shake the second dilution twenty-five times, then with a sterile pipette transfer 1 c. c. to the Petri dish, using care to raise the cover only as far as necessary to insert the end of the pipette.

Take a tube of agar from the water bath, wipe the water from the outside of the tube with a piece of cloth, remove the plug, pass the mouth of the tube through the flame and pour the agar into the plate, using the same care as before to avoid exposure of the plate contents to the air.

Carefully and thoroughly mix the agar and diluted milk in the Petri dish by a rotary motion, avoiding the formation of air bubbles or slopping of the agar, and after allowing the agar to harden for at least fifteen minutes at room temperature place the dish bottom down in the incubator.

Controls.

Plating should always be checked by controls. A blank plate should be made with each series of milk plates for control on the agar, water, air, Petri dishes, pipettes, etc.

For control of the technique of plating, it is recommended that for work on "market milk" duplicate plates be made each day on several samples.

"Certified milk" should always be plated in duplicate and where it is possible it is well to have one man's work occasionally checked by another.

Unless duplicate plates show as a rule approximately the same count the worker should see if there is error in his technique.

Plating should always be done in a place free from dust or currents of air.

In order that colonies may have sufficient food for proper development 10 c. c. of agar shall be used for each plate. In plating a large number of samples at one time the dilution and transfer of diluted milk to the plated may be done for four or eight samples then the agar poured, one tube to each plate, then another eight samples diluted, etc.

INCUBATION AND COUNTING.

Two standard temperatures are recognized:

1. 48 hour incubation at 37 degrees C.
2. Five day incubation at 21 degress C.

Regulations governing the number of bacteria allowable in milk should direct the method to be used in examination and in all reports, papers, etc. on the bacterial count of milk this factor should be explicitly stated.

Incubators should be carefully regulated. Whatever temperature of incubation may be used it is important that the incubator air should be saturated with moisture; this may be accomplished by either having a depression in the floor of the incubator filled with water or by setting a pan of water on one of the shelves.

Counting.

Expressing of results. Since minor differences in milk counts are within the working error of methods and are of no significance in practice, the following scale has been adopted for recording results of market milk examination:

Counts below 50,000 are distinguished by five thousands.

Counts between 50,000 and 100,000 are distinguished by ten thousands.

Counts between 100,000 and 500,000 are distinguished by fifty thousands.

Counts between 500,000 and 5,000,000 are distinguished by hundred thousands.

Counts above 5,000,000 are distinguished by millions.

Therefore only the following figures are used in reporting:

5,000	400,000
10,000	450,000
15,000 etc to 50,000	500,000
60,000	600,000
70,000	700,000
80,000	800,000
90,000	900,000
100,000	1,000,000
150,000	1,000,000 etc. to 5,000,000
200,000	6,000,000
250,000	7,000,000
300,000	8,000,000 etc. by millions

Counts on "Certified" or "Inspected" milk shall be expressed as closely as the dilution factor will allow.

The whole number of colonies on the plate shall be counted, the practice of counting a fractional part being resorted to only in case of necessity, such as partial spreading.

Various counting devices have been recommended by different workers. The more simple ones, where the whole plate can be seen at once, are more desirable on account of there being less likelihood of recounting colonies. Colonies too small to be seen with the naked eye or with slight magnification shall not be considered in the count.

(B) MICROSCOPIC COUNT OF BACTERIA[7] (BREED METHOD).

Various methods for counting bacteria in milk by microscopic examination have been described, but the method that is commonly described as a **direct microscopic examination** of a dried film of milk has been found to be the simplest and most reliable method of counting the bacteria as they exist in the milk itself. It is recognized in this report as a standard or official technique of equal standing with the colony count from agar plates where used for judging the quality of unpasteurized milk.

Apparatus required.

In addition to a microscope, microscopic slides, stains, etc., the only special apparatus required is a capillary pipette which discharges 1/100 cc. of milk. The most satisfactory form of pipette is made from a straight piece of thick walled capillary tubing with a bore of such a size that the single graduation mark is from 1½ to 2½ inches from the tip. The tip shall be blunt and of such a form that it will discharge the milk cleanly without running back on the side of the tip. Pipettes of this type are now listed by all of the usual supply houses. The pipettes shall be calibrated so as to **deliver** 1/100 cc., not to **contain** 1/100 cc. Because there are many inaccurately calibrated pipettes on the market, the calibration of all pipettes shall be tested by weighing the amount of milk discharged on chemical balances. The weight for milk should be .0103 grams.

Only a single pipette is needed in making a series of tests, provided this is kept clean while in use. In this kind of work cleanliness of glassware is more important than sterilization.

Clean towels may be used for wiping the exterior of the pipettes while making the microscopic preparations, and their bores may be kept clean by rinsing them in clean water between each sample. The small amount of water left in the bore may be rinsed out in the milk sample under examination. This method of procedure, while adding a small number of bacteria to each sample, introduces only a theoretical error, tests showing that such bacteria cannot subsequently be detected, and make no difference in the final result. After use, the pipettes should be kept in a glass-cleaning solution, such as the commonly used mixture of sulphuric acid and potassium bichromate.

Routine laboratories will find it convenient to use larger microscopic slides than the ordinary 1 by 3 inch slide. The largest slides that have been found to be conveniently examined with the use of a mechanical stage are cut 2 by 4½ inches. Such slides may be stored in ordinary card catalogue cases and may be very cheaply prepared from thin window glass or old photographic negatives. A margin of ground or etched glass on the longer edges of the slide about ¼ inch in width allows lead pencil labeling. The margins may be ground with an emery wheel, or they may be etched with hydroflouric acid. The cost of these home made slides ought to not to exceed 2 to 3 cents each, whereas the similar slides listed by supply houses cost much more than this. A special guide plate (size 2 by 4½ inches) marked off with 16 square centimeter areas is also needed. This can be obtained from regular supply houses. Only one of these is needed as it is used as a guide plate underneath the slides on which the milk preparations are made.

Preparation of films of dried milk.

After a thorough shaking of the sample, 0.01 cc. of milk or cream shall be deposited upon a clean glass slide by means of the pipette above described. Spread the drop of milk uniformly over an area of one square centimeter by means of a clean, stiff needle. This may be most conveniently done by placing the slide upon the guide plate just described, or upon any other form of guide plate of glass or paper which is ruled in square centimeter areas. The marks showing through the glass serve as guides. After spreading, the preparation shall be dried in a warm place upon a level surface protected from dust. In order to prevent notice-

able growth, this drying must be accomplished within five to ten minutes; but excessive heat must be avoided or the dry films may crack and peel from the slide in later handling.

After drying, the slides are to be dipped in xylol, or any other suitable fat solvent, for a sufficient time to remove the fat (at least one minute), then drained and again dried. After this, the slides are to be immersed in 90 per cent grain or denatured alcohol for one or more minutes, and then transferred to a fresh aqueous or carbolic acid solution of methylene blue (about 1 per cent, exact strength unimportant) that has previously been tested and found to stain the bacteria satisfactorily in milk preparations. Some methylene blue now on the market in powder form is very unsatisfactory in that solutions will dissolve the milk films, or will wash them with an even blue color in which the bacteria fail to show distinctly. Old or unfiltered stains are to be avoided as they may contain troublesome precipitates.

The slides are to be left in the stain until overstained. They are then to be rinsed in water and decolorized in alcohol. The decolorization takes from several seconds to a minute or more, during which time the slide should be under observation, in order that the decolorization may not proceed too far. When properly decolorized the background of the film should show a faint blue tint. Poorly stained slides may be decolorized and stained without apparent injury. After drying, the slides may be examined at once, or they may be preserved indefinitely.

Standardization of the microscope.

The microscope used must be so adjusted that each field covers a certain known fraction of the area of a square centimeter. This adjustment is simple if a micrometer slide, ruled in hundreths of a millimeter, is at hand (sometimes called a stage micrometer as it is used under the objective on the stage of the microscope). The microscope should have a 1.9 mm. (1/12 inch) oil immersion lens, and an ocular giving approximately the field desired (for example a 6.4 x ocular). It sould also be fitted with a mechanical stage. If the large slides described above are used, this must be a special stage allowing a larger area of the slide to be examined than can be examined with the usual mechanical stage.

To standardize the microscope, place the stage micrometer on the stage of the microscope, and by selection of oculars or by

adjustment of the draw tube, or both, bring the diameter of the whole microscopic field to .205 mm. When so adjusted, each field of the microscope covers an area of approximately 1/3000 cm. (actually 1/3028 cm). This means that the dried milk solids from 1/300,000 part of a cc. of milk are visible in each field of the microscope. Therefore if the bacteria in one field only are counted, the number found should be multiplied by 300,000 to give the estimated number of bacteria per cc. In practice, however, more than a single field is examined so that the number used for multiplication is smaller than this.

As the microscopic examinations must be made with greater care where the bacteria are relatively few in number, it is required that, in grading low count milk, a special ocular micrometer with a circular ruling divided into quadrants shall be used. In using this micrometer, the microscope shall be so adjusted that the diameter of the circle on the eye piece micrometer shall be .146 mm. In this case the amount of dried milk solids examined in each field of the microscope is 1/600,000 part of a cc. of milk. The limitation of the examination of the slide to the central portion of each field, avoids using the margins of the field where definition is hazy, and lessens the danger of overlooking bacteria. Likewise the magnification used is greater than that used where the whole field is examined.

Counting and Grading Milk.

The number of fields of the microscope to be examined varies with the character of the milk, and with the character of the data desired. Experience has shown that where the purpose is primarily to detect and eliminate the worst milk from ordinary market milk supplies, it is entirely permissible to use the entire field of the microscope for examination. At least thirty representative fields of the microscope should be examined for each sample of milk. Where the average number of individual bacteria (not groups of bacteria) is less than one per field, it may be assumed that the milk will ordinarily give an official plate count of less than 60,000 per cc. Where the number is less than 100 in 30 fields (average of less than 3 1/3 bacteria per field) it may be assumed that the official plate count will be less than 200,000 per cc. Where less than 1000 per 30 fields (average of less than 33 1/3

per field) is may be assumed that the official plate count will not exceed one to two million per cc.

Where counts are made in order to enforce stringent standards, as at Grade A plants[15] or as a basis for premiums on milk giving an official plate count of less than 10,000 per cc., the special eyepiece micrometer described above shall be used and the microscope so adjusted that only the central portion of each field is examined for counting. Where less than 5 bacteria are found in 60 fields (average of less than 1/12 of a bacterium per field) it may be assumed that the milk would ordinarily give an official plate count of less than 10,000 per cc. The grading of milk of this type must be done with especial care as persons inexperienced with microscopic work have been found readily to confuse extraneous objects with bacteria, in milk containing very few organisms. Where the number is less than 30 per 60 field (average of less than ½ a bacterium per field), it may be assumed that the official plate count will be less than 60,000 per cc. Where the number is less than 100 per 60 fields (average of less than 1⅔ bacteria per field), it may be assumed that the official plate count will be less than 200,000 per cc. Where the number is less than 1,000 per 60 fields (average of less than 16⅔ bacteria per field), it may be assumed that the official plate count will be less than one to two million.

The standards given are computed (with the exception of the poorest grades) on the assumption that the official plate count will be normally **average** 1/5 of the total number of individual bacteria present. As many cases will be found which diverge markedly from the **average,** it is self evident that this average represents only an approximation to the real conditions in any specific case so that in some cases the microscopic grading will be more severe than that based on the plate counts, and vice versa. There is still a lack of sufficient data from which to judge fairly which system of grading is the more accurate. The indications are, however, that where the work is done with equal skill and care, and the allowances indicated are made, a reasonably close agreement in grade will be secured[16]. This fact is highly reassuring as to the general accuracy of both systems of grading.

In the routine grading of milk by the microscopic method it is not expected that exact counts will be made. A high grade

milk will show field after field of the microscope in which no bacteria are seen, while a poor grade of milk will show numerous bacteria in every field examined. It is only where the number of bacteria present is close to the border line between grades that counts need to be made. The examination, however, must be sufficiently thorough to make sure of the grade as specified above.

In order to ensure careful work in grading, it is required that laboratories conforming to standard procedure shall preserve microscopic preparations until a reasonable period has elapsed after the reports are rendered to the person or persons whose milk has been examined. It is an excellent custom occasionally to have the grading done by one analyst repeated by a second analyst, particularly in those cases where punitive actions are to be based on the reports made.

Common Sources of Error in Count.

Routine microscopic counts, like all bacterial counts, are to be regarded as estimates of numbers only. They cannot be made with absolute accuracy even with the most careful technique. Errors will arise from inaccuracies in measurement of the minute quantities of milk examined at any one time, from faulty staining or preparation of slides, from mistakes in observation and the like. These limitations, while important, are not difficult to overcome in sufficient measure to make microscopic grading a satisfactory method of controlling the quality of unpasteurized milk. As it is only in this way that counts of the bacteria themselves can be made, it must be recognized that accurately carried out microscopic counts of individual bacteria give the truest picture of the actual conditions of raw milk that can be obtained with any technique.

Where there is reason to fear the presence of large numbers of dead organisms, as for example in pasteurized milk, it is improper to place reliance upon microscopic counts. Valuable information may, however, sometimes be obtained by making both plate and microscopic counts from samples of pasteurized milk.

Reports.

As only a few ordinances[17] have yet been adopted in which both official and microscopic count standards have been given,

the form of report used will need to be adapted to the circumstances under which each laboratory is working. Specific counts should not be given under normal circumstances, and care should be taken to avoid making finer distinctions in grade than are justified by the accuracy of the grading. A series of samples should be examined in all cases before rendering judgment as as to the quality of any milk supply.

VERIFICATION AND RESEARCH METHODS.

Because of the fact that the Committee on Technique of the Society of American Bacteriologists has undertaken the study of methods of making bacterial counts for research purposes, it is not necessary to discuss further the use of standard methods as research methods. The standard methods are designed for use in routine analytical work and should also be used in those cases where investigations involving routine milk control are under consideration. They may also be suitable for use in other cases, but ordinarily will not be found to give the grade of accuracy expected in research work.

There is in all routine laboratories a very important use for methods giving more accurate data than can be obtained from the use of the routine count. These may be termed verification methods; and they should be used in all cases where administrative actions are taken which depend upon the analytical results[18].

The simplest form of verification for official plate count in the case of raw milk is to make a count from the same sample of milk by direct microscopic examination, and vice versa. If the counts found from the second examination are such that they are readily understandable under the known conditions, a very large part of the uncertainty existing in regard to the first count is eliminated at once. Under other conditions it may be found advantageous to verify the routine plate counts by making plate counts in which additional dilutions, or plates are used. Likewise more careful microscopic counts may be obtained either by examining duplicate preparations from the same sample of milk, or by making a more careful examination of the original preparation than that made for routine purposes.

If procedures of this sort were more common in bacteriological laboratories, control officials would have much firmer ground upon which to defend their actions in court if necessary.

DETECTION OF SPECIFIC PATHOGENS IN MILK.

There is no part of the field of sanitary analysis of milk where routine laboratory methods have so failed to meet the need of the control official as at this point. Some notable attempts have been made to secure the elimination of the bacillus of bovine tuberculosis from market milk supplies through routine laboratory examinations of milk samples; but none have been found to be sufficiently practical to have been widely followed. Other pathogenic organisms, such as those of typhoid fever, are rarely sought for in milk, though methods for detecting this organism have been suggested.[19] In all of these cases, it has become necessary to rely on elimination of the pathogens in market milk supplies through pasteurization, or by veterinary inspection of the herds, and medical supervision of dairy employees.

Several of our important control laboratories are, however, using a laboratory method for the elimination of long chain streptococci derived from inflamed udders. Certain precautions must, however, be used in this case as false interpretations of findings are easily possible. The long chain streptococci are readily found by microscopic examination of dried films of milk or sediments from centrifuged samples of milk. Perhaps the two most frequently used routine methods are the Breed method already described, and the Stewart-Slack method described in detail in the first edition issued by the American Public Health Association.

The use of these methods for this purpose has shown that even the presence of large numbers of long chain streptococci may be of little significance where there has been opportunity for their growth after the milk has been drawn. Streptococci of the long chain type occur frequently in apparently normal udders, and may even occur in very large numbers where there is no clinical evidence of inflammation.[20] Nevertheless, where samples of milk can be taken from individual cans as delivered within 6 hours after milking, it has been found that it is almost invariably possible to find a cow suffering from an inflamed udder if the count of individual cocci in long chains is in excess of 1,000,000 per cc. Such milk usually contains leucocytes in excess of 1,000,000 per cc.; but this relationship is not an invariable one. Because of the presence of alkaline substances from blood serum,

milk from cows with inflamed udders usually has a pH value greater than 6.8 and may also contain detectable mucin fibers.[21]

Where milk is centrifuged and the sediment examined, even greater caution should be used in drawing conclusions, as the concentration of material may cause insignificant numbers of these organisms to be regarded as significant. In this connection it should be remembered that many entirely satisfactory butter starters are composed of streptococci which occur in fairly long chains. These supposedly saphrophytic streptococci cannot be distinguished from the udder streptococci through microscopic examination alone.

Under these conditions, the laboratory findings should in every case be confirmed by clinical examination of suspected herds before action is taken.

COMMERCIAL APPLICATIONS OF BACTERIA TO DAIRY PRODUCTS.

Preliminary.

As already pointed out several types of bacteria find a most useful application in several branches of the dairy industry. The products in which they play a useful role are of great commercial and economic importance, and include butter, cheese and cultured buttermilk as the best representatives in the list. The product carrying the bacteria is known as the culture or the starter. In this chapter the term culture will be used.

STRAIN OF BACTERIA RECOMMENDED.

In the experiments reported in this chapter, the bacteria used was a strain of Streptococcus Lacticus Kruse described upon page 491. This is illustrated under Fig. 118. The culture has been propagated continuously for about four and one half years under ideal conditions so that as a result of this intensive breeding, all undesirable properties had been bred out, and the culture was one of unusual virility which yielded in practice products of most desirable flavor and keeping qualities. Under similar conditions, the same favorable results can be duplicated in any dairy plant.

TEMPERATURE TO USE IN RIPENING.

It is practically universally agreed that the best temperature for the propagation of Streptococcus Lacticus of the strain used

in cultures employed in the dairy industry is 20° C. (68° F.) The control of temperature during the propagation period is of vast influence upon the resulting culture.

Cultures of the Bulgaricus type have an optimum temperature of growth of 37° C (98.6° F.). The use of this type is greatly upon the decline, and is but little used in commercial work.

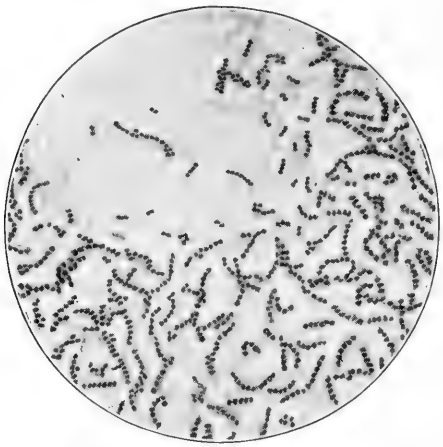


Fig. 118. Streptococcus Lacticus. Photomicrograph from Research Laboratories, Telling-Belle Vernon Co. Magnified 950 Diameters. Isolated from Cultured Buttermilk.

FACTORS RELATING TO THE GROWTH OF CULTURES IN DAIRY PRODUCTS.

Several investigators have shown that the rate of growth of the organisms in a culture varies during different periods or phases of its life. By its life is meant a condition of environment in which the culture is permitted to grow without any unfavorable interference.

Buchanan[22] divides the life cycle of a culture into given phases, each phase having a different rate of growth per organism than the phase next preceding it as follows:

(1). The initial stationary phase. During this phase the bacteria remain constant or nearly so.

(2). The lag or positive growth acceleration phase. During this phase the average rate of growth per organism increases with the time.

(3). The logarithmic growth phase. The rate of growth per organism in this period is constant. The organisms are dividing regularily, and the number of organisms are increasing in a geometric ratio.

(4). The phase of negative growth acceleration. The average rate of growth per organism decreases during this period.

(5). The maximum stationary phase. There is little or no increase or decrease in the number of organisms during this period.

(6). The phase of accelerated death. The number of bacteria decreases slowly at first, but the rate of death per organism gradually increases until it reaches a maximum.

(7.) The logarithmic death phase. During this phase, the rate of death per organism is constant.

Barber[23] observed that the age of the culture influenced the lag phase. He found that if a sub-culture was made in the same medium during the logarithmic period, this sub-culture does not go through a lag period, but continues to grow, at the same rate per organism as the parent culture. If the sub-culture is made after the logarithmic period there is a distinct lag period. These observations were confirmed by Penfold and by Chesney.[24]

RELATION OF ACID, DEVELOPMENT AND TIME OF RIPENING.

Frohring[25] conducted a series of careful experiments with a strain of Bacillus Streptococcus Lacticus using the development of the lactic acid in the culture as the criterion of the growth of the organisms. This method was selected because of the considerable errors that may result when counting bacteria by the plate method. Another important reason for this choice was the desirability of obtaining exact data regarding the relation between time and acidity in culture growth.

Frohring points out that this method of study gives a fairly good conception of the first four growth phases mentioned above, but that it is valueless in determining the last three.

The results obtained by Frohring are given in Fig. 119.

As the results in Fig. 119 indicate, the acid development is not in direct proportion to the time, as is commonly believed to be the case by many accustomed to using cultures. The results

are typical of the acid development curve produced by a fresh vigorous culture which is being propagated daily under optimum conditions which are under exact control. 15 cc. of this culture was added to 750 cc. of the media.

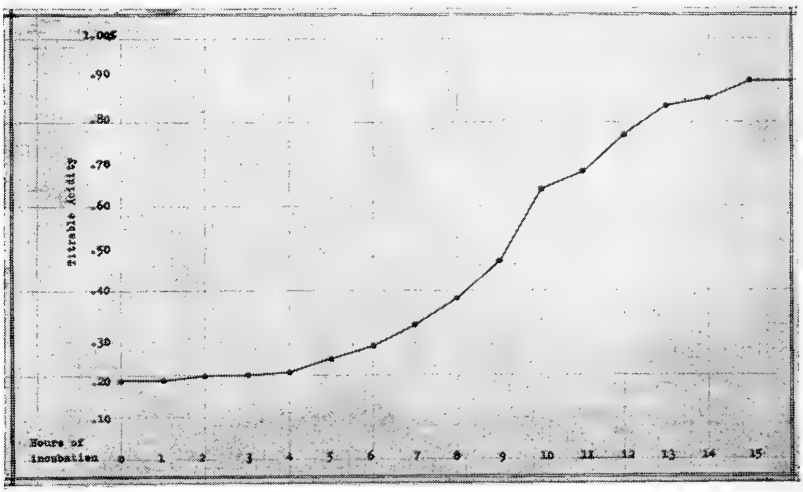


Fig. 119. The Relation Between Time of Incubation and Acid Development in the Growth of Culture.

As shown in the graph, there is scarcely any increase in acidity during the first four hours. From the fourth to the tenth hour, the increase is a gradual one. In this particular experiment coagulation started at the tenth hour, with a total acidity of .64 per cent and from that point the growth was very much retarded, but it continued to increase until the ripening had continued for seventeen and a half hours, at which point it became constant with a total acid content of 1.00 per cent, being still of this acidity at the end of 74 hours.

INFLUENCE OF QUANTITY OF CULTURE ADDED TO MEDIA.

In another series of experiments Frohring studied the influence of the addition of varying quantities of culture to a given media. The cultures were fresh, vigorous ones, similar to those employed in the previous experiment, and these were added to a

good quality of pasteurized skim-milk. The results obtained are given in Table 93.

TABLE 93.

Influence of Quantity of Culture Added to Media. Acidity Given Is That Developed in Addition to Initial Acidity, and Acid Added in Starter.

Experiment No.	Quantity of culture added to 750 c. c. of media	Per cent of lactic acid in media at end of 15 hours.	Experiment No.	Quantity of culture added to 750 c. c. of media.	Per cent of lactic acid in media at end of 1 hours.
1	5 c. c.	.88	2	5 c. c.	.94
1	10 c. c.	.89	2	10 c. c.	.90
1	20 c. c.	.91	2	20 c. c.	.94
1	30 c. c.	.92	2	30 c. c.	.99
1	40 c. c.	.93	2	40 c. c.	.97

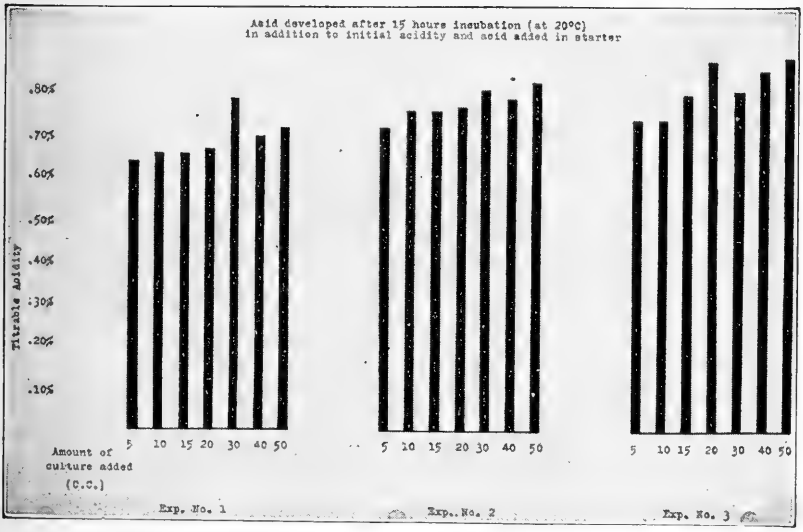


Fig. 120. Influence of Quantity of Culture Used Upon Acid Development in Media.

The results of another series of experiments by Frohring are given in the graph under Fig. 120.

The results of the preceding experiments by Frohring indicate that the amount of culture added is not so important as the growing condition of the organisms that are introduced, and their ability to divide, and go through the logarithmic stage of growth after a few hours of incubation. The determining factor in judging the value of a culture is not the total number of organisms contained, but rather the number of organisms capable of properly reproducing themselves. He has applied this knowledge in practice with marked success.

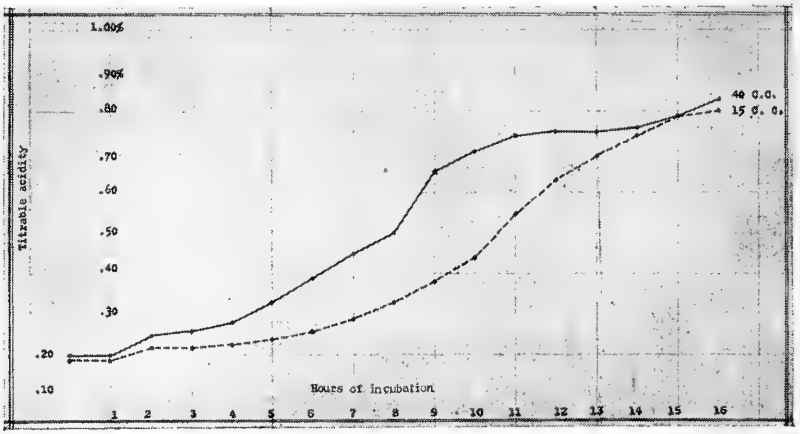


Fig. 121. Increase in Titratable Acidity Using 15 c.c. and 40 c.c. of Culture to 750 c.c. of Media.

In the above figure it is shown that the same results are obtained at the end of the ripening period when only 15 cc. (About 2.0 per cent), or when 40 cc. (about 5.0 per cent) of culture are added to the media.

In the manufacture of cultured buttermilk, cottage cheese, cheddar cheese, soft cheeses, margarine and butter made from ripened cream, or where the culture is worked directly into the butter, it is universally conceded that the quality and uniformity from day to day of the culture is of the greatest importance to the manufacturer who is endeavoring to maintain a uniform product.

A careful study of culture propagation reveals a great many factors which, when properly controlled, will insure the successful

propagation of a uniform culture free from contamination. Under ordinary factory conditions, painstaking care may eliminate some of the variables. There still remains, however, many variables over which the operator has no control. This means a constant risk, or hazard of meeting unfavorable conditions, and as a consequence, frequent off flavored or inferior products.

TIME OF RIPENING.

Frohring has proved that if too much time is taken for the ripening period, undesirable types of bacteria may gain the ascendency before the logarithmic stage of growth is reached, and as a result bad favors may appear in the finished product. This condition may exist if too small an amount of culture is added to the media.

Upon the other hand, if the ripening time is too short, due to the addition of an excessive amount of culture, the results are also not satisfactory.

In general, it can be stated that the least amount of culture should be added to produce a satisfactory product. No more acid should be added mechanically than necessary. The most practical ripening time is 14 hours.

EFFECT OF HOLDING CULTURE AT VARIOUS TEMPERATURES.

In handling cultures it is important to know the influence of the holding temperature upon the growing qualities of the culture. This is the determining factor in establishing the frequency of repropagation. This was carefully studied by Frohring, under four different temperature conditions. In one experiment the mother culture was frozen; in a second experiment it was kept in ice water; in a third experiment it was kept at 45° F., and in a fourth experiment at 68° F. Inoculations from each of the above mother cultures were made in pasteurized skim-milk media upon successive days as indicated. In each test 15 cc. of the four respective cultures were inoculated into 750 cc. of skim-milk, and these sub-culture were incubated for 15½ hours at 68° F. The titratable acidity was determined at the end of each incuba-

tion period, and this was used as the criterion of the growing qualities of the respective cultures.

The results in the following chart show plainly how the growing qualities of a culture are influenced by the temperature at which it is kept following the end of the incubation period. The culture that was frozen lost little of its reproductive powers up to eight days. After that it deteriorated rapidly, and at the end of eleven days it had practically lost its ability to grow. The following table gives the main conclusions that can be derived from this experiment.

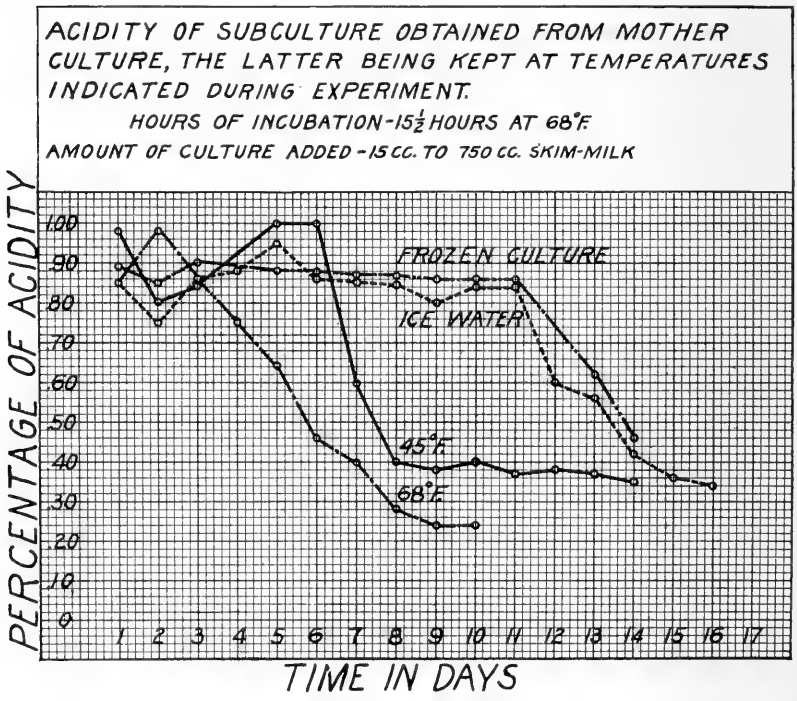


Fig. 122. Influence of Holding Temperatures of Cultures Upon the Growing Qualities of the Same.

TABLE 94.

Summary of Experiment to Determine Influence of Holding Temperature Upon the Growing Qualities of Cultures.

Temperature at which cultures were held.	Number of days held at temperatures indicated before growing qualities began to deteriorate.	Number of days held at temperatures indicated when cultures had practically lost their ability to grow.	Number of days during which cultures can be kept at temperatures indicated before requiring repropagation of culture.
Frozen	8	12	5
Ice water, 32° F..	11	15	7
45° F..	7	8	2
68 F°..	2	7	1

The results given in the above described experiment show plainly the great influence of holding temperature upon the growing qualities of cultures. The best results are obtained where the cultures are kept in ice water. In practice even when the cultures are kept in ice water, a limit of one week should not be exceeded, before repropagating the culture. When held between 32 and 45° F. the limit should not exceed two days. At temperatures above 45° F. the deterioration of the culture is so rapid, as to render such temperatures impractical for holding purposes.

APPARATUS DESIGNED TO PROPAGATE PURE CULTURES.

To W. O. Frohring, Director of Laboratories of the Telling-Belle Vernon Co., belongs the credit for the origin and development of the Mojonnier Culture Controller. The principles underlying the construction and operation of this apparatus were established by him in a large plant devoted to the manufacture of numerous dairy products requiring the use of pure cultures, the principal being commercial buttermilk, cottage cheese and butter.

The Mojonnier Culture Controller illustrated under Fig. 123 places the propagation of pure cultures upon a scientific basis. It is a highly specialized apparatus by means of which all variables are eliminated. It makes the propagation of the culture a

definite and a simple operation. It eliminates the necessity of obtaining cultures from outside sources. Its great advantage is the fact that it insures a uniform culture from day to day. This in turn is reflected in the uniformity of the finished product, since a good culture is the starting point of a good finished product.

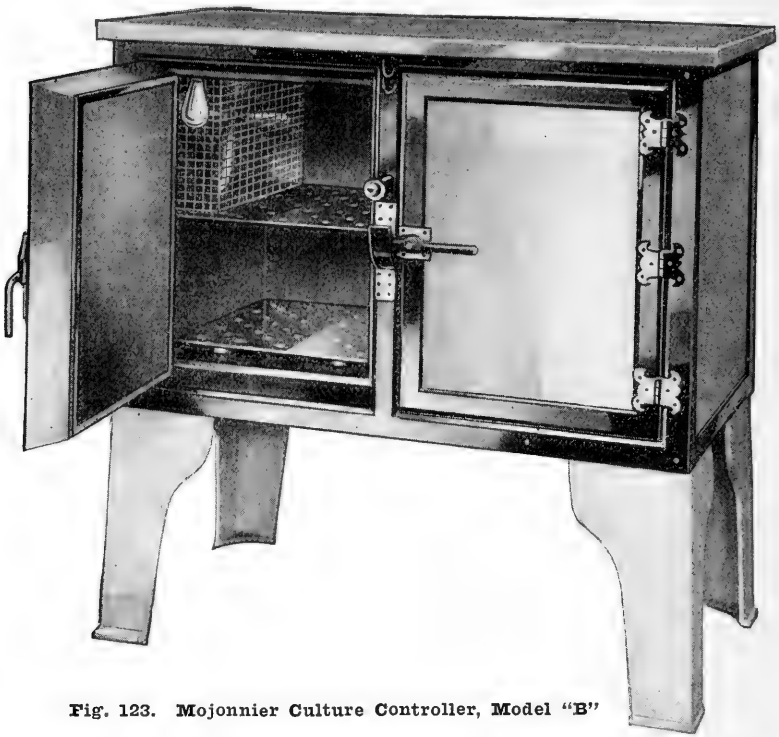


Fig. 123. Mojonnier Culture Controller, Model "B"

DESCRIPTION OF MOJONNIER CULTURE CONTROLLER.

It consists of two chambers. The chamber to the right is intended to hold a sufficient supply of ice to maintain a temperature of 68° F. in the other chamber, over a considerable period of time. Or it is also furnished so that it can be used interchangeably for ice, or for circulating brine through the lead coils placed in the chamber. Either method works out satisfactorily in practice, and the choice is governed by the conditions prevail-

ing at the plant where the apparatus is to be used. The ice chamber also frequently serves as a refrigerator for holding the cultures after the same have been incubated.

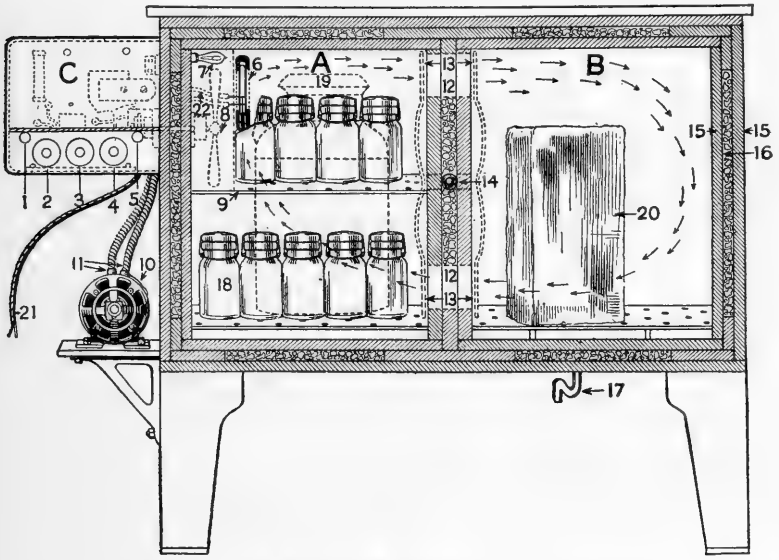


Fig. 124. Cross Section, Mojonnier Culture Controller.

A—Incubator Chamber. B—Refrigerator Chamber. C—Relay and Fan Motor Housing.

With electro-thermostatic control showing cross section of the two compartments. The arrows indicate complete circulation of air in the chambers. The relay cabinet on side insures positive and continuous control of temperatures in the incubation chambers.

The chamber to the left is the incubating chamber. It can be used for the propagation of both Bacillus Lacticus which is incubated at 68° F., and of Bacillus Bulgaricus which is incubated at 98.6° F. When desired to change from one culture to the other, all that is necessary is to change the thermostat inside the chamber using the one that gives the proper temperature control. The incubating chamber is provided with a fan operated by means of a motor, thus insuring uniform temperature in all parts of the chamber. It is fitted with heating elements of the proper design. Ports fitted with shutters connecting with the ice chamber makes possible the necessary air circulation. The temperature control is based upon the use of a mercury thermo-

stat operating with special design of relay. Only 1/100 of an ampere passes through the thermostat thus eliminating all oxidation at points of contact. The operation is entirely automatic.

The ice chamber has a capacity of about 400 pounds of ice. The incubating chamber has a capacity of 54 quarts or bottles or 12½ gallons of milk, in one model, and 17 quarts or 4¼ gallons in another model.

STERILIZER USED IN CONNECTION WITH THE MOJONNIER CULTURE CONTROLLER.

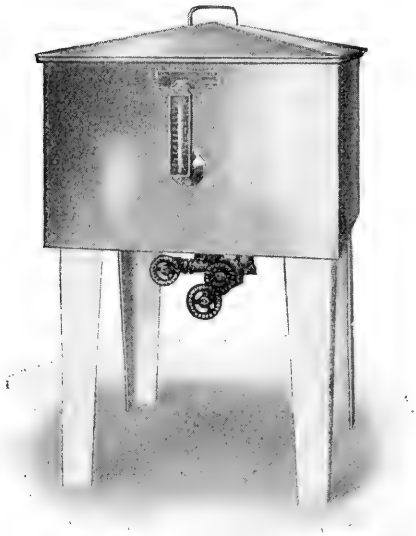


Fig. 125. Sterilizer Recommended to Be Used in Connection with the Mojonnier Culture Controller.

The sterilizer that was especially designed for use in connection with the Mojonnier Culture Controller is illustrated under Fig. 125. The quart culture jars can be both heated and cooled to the proper temperatures in it, and the entire design and arrangement is such as to facilitate this important operation.

How to propagate cultures using the Mojonnier Culture Controller.

The successive steps in the propagation of pure cultures need to be well understood, and the details of each step closely followed from day to day no matter how trivial the same may seem, otherwise satisfactory results cannot be obtained.

The kind of media to use.

Although the pure culture organisms will grow in a variety of different mediums, such as nutrient broth, gelatin, etc., the preponderance of evidence is in favor of the use of skim-milk of first class quality. Whole milk is the next best, but should not

be used if skim-milk is obtainable. If whole milk is to be used, remove as much cream as possible by the gravity method. Skim-milk produced by centrifugal or gravity methods,—the former method of course, being preferable. It is needless to say that this should be as fresh as possible, and of the best quality obtainable. It is desirable that as little change as possible should have taken place in the milk, not on account of any danger from the organisms present, as the media is subsequently pasteurized, but on account of undesirable by-products that may be present where change has occurred as a result of chemical action wrought by bacteria differing from pure culture varieties. It is possible to have such chemical changes take place in milk which may later tend to have an inhibiting effect upon the growth of the Bacillus Lacticus organisms. The use of skim-milk of good quality, promptly sterilized, will eliminate the above factor.

STERILIZATION AND PREPARATION OF MEDIA.

Probably the most common method of sterilization in laboratories is by means of steam pressure of 15 to 20 pounds for fifteen minutes to one half hour, in an autoclave. This method is a quick and positive means of sterilization, however, it has a decided disadvantage as a method of sterilizing milk used in propagating cultures. It is practically impossible to sterilize under pressure without causing an appreciable change in the milk. The most important change is probably in the milk sugar, which is caramelized more or less by the high temperature used during sterilization. In the metabolism of the bacteria during the process of growth, some of the milk sugar is changed to lactic acid. It would seem reasonable to conclude that any decided change in the milk sugar would be undesirable. This proves in actual practice to be the case, and can be easily demonstrated. At the same time a change takes place in the casein. This is not definitely understood at present, but all the evidence is in favor of the view that certain chemical changes take place in the casein molecule. While this is probably not so important from the standpoint of food material of the bacteria, yet it is very undesirable as it makes it next to impossible to judge accurately the degree of ripening by the extent to which the milk is curdled. Two possible explanations of the chemical

changes in casein due to heating are advanced. One theory is that part of the calcium is split off from the casein molecule. Another theory is that the casein is partly dehydrated. The more change that has taken place in the casein the less it will be curdled, by the same amount of acid. A culture may thus be over ripe, and at the same time not set in a good firm curd. Due to these physical changes, the end point in ripening may be easily misjudged. Overheating of the milk probably causes changes in the mineral salts, and it exerts an unfavorable effect upon water soluble C vitamine, all of which may have some possible bearing upon culture development.

By means of intermittent sterilization, the milk is heated to a temperature above 212° F. Heating for one hour at 212° F. will destroy almost all organisms, except the spore formers. By allowing the milk to incubate between the heatings, the spores are given a chance to vegetate, and by the end of the heating on the third day they are nearly all destroyed, being caught while in the vegetative or non-resistant state. This method of sterilization has not the disadvantage of the one previously mentioned, and the heat may be applied uniformly. However, it has the disadvantage in time, and is not very practical for this purpose. Where the milk used as media is of first class quality, it will be found that heating to 170° F. for one and one half hours in the sterilizer described under Fig. 125, will be sufficient to insure good results. At the end of the heating period, cold water is to be turned into the sterilizer to displace the hot water, and the milk in the jars cooled as promptly as possible to about 68° F. It must be remembered that this cannot be called sterilization but rather high temperature pasteurization, and the results may not be an absolutely sterile media. However, where the milk is of first class quality the organisms left will be insignificant numerically, and of a type that will cause no trouble in the culture if it is inoculated the same day.

CULTURE JARS USED—HOW TREATED.

Several types of culture jars can be successfully used. In some cases pint size or quart size milk bottles, sealed with a paper cap, are very successfully employed. Experience has proved that culture jars such as illustrated under Fig. 126 are

the most satisfactory to use. Both the jars and the covers can be successfully sterilized by inverting the same in the sterilizer described in this chapter (See Fig. 125) and heating with flowing steam.

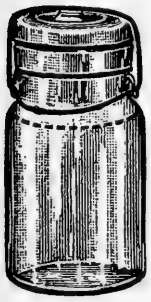


Fig. 126. Type of Jars for Culture Propagation.

To seal the jars, parchment paper is placed between the lid and the jar. This paper can itself be sterilized by dipping it in hot paraffine, grain alcohol, or sodium hypochlorite.

FILLING THE JARS WITH SKIM-MILK.

After the jars illustrated under Fig 126 are thoroughly cleansed and sterilized they are weighed upon a balance, and for the quart size, 750 grams of the sterilized skim-milk are added to each jar from the metal percolator suspended above the balance. This is done with all the jars. Pint size jars are used where only a few cultures are made daily, and they may also be used for the culture held over to propagate the next day's culture. Measuring may be done by volume if more convenient. The essential thing is to use a definite amount every day. Half gallon glass jars can frequently be used to good advantage.

SEALING THE JARS.

The method of sealing must accomplish the following results:

(1). It must eliminate the possibility of bacteria getting into the milk after it is sterilized.

(2). At the same time, it should not be so the air cannot expand without breaking the bottle while sterilizing, or form a vacuum when cooled.

(3). It must protect a sterilized lip surface over which the culture is poured when emptying.

(4). It must protect the lip surface while handling.

(5). It must be air and water tight after inoculating.

(6). It must protect against molds.

All these things are accomplished by using the glass jars illustrated above. The method of sealing is as follows:

The jars with the covers must be first thoroughly cleaned and sterilized in an inverted position in the sterilizer using just enough steam pressure to insure circulation, and kept in this position until ready for use. After the proper amount of milk is weighed or measured into the jars, two circles of parchment paper previously sterilized, are placed over the jar opening, and the cover then placed in position and loosely clamped in place.

STERILIZING OR HIGHLY PASTEURIZING THE MILK.

Without further delay the jars of milk are placed in the sterilizer, and heated for one to one and a half hours at 170° F. using preferably, flowing steam. This has the advantage of heating the jars rapidly, and of reaching with the heat, all parts of the joint between the lid and the jar. However, it is usually equally satisfactory to use hot water of the temperature indicated, instead of flowing steam. At the end of the heating period the cold water valve is opened, and the jars with their contents are rapidly cooled to 68° F. without removing from the sterilizer. The media in the jars is now ready to inoculate. The inoculation should be done promptly, and before the media has undegone a change in temperature. The method to use in inoculating the media immediately follows.

PREPARATION OF CULTURE PIPETTES.

These pipettes are especially designed with bulb for holding cotton, and they are of 10 cc. capacity graduated to 1 cc. all being as illustrated under Fig. 127. The top, which is placed in the mouth, should be plugged (not too tightly) with the non-absorbent cotton. This cotton is for the purpose of preventing the possibility of contamination of the culture from the mouth, or saliva getting into the pipette. After the pipettes are thoroughly cleaned and the cotton plug is inserted near the upper end, they are wrapped in ordinary cheap wrapping paper, using just enough to cover them, and fastened by twisting the end. While thus wrapped, they should be sterilized either under steam pressure of 15 pounds for 15 minutes, or they may be steamed in the sterilizer under low pressure using streaming steam. They are kept wrapped after sterilizing and until ready to use.

HOW TO DETERMINE THE PROPER AMOUNT OF CULTURE TO ADD FOR A GIVEN LENGTH OF TIME OF INCUBATION.

When starting out to use the Mojonnier Culture Controller, it is necessary to determine the amount of culture to be added in order to have the new culture ripened to the proper degree in a given length of time. This time should not be over 15 hours nor less than 8 hours. Prepare six quart jars containing 750 grams each of sterilized milk. After sterilizing, cooling and adjusting the temperature at 68° F., hold them at that temperature in the incubator until the regular time for propagating the cultures. This should not exceed one hour. At that time, to No. 1, add 3.75 grams of culture from the pipette; to No. 2, 10 grams; to No. 3, 15 grams; to No. 4, 20 grams; to No. 5, 25 grams, and to No. 6, 30 grams. The bottles are then resealed. They are **shaken up thoroughly,** and placed in the incubator, and left until the time convenient to take them out every day. At this time they should be removed from the incubator,—carefully, so as not to break the curd, and examined. The proper amount of culture to use every day is the quantity placed in the bottle in which the milk is curdled with a rather firm, jelly-like consistency without showing traces of whey on the top. This proportion should then be used and continued, unless the culture increases in strength, in which case the amount is reduced in proportion.

Fig. 127. Pipette for Measuring Cultures Into Media.

In this connection, it must be remembered, that, although the amount of culture may be changed to take care of the ripening in the desired length of time, the temperature at which the culture is incubated must never be changed. This, of course, means the cultures of the same type, for the Bulgaricus type requires a higher temperature as will be explained later. Ordinarily this will be sufficient range to find the proper amount for ordinary cultures where the incubating time is about 14 hours.

A culture of ordinary strength should require the addition of about 15 grams to 750 grams of sterile milk in order to coagulate

or ripen the new culture properly in 14 hours. If less than these amounts are found to be sufficient it will indicate that the culture is possibly a little stronger, or more active than ordinarily. Of course, if it is necessary to add more than this amount, it will indicate that the culture is not as vigorous as the average. After the right proportion has been established, the same time and amounts should be used regularly. In this way, an increase or decrease in the activity of the culture can be quickly noted. It has been found that wherever practical the 12-14 hour incubation using 15 grams of culture to 750 grams of milk gives the most satisfactory control.

If the culture is of a good type, it will gradually tend to increase in strength or activity, and a decrease would indicate that it is either an undesirable strain of Bacillus Lacticus, or there is some mistake being made in the method of handling. Frohring has proved that when cultures are given improper environment, they may have sufficient life and vigor to reach the curdling point of milk, but not sufficient to pass through the logarithmic phase of growth. Be sure to see that the ice container is filled with cracked ice each time, and that the thermometer in the incubator shows that the temperature control is working properly. From the relation established by the trial propagation described above, it is also possible to arrive at the proper amount of starter to add to the big starter can, or to the finished product to be ripened. Since the temperature in these subsequent operations is generally not under as exact control as in the culture controller, a slight difference in the relation may be noted. However, this may easily be determined by observation of the first ripening.

FINAL SEALING OF CULTURE JARS.

After the proper amounts of culture has been added to the jars of milk to be incubated, the parchment paper and the glass top are replaced upon the jars, care being taken that the milk in the jar does not become contaminated. The jars are then tightly sealed, and the tops of the same properly dated.

INCUBATION.

After the final sealing, it is very important that each jar be **well shaken** to mix the culture with media. The jars are then

placed in the incubator which is kept in operation at 68° F. The ice container should be filled with block ice; the door on the refrigerating chamber closed tightly; the shutter between it and the incubating chamber should be opened to the proper degree, and the fan in the incubating chamber set in operation. The jars should not be disturbed, or the incubator door opened until the time of incubation has passed, which is usually 12 to 14 hours.

COOLING.

After removing the jars containing the culture from the incubator,—being careful not to break the curd, they should be quickly cooled by placing in the sterilizer to which has been added water containing a generous amount of ice. They must be kept in ice water but not frozen, until ready for use. A culture may be all right to use after being in ice water for as long as one week, and sometimes even longer, but the best results are obtained when the cultures are used within 48 hours of ripening. The cultures to be used in re-propagating should be given special attention, and as a rule should be reinoculated at least every other day. They should be stored in ice water.

When the desired length of time has intervened for incubation, the milk should be found coagulated to about the consistency of jelly, without the presence of any whey. The whey indicates over ripeness which if continued will weaken the culture.

Overripening of the culture is undesirable since the culture is carried through the phase following the logarithmic phase, after which the culture may reach the phase of accelerated death in which the organisms die off very rapidly. The appearance occasionally of a small amount of whey on one or two cultures should not indicate that the ones having this whey are not all fit to use, however, if this continues, either the time of incubation should be shortened or the amount of culture added decreased, preferably the latter. The best way is to run another trial batch as described above, using the same time of incubation, and varying the amount of culture added to each of the trial jars. At no time should the culture show the presence of gas forming organisms which is indicated by the presence of bubbles or "pin heads" in the curd.

When ready to inoculate again, the cultures kept for this purpose are taken from the ice water carefully wiped dry with

a clean cloth, and the same precedure carried out with the exception of course, of the trial incubation. It is always a good plan to have one extra culture which may be left in the ice container in case of an accident to the growing culture such as the power being turned off, and the temperature going down too low for ripening.

The propagation of B. Bulgaricus is conducted the same as described above, excepting that the thermostat in the incubating chamber is changed from 68 to 98.6° F.

A BRIEF SUMMARY OF DIRECTIONS FOR OPERATING THE MOJONNIER CULTURE CONTROLLER.

(1). Jars to be thoroughly cleaned and steamed.

(2). Secure best fresh milk or skim-milk available, preferably the latter. Pour off or remove the cream so that approximately 750 grams of skim-milk are left in the jar. Weigh off exactly this amount in each jar.

(3). Place the jars containing the milk in the sterilizer, and heat to 190° F. for one hour, if short of time. Preferably heat to 170° F. for one hour and a half.

(4). Cool the skim-milk in the jars until it has a temperature of 68° F.

(5). Remove the cap and inoculate with the exact amount of culture found necessary by previous experiment.

(6). Replace the caps and seal the jars. Shake the jars thoroughly. This is very important. Jars cannot be shaken too much.

(7). Place the jars in the incubator.

(8). Turn on the fan and the thermostatic control; close doors tightly, and leave the jars undisturbed for 14 hours. Make sure that there is plenty of ice in the ice compartment.

(9). At the end of incubating period examine the jars, and see that a heavy culture is produced. It should not show the presence of any whey on the top, or any signs of gas.

(10). Place the jars in the ice chamber with plenty of cracked ice, or preferably keep it in ice water. Do not allow it to freeze. Culture is now ready to use.

(11). Always keep in reserve one jar to make succeeding inoculations of the mother culture.

THE APPLICATION OF PURE CULTURES TO THE MANUFACTURE OF BUTTERMILK.

In the manufacture of commercial buttermilk, there are various essentials that must be kept under careful control if the desired results are to be obtained. The success of the business will depend upon the ability to produce buttermilk with a good aroma, and a good flavor; one that is free from gas, and that will not separate, but that will remain smooth and creamy. Such a result can only be obtained by the application of scientific methods of control, in its manufacture.

The factors of the greatest importance are:

(1). The use of a culture of the desired bacteria. This can be obtained and maintained only if propagated under conditions insuring uniform temperature control.

(2.) A proper understanding of the process underlying the care, propagation and application of pure cultures as related to the production of buttermilk.

(3). The use of skim-milk of the proper quality, the same to be successively pasteurized, cooled, inoculated, propagated, cooled again, and finally bottled at a low temperature. Butter fat may, or may not be added depending upon the trade requirements.

QUANTITY OF CULTURE TO USE.

The method of determining the quantity of culture to use as outlined earlier in this chapter, and which method is used so successfully by Frohring, is especially recommended. The success of the method hinges upon the use of a strain of culture of unusual vigor due to having been propagated under ideal conditions over a large number of unbroken generations. The potential ripening possibilities of such a culture is much greater than in the case of ordinary Cultures produced under usual factory conditions. A culture propagated under these ideal conditions possesses the ability to reach and pass through the logarithmic stage of growth in minimum time.

Highly satisfactory results are obtained in practice by using two quarts of culture propagated as described above to every 100 gallons of skim-milk. The use of such a limited amount of culture effects several economies. Intermediate propagations between

the Culture Controller and the skim-milk to be inoculated can be entirely dispensed with. This makes it possible to propagate sufficient culture for relatively large amounts of buttermilk in the Culture Controllers only. No harm is likely to result if more than .50 per cent of culture is added, but the limit should be 2.00 per cent. When using .50 per cent of culture great care must be taken to thoroughly distribute the culture in all parts of the skim-milk.

WATER TO ADD TO THE SKIM-MILK.

A good quality of skim-milk must be used. It is seldom possible to make a satisfactory product if the skim-milk is derived entirely from skim-milk powder. Fat may or may not be added in the form of milk, or cream, depending upon the kind of butter milk that it is desired to make. A high quality of commercial skim-butter milk is obtained when 10 per cent of water is added to the skim-milk before pasteurizing. The product thus obtained is of the viscosity usually demanded.

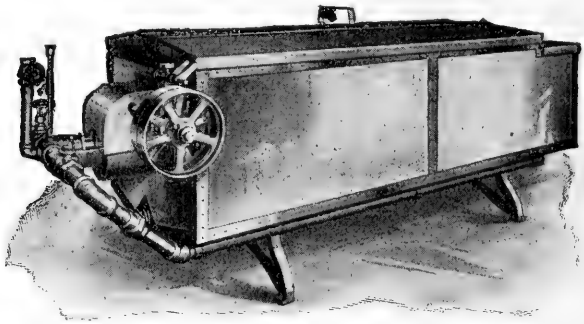


Fig. 128. Buttermilk Machine.
Courtesy Creamery Package Manufacturing Co.

HOW TO PASTEURIZE, INOCULATE AND INCUBATE THE SKIM-MILK.

The skim-milk obtained as above is heated in a suitable butter milk vat; either tinned copper or glass enameled, to 190° F., held at this temperature for one hour, and cooled promptly by means of both well water and ice water, or brine to about 70° F. Equally

satisfactory results are obtained if the skim-milk is heated to 170° F. for one hour and a half and then promptly cooled as described.

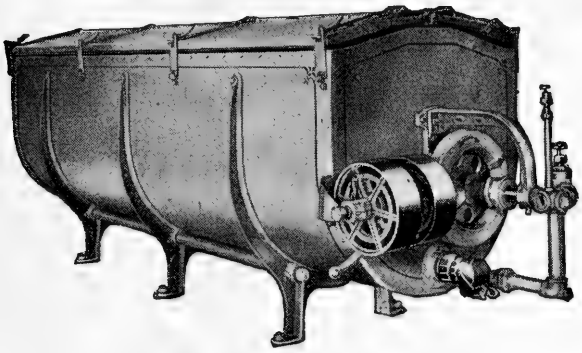


Fig. 129. Buttermilk Machine.
Courtesy J. G. Cherry Co.

At this point the culture is added at the rate of two quarts to every 100 gallons. This refers to the culture propagated in the Mojonnier Culture Controller by the use of methods described in this chapter. The use of so little culture could not be advocated if the culture is obtained from different sources. The mixture is now thoroughly agitated for half an hour, and the cooling is continued to 68° F. The agitation is now stopped, and the milk in the vat held at 68° F. without agitating it, for about 14 hours. In practice the best plan is to so prepare the skim-milk that the pure culture can be added to it at about 5 p. m. At 7 a. m. the batch is then completely incubated, provided the proper method was used throughout. If the milk is propagated below 68° F. a bitter flavor may develop, and if over 68° F. gassy fermentation may result. In summer the incubation should be started when the milk is a little under, and in winter a little over 68° F. This is of course, on account of the tendency of the milk to go to a temperature approaching room temperature. The critical point at the end of the ripening process is the point where whey begins to appear upon the top

of the milk. When the ripening is properly completed the curd will break clear and sharp when a spoon is inserted into the coagulated mass. The acidity at this point will be about .70 per cent.

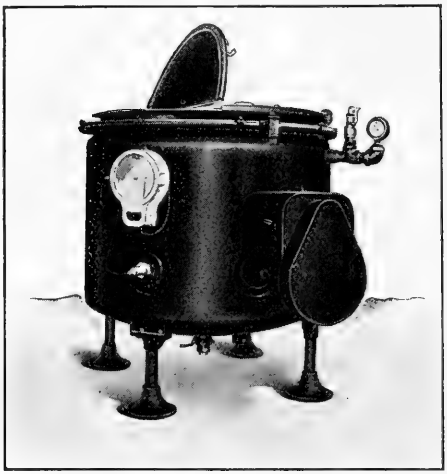


Fig. 130. Pfaudler Buttermilk Tank.
Courtesy The Pfaudler Co.

The agitation after ripening must not be too violent, nor carried on too long, as there is danger of a physical separation of the curd. The use of a centrifugal pump in handling the buttermilk should be avoided on account of its tendency to cause mechanical separation of the curd in the buttermilk.

After the inoculation and agitation are complete, the buttermilk should be cooled immediately to at least 50° F., preferably under 50° F., but not under 40° F., and kept cold until delivered to the consumer whether in bottles or in bulk. If the buttermilk is cooled under 40° F., there is danger of freezing, causing ice crystals and subsequent dehydration of the casein which changes the physical properties of the product.

All utensils must be kept clean and sterile and well tinned, otherwise bad flavors may be introduced into the product.

HOW BULGARICUS CULTURES ARE USED.

Bulgaricus cultures are added for the purpose of giving to the buttermilk a characteristic sharp flavor, and particularly for advertising purposes in order to call the product Bulgarian buttermilk. Equally good results are obtained without using any Bugaricus culture, and its use is largely upon the decline.

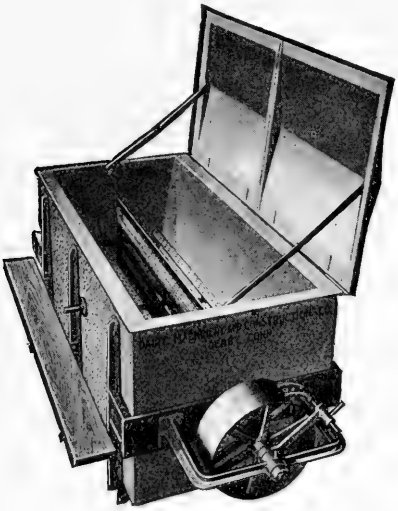


Fig. 131. Buttermilk Machine.
Courtesy Davis-Watkins Dairymen's Mfg. Co.

HOW TO PREVENT WHEYING-OFF, OR SEPARATION IN BUTTERMILK.

It sometimes happens that the coagulated constituents in buttermilk will settle slightly upon standing, either in bottles or in cans, after the incubation and the cooling of the product have been completed. This will cause the appearance of a small layer of whey upon the top of the container. Sometimes this defect is objectionable, but as a rule by simple agitation the product can all be remixed. Inasmuch as this defect has no effect upon the flavor, remixing restores the buttermilk to its original condition. This defect sometimes occurs in the opposite

direction than as indicated above,—namely the water appears upon the bottom instead of upon the top of the container. Buttermilk containing no fat, or but little fat generally wheys off upon the top. That containing much fat wheys off upon the bottom. The difference is due to the relative density of the curd, in the two cases. Buttermilk in which the curd contains the proper amount of fat to balance the specific gravity of the milk serum obviously will not whey-off so readily. This relation at the present time is not well established.

The exact cause of wheying-off is not clearly understood at this time. The two most important factors causing this defect are over-ripening and insufficient cooling after incubating. Other important factors are the use of too much starter, the use of skim-milk of inferior quality, the use of skim-milk containing too much fat, and too high holding temperatures.

This emphasizes the importance of proper incubation as already described, and of prompt cooling at the close of the incubation period to at least 50° F., and keeping the buttermilk at this low temperature until used. Likewise only skim-milk with a low fat content, of good flavor, and of good quality should be used.

THE APPLICATION OF PURE CULTURES IN THE MANUFACTURE OF ICE CREAM.

A new use for pure cultures that promises well, is in the manufacture of ice cream. Such a culture, imparts to ice cream a sharp, pleasing flavor; it gives increased viscosity to the mix, and it inhibits the growth of certain bacteria that cause bad flavors. This is a comparatively new application for pure cultures, and much remains to be learned upon this subject.

THE APPLICATION OF PURE CULTURES IN THE MANUFACTURE OF COTTAGE CHEESE.

The manufacture of cottage cheese is in many respects similar to the manufacture of buttermilk. The pure culture is added, in the same amounts as when manufacturing buttermilk; the propagation is continued at 68° F. for about 14 hours, or until the titratable acidity amounts to about .8 per cent. The coagulated milk is now gently heated to about 95° F., taking thirty to forty minutes, and the liberated whey is drained off. The

process of manufacture is then continued as usual, and is subject to several modifications that influence the composition, and also the physical properties of the product.

The yield of cottage cheese ranges from 15 to 22 pounds per 100 pounds of skim-milk depending upon the composition of the skim-milk used, and the methods of manufacture employed. The total solids vary between quite wide limits, ranging from 20 per cent to 30 per cent. By using more scientific methods of control a product more uniform in composition can be manufactured. The reader is especially referred to the works of Hall, Van Slyke and Hart[26], and Stocking[27], for more detailed information upon this subject.

THE APPLICATION OF PURE CULTURES IN THE MANUFACTURE OF BAKERS' CHEESE AND POT CHEESE.

These are soft cheeses and the same are fully described by Stocking.[27]

In the case of bakers' cheese, Stocking recommends the use of from 1 to 3 pounds of culture for every 1000 pounds of milk. Likewise the addition of from ⅓ to ½ ounce of rennet dissolved in water in the proportion of one part of rennet to forty parts of water. The incubating period is from twelve to fifteen hours, at a temperature of 75° F. The titratable acidity is then about .45 to .50 per cent. The curd is separated without heating.

In the case of pot cheese, Stocking recommends the use of from .50 to 5.00 per cent of culture. The skim-milk from the separators is cooled to about 80° F. before adding the culture. The separation of the curd is hastened by heating slightly, before removing the whey.

The curd from either bakers' cheese or pot cheese can be used to make cottage cheese.

THE APPLICATION OF PURE CULTURES IN THE MANUFACTURE OF CHEDDAR CHEESE.

The principle underlying the manufacture of all kinds of cheese is based upon condensing certain of the milk solids by separating the same from the water and certain other solids contained in the milk.

If properly used pure cultures may be of very great value in the manufacturing of either American Cheddar Cheese or of

many other types of cheese. The pure culture inhibits the growth of undesirable bacteria and hastens the proper ripening of the sweet milk. Only the best and purest culture should be used. The presence of undesirable bacteria may later cause serious defects in the cheese.

According to Stocking, "ordinarily from 2½ to 5 per cent of culture will be sufficient to give the desired results." The growing power of the culture is no doubt a large factor in determining the quantity to use.

The use of pure culture in cheese making helps to develop sufficient acidity to make it unnecessary for the curd to remain in the whey longer than is desired for the best results. The proper degree will usually be shown by an acid test of .19 to .21 per cent. At this point both color—if any is desired, and rennet or pepsin are added.

The principles enumerated for making cultured buttermilk can be applied with marked advantage in the manufacture of cottage cheese. This applies particularly to the advantages derived from pasteurizing the milk before adding the culture, the quantity of culture to use, and the temperature to employ.

THE APPLICATION OF PURE CULTURES IN THE MANUFACTURE OF BUTTER.

One of the most important applications of pure cultures is in the butter industry. A good quality of culture inhibits the growth of bacteria that may cause the development of bad flavors in the butter, and it in itself helps to insure a good flavor in the finished product. These advantages are especially apparent in the case of butter that is held for some time before being consumed.

Through the courtesy of the Telling-Belle Vernon Co.[28], we give outline of method used by them in applying cultures in making butter.

In the case of cream that is to be churned the day that it is received, the cream is neutralized to about .16 to .18 per cent of acid. The neutralizer is added after the cream has been cooled from pasteurizing temperature to a temperature of about 90° F. Great care is taken to mix the neutralizer properly with the

cream. The reader is especially referred to Hunziker[29] for detailed information regarding the best methods of neutralizing cream. After neutralizing about ten per cent of pure culture is added, and the cream is cooled immediately to 48 to 52° F. It is held at this temperature for 3 to 4 hours, at which time the acidity is about .23 to .24 per cent, and the cream is then churned.

In the case of cream that is to be held over night, the procedure is slightly different than that outlined above. After pasteurizing the cream is cooled from pasteurizing temperatures to about 90° F. The cream is now neutralized carefully to a final acid content of .10 per cent. The cream is then cooled to 52° F., and about 7 per cent of pure culture is added. The cream is held for about 12 hours, at the end of which time the acidity has reached about .30 per cent. The cream is now churned, and it yields a high quality of butter. The cream is held over night as described above, whenever this is possible.

REFERENCES.

[1] Melick, Chas. W. Dairy Laboratory Guide, p. 79, D. Van Nostrand Co. 1907.

[2] Wilcox, E. V. Production and Inspection of Milk. 1912 Hawaii Agri. Sta. Bul. U. S. Dept. of Agri.

[3, 4] Duckwall, E. W. Canning and Preserving, p. 365, plate 122.

[5] Committee on Standard Methods for the Bacteriological Examination of Milk. Report, 3rd ed., American Public Health Association, 1921.

[6] Committee on Standard Methods of Bacteriological Analysis of Milk. Report. Amer. Jour. Pub. Health, 6, 1315 — 1326, 1916.

Committee on Bacterial Milk Analyses. Report of Progress. Amer. Jour. Pub. Hygiene, 4, 425 — 435, 1908.

Slack, Francis H. Some observations on the bacterial examination of milk. Amer. Jour. Pub. Health, 7, 690 — 697, 1917.

Berry, Jane L. Studies of laboratory media. Collected Studies, Bur. Laboratories, N. Y. City. 8, 288 — 293, 1915.

Sherman, J. M. The advantages of a carbohydrate medium in the routine bacteriological examination of milk. Jour. Bact., 1, 481 — 488, 1916.

Conn, H. W. Standards for determining the purity of milk. The limit of error in bacteriological milk analyses. U. S. Pub. Health Service, Pub. Health Repts., 30, 2349 — 2395, 1915.

Committee on Standard Methods for the Bacterial Examination of Milk. Report. Amer. Jour. Pub. Hygiene, 6, 315 — 345, 1910.

Brew, J. D. and Dotterrer, W. D. The number of bacteria in milk. N. Y. Agr. Exp. Sta., Bull. 439, 1917.

Breed, R. S. and Stocking, W. A. The accuracy of bacterial counts from milk samples. N. Y. Agr. Exp. Sta., Tech. Bull. 75, 1920.

[7] Breed, R. S. and Brew, J. D. Counting bacteria by means of the microscope. N. Y. Agr. Exp. Sta., Tech. Bull. 49, 1916.

REFERENCES.

Werner, Percy. Plan for control of milk supplies in small cities. Jour. Dairy Sci.. 1, 284 — 289, 1917.

[8] Committee on Standard Methods for the Examination of Water and Sewage. Report, 4th ed., 115 pp., American Public Health Assn. 1920.

[9] Sörensen, S. P. L. Ztschr. Biochem., 21, 131, 201, 1909; Ergebn. Physiol., 12, 393, 1912.

Clark, W. M. and Lubs, H. A. The colorimetric determination of hydrogen ion concentration and its applications in bacteriology. Jour. Bact., 2, 1 — 34, 109 — 136, 191 — 236, 1917.

Clark, W. M. The determination of hydrogen ions. Baltimore, 1920.

[10] Barnett, G. D. and Chapman, H. S. Colorimetric determination of reaction of bacteriologic mediums and other fluids. Jour. Amer. Med. Ass., 70, 1062 — 1063, 1918.

[11] Medalia, L. S. "Color standards" for the colorimetric measurement of H-ion concentration pH 1.2 to pH 9.8. Jour. Bact., 5, 441—468, 1920.

[12] Dearstyne, R. S. A study of the effect of cotton stoppers used in dilution blanks on the numerical bacterial count, and of other practices in the technique of bacteriological laboratories. Jour. Dairy Sci., 1, 512 — 516, 1918.

[13] Hill, H. W. The mathematics of the bacterial count. Amer. Jour. Pub. Hygiene, 4, 300—310, 1908.

Breed, R. S. and Dotterrer, W. D. The number of colonies allowable on satisfactory agar plates. N. Y. Agr. Exp. Sta., Tech. Bull. 53, 1916.

[14] American Public Health Ass'n., 370 7th Ave., New York. 1921.

[15] Commission on Milk Standards. Third report. U. S. Pub. Health Service, Pub. Health Repts., 32, 271 — 296, 1917. See also N. Y. City and N. Y. State Sanitary Codes.

[16] Breed, R. S., and Brew, J. D. The control of bacteria in market milk by direct microscopic examination. N. Y. Agr. Exp. Sta., Bull. 443, 1917.

[17] Model ordinance, Penn. State Dept. Health. Local ordinances, Butler and Reading, Penn.

Frost, W. D. Comparison of a rapid method of counting bacteria in milk with the standard plate method. Jour. Inf. Dis., 19, 273—287, 1916.

Frost, W. D. Counting the living bacteria in milk. A practical test. Jour. Bact., 2, 567 — 583, 1917.

[18] Tonney, F. O. Organization of control of pasteurization. Amer. Jour. Pub. Health, 10, 716 — 723, 1920.

Schroeder, M. C. Dirt sediment testing. A factor in obtaining clean milk. Amer. Jour. Pub. Health, 4, 50 — 64, 1914.

Ruehle, G. L. A., and Kulp, W. L. Germ content of stable air and its effect upon the germ content of milk. N. Y. Agr. Exp. Sta., Bull. 409, 1915.

Prucha, M. J., and Weeter, H. M. Germ content of milk. 1. As influenced by the factors at the barn. Ill. Agr. Exp. Sta. Bull. 199, 1917.

Ayers, S. H., Cook, L. B., and Clemmer, P. W. The four essential factors in the production of milk of low bacterial content. U. S. Dept. Agr., Bull. 642, 1918.

Anderson, J. F. The frequency of tubercle bacilli in the market milk of the City of Washington, D. C. U. S. Pub. Health and Marine Hosp. Ser., Hygienic Lab., Bull. 56, 167 — 197, 1909.

[19] Jackson, D. D., and Melia, T. W. Differential methods for detecting the typhoid bacillus in infected water and milk. Jour. Infect. Diseases, 6, 194 — 204, 1909.

[20] Hastings, E. G., and Hoffman, C. Bacterial content of the milk of individual animals. Wis. Agr. Exp. Sta., Research Bull. 6, 1909.

REFERENCES.

Sherman, J. M. Studies on the production of sanitary milk. Penn. State Co—— Assn. Report for 1914—15, p. 299—305, 1916.

[21] Baker, J. C., and Breed, R. S. The reaction of milk in relation to the presence of blood cells and of specific bacterial infections of the udder. N. Y. Agr. Exp. Sta., Tech. Bull 80, 1920.

[22] Buchanan (Journal of Infectious Diseases, 1918, 23, p. 109).

[23] Barber (Journal of Infectious Diseases. 1908, 5, p. 379).

[24] Penfold (Journal of Experimental Medicine in 1916, 24, p. 387).

Buchner, Lougard & Riedlin (Centralblath f. Bakteriol, 1887, 11, p. 1).

[25] W. O. Frohring, Creamery and Milk Plant Monthly, 1919, Vol. 8, No. 11, p. 61.

[26] Hall, F. H. Van Slyke, L. L., and Hart, E. B. The Chemistry of Cottage Cheese. N. Y. Station Bulletin 245, 1904.

[27] Stocking, W. A. Manual of Milk Products. The McMillan Co., New York, 1921.

[28] Submitted by W. O. Frohring.

[29] Hunziker, O. F. The Butter Industry. La Grange, Illinois.

CHAPTER XVII

ANALYSIS AND MISCELLANEOUS TESTS OF DAIRY PRODUCTS

Methods for determining the percentages of fat and solids in dairy products are given in Chapters III, VII, VIII. This chapter contains methods for determining the percentages of other constituents of milk and its products and various tests of value in the dairy industry.

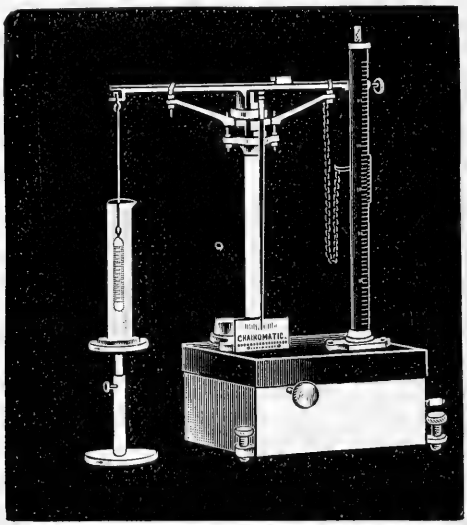


Fig. 132. Specify Gravity Chainomatic Balance.
Courtesy Christian Becker Co.

SPECIFIC GRAVITY DETERMINATIONS.

Equal volumes of the same, or of different milk products, usually do not have equal weights. This is due both to difference in the quantity of solid matter present and to differences in the density of the various components of the solid matter.

In the metric system the unit of volume is the cubic centimeter, and the unit of weight is the gram.

A mass of one gram of water at its temperature of greatest density (4°C.) has a volume of 1 cubic centimeter, and the specific gravity of a substance is the weight of one cubic centimeter expressed in grams. Therefore, it follows that the specific gravity of water at 4°C. equals 1. The specific gravity of any other liquid, or of a solid, may be obtained by dividing the weight of any volume of it by the weight of an equal volume of water.

When the temperature of water changes in either direction from 4°C. the volume expands and its specific gravity decreases. In practice, however, it is customary to make specific gravity determinations at 15.55° C. (60° F.) and to assume that water at that temperature has a specific gravity of 1.

The specific gravity of liquids is most accurately determined by using a specific gravity bottle, and a delicate chemical balance. The best form of specific gravity bottle is fitted with a thermometer that also serves as a ground glass stopper, the bulb of the thermometer extending down into the center of the body of the bottle. A side arm with capillary tube opening and extending upward a short distance from the shoulder permits the bottle to be filled completely.

Fig. 133. Specific Gravity Bottle. Courtesy Arthur H. Thomas Co.

Before making a determination the bottle must be thoroughly cleaned, dried, and cooled to the temperature to be used in the determination, until its weight is constant. It is then weighed accurately on the chemical balance and the weight is recorded. The bottle is then filled with water and brought to the temperature it had when it was first weighed. The bottle is wiped dry, weighed and the weight recorded. The exact temperature of the water in the bottle when the weighing is made should be noted.

The bottle is then emptied, rinsed free of water with some of the liquid the specific gravity of which is to be determined, and finally filled with the liquid, wiped dry and weighed. The weight of the liquid divided by the weight of the water gives the specific gravity of the liquid. If milk is the liquid under observa-

tion, great care must be taken to have it thoroughly mixed before rinsing and filling the bottle.

A Sprengel Tube may be used in place of a specific gravity bottle. It is a U shaped glass tube, holding about 15 cc., the free ends being drawn to narrow capillaries and bent outward at right angles. Ground glass caps are fitted to the free ends and a line to be used in exact adjustment of the liquid, is etched on one of the capillary tubes.

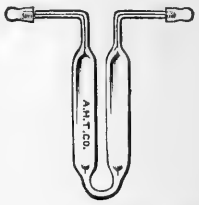


Fig. 134. Sprengel Tube. Courtesy Arthur H. Thomas Co.

In determining the specific gravity of milk the weight of the empty dry tube is accurately determined. The tube is then filled with water and weighed again after bringing its contents to the desired temperature by immersing the tube in water the temperature of which is controlled at 15.5° or 20° C. as desired. The operation is then repeated placing the milk in the tube in place of water. Divide the weight of the milk by the weight of the water to obtain the specific gravity.

The Westphal balance is an instrument devised especially for the purpose of making specific gravity determinations of liquids. It consists of a perpendicular rod supporting a beam that has a glass plummet suspended at one end and a pointer attached to the other. When the plummet is suspended in the air the pointer indicates zero. When the plummet is immersed in a liquid its weight is decreased in amount equal to that of the liquid displaced. The arm carrying the plummet is provided with notches and respective riders which indicate definite weights. The riders are added until the loss of weight due to the displaced liquid is overcome and the pointer again rests at zero. The sum of the weights represented by the riders used equals the weight of the liquid displaced. The weight of the liquid displaced, divided by the weight of water displaced when determined in a like manner, gives the specific gravity of the liquid. A single weight is provided with the instrument which brings the pointer to zero when the plummet is suspended in water. The temperature of the

liquid and the water should be the same (15.55° C.) when the determination is made.

Fig. 135. Westphal Balance. Courtesy Arthur H. Thomas Co.

Determining the specific gravity of milk by means of lactometers:—Hydrometers are instruments used for the purpose of determining the specific gravity of liquids. They consist of hollow cylindrical shaped bodies of glass weighted at one end with shot or mercury and drawn out to a long narrow stem at the other end. The weight is added to make the instrument take a perpendicular position when it is floated in a liquid. The stem contains a scale that indicates the specific gravity of the liquid. In the better form of instrument the bulb of a thermometer is sealed in the lower end, the stem of the thermometer extending up through the hollow body and the thermometer scale appearing in the stem of the hydrometer above, or on the side opposite the hydrometer scale.

Lactometers are forms of hydrometers made for the purpose of determining the specific gravity of milk. While the results obtained by their use are not quite as accurate as those obtained by means of a delicate balance, they enable an operator to make a large number of specific gravity determinations in a comparatively short time with sufficient accuracy to serve the purpose of routine inspection work.

Several different lactometers have been devised in this country and Europe. They all depend upon the same principle, namely, that bodies floating in a liquid displace a mass of the liquid equal to their weight. The only real difference between the varieties of lactometers is in the graduations on the lactometer scale.

Only two kinds af lactometers have come into general use in the United States. They are the Quevenne lactometer and the N. Y. State Board of Health lactometer (B. of H. lactometer) The

Quevenne instrument derives its name from the man who invented it. The scale in its stem is graduated from 15 at the top to 40 at the bottom, each graduation representing a difference of 1.0 on the lactometer scale. When the instrument is floated in milk of average composition the reading on the scale at the surface of

Fig. 136.
Quevenne Lactometer.

Fig. 137.
Baume Hydrometer.

Fig. 138.
N. Y. Board of Health or Spence Lactometer.

the liquid should be about 32. By prefixing "1.0" to the lactometer reading, the specific gravity is obtained. Thus the specific gravity of average milk is 1.032. A vessel that holds exactly

1000 pounds of water when full would hold 1032 pounds of milk of average composition. It is considered that the Quevenne lactometer reading of pure milk should not fall below 29.0.

Lactometers are made to show correct readings at 60° F. In practice, however, it is permissible to make the lactometer reading when the temperature is within 10° of 60 either above or below. As changes in temperature affect the density of liquids, it is then necessary to make a temperature correction. The correction on the Quevenne scale is made by adding 0.1 to the lactometer reading for each temperature degree above 60° F. and to subtract 0.1 from the lactometer reading for each degree below 60° F. Assuming that the Quevenne lactometer reading of a sample of milk was 31 at 67° F., the correction to be added would be 0.7. Then 31.0+0.7=31.7. And the specific gravity of the milk would be 1.0317.

Shaw and Eckels[1] devised a modification of the Quevenne lactometer the graduations of which indicate variations in specific gravity as small as 1 in the fourth decimal place. Such an instrument must have a very slender stem and large body, which makes it very fragile, and while it can be used sometimes to advantage in the laboratory, the stronger though less accurate instrument is favored for general inspection work.

The B. of H. lactometer, somtimes known as Spence's lactometer (from the name of the man who devised it) has a scale that is graduated from 0 to 120. There are 60 divisions in the scale, each division equaling 2 B. of H. lactometer degrees. When the instrument is floated in water the 0 point on the scale is located at the surface of the liquid, and when it is floated in milk of average composition the reading at the surface of the milk is about 110. The instrument shows correct readings in milk at 60° F., but when the temperature of the milk is within 10 degrees of 60 a correction factor may be used. The correction is made by adding 1.0 to the lactometer reading for each 3° F. above 60. and subtracting 1.0 for each 3° F. below 60. Thus if a sample of milk gave a B. of H. lactometer reading of 112 at 51° F. it would read 109 at 60° F.

$$112-\left(\frac{60-51}{3}\right)=109$$

The relation between the lactometer scales. A reading of 29 on the Quevenne scale corresponds to a reading of 100 on the B. of H. scale. Therefore 1 on the B. of H. scale equals 0.29 on the

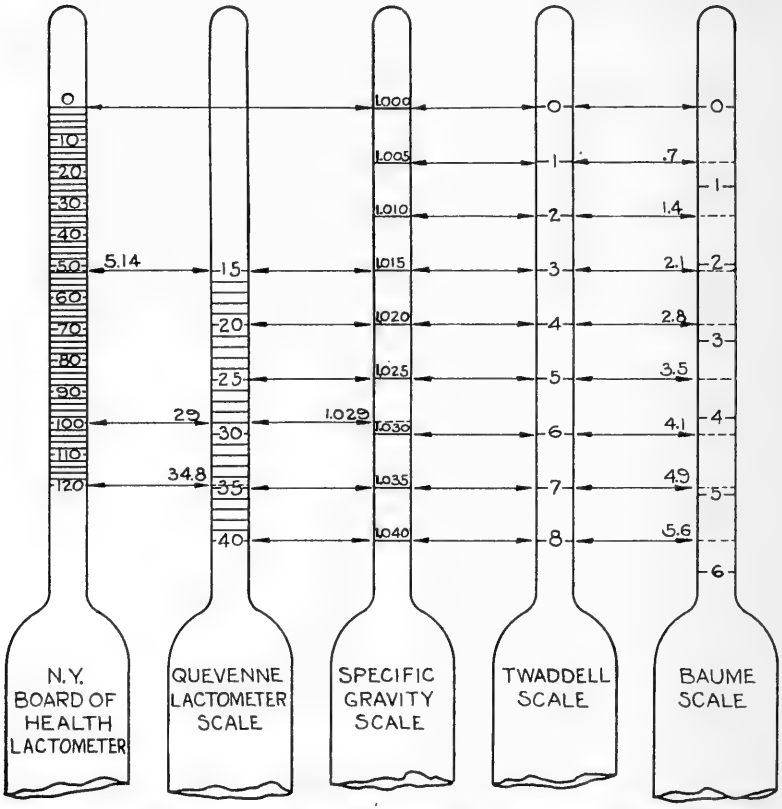


Fig. 139. Relation between B. of H. Lactometer, Quevenne Lactometer and Specific Gravity Scales.

Quevenne scale. (29÷100=0.29.) To convert the B. of H. reading to the Quevenne reading, multiply the B. of H. reading by 0.29. Then, by prefixing "1.0" to the product the specific gravity is obtained.

As a result of the extended study of the density of pure milk it has been learned that the lactometer readings with rare exceptions fall between 29 and 33.5 for the Quevenne lactometer and between 100 and 116 for the B. of H. lactometer. But a correct lactometer reading alone is not a guarantee of purity, as removing a part of the fat increases the reading and the addition of water decreases it. By operating skillfully the lactometer reading may be held constant as long as any fat is present. For this reason experienced inspectors depend to a considerable extent upon the appearance of the milk, especially the richness of the coating and the rate of its flow off of the lactometer when the instrument is removed from the mass of milk. If the coating appears thin a sample may then be taken for chemical analysis.

The relative effect of fat and solids not fat on the lactometer reading. The fat is the lightest solid that milk contains. Any increases in its percentage, without an increase in the other solids, tends to lower the lactometer reading. It happens that, in the elaboration of milk in the udder of the animal, when an increase in the fat occurs, there is also a sufficient increase in the solids not fat to a little more than offset the lowering of the density occasioned by the increase in fat. Therefore, it is normally found that naturally rich milk gives a higher lactometer reading than poor milk. If the percentage of fat rises much above 6%, however, the increase in solids not fat is usually not enough to counterbalance the fat and the lactometer reading is then lowered a little.

The relative effect of the percentages of fat and solids not fat on the density of the milk may be explained by an example. Suppose that a sample of milk containing 4 per cent of fat and 9 per cent of solids not fat gives a Quevenne lactometer reading of 33, and that after all of the fat is removed by skimming the lactometer reading is 37. The increase in density due to the removal of the fat is 4 on the lactometer scale. As there was 4 per cent of fat in the milk each per cent of fat caused a decrease of 1 on the lactometer reading. The whole milk contained 96 parts of skim-milk (milk serum) and 4 parts of fat, but when the fat was removed the remainder was 100 parts skim-milk. As the whole milk contained 9 parts of solids not fat the solids not fat in the skim-milk may be calculated by the following proportions:

96 : 100 : : 9 : X

X=9.37, or the percentage of solids not fat in the skim-milk.

If there were no solids not fat in the skim-milk the remainder would be water and the lactometer reading would be 0. Therefore 37, or the lactometer reading of the skim-milk, divided by 9.37 gives the effect of 1 per cent of solids not fat in increasing the lactometer reading.

37.00 ÷ 9.37=3.94, or the increased reading due to 1 per cent of solids not fat.

As it was shown above that 1 per cent of fat decreased the lactometer reading 1, it appears that 1 per cent of solids not fat has 3.94 times the effect in raising the reading that 1 per cent of fat has in lowering it.

The use of formulas in calculating the composition of milk. When the percentage of fat in a sample of milk and the lactometer reading are known the approximate composition may be derived by the application of a formula. As a result of much study different formulas have been developed by Fleischmann, Richmond, Babcock and others. Babcock's formula is more generally used in the United States.

Babcock's formula:

(1.) $\frac{L}{4}+.2F$=solids not fat.

Another formula which gives good results especially with naturally rich milk is the following:

(2.) $\frac{L+F}{4}$=solids not fat.

L=Quevenne lactometer reading at 60° F.

F=Per cent of fat.

The following example shows the application of formula (1). A sample of milk contained 3.60 per cent of fat and gave a lactometer reading of 31.6. What was the percentage (a) of solids not fat, (b) of total solids, (c) of water.

31.6 ÷ 4=7.9

3.6 × .2=0.72

7.9+0.72=8.62, or per cent of solids not fat

8.62+3.60=12.22, or per cent of total solids.

100.00—12.22=87.78, or per cent of water.

Another formula[2] for calculating the solids not fat in milk when the N. Y. State Board of Health lactometer is used, is the following:

$$\left[\left(\frac{1}{10}\mathrm{L}\right)-3\right]+\frac{\mathrm{F}}{4}=\text{S. N. F. in which}$$

L=N. Y. Board of Health lactometer reading,

F=per cent of fat.

This formula gives fairly good results with milk of average composition and with rich milk but the results are liable to be a little too high when it is used on milk of low solids content.

Lactometers used to determine the specific gravity of concentrated milk product. The determination of specific gravity is frequently of very great importance in arriving at the approximate total solids content of various concentrated milk products. The lactometers most commonly used for this purpose are the Baume and the Twaddell. In order to permit of closer readings, the practice is to make lactometers of various ranges, to suit the products upon which they are to be used. In the case of the Baume lactometer, the ranges given in Table 95 are those most commonly used.

TABLE 95.

Range of Baume Lactometers with Products Upon Which They Are to Be Used.

Baume readings upon scale 60° F. 1/10 degree divisions.	Corresponding specific gravity scale.	Name of products upon which lactometers are to be used.
0 to 15	1 to 1.1154	Evaporated milk, plain condensed milk, ice cream mix, condensed buttermilk.
15 to 27	1.1154 to 1.2288	Extra heavy plain condensed milk and light sweetened condensed milk.
27 to 36	1.2288 to 1.3302	Sweetened condensed whole and skimmilk.

The corresponding readings, with converting formulas upon true specific gravity, Baume and Twaddell scales are given in several tables in appendix, covering a wide range. This affords a ready means of converting one scale into another. A comparison of the scale readings of the different instruments used in determining the specific gravity of milk and its products is shown in Fig. 139.

CALCULATING THE PERCENTAGE OF ADULTERATION WHEN MILK HAS BEEN SKIMMED OR WATERED.

The forms of milk adulteration that are practiced most frequently are watering and skimming. They may be very difficult to detect where the adulteration is small, and especially difficult when there is no means of learning the composition of the original pure milk. This must be known where accurate calculations are to be made, and it is necessary to also know the percentages of fat and solids not fat in the adulterated sample. The latter may be determined by any of the means of analysis at hand. In routine work where the aim is to obtain the approximate composition of a large number of samples the solids not fat may be determined by means of the formulas given on page 562.

In the absence of means for determining the composition of the original pure milk, it becomes necessary to take as a basis for the calculation, the prevailing standard fixed by Legislative or Health Board enactments for the location where the adulterated milk was exposed for sale.

Calculating the percentage of fat removed by skimming. Subtract the percentage of fat found in the suspected sample from the percentage of fat in the pure milk, or in the absence of this information, subtract it from the percentage fixed as a standard. Then divide the difference by the percentage of fat in the pure milk, or by the standard as the case may be. Multiply the quotient by 100 and the product equals the percentage of fat that was removed by skimming the pure milk.

Problem: Suppose that a sample of partially skimmed milk contained 2.8 per cent of fat, and that before it was skimmed it contained 3.8 per cent of fat. What percentage of the fat was removed by skimming?

Solution:

3.80—2.80=1.00

1.00÷.038=25.78, per cent of fat removed by skimming.

Calculating the per cent of water added to milk. This calculation should be made on the solids not fat.

Problem: Suppose that a sample of milk contained 8.8 per cent of solids not fat before it was watered, and 7.00 per cent of solids not fat after it was watered. What percentage of water was added?

Solution:

8.80—7.00=1.80

1.80÷8.80=.2045

.2045×100=20.45, or per cent of water added.

Calculations when the milk is both skimmed and watered. The specific gravity of milk is increased by skimming and decreased by watering. Therefore by skimming off some of the fat and skillfully adding water the specific gravity or lactometer reading may be kept the same after the adulteration that it was before. When naturally rich milk is adulterated lightly in this way, the adulteration is very difficult to detect unless it is possible to learn the composition of the original pure milk.

Problem: A sample of pure milk contained 4.6 per cent of fat and 8.86 per cent of solids not fat. After adulteration by skimming and watering the milk contained 3.00 per cent of fat and 8.10 per cent of solids not fat.

What percentage of the fat was removed by skimming and what percentage of water was added?

Solution: (1). Calculate the percentage of water that was added as indicated by the relative amounts of solids not fat in the two samples::

8.86—8.10=.76

.76÷8.86=.0857

.0857×100=8.57, or per cent of water added.

(2). Calculate the total loss of fat:

4.6—3.00=1.6

1.6÷4.60=.3478

.3478×100=34.78, or total per cent of fat lost.

(3). Calculating the fat removed by skimming: When water is added to milk it reduces the percentages of all the

solids present in the same proportion. Therefore the loss of fat by watering must have been 8.57 per cent, or the same percentage as the solids not fat, then:

34.78—8.57=26.21, or percentage of the fat removed by skimming. This answer is not absolutely correct as the percentage of solids not fat in the partly skimmed milk is slightly increased by the removal of some of the fat from the pure milk.

THE DETERMINATION OF VISCOSITY IN LIQUID DAIRY PRODUCTS.

The viscosity of liquid dairy products is most easily and most accurately determined by means of the Mojonnier-Doolittle Viscosimeter, illustrated under Fig. 140. This instrument embodies all the principles of the original Doolittle viscosimeter.

The viscosity readings obtained by this method are relative only. Under equal conditions they are strictly comparable. The standard viscosimeter is fitted with viscosity balls giving three ranges of viscosity as follows:

(1). Large viscosity ball. Applicable to fresh whole milk or skim-milk or other fluids of similar viscosity.

(2). Medium viscosity ball. Applicable to evaporated milk, cream, plain condensed milk, or products of similar viscosity.

(3). Small viscosity ball. Applicable to sweetened condensed milk, superheated milk, or products of heavy viscosity.

The wires, balls and dials of equal range can all be accurately calibrated, and the results obtained within a given range are closely comparable. The results are expressed in terms of "degrees of retardation." The dial is graduated in single degree divisions up to 360 degrees.

Temperature exerts a large influence upon viscosity. In expressing viscosity the reading should always be reduced to a standard temperature. In the case of evaporated milk the corrections to make for temperature are expressed in Table 141. The most satisfactory results are obtained where the viscosity determination can be made under standard temperature conditions.

DIRECTIONS FOR OPERATING MOJONNIER-DOOLITTLE VISCOSIMETER.

(1). Fasten one end of the wire in the knurled nut upon the top of the bent support, and the other end in the dial knob. Adjust the vertical position of the dial by raising or lowering

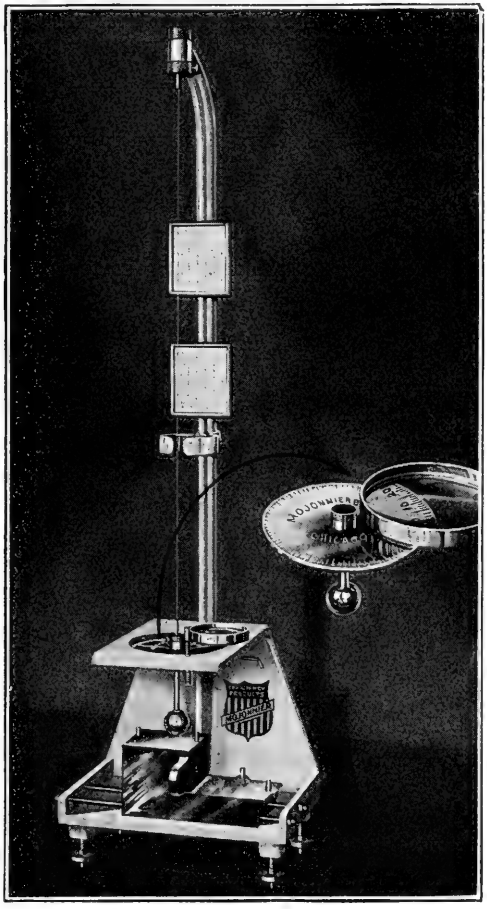


Fig. 140. Mojonnier-Doolittle Viscosimeter.

the wire holder until the small lug upon the bottom of the dial is in the proper position to engage the trip upon the under right hand side of the stand.

(2). Adjust the horizontal position of the dial until 0° is in a line with the pointer upon the front of the frame when the dial is in balance in the air. Center the dial in the open space by means of the adjusting screws.

(3). Place the sample in a cup, or make the test directly in the can. Temperature exerts a large influence upon viscosity. Viscosity increases as the temperature decreases, or vice versa. Therefore, test at constant temperature, or correct for the difference in the temperature, using the proper corrections to apply upon the product under test. Obviously the correction will vary with the product. Properly center the cup or can.

(4). Lower the ball into the sample. Turn the dial clockwise through one revolution, stopping at the 0° in the line with the pointer. Hold dial in place by means of the lug and trip. When ready, sharply release the trip. Note the degree where the dial stops just before it starts upon return round. This will occur after the dial has made one complete, and part of a second revolution. The degree at which the dial stops will represent the viscosity of the sample, to be expressed as degrees of retardation.

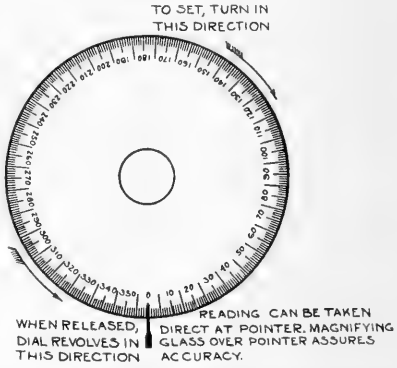


Fig. 141. Mojonnier-Doolittle Viscosimeter Dial.

THE DETERMINATION OF CASEIN IN MILK.

A. O. A. C.[3] **Method.** "The determination should be made when the milk is fresh, or nearly so. When it is not practical to make this determination within 24 hours, add 1 part of formaldehyde to 2,500 parts of milk, and keep in a cool place. Place about 10 grams of milk in a beaker with about 90 cc. of water at 40° to 42° C., and add at once 1.5 cc. of a 10 per cent acetic acid solution. Stir with glass rod and let stand from three to five minutes longer. Then decant into a filter, wash three times with cold water by decantation, pour the wash water on the filter each time, then transfer the precipitated casein completely to the filter. Wash once or twice on the filter. The

filtrate should be clear or very nearly so. If it is not clear when it first runs through, it can generally be made so by two or three separate filtrations, after which the washing of the precipitate can be completed. Determine the nitrogen in washed precipitate and filter paper by the Kjeldahl-Gunning method,'' page 570.

To calculate the equivalent amount of casein from the nitrogen multiply the percentage of nitrogen by 6.38.

In working with milk which has been kept with preservatives, acetic acid should be added in small proportions, a few drops at a time, with stirring, and the addition continued until the liquid above the precipitate becomes clear, or nearly so.

The Walker casein test for milk.[4] In this test, advantage is taken of the fact that when formaldehyde is added to proteins the neutral character of the protein molecule disappears and the acidic properties predominate. In the Walker test, these acidic properties are neutralized with standard alkali and the value of the alkali in terms of protein is given.

Operation. Titrate 9 cc. of the milk in a white cup or beaker with tenth-normal sodium hydroxide, using 1 cc. of a one per cent phenolphthalein solution as an indicator. Stir constantly with a glass rod during the titration and titrate to a fairly deep pink color. Then add 2. cc. of neutral 40 per cent formaldehyde. Take the reading on the burette containing the alkaline solution and again titrate the mixture until the same degree of pink color develops. The number of cc. of tenth-normal alkaline solution used in the second titration multiplied by 1.63 gives the percentage of casein in the milk.

Fig. 142. Tube for Hart Casein Test.
Courtesy Louis F. Nafis, Inc.

The Hart casein test.[5] Hart makes use of chloroform to dissolve the fat in milk, dilute acetic acid to precipitate the casein, a special test tube to measure the volume of casein and a centrifuge to collect it. The chloroform-fat solution is throw to the bottom of the test tube in the centrifuge owing to its high specific gravity, and the casein collects over the fat solution in a compact layer

that permits its percentage to be read by means of graduations on the side of the tube.

Operation. Place 2 cc. of chloroform in the casein test tube, add 20 cc. of a 0.25 of 1 per cent solution of acetic acid at a temperature of 65° to 75° F. (The Acetic acid solution is made by diluting 10 cc. of glacial acetic acid with 100 cc. of water, then dilute 25 cc. of this solution to 1000 cc. with water). Then place 5 cc. of milk at a temperature of 65 to 75° F. into the test tube, cover the tube with the thumb, invert and shake the tube vigorously for exactly 20 seconds. Within 20 minutes centrifuge the tube for 7 minutes at a speed of 2000 revolutions per minute. After the tube has been centrifuged, it should stand for 10 minutes before reading the percentage of casein.

DETERMINING THE TOTAL NITROGEN IN MILK.

A. O. A. C. Official Method. Place about 5 grams of milk in a Kjeldahl digestion flask and proceed without evaporation as directed under the Kjeldahl-Gunning method for determining nitrogen which follows. Multiply the nitrogen by 6.38 to obtain the nitrogenous compounds.

KJELDAHL-GUNNING METHOD FOR DETERMINING NITROGEN.

Official Method. Place the substance to be analyzed in a digestion flask, employing from 0.7 to 3.5 grams, according to its proportion of nitrogen. Add 10 grams of powdered potassium sulphate and from 15 to 25 cc. (ordinarily 20 cc.) of sulphuric acid Sp. Gr. 1.84. Place the flask in a slanting position in a holder under a ventilated hood. Heat slowly for 20 or 30 minutes raising the temperature gradually until foaming ceases and the boiling point is reached. Digest for a time after the mixture becomes colorless or nearly so, making certain that oxidation is complete and all of the nitrogen is in the form of ammonia. Let the mixture cool, then dilute with 200 cc. of water and add 50 cc. of saturated sodium hydroxide solution until strongly alkaline. In order to prevent the loss of ammonia, it is a good practice to allow the sodium hydroxide solution to run down the side of the flask and under the liquid where it is allowed to remain while adding a little zinc dust or a few pieces of granulated zinc or pumice stone to prevent

bumping, and a few drops of phenolphthalein indicator. Quickly connect the flask to the distilling apparatus, then shake it to mix the contents before applying the heat. The indicator will show if the solution is alkaline, remembering that in strongly alkaline solutions the color of the indicator may disappear. The ammonia formed from the nitrogen in the casein is set free from the sulphuric acid by the sodium hydroxide and upon

Fig. 143. Kjeldahl Apparatus for Single Nitrogen Determination.
Courtesy Arthur H. Thomas Co.

heating the flask it is driven over with water vapor into the condensor where it is condensed to a liquid. Collect the distillate in a flask containing an accurately measured volume (40 to 50 cc.) of tenth-normal sulphuric acid. The tip of the condenser should extend beneath the surface of the tenth-normal solution to prevent the escape of ammonia. A few drops of cochineal indicator is added to the standard acid solution in the receiving flask before beginning the distillation. All of the ammonia formed from the nitrogen in the protein will usually be contained in the first 150 cc. of distillate, the distilling operation

occupying about one hour. The distillate is then titrated with standard alkali.

The difference between the number of cc. of tenth-normal caustic alkali required and the number of cc. of tenth-normal acid placed in the flask, equals the number of cc. of tenth-normal ammonium hydroxide that would be formed by the ammonia distilled over. The weight and percentage of nitrogen may then be calculated. Multiply the percentage of nitrogen by 6.38 to obtain the nitrogen compounds.

Problem. Suppose that 50 cc. of tenth-normal acid were placed in the flask receiving the distillate from a casein determination in which 10 grams of milk were used, and 20 cc. of tenth-normal sodium hydroxide were required to neutralize the liquid in the flask when the distillation was completed.

What percentage of casein did the milk contain?

Solution: 50—20=30, or cc. of tenth-normal ammonium hydroxide formed by the nitrogen in the casein.

One cc. of tenth-normal ammonium hydroxide contains 0.0014 gram of nitrogen.

$0.0014 \times 30 = 0.042$, or gram of nitrogen from the casein.

$0.042 \times 6.38 = 0.26796$, or gram of casein from 10 grams of milk.

$0.26796 \div 10 = 0.026796$, or gram of casein in 1 gram of milk.

$0.026796 \times 100 = 2.67963$ or the percentage of casein in the milk.

DETERMINATION OF CASEIN IN MILK CHOCOLATE.

A. O. A. C. Tentative Method. It is unnecessary to de-fat the chocolate. Weigh 10 grams of the chocolate into a 500 cc. Erlenmeyer flask and add 250 cc. of 1 per cent sodium oxalate solution. Heat to boiling and boil gently for a few minutes, then cool, add 5 grams of magnesium carbonate and filter. Determine nitrogen in 50 cc. of this filtrate. Pipette 100 cc. of the filtrate into a 200 cc. volumetric flask and dilute almost to the mark with water. Then precipitate the casein by the addition of 2 cc. of glacial acetic acid or 1 cc. of concentrated sulphuric acid. Make to volume, shake, filter and determine nitrogen in 100 cc. of the filtrate. The difference between the two nitrogen determinations gives the nitrogen derived from

the casein which, multiplied by 6.38, gives the amount of casein present in 2 grams of the sample.

DETERMINING THE QUALITY OF CASEIN.

In addition to its use as a food, casein serves for a variety of purposes in the industrial arts. The condition and quality of the skim-milk and buttermilk from which commercial casein is ordinarily made as well as the method of manufacture, usually affect to some extent, the composition and physical properties of the product found on the market. Where the technical purpose for which the casein is to be used is known, the method of its manufacture from milk is sometimes stipulated. Yet, it may be that casein made by other methods would serve equally well if a method for bringing it into solution and workable condition were known.

Butterman[6] (1920) has shown that the percentage of ash in casein varies between 1.28 per cent and 8.6 per cent according to the method employed in its manufacture. He also shows that when the casein is used in the manufacture of glue the amount of water required to give a glue of medium viscosity is a linear function of the ash content. Thus the casein made by one method, and which contained 1.8 per cent of ash, required 2.3 parts of water to one part of casein to give a glue of medium viscosity, while the casein made by another method, and which contained 8.6 per cent of ash required 3.9 parts of water. In making the comparisons the amount of water used on a sample was varied until the desired viscosity was obtained.

The operation was carried out as follows: 100 to 200 grams of dry powdered casein were weighed and mixed with X parts of water. After soaking a few minutes until the casein was thoroughly wet, a suspension of lime containing one part of hydrated lime to 6 parts of water was stirred in. The amount of lime used in this suspension was equivalent to 15 per cent of the weight of casein used. Finally an amount of sodium silicate solution (Sp. Gr. 1.4) equal to 0.7 of the weight of the casein was added, and the mixture was then vigorously stirred until all particles of casein had dissolved, giving a homogeneous mass. Among the characteristics observed in these glues were the consistency and glue "life." If the glues exhibited, by simple observation, a viscosity intermediate between a thin watery

mixture and a thick, heavy mixture, its consistency was recorded as "medium." Similarly a very high viscosity was described as "stiff." By the term "life" is meant the period of time between the preparation of the glue and the point where it becomes too thick to spread properly.

It is stated that "by making a determination of the ash content of a given sample of casein, it is therefore possible to tell at once the proper proportion of the ingredients required to mix it into a satisfactory glue, regardless of the method by which the casein has been prepared.

Adhesive or strength tests of casein. Dalberg[7] (1918) describes the following method for determining the adhesive strength of casein: Fifty grams of casein ground fine enough to pass through a screen with 20 meshes to the inch is weighed into a casserole having a known weight, 100 cc. of cold distilled water is added, the two mixed well and allowed to stand for a short time, when 90 cc. more of distilled water is added in which 5 grams of borax have been dissolved. Distilled water is then added until the mixture weighs 250 grams, and the casserole placed in a water bath having a temperature not to exceed 149° F. (65° C.) and stirred until the casein is dissolved. When the casein is completely dissolved more water must be added to take the place of that lost by evaporation, so that each 5 grams of the solution will represent one of casein. Some samples of casein may require more than the specified quantity of borax or other alkali. No trouble was experienced in dissolving the samples reported in the proportion of borax given.

One hundred grams of china clay or kaolin, previously dried at the temperature of boiling water for one hour, is weighed into a heavy casserole, and 70 cc. of distilled water added and mixed to a smooth paste, care being taken to work up any lumps that may settle to the bottom. After weighing the casserole with its content of clay paste, 30 grams of the casein solution, representing 6 grams of casein, is added to it and thoroughly mixed with the paste. A stiff brush is helpful in getting a good mixture. A thin coating of the mixture is then applied to several small sheets of test paper (unsized writing paper serves well), by means of a thin brass scraper or camel's hair brush, using care to spread uniformly. The casserole is again balanced and 5

additional grams of the casein solution added, the solution well mixed and another set of test sheets coated, continuing the procedure of adding 5 grams of the casein solution and making a set of test sheets until sufficient casein has been added to hold the coating mixture properly to the paper. Best results were obtained by using the straight edged brass scraper, which requires that the paper be placed on a perfectly flat surface such as a piece of smooth plate glass. When using a brush the coating mixture must be placed on very quickly, first lengthwise and then crosswise.

When the sets of test papers having an increase of one gram in casein for each succeeding set are perfectly dry, short sticks of sealing wax softened by heating at one end are applied with a fairly firm pressure to various points where the coating is uniform, and allowed to cool. The paper is then held down firmly by placing the fingers on each side of the wax and the latter pulled away with a steady pull. In case of an insufficient quantity of casein the wax will pull only the clay mixture, but where sufficient casein has been used it will pull out the paper fibers strongly to the edge of the wax, showing that the coating material had actually become a part of the paper. Usually a transition point is found when the center of the stick of wax will pull out the paper fibers partially, while the next set having one gram more of casein will pull all the fibers to the extreme edge of the wax. A good grade of casein should not require more than 8 or 9 grams to hold strongly.

The strength of casein as shown by this laboratory test bears some direct relation to the percentage of casein necessary to use in solutions in practical coating work.

DETERMINING THE ALBUMIN IN MILK.

Official Method. Exactly neutralize with caustic alkali the filtrate from the casein precipitate in the A. O. A. C. method for determining the casein. Add 0.3 cc. of a 10 per cent solution of acetic acid and heat the liquid to the temperature of boiling water until the albumin is completely precipitated. Collect the precipitate on a filter, wash, and determine the nitrogen therein by the Kjeldahl-Gunning method. The nitrogen multiplied by 6.38 equals the albumin.

Other nitrogenous compounds. Van Slyke[8] gives the following method for determining the modified proteins, amine derivatives and ammonium compounds. Heat the filtrate from the albumin precipitate obtained in the above operation to 70° C. and add 1 cc. of a 5 per cent sulphuric acid solution, then add solid zinc sulphate until the solution is saturated. Hold the solution at 70° C. until the precipitate settles, cool, filter, and wash the precipitate with a saturated solution of zinc sulphate that has been slightly acidified with sulphuric acid. Determine the nitrogen in the precipitate by the Kjeldahl-Gunning method.

To determine the amino-derivatives and ammonium compounds place 50 c. c. of the milk in a 250 c. c. graduated flask and add 1 gram of sodium chloride. Add drop by drop a 12 per cent solution of tannin until precipitation is complete. Fill the flask to the mark with water, shake, and pass through a dry filter. Determine the nitrogen in 50 c. c. of the filtrate by the Kjeldahl-Gunning method to obtain the amino-derivatives. The ammonium compounds are obtained by mixing magnesium oxide in slight excess with 100 c. c. of the filtrate, then distilling off about 50 c. c. into a measured volume of standard acid.

ASH DETERMINATION.

A. O. A. C. Method. "Weigh about 20 grams of the milk in a weighed dish, add 6 c. c. of nitric acid, evaporate to dryness, and burn at a low red heat until the ash is free from carbon."

The burning should be done in a muffle, care being taken to avoid heating too rapidly, while burning off the fat and other organic matter as flames may carry off some of the mineral matter, and too high a temperature later may volatilize some of it.

METHOD FOR DETERMINING LIME IN DAIRY PRODUCTS.

Description of Method. Two variations of the method are possible:

(1). Measure or preferably weigh the samples into clean Babcock test bottles. In all cases except when testing whole milk, add to the bottle sufficient distilled water to bring the total weight up to 18 grams. Mix samples with the water in the bottle very thoroughly. Now add slowly with constant shaking

about 15 grams C. P. sulphuric acid; centrifuge for about ten minutes. Add sufficient distilled water to float off the fat. Centrifuge until the last visible traces of fat are gone, adding additional water if this might be required. Pour the solution into a beaker, and wash out the bottle with three successive small portions of distilled water. Add two volumes of 95 per cent grain alcohol, and allow to stand over night. Filter, using preferably, a Gooch crucible with asbestos. Wash the precipitate by decantation, using grain alcohol. Dry thoroughly. Ignite at a moderate temperature, to a constant weight. If a filter paper is used, dry the precipitate in the filter and ignite together.

(2) Transfer to a beaker the residue remaining in a Mojonnier fat extraction flask at the end of a fat extraction. Neutralize the ammonia carefully with C. P. sulphuric acid. Add 10 cc. in addition to that required for neutralizing. Add two volumes of 95 per cent grain alcohol, and allow to stand over night. Proceed as under (1).

Size of Samples Recommended. The size of sample to use can be varied with the method employed. Table 96 gives the amount recommended under the two methods. Slight variations will not affect the accuracy of the results.

TABLE 96.

Weight of sample recommended.

Product.	Babcock method	Mojonnier method
	Grams.	Grams.
Whole milk, skim-milk, buttermilk and whey.	18	10
Evaporated milk, plain condensed whole and skim-milk, ice cream mix and cream.....	9	5
Milk chocolate, cheese, malted milk, whole and skim-milk powder and butter.....	..	1

Experimental evidence upon the accuracy of the method. Ten grams of gypsum were heated to a red heat. Weighed samples of this were ignited with filter paper, and found upon reweighing to have undergone no change in weight.

In another experiment a sample of gypsum was treated with sulphuric acid diluted 1-5, decanted, filtered, washed, dried in electric vacuum oven, and ignited to constant weight. To about 0.10 gram portions of this ignited product was then added 17 cc. of distilled water; 17 cc. of C. P. sulphuric acid, and after cooling, 100 cc. of 95 per cent alcohol. After standing over night, the precipitate was filtered, dried, ignited and weighed. The samples showed no loss in weight.

Results obtained by the above method. The results obtained by means of the above method in the case of different dairy products are given in Table 97.

The method does not apply in the case of sweetened condensed milk or other products containing large amounts of sugar, on account of the solubility of calcium sulphate in sucrose solutions.

TABLE 97.

Lime Content of Dairy Products As Found by Above Method.

Test Number	PRODUCT	Per Cent Calcium Oxide		OPERATOR
		Original	Duplicate	
1	Whole milk	0.122	0.136	Author
2	Evaporated milk	0.284	0.276	Author
3	Evaporated milk	0.306	0.302	Author
4	Evaporated milk	0.344	0.340	Author
5	Evaporated milk	0.364	0.361	Author
6	Evaporated milk	0.288	0.289	Author
7	Evaporated milk	0.357	0.354	Author
8	Evaporated milk	0.371	0.364	Author
9	Whole milk	0.141	0.141	Author
10	Powdered skim-milk	1.410	1.420	Author
11	Buttermilk	0.159	0.156	H. J. Liedel
12	Ice cream mix	0.195	0.188	H. J. Liedel
13	Cheese		0.969	H. J. Liedel

Conclusions. The method described can be used to determine the lime content of all dairy products excepting those containing large amounts of sucrose. It is simple and accurate.

SUGARS.

The power of reducing sugars to separate oxygen from alkaline solutions of certain metallic salts and to precipitate the metals as lower oxides is used to advantage in a number of methods employed in sugar analysis. Other methods take advantage of the power of sugar solutions to rotate a plane of polarized light. When the operation is carried out under conditions that are properly controlled, the angle of rotation produced by a sugar solution may be measured and the percentage of sugar determined.

Some of the more practical methods that are of interest in the dairy industry for determining sugars are given here. When further information on the chemistry of the sugars is desired, a more comprehensive work on the subject should be consulted.

MILK SUGAR DETERMINATIONS.

A. O. A. C. Optical Method. Preparation of reagents: (a) Dissolve mercury in double its weight of nitric acid, specific gravity 1.42, and dilute with an equal volume of water. One cc. of this reagent is sufficient for the quantity of milk mentioned below. Larger quantities may be used without affecting the results of polarization.

(b). Mix 33.2 grams of potassium iodide, 13.5 grams of mercuric chloride, 20 cc. of glacial acetic acid and 640 cc. of water.

Determination. The milk should be at a constant temperature and its specific gravity determined with a delicate hydrometer or lactometer. When greater accuracy is required, pycnometer is used.

The quantities of the milk measured for polarization vary with the specific gravity of the milk as well as with the polariscope used. The quantity to be measured in any case will be found in the following table.

Place the quantity of the milk indicated in the table in a flask graduated at 102.4 cc. for a Laurent or 103.6 cc. for a Ventzke polariscope (Mohr cc.). Add 1 cc. of mercuric nitrate solution or 30 cc. of mercuric iodide solution (an excess of these reagents does no harm) fill to the mark, agitate, filter through a dry filter,

TABLE 98.

Volume of Milk to Be Used

Specific gravity.	For polariscopes of which the sucrose normal weight is 16.19 grams.	For polariscopes of which the sucrose normal weight is 26.048 grams.
	c. c.	c. c.
1.024	60.00	64.40
1.026	59.90	64.30
1.028	59.80	64.15
1.030	59.70	64.00
1.032	59.60	63.90
1.034	59.50	63.80
1.035	59.35	63.70

and polarize. It is not necessary to heat before polarizing. In case a 200 mm. tube is used, divide the polariscope reading by 3 when the sucrose normal weight of the instrument is 16.19 grams, or by 2 when the normal weight for the instrument is 26.048. When a 400 mm. tube is used, these divisors become 6 and 4 respectively. For the calculation of the above table the specific rotary power of lactose is taken as 52.52°, and the corresponding number for sucrose as 66.5°. The lactose normal weight to read 100° on the sugar scale for the Laurent instruments is 20.496 grams, and for Ventzke instruments, 32.975 grams. In case metric flasks are used the weights here mentioned must be reduced to 16.160 and 26.000 grams respectively.

GRAVIMETRIC METHOD A. O. A. C. OFFICIAL.

Preparation of reagents. (a). Copper sulphate solution. Dissolve 34.639 grams of clear crystals of copper sulphate ($CuSO_4 \cdot 5H_2O$), in water and make up to 500 cc.

(b). Alkaline tartrate solution. Dissolve 173 grams of pure Rochelle salts (sodium potassium tartrate) and 50 grams of pure sodium hydroxide in water and dilute to 500 cc.

(c). Mix equal volumes of solutions (a) and (b) immediately before use. (The mixture forms Fehling's solution).

Preparing the milk solution. Dilute 25 cc. of the milk with 400 cc. of water and add 10 cc. of copper sulphate solution (34.639 grams of $CuSO_4$. $5H_2O$ in water and dilute to 500 cc.). Add about 7.5 cc. of a solution of potassium hydroxide of such strength that one volume of it is just sufficient to completely precipitate the copper as hydroxide from one volume of the solution of copper sulphate. Instead of a solution of potassium hydroxide of this strength 8.8 cc. of a half normal solution of sodium hydroxide may be used. After the addition of the alkali solution the mixture must still have an acid reaction and contain copper in solution. Fill the flask to the 500 cc. mark, mix, and filter through a dry filter.

Place 25 cc. of each reagent (a) and (b) together in a beaker and heat to the boiling point. While boiling briskly, add 100 cc. of the lactose solution containing not more than 0.300 gram of lactose and boil for 6 minutes. Filter immediately through asbestos and determine amount of copper reduced.

The Official Method directs that the amount of copper reduced be determined by one of the following methods:

(1). Reduction in hydrogen.

(2). Electrolytic deposition from sulphuric acid solution.

(3). Electrolytic deposition from sulphuric and nitric acid solution.

(4). Electrolytic deposition from nitric acid solution.

(5). Volumetric permanganate method.

(6). Direct weighing of cuprous oxide.

As method (6) is adaptable to the ordinary laboratory it is given here:

Prepare a Gooch crucible with an asbestos felt one fourth of an inch thick. Then thoroughly wash the asbestos with water to remove small particles, follow successively with 10 cc. of alcohol and 10 cc. of ether, and dry the crucible and contents thirty minutes in a water oven at the temperature of boiling water. (This drying operation could be shortened by using the Mojonnier Tester solids oven held at 100° C.)

Collect the precipitate of cuprous oxide on the felt as usual, thoroughly wash with hot water, then with 10 cc. of alcohol, and finally with 10 cc. of ether. Dry the precipitate 30 minutes in

TABLE 99.

Table for the Determination of Lactose (Soxhlet-Wein)

Milligrams of Copper	Milligrams of Lactose	Milligrams of Copper	Milligrams of Lactose	Milligrams of Copper	Milligrams of Lactose	Milligrams of Copper	Milligrams of Lactose	Milligrams of Copper	Milligrams of Lactose
100	71.6	161	117.1	222	163.4	283	210.7	344	259.0
101	72.4	162	117.9	223	164.2	284	211.5	345	259.8
102	73.1	163	118.6	224	164.9	285	212.3	346	260.6
103	73.8	164	119.4	225	165.7	286	213.1	347	261.4
104	74.6	165	120.2	226	166.4	287	213.9	348	262.3
105	75.3	166	120.9	227	167.2	288	214.7	349	263.1
106	76.1	167	121.7	228	167.9	289	215.5	350	263.9
107	76.8	168	122.4	229	168.6	290	216.3	351	264.7
108	77.6	169	123.2	230	169.4	291	217.1	352	265.5
109	78.3	170	123.9	231	170.1	292	217.9	353	266.3
110	79.0	171	124.7	232	170.9	293	218.7	354	267.2
111	79.8	172	125.5	233	171.6	294	219.5	355	268.0
112	80.5	173	126.2	234	172.4	295	220.3	356	268.8
113	81.3	174	127.0	235	173.1	296	221.1	357	269.6
114	82.0	175	127.9	236	173.9	297	221.9	358	270.4
115	82.7	176	128.5	237	174.6	298	222.7	359	271.2
116	83.5	177	129.3	238	175.4	299	223.5	360	272.1
117	84.2	178	130.1	239	176.2	300	224.4	361	272.9
118	85.0	179	130.8	240	176.9	301	225.2	362	273.7
119	85.7	180	131.6	241	177.7	302	225.9	363	274.5
120	86.4	181	132.4	242	178.5	303	226.7	364	275.3
121	87.2	182	133.1	243	179.3	304	227.5	365	276.2
122	87.9	183	133.9	244	180.1	305	228.3	366	277.1
123	88.7	184	134.7	245	180.8	306	229.1	367	277.9
124	89.4	185	135.4	246	181.6	307	229.8	368	278.8
125	90.1	186	136.2	247	182.4	308	230.6	369	279.6
126	90.9	187	137.0	248	183.2	309	231.4	370	280.5
127	91.6	188	137.7	249	184.0	310	232.2	371	281.4
128	92.4	189	138.5	250	184.8	311	232.9	372	282.2
129	93.1	190	139.3	251	185.5	312	233.7	373	283.1
130	93.8	191	140.0	252	186.3	313	234.5	374	283.9
131	94.6	192	140.8	253	187.1	314	235.3	375	284.8
132	95.3	193	141.6	254	187.9	315	236.1	376	285.7
133	96.1	194	142.3	255	188.7	316	236.8	377	286.5
134	96.9	195	143.1	256	189.4	317	237.6	378	287.4
135	97.6	196	143.9	257	190.2	318	238.4	379	288.2
136	98.3	197	144.6	258	191.0	319	239.2	380	289.1
137	99.1	198	145.4	259	191.8	320	240.0	381	289.9
138	99.8	199	146.2	260	192.5	321	240.7	382	290.8
139	100.5	200	146.9	261	193.3	322	241.5	383	291.7
140	101.3	201	147.7	262	194.1	323	242.3	384	292.5
141	102.0	202	148.5	263	194.9	324	243.1	385	293.4
142	102.8	203	149.2	264	195.7	325	243.9	386	294.2
143	103.5	204	150.0	265	196.4	326	244.6	387	295.1
144	104.3	205	150.7	266	197.2	327	245.4	388	296.0
145	105.1	206	151.5	267	198.0	328	246.2	389	296.8
146	105.8	207	152.2	268	198.8	329	247.0	390	297.7
147	106.6	208	153.0	269	199.5	330	247.7	391	298.5
148	107.3	209	153.7	270	200.3	331	248.5	392	299.4
149	108.1	210	154.5	271	201.1	332	249.2	393	300.3
150	108.8	211	155.2	272	201.9	333	250.0	394	301.1
151	109.6	212	156.0	273	202.7	334	250.8	395	302.0
152	110.3	213	156.7	274	203.5	335	251.6	396	302.8
153	111.1	214	157.5	275	204.3	336	252.5	397	303.7
154	111.9	215	158.2	276	205.1	337	253.3	398	304.6
155	112.6	216	159.0	277	205.9	338	254.1	399	305.4
156	113.4	217	159.7	278	206.7	339	254.9	400	306.3
157	114.1	218	160.4	279	207.5	340	255.7	...	.....
158	114.9	219	161.2	280	208.3	341	256.5	...	.....
159	115.6	220	161.9	281	209.1	342	257.4	...	.....
160	116.4	221	162.7	282	209.9	343	258.2	...	.....

a water oven at the temperature of boiling water; cool and weigh. The weight of cuprous oxide multiplied by 0.8883 gives the weight of metallic copper. Obtain the weight of lactose equivalent to the weight of copper found from Table 99.

DETERMINING THE PERCENTAGE OF LACTOSE AND SUCROSE IN SWEETENED CONDENSED MILK.

White[9] has developed a method for determining the percentages of lactose and sucrose in sweetened condensed milk in which the lactose is first determined by the cuprous oxide precipitation method, then by inverting the sucrose in an aliquot of the filtrate and again precipitating the cuprous oxide, the percentage of sucrose is obtained. In applying the method certain precautions must be observed and corrections made, but the operation is not difficult, is fairly rapid, and the results appear to be more accurate than those obtained by gravimetric methods heretofore employed.

Operation. Ten grams of the well mixed sample are weighed into a calibrated 250 cc. flask, and approximately 125 cc. of water nearly boiling hot added, rinsing down any condensed milk attached to the inside of the neck. Shake well for 4 or 5 minutes, cool to 20° C. and add gradually with shaking, 10 cc. of Fehling's copper sulphate solution. Then add 6 cc. of half-normal sodium hydroxide solution with shaking. This precipitates the proteids and fat and leaves a trace of copper sulphate in solution. The flask is then filled to the 250 cc. mark with water and 1.5 cc. more of water are added to make up for the volume of precipitate. Shake until the liquid is homogeneous, filter, and discard the first few cc. of the filtrate that pass through. The filtrate should have a slight blue color showing that it still retains a trace of copper in solution.

Place 25 cc. each of Fehling's copper sulphate and alkaline tartrate solutions in a 400 cc. resistant glass beaker and add 50 cc. of the filtrate, heat over a flame that will bring the mixture to boiling in 4 minutes or a few seconds less, then boil for 2 minutes and filter immediately through asbestos felt in a weighed Gooch crucible, using suction to assist in obtaining rapid filtration. Rinse the last traces of cuprous oxide onto the filter

with hot water using a rubber tipped rod to assist and wash the precipitate 4 or 5 times with hot water, and once with alcohol. Transfer the filtrate to a 250 cc. calibrated flask and set aside for use in the sucrose determination. Dry the Gooch crucible and contents in an oven at 100° C. for 30 minutes.

While the cuprous oxide for the lactose determination is drying invert the sucrose in the filtrate, and precipitate and filter the cuprous oxide from a 50 cc. aliquot of it as follows: Add to the filtrate in the 250 cc. flask 9 cc. of 1 to 1 hydrochloric acid solution made by dissolving concentrated HCl with an equal volume of water. This will bring the mixture to about the neutral point. Next add 25 cc. more of the 1 to 1 hydrochloric acid to invert the sucrose. Heat rapidly to 70° C. with constant stirring to prevent overheating any part of the liquid. Hold the liquid at a temperature of 70° C. for 45 minutes, cool somewhat, and neutralize with a 50 per cent solution of caustic soda, using a few drops of phenolphthalein solution as an indicator. Use care in neutralizing not to pass the neutral point; but if it is passed it may be brought back by adding a little of the 1 to 1 hydrochloric acid. Cool to 20° C. and fill the flask to the 250 cc. mark. Mix until homogeneous and transfer 50 cc. of it (equal to 0.4 gram condensed milk) to a 400 cc. resistant glass beaker in which has previously been placed 25 cc. each of the copper sulphate and alkaline potassium tartrate solutions. Heat the beaker over a flame that will bring the contents to boiling in 4 minutes or a few seconds less, and boil for two minutes more. Filter at once through asbestos felt in a weighed Gooch crucible using suction filtration. Wash the last traces of cuprous oxide precipitate from the beaker into the Gooch with hot water using a rubber tipped rod to assist, then wash the precipitate 4 or 5 times with hot water and once with 95 per cent alcohol. Place the crucible in a drying oven and dry for 30 minutes at a temperature of 100° C.

When the crucible containing the cuprous oxide thrown down by the lactose and obtained in the first precipitation has dried for 30 minutes, cool it in a desiccator and weigh to determine the milligrams of cuprous oxide. The percentage of lactose in the sweetened condensed milk may now be calculated as explained in the following problem:

Suppose that 374.5 milligrams of cuprous oxide are thrown down by the lactose. Look in the first column of Munson and Walker's table page 587 for the number nearest in size to 374.5. It is 370.0. To the right in line with 370.0, in the column marked at the head "1 lactose, 4 sucrose" there is found the figure 248.1 which is the milligrams of lactose equivalent to 370 milligrams of cuprous oxide. But there were 374.5 milligrams of cuprous oxide and there remains to be found the lactose value of 4.5 milligrams. The figure 374.5 falls between the figures 370 and 380 in the first column, and the lactose value of 380 as shown in the column under the heading "1 lactose, 4 sucrose" is 255.0. Then subtracting 248.1 from 255.0 gives 6.9, the lactose value of 10 milligrams of cuprous oxide, and 6.9 divided by 10 gives 0.69, the lactose value of one milligram of cuprous oxide. Then 4.1 multiplied by 0.69 gives 3.1. Add 3.1 to 248.1 and the sum equals 251.2, the lactose value of 374.5 milligrams of cuprous oxide under the conditions existing in the determination.

The percentage of lactose in the sweetened condensed milk may then be found by dividing the milligrams of lactose by the weight of the condensed milk in the 50 cc. aliquot which was used in the determination. As 10 grams of the condensed milk was weighed out and made up to 250 cc., 50 cc. represents one fifth of 10 grams, or 2 grams (2000 mg.) Then 251.2 divided by 2000 equals .1256 and this quotient multiplied by 100 gives 12.56, per cent of lactose in the sweetened condensed milk.

When the cuprous oxide obtained from the inverted sucrose determination has dried for 30 minutes, cool in a desiccator and weigh to find its weight in milligrams. The percentage of sucrose in the condensed milk may then be calculated. To permit explanation it may be assumed that 378.5 milligrams of cuprous oxide were obtained from the aliquot used after inverting the cane sugar. But a little lactose remained in the solution after the first cuprous oxide precipitation, and a correction must be made for it. It amounts to 4.1 milligrams of cuprous oxide as found by the average of a large number of determinations. Also some sucrose entered into the lactose determination for which a correction must be made. The total correction may be calculated as follows: The lactose determination in the presence of sucrose gave 274.5 milligrams of cuprous oxide which equals 251.2 milli-

grams of lactose. If the lactose determination were made in the absence of sucrose the 251.2 milligrams of lactose would have thrown down only 366.4 milligrams of cuprous oxide. (This may be seen by finding the cuprous oxide equivalent in the first column of Munson and Walker's table, for 251.2 milligrams of lactose in the column under the heading "lactose"). The difference between 374.5 and 366.4 is 8.1, or the number of milligrams of cuprous oxide thrown down in the lactose determination due to the inversion of some sucrose during the operation. Since only a one-fifth aliquot was used later in making the sucrose determination the correction to be added is one-fifth of 8.1 milligrams or 1.6 milligrams. This positive correction of 1.6 milligrams combined with the negative correction of 4.1 milligrams equals 2.5 milligrams to be subtracted from the 378.5 milligrams, which leaves 376 milligrams of cuprous oxide that may finally be credited to the inverted sucrose.

Next find in Munson and Walker's sugar table, first column, the figures nearest in size to 376. They are 380 and 370. The invert sugar value for 370 milligrams of cuprous oxide as given in the invert sugar column of the table is 177.7 milligrams and the invert sugar value for 380 milligrams of cuprous oxide is 183.0 Therefore a difference of 10 milligrams of cuprous oxide is here equal in invert sugar to the difference between 183.0 and 177.7, or 5.3 milligrams. Then one milligram of cuprous oxide equals 5.3 divided by 10, or 0.53 milligram of invert sugar. Accepting 177.7 milligrams as the invert sugar value of 370 milligrams of cuprous oxide there remains to be found the difference between 370 and 376, or 6 milligrams of cuprous oxide. Since one milligram of the oxide as shown above equals 0.53 gram of invert sugar, 6 milligrams equals 6 times 0.53, or 3.18 milligrams. Then 177.7 plus 3.18 equals 180.88, milligrams of invert sugar in the aliquot used in making the sucrose determination. Since the weight of invert sugar is 5 per cent greater than the weight of sucrose before inversion, it is necessary to multiply the 180.88 by 100 minus 5, or 95 per cent to obtain the milligrams of sucrose in the aliquot used in the determination. Thus 180.88 times 95 per cent gives 171.83, milligrams of sucrose. The aliquot used in making the lactose determination equaled 2.0 grams of condensed milk and the aliquot used for the sucrose determination was

TABLE 100.

Munson and Walker's Table for Calculating Dextrose, Invert Sugar, Invert Alone, Invert Sugar in the Presence of Sucrose (0.4 Gram and 2 Grams Total Sugar), Lactose, Lactose and Sucrose (2 Mixtures) and Maltose (Crystalized).

Expressed in Milligrams.

Cuprous Oxid (Cu_2O)	Copper (Cu)	Dextrose (d-glucose)	Invert Sugar	Invert Sugar and Sucrose		Lactose	Lactose and Sucrose		Maltose	Cuprous Oxid (Cu_2O)
				0.4 gm. Total Sugar	2 gms. Total Sugar	$C_{12}H_{22}O_{11}+H_2O$	1 Lactose, 4 Sucrose	1 Lactose, 12 Sucrose	$C_{12}H_{22}O_{11}+H_2O$	
10	8.9	4.0	4.5	1.6	.....	6.3	6.1	.....	6.2	10
20	17.8	8.3	8.9	6.1	.....	12.5	12.1	.....	14.6	20
30	26.6	12.6	13.4	10.7	4.3	18.8	18.2	.....	22.9	30
40	35.5	16.9	17.8	15.2	8.8	25.5	24.7	.....	31.3	40
50	44.4	21.3	22.3	19.7	13.4	32.3	31.3	.....	39.6	50
60	53.3	25.6	26.8	24.3	18.0	39.2	37.9	.....	48.0	60
70	62.2	30.0	31.3	28.9	22.6	46.0	44.6	41.9	56.3	70
80	71.1	34.4	35.9	33.5	27.3	52.9	51.3	47.8	64.6	80
90	79.9	38.9	40.4	38.2	31.9	59.7	57.9	53.7	73.0	90
100	88.8	43.3	45.0	42.8	36.6	66.6	64.6	59.6	81.3	100
110	97.9	47.8	49.6	47.5	41.3	73.5	71.3	65.6	89.7	110
120	106.6	52.3	54.3	52.3	46.0	80.3	78.0	71.5	98.0	120
130	115.5	56.8	58.9	56.9	50.7	87.3	84.7	77.5	106.4	130
140	124.4	61.3	63.6	61.6	55.5	94.1	91.4	83.5	114.7	140
150	133.2	65.9	68.3	66.4	60.2	101.0	98.1	89.5	123.0	150
160	142.1	70.4	73.0	71.2	65.5	107.9	104.8	95.6	131.4	160
170	151.0	75.1	77.7	76.0	69.8	114.8	111.6	101.6	139.7	170
180	159.9	79.7	82.5	80.8	74.6	121.6	118.3	107.7	148.0	180
190	169.8	84.3	87.2	85.6	79.5	128.5	125.1	113.8	156.4	190
200	177.7	89.0	92.0	90.5	84.4	135.4	131.9	119.8	104.7	200
210	186.5	93.7	96.9	95.4	89.2	142.3	138.6	126.0	173.0	210
220	195.4	98.4	101.7	100.3	94.2	149.3	145.4	132.1	181.4	220
230	204.3	103.2	106.6	105.2	99.1	156.2	152.2	138.2	189.7	230
240	213.2	108.0	111.5	110.1	104.0	163.1	159.0	144.4	198.0	240
250	222.1	112.8	116.4	115.1	109.0	170.1	165.8	150.6	206.3	250
260	231.1	117.6	121.4	120.1	114.0	177.0	172.6	156.8	214.7	260
270	239.8	122.5	126.4	125.1	119.0	184.0	179.4	163.0	223.0	270
280	248.7	127.3	131.4	130.2	124.1	190.9	186.3	169.3	231.3	280
290	257.6	132.3	136.4	135.3	129.2	197.8	193.1	175.5	239.6	290
300	266.5	137.2	141.5	140.4	134.2	204.8	199.9	181.8	247.9	300
310	275.4	142.2	146.6	145.5	139.4	211.8	206.8	188.1	256.3	310
320	284.2	147.2	151.7	150.7	144.5	218.7	213.6	194.4	264.6	320
330	293.1	152.2	156.8	155.8	149.7	225.7	220.5	200.8	272.9	330
340	302.0	157.3	162.0	161.0	154.8	232.7	227.4	207.1	281.2	340
350	310.9	162.4	167.2	166.3	160.1	239.7	234.3	213.5	289.5	350
360	319.8	167.5	172.5	171.5	165.3	246.7	241.2	219.2	297.8	360
370	328.7	172.7	177.7	176.8	170.6	253.7	248.1	226.3	306.1	370
380	337.5	177.9	183.0	182.1	175.9	260.7	255.0	232.8	314.5	380
390	346.4	183.1	188.4	187.5	181.2	267.7	261.9	239.2	322.8	390
400	355.3	188.4	193.7	192.9	186.0	274.0	268.2	245.1	330.2	400
410	364.2	193.7	199.1	198.3	191.9	281.7	275.8	252.3	339.4	410
420	373.1	199.0	204.6	203.7	197.3	288.8	282.8	258.8	347.7	420
430	382.0	204.4	210.0	209.2	202.7	295.8	289.8	265.4	356.0	430
440	390.8	209.8	215.5	214.7	208.8	302.8	296.8	272.0	364.3	440
450	399.7	215.2	221.1	220.2	213.7	309.9	303.8	278.6	372.6	450
460	408.6	220.7	226.7	225.8	219.2	316.9	310.8	285.2	380.9	460
470	417.5	226.2	232.3	231.4	224.8	323.9	317.7	291.8	389.2	470
480	426.4	231.8	237.9	237.1	230.5	331.0	324.7	298.5	397.2	480
490	435.3	237.4	243.6	242.7	236.0	338.0	331.7	305.1	405.8	490

one-fifth of that amount, which is 0.4 gram, or 400 milligrams. Then 171.83 divided by 400 milligrams gives 0.4297, which, multiplied by 100, gives 42.97, per cent of sucrose in the sweetened condensed milk.

TABLE 101.

A Comparison of Results by White's Method.

Batch	Sample	Per Cent Calculated from Lbs. of Sugar and Lbs. of Condensed Milk	Per Cent of Sucrose by White's Method	Percentages Obtained in 3 Separate Aliquots of the Filtrate from Sample No. 3 of Each Batch	
1	1	43.75	43.85		
2	1	45.40	45.25		
2	2	45.40	45.04		
2	3	45.40	45.16	45.03	45.02
3	1	42.81	42.98		
3	2	42.81	42.99		
3	3	42.81	42.96	42.94	42.85
4					
Condensed skim-milk	1	47.56	47.44		
	2	47.56	47.20		
	3	47.56	47.43	47.41	47.23

THE POLARIMETRIC METHOD FOR DETERMINING LACTOSE AND SUCROSE IN SWEETENED CONDENSED MILK.

The polarimetric method for determining sugars in sweetened condensed milk, originally developed by Harrison[10], is most accurate and reliable. It also requires less of the operator's time than the gravimetric methods, but there is danger of error occuring in the results unless the analyst understands his work and follows directions closely. For determining the percentage of lactose in milk products that have been highly heated, as in sterilized evaporated milk, it is safer to use the gravimetric method, as the high temperature to which the milk sugar has been subject is believed to cause a slight change of the specific rotation.

The polarimetric method is carried out as follows: For instruments reading in the Ventzke scale weigh into a 100 cc. flask

26.048 grams of the homogeneous sample, add boiling hot water and shake thoroughly until the substance is fluid and all sugar crystals are dissolved, allow to stand over night preferably at a temperature of 30° to 35° C. to destroy mutarotation. The addition of a little ammonia at this point does not seem to destroy all mutarotation. It is frequently advised to boil the solution before allowing it to stand over night. In such case the flask should be heated in a boiling water bath, as there is danger of superheating parts of the substance when using a flame or hot

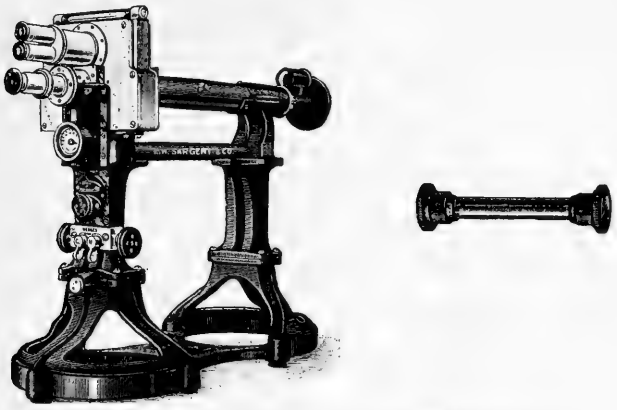


Fig. 144. Polariscope and Tube for Sugar Solution.
Courtesy E. H. Sargent & Co.

plate. After the solution has stood the proper length of time, cool to 15° C., add 3 cc. of acid mercuric nitrate, make up the volume to 100 cc. and add 4 cc. of water in excess for condensed whole milk, and 2.5 cc. in excess for condensed skim-milk. Shake thoroughly, filter, fill the polariscope tube with some of the filtrate and take the polariscope reading at about 20° C. within five minutes after adding the mercuric nitrate.

Place another portion of the filtrate in a flask, weigh and place the flask in boiling water for 7 minutes, cool rapidly, reweigh and make up any loss in weight due to evaporation. Filter, fill the polariscope tube with some of the filtrate and polarize to

obtain the invert reading, noting the temperature. The direct and invert reading should be made at the same temperature. If not exactly at the same temperature use the invert reading temperature in the formula.

The per cent of cane sugar is then obtained by the use of Clerget's formula:

$$S = \frac{100\ (D - I)}{142.68 - \frac{T}{2}}$$

S = Per cent of cane sugar

D = Direct reading

I = Invert reading

T = Temperature of invert reading

Lactose ($C_{12}\ H_{22}\ O_{11} + H_2\ O$) % = (D—S) × 1.266.

Bigelow and McElroy's Modification of the Polariscope Method. "Thoroughly mix the condensed milk and weigh 26.048 grams into a 100 cc. sugar flask, add water and boil. Add 30 cc. of mercuric iodide solution (53 grams of potassium iodide, 22 grams of mercuric chloride, and 32 cc. of glacial acetic acid dissolved in water and made up to a liter). Make up to the 100 cc. mark with water, mix thoroughly by shaking and filter through a dry filter. Polarize a portion of the filtrate after rejecting the first part that passes through.

"Weigh out another 26.048 gram quantity of the condensed milk, add water to dissolve and heat to 55° C. Add half a cake of compressed yeast to invert the sucrose and hold the mixture at 55° C. for five hours to complete the inversion. Add the clarifying solution, cool, make up to 100 cc. with water and filter. Obtain the invert reading of a portion of the filtrate. Calculate the percentage of cane sugar by the Clerget formula as follows:

$$S = \frac{A - b}{142.66 - \frac{t}{2}}$$

S = the per cent of cane sugar

A = the direct reading

b = the invert reading

t=temperature of the solution when the reading is taken.

In applying the method several determinations should be made and the average of these taken. Unless the condensed milk is mouldy or decomposed invert sugar should be absent from the sample.''

QUALITATIVE TEST FOR SUCROSE IN MILK POWDER.[12]

Preparation of Di-phenylamine. Dissolve 1 gram of di-phenylamine in 20 cc. of 95% alcohol and mix it with 60 cc. of glacial acetic acid and 120 cc. of dilute hydrochloric (equal parts of concentrated hydrochloric acid and water). The reagent should be prepared from its alcoholic solution within a few hours of being used.

Preparation of ammoniacal lead acetate. Add 560 cc. of water to 430 grams of neutral lead acetate and 130 grams of litharge, and boil for half an hour, cool, decant the clear solution, and reduce its specific gravity to 1.15 with cold, recently boiled, distilled water. Immediately before use mix 2 volumes of the lead acetate solution with 1 volume of ammonia (10 grams NH_3 in 100 cc.).

Operation. Warm one gram of the milk powder with 10 cc. of water in a test tube and add 10 cc. of freshly made ammoniacal lead acetate solution. Shake thoroughly and filter at once. To about 4 cc. of the filtrate, add about 8 cc. of the di-phenylamine reagent and place the tube in a boiling water bath for 10 minutes. The presence of sucrose is indicated by the formation of a blue color.

Milk containing 0.05 per cent of sucrose gives a faint tint of blue and 0.1 per cent gives a strong reaction.

TEST FOR RELATIVE SOLUBILITY OF MILK POWDER.

Reconstitute the milk powder in the following proportion:

9 parts of milk powder to 91 parts of water when testing skim-milk powder.

12 parts of milk powder to 88 parts of water when testing whole milk powder.

Using the "Wizard" or "Lorenz" Sediment Tester proceed as follows:

Dry and weigh all disks carefully.

Use about 200 cc. of the reconstituted milk and make sediment test in the regular way, passing the milk through the filter twice.

Rinse tester thoroughly with distilled water before removing disk.

Dry disk thoroughly and weigh.

The increase in weight of the disk divided by the weight of milk powder contained in the 200 cc. solution multiplied by 100 equals the per cent of insoluble substance in the milk powder.

LECITHIN DETERMINATION.

The lecithin in milk may be determined by the method of Bordas and Rackowski.[13]

Procedure. To a mixture consisting of 100 cc. of 95 per cent alcohol, 100 cc. of water and 10 drops of acetic acid add very slowly with constant stirring 100 cc. of the milk. Separate the coagulum by filtration, close the lower end of the funnel tube and add 50 cc. of warm absolute alcohol. By means of a platimum spatula stir the coagulum in the alcohol and after a few minutes open the funnel tube and allow the alcohol to run into the filtrate. Wash the coagulum three times in this manner. Remove the alcohol from the filtrate by distillation and dry to drive off the last traces. Extract the residue with a mixture of equal parts of ether and alcohol, filter, and heat on a water bath until all ether is evaporated. Saponify the remaining alcoholic solution with caustic potash and add dilute nitric acid to decompose the soap formed. Heat the mixture to boiling and evaporate on the water bath to dryness, add 10 cc. of concentrated nitric acid, then add powdered potassium permanganate until the color remains for a short time. Add a few drops of a dilute solution of sodium nitrite to dissolve any manganese oxide that forms and boil. Precipitate the phosphoric acid by adding ammonium molybdate solution and after it has stood for at least 12 hours filter, and dissolve the precipitate with ammonium hydroxide. Wash the filter with hot water, cool, and add hydrochloric acid until nearly neutral. Add a small excess of magnesia mixture, drop by drop, with constant stirring. Let stand for 15 minutes, then add about 10 cc. of

concentrated ammonia, and after standing at least four hours filter. Wash the precipitate with 3 to 5 per cent ammonia solution to remove chlorides, ignite, cool in a desiccator and weigh as magnesium pyrophosphate $Mg_2P_2O_7$. Multiply the weight by 0.36036 to obtain the magnesia (MgO), and the phosphoric acid multiplied by 7.27 gives the quantity of lecithin.

THE CITRIC ACID CONTENT OF MILK AND METHODS FOR DETERMINING IT.

Fresh milk contains between 0.1 and 0.2 per cent of citric acid, the content varying primarily according to the individuality of the cow from which the milk is obtained. It is probable that the citric acid content may also be affected slightly by the feed of the cow. The acid is present in milk in the form of salts of the alkaline elements, but investigators are not in definite agreement as to which of these elements are united with it. During the aging of milk and the development of lactic acid by the action of bacteria, the citric acid content gradually decreases. Other factors may also influence the rate at which it disappears.

Supplee and Bellis[14] after making a study of the citric acid content of fresh milk and concentrated milk products make the following statement:—

"There is apparently no effect upon the citric acid content of milk caused by heating during the manufacture of evaporated, condensed, and dried milks. The results indicate that the amounts found in these products, if subject to variation, must be attributed to causes other than heat."

The methods used by Supplee and Bellis for determining the citric acid content and a table showing the relative accuracy of the methods follow.

Determination of Citric Acid in Milk.—50 c.c. of milk are treated with 10 cc. of dilute sulfuric acid (1:1) and thoroughly agitated. 2 cc. of 40 per cent potassium bromide solution and 20 cc. of a solution of phosphotungstic acid are then added. After a thorough mixing, the precipitate is separated by filtration. To the perfectly clear filtrate in an Erlenmeyer flask is added an excess of freshly prepared saturated bromine water (usually between 5 and 10 cc.). The mixture is then placed on the water bath at a temperature of from 48-50° C. for about 5 minutes. After re-

moving from the bath, add rapidly from a burette 25 cc. of potassium permanganate solution (5 per cent) drop by drop with frequent interruptions, and with constant and vigorous shaking, avoiding a temperature during the oxidation exceeding 55° C. Set the flask aside until the hydrated peroxide of manganese begins to settle. The supernatant liquid should be dark brown showing an excess of permanganate. Add more permanganate if an excess is not indicated. When the precipitation assumes a yellow color and most of it is dissolved, add drop by drop a clear solution of ferrous sulfate until the hydrated peroxide of manganese and excess of bromine are removed. Allow the solution to cool, shaking occasionally. Allow the mixture to stand over night. Collect by means of gentle suction on a tared Gooch crucible provided with a thin pad of asbestos previously dried over sulfuric in a vacuum desiccator; wash with water slightly acidified with sulfuric acid and finally wash twice with water. Dry the precipitate to constant weight over sulfuric acid in a vacuum desiccator protecting the precipitate from strong light. The weight of the precipitate multiplied by the factor 0.424 give the equivalent weight of anhydrous citric acid in the sample.

Determination of Citric Acid in Milk Powder.—Weigh 5 gm. of powder into a beaker and reconstitute with 45 cc. of warm water. Mix thoroughly and proceed as with liquid milk.

Determination of Citric Acid in Sweetened Condensed Milk.—Weigh out 25 gm. of the sample and add 200 cc. of 95 per cent alcohol. Mix thoroughly and filter. To the filtrate add enough 0.25 N barium hydroxide to almost neutralize the solution and then 5 cc. of 50 per cent barium acetate in order to insure an excess of barium. Add about 150 cc. of 95 per cent alcohol and reflux until the precipitate settles readily after being shaken. Filter and thoroughly wash the precipitate in the flask and on the paper with 95 per cent alcohol. Transfer the precipitate from the filter to the flask with a jet of hot water. Boil until alcohol can no longer be detected by odor and add enough sulfuric acid (1:5) to precipitate all of the barium originally present and to allow 2 cc. in excess. Evaporate to a volume of 60 to 70 cc.; cool and add an excess of bromine water. Filter and add 10 cc. of potassium bromide, then place on the water bath at a temperature of 48-50° C. and proceed as with liquid milk.

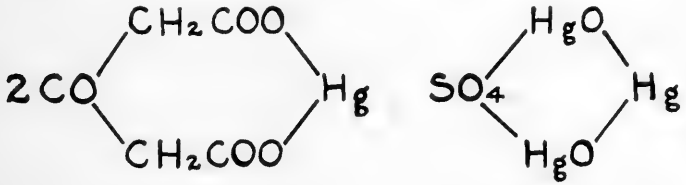
TABLE 102.

Percentage of Citric Acid Recovered from Milk Products.

	Liquid Milk		Liquid Milk and Sugar		Evaporated Milk		Condensed Milk	
	No. 1	No. 2	No. 1	No. 2	No. 1	No. 2	No. 1	No. 2
Original	0.132	0.129	0.131	0.130	0.202	0.204	0.096	0.090
After adding 0.02 per cent							0.110	0.104
After adding 0.05 per cent	0.179	0.180	0.182	0.179	0.252	0.253	0.143	0.148
After adding 0.10 per cent							0.190	0.197
After adding 0.15 per cent	0.279	0.279	0.279	0.275				

"The relative accuracy of these methods is shown in Table 102 in which is given the results of duplicate determinations on liquid milk with and without sugar, on evaporated milk, and on sweetened condensed milk; also duplicate results from each of these products after known amounts of citric acid in the form of sodium citrate had been added. It will be noted that the maximum variation in duplicate results does not exceed 0.006 per cent; it is believed, therefore, that any significant variations occurring in the products examined were easily detected by the methods used.

Second Method for Determining Citric Acid in Milk Powder. This method[15] depends upon the oxidation of citric acid to acetone di-carboxylic acid, and the precipitation of a double salt of mercury acetone di-carboxylate and basic mercury sulphate.



Five grams of milk powder are made into a paste with warm water and washed into a 200 cc. calibrated flask, with about 120 cc. of water. Cool to room temperature and add 50 cc. of the mercury reagent* and 2 cc. of Kahlbaum's phospho-tungstic acid

*Preparation of the Mercury Sulphate Reagent: Boil 68.5 grams of mercuric sulphate in a liter of water and add a mixture of equal parts of concentrated sulphuric acid and water until the basic salt at first precipitated is completely dissolved. Boil to less than a liter, filter, cool, and make up to a liter. Five c. c. of the reagent should require 7 to 8 c. c. of normal sodium hydroxide to give a permanent turbidity.

solution. Make the volume up to 200 cc. with water. Thoroughly mix and filter through dry paper, refiltering the first portions of the filtrate. Transfer 100 cc. of the clear filtrate to a beaker and raise to the boiling point over a flame. Remove the flame and add 1% potassium permanganate solution drop by drop with constant stirring until the precipitate assumes a brown color owing to precipitated manganese hydroxide. Place the flame under the beaker and add hydrogen peroxide solution (10 to 20 volumes) to the boiling solution, drop by drop, to remove the precipitated manganese. Five to 10 drops should usually be sufficient. Collect the precipitate on a Gooch crucible, wash with water, dry at 100° C. and weigh. Multiply the weight obtained by 0.271 to obtain the weight of citric acid ($C_6H_8O_7$).

STANDARD SOLUTIONS.

In volumetric methods of chemical analysis solutions of known chemical strength are employed. They are called "standard" solutions. When a standard solution contains in 1000 cc. a quantity of the active reagent chemically equal to one gram of hydrogen it is defined as a "normal" solution. As 1000 cc. of a normal solution of any reagent is chemically equal to one gram of hydrogen it follows that equal volumes of normal solutions of different reagents are chemically equal to each other. The term "normal" as applied to solutions of chemical reagents is sometimes expressed by the symbol "N/1." As normal solutions are rather concentrated for use in making accurate analyses, solutions of one-tenth the normal strength are usually employed. Solutions of one-tenth normal strength may be expressed by the symbol "N/10."

A standard acid solution and a standard alkaline solution are a necessity in every chemical laboratory. Since any error in their accuracy will cause a corresponding error in results obtained by their use great care should be taken to determine their exact strength. Any soluble acid or base may be used in making a standard acid solution or alkali solution respectively. But hydrochloric acid or sulphuric acid are usually preferred for making the stock standard acid solution and sodium or potassium hydrate are preferred for making the standard alkali solution.

First Method. When it is desired to make up a hydrochloric acid solution of tenth-normal strength, first make up a solution of approximate strength, making certain that it is somewhat stronger than is finally desired. Then, after determining its exact strength by the method given below, calculate and add the volume of water necessary to bring the solution to tenth-normal strength.

Operation: When the specific gravity of the concentrated hydrochloric acid, from which the standard solution is to be made, is 1.170 or more place about 9.5 cc. of it in a liter flask graduated at the 1000 cc. mark. Fill the flask to the mark with distilled water and mix the solution thoroughly. Place 25 cc. of the solution in a glass stoppered, 150 cc. Erlenmeyer flask and add 75 cc. of distilled water. Add slowly and with constant agitation a 5 per cent solution of silver nitrate until precipitation is complete and a slight excess of silver nitrate is present. About 15 cc. of the silver nitrate solution will usually be sufficient. The precipitate should be protected from the light as much as possible by wrapping the flask in a piece of black cloth during the whole operation. While it is very important to have a slight excess of silver nitrate present in order to obtain proper flocculation of the precipitate, any large excess should be avoided as the precipitate is slightly soluble in a silver nitrate solution. Immediately after adding the silver nitrate, stopper the flask, cover it completely with the black cloth and shake it vigorously for five minutes. The precipitate should then settle quickly and leave a clear supernatant liquid that is entirely free from cloudiness. Filter with the aid of suction through a previously prepared, dried and weighed Gooch filter. Carefully break up the compact mass of silver chloride on the filter with a small glass rod and rinse the last traces of precipitate from the flask and onto the filter using distilled water containing one cc. of concentrated nitric acid per 100 cc. of water. Continue to wash the precipitate with the acidified water, to remove the last traces of silver nitrate, until a few cc. of the water passing through shows no turbidity upon the addition of a few drops of hydrochloric acid. When fissures appear in the precipitate during the washing process close them by means of a glass rod. After washing is completed place the crucible in an oven at a temperature of about 140° C. for 2 or 3

hours, cool in a desiccator and weigh. Heat again for one hour, weigh, and repeat until constant weight is obtained.

Having obtained the exact weight of the silver chloride precipitate the weight of hydrochloric acid in one cc. of the solution may then be obtained by applying the following rule:

The molecular weight of one substance is to the molecular weight of a second substance, as the actual weight in grams of the first is to the actual weight in grams of the second, when the molecules are chemically equal.

The reaction between the hydrochloric acid and the silver nitrate is shown in the equation:

$$HCl+AgNO_3=AgCl+HNO_3$$

The molecular weight of AgCl is 143.33 and the same for HCl is 36.45. Assuming that the silver chloride precipitate obtained above weighed 0.3828 gram the following proportion may be formed:

$$143.33 : 36.45 :: 0.3828 : X$$

$$X=\frac{(36.45\times 0.3828)}{143.33}=0.09734,$$ or gram of HCl in 25 cc. of the acid solution.

$0.09734 \div 25=0.003893$, or gram of HCl in one cc.

The weight of hydrochloric acid in one cc. of a tenth-normal solution is 0.003645, therefore, the acid solution containing 0.003893 grams is slightly too strong. The volume to which the remaining 975 cc. should be made up by the addition of distilled water may be estimated by the following equation:

$$0.003645 : 0.003893 :: 975 : X$$

$$X=\frac{(975\times 0.003893)}{0.003645}=1024$$

Then, 1024—975=49, or cc. of water to be added to the 975 cc. of the solution to make it an exact tenth-normal hydrochloric acid solution.

Second method. Another method for making a tenth-normal hydrochloric acid solution, while probably not so accurate as the one described above, is often convenient to use. It is based on the fact that when a solution containing more than 20.2 per cent of hydrochloric acid in water is boiled the percentage of

acid will decrease until exactly 20.2 per cent of acid is present. At that point the acid and water evaporate in such proportion that the boiling liquid remains constant in composition, containing very close to 20.2 per cent of the acid and having a specific gravity of 1.10 while any liquid remains unevaporated. Then 180 grams of the solution will contain very close to 36.46 grams of hydrochloric acid, which is the weight of absolute acid that is contained in 1000 cc. of a tenth-normal solution.

Operation:—Place 200 cc. of distilled water in a medium tall beaker, and place a mark on the outside of the beaker at the upper surface of the water, using a pencil for marking on glass. Add to the water in the beaker 300 cc. of concentrated hydrochloric acid. Boil the liquid until so much has evaporated that its upper surface is again on a level with the pencil mark, or until the beaker contains approximately 200 cc. Cool the liquid to room temperature and weigh out 180 grams of it. Dilute the 180 grams to 1000 cc. with distilled water. The resulting solution is a normal solution of hydrochloric acid, and 100 cc. of it diluted to 1000 cc. with distilled water gives a tenth-normal acid solution.

Standard alkaline solution:—A normal or tenth-normal alkaline solution may be made by standardizing an alkaline solution of unknown strength against the tenth-normal acid solution. The process may be carried out as follows: Weigh in a closed container about 44 grams of chemically pure caustic soda (stick form). Dissolve the caustic soda in distilled water and make the solution up to 1000 cc. This will give a solution a little stronger than normal. Dilute exactly 10 cc. of it to 100 cc. and titrate exactly 10 cc. of the tenth-normal acid solution with the diluted alkaline solution, using phenolphthalein as an indicator and running the alkaline solution from a burette into the ten cc. of acid until exact neutrality is reached. Less than 10 cc. of the alkaline solution will be required if the work is done correctly. Next calculate the volume of water to add to the normal alkaline solution.

Problem: Suppose it required 9.5 cc. of the alkaline solution to neutralize 10 cc. of the acid solution.

How much distilled water must be added to the alkaline solution to dilute it to proper strength?

1000—10.0=990, cc. of alkaline solution remaining.

990÷9.5=104.

104×.5=52, cc. of distilled water to be added to the alkaline solution. 100 cc. of this standardized normal alkaline solution diluted to 1000 cc. will give a tenth-normal alkaline solution and 10 cc. of the latter should exactly neutralize 10 cc. of the tenth-normal acid.

TENTH-NORMAL SOLUTION OF SILVER NITRATE.

The molecular weight of silver nitrate is 169.89. As silver is a univalent element and the molecule of silver nitrate contains only one atom of it, 16.989 grams of pure silver nitrate in 1000 cc. of water solution gives a tenth-normal solution. The so-called chemically pure silver nitrate available at chemical supply houses usually contains traces of water and other foreign substances. When it is used in making up a standard solution allowance must be made for these impurities. A number of determinations have shown that 17.6 grams of the so-called chemically pure silver nitrate are usually required to make a liter of tenth-normal silver nitrate solution. After weighing out 17.6 grams of silver nitrate, dissolving it in water and making the solution up to 1000 cc., its exact strength may be determined by checking it against tenth-normal hydrochloric acid as follows:

Neutralize 25 cc. of tenth-normal hydrochloric acid with dilute sodium hydroxide. Add a couple of drops of 10% potassium chromate solution as indicator and run in, from a graduated burette, some of the silver nitrate solution until a drop or two changes the color from a light yellow to a permanent light brown color, which shows that all of the chlorine has combined with the silver and that there is present a trace of silver in excess to form red silver chromate. If 25 cc. of the silver nitrate solution is required to neutralize 25 cc. of the tenth-normal hydrochloric acid, the former solution is of tenth-normal strength. If less than 25 cc. is required the solution is too concentrated and may be diluted to the proper strength by calculating and adding the necessary volume of water. Then again check against tenth-normal hydrochloric acid as in the first instance.

ACID TESTS OF MILK AND CREAM.

Since the percentage of acid in dairy products has an important bearing on the quality and method of handling the products and the use to which they may be put, the acid test becomes of importance in the dairy industry. The test is based on the principle that a definite weight of a given alkali unites with a definite weight of a given acid. Therefore, when the weight of an alkali required to neutralize the lactic acid in a definite weight of milk is known, the weight and percentage of acid in the milk may be readily calculated.

Sodium hydrate is the substance commonly used in making the neutralizing solution used in the acid test. The weight of sodium hydrate (NaOH) chemically equal to 1 gram of hydrogen is 40 grams, and 1 cc. of a normal solution of it contains 0.04 gram. The weight of lactic acid ($C_3H_6O_3$) chemically equal to one gram of hydrogen is 90 grams, and one cc. of a normal solution of it contains 0.09 gram. Since equal volumes of normal solutions are chemically equal to each other, 0.04 gram of sodium hydrate is equal to 0.09 gram of lactic acid. As normal solutions are too concentrated for accurate work, solutions of one-tenth the normal strength are commonly used. These are known as tenth-normal solutions. One cc. of tenth-normal sodium hydrate solution contains 0.004 gram and is chemically equal to 0.009 gram of lactic acid.

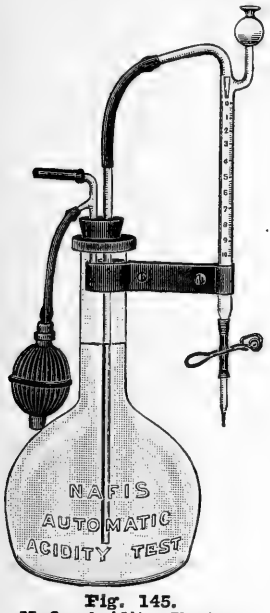


Fig. 145.
Nafis Acidity Tester.
Courtesy
Louis F. Nafis, Inc.

In making an acid test a known weight of the milk is neutralized with tenth-normal sodium hydrate solution using phenolphthalein as an indicator. The cc. of tenth-normal solution required are multiplied by 0.009 to obtain the weight of lactic acid. The product thus obtained divided by the weight of milk neutralized, and the quotient multiplied by 100 gives the percentage of acid in the milk.

A number of different titration tests for determining the percentage of acid in milk have been devised. They aim to simplify the operation and remove factors that might cause error. Some of the more important tests follow.

Mann's acid test:—Measure 50 cc. of milk or cream from a pipette into a beaker. Draw the pipette full of water and run the water into the beaker, add 7 or 8 drops of phenolphthalein indicator solution and run in from a burette tenth-normal sodium hydroxide solution with constant stirring until the pink color that develops does not disappear within 15 seconds. Calculate the per cent of acid by multiplying the cc. of tenth-normal alkali required by 0.018. One cc. of the alkaline solution neutralizes 0.018% of lactic acid when 50 cc. of milk is used in the test.

The Publow Acid Test:—Measure 8.8 cc. of milk or whey into a white cup, add 3 or 4 drops of phenolphthalein indicator solution and run in, from a graduated burette, tenth-normal sodium hydroxide solution with constant stirring until a slight permanent pink color develops. Each cubic centimeter of the tenth-normal alkali required equals 0.10% of acid in the milk. The test is simple, accurate, and uses a very small amount of neutralizing solution. In testing cream weigh 9 grams into the white cup then proceed as in testing milk.

The apparatus as originally devised consists of a bottle, for holding the alkaline solution, which has a hole drilled through the bottom. A brass tube is sealed in the hole and provided with a pinch cock which permits the alkaline solution to be drawn from the bottle into a burette suspended from the shelf on which the bottle rests.

Farrington's Alkaline Tablet Test:—In this test alkaline tablets are used for making up the neutralizing solution. Each tablet contains indicator and sufficient alkali to neutralize .03492 gram of lactic acid. When 5 tablets are dissolved in water and the solution is made up to 97 cc. one cc. of it will neutralize 0.01 per cent of lactic acid if a Babcock pipette full of the milk, or 18 grams are used in making the test. A tenth-normal alkaline solution may be made by dissolving the tablets in water at the rate of 24 tablets for each 100 cc. of water. As the strength of the tablet solution will change if held indefinitely, it is necessary to make up the solution on the day that it is to be used.

Operation:—For routine work in testing milk or cream, dissolve 5 tablets in distilled water or rain water and make the solution up to 97 cc. Fill a burette with the tablet solution and run it slowly into 18 grams of milk, or cream, that has been placed in a white cup, until the acid is neutralized. The milk may be measured into the cup with a Babcock pipette, but for obtaining maximum accuracy in testing cream, the test sample should be weighed. Stir the contents of the cup while the tablet solution is running in. When a permanent very light pink color develops, all of the acid has been neutralized and no more solution should be run in.

Each cubic centimeter of the solution used equals 0.01 per cent of acid. Thus, when 20 cc. of the tablet solution is required to neutralize the acid in 18 grams of milk, the per cent of acid present is $20 \times 0.01 = 0.20$ per cent.

The Alakali Required to Neutralize One Hundred Grams of the More Common Dairy Products and Its Lactic Acid Equivalent.

When phenolphthalein is used as the indicator the volume of tenth-normal alkali required to neutralize 100 grams of fresh milk may vary quite widely for samples of milk from different sources. But rarely would less than 10 cc., or more than 25 cc. of the alkali be required, the average being about 16 cc. The amount of alkali required appears to be largely independent of the amount of the principal milk solids present, but it is more directly affected by the amount of phosphates. The richer milk does not always have the higher phosphate content.

For milk and milk derivatives that have been concentrated or allowed to undergo acid development, the volume of tenth-normal alkali required to neutralize 100 grams may be largely increased as shown in the table that follows:

TABLE 103.
Titratable Acidity of Various Dairy Products.

NAME OF PRODUCT	Approximate Average Percentages		Number of cc. of N/10 Alkali Per 100 Grams of Product	Acid Equivalent Calculated as Per Cent Lactic Acid
	Fat	Total Solids		
Whole milk, freshly drawn	3.70	12.30	17.0	.153
Skim-milk, fresh	.10	8.90	18.0	.158
Cream, fresh	18.00	25.60	14.5	.130
Cream, fresh	22.00	29.25	13.8	.126
Cream, fresh	30.00	36.50	12.4	.111
Cream, fresh	40.00	45.55	10.6	.095
Whole milk, sour, curdled upon heating	3.70	12.30	31.0	.280
Buttermilk from churn—				
From sweet cream	.50	9.50	24.4	.22
From ripened cream	.30	9.30	77.7	.70
Buttermilk prepared from skim-milk using pure cultures, ten per cent water added	.18	8.10	83.2	.75
Buttermilk condensed to semi-solid condition	2.50	32.50	511.0	4.60
Whey from American cheddar cheese when drawn from curd	.30	6.8	31.0	.28
Evaporated milk just after condensing and before sterilizing	8.00	26.15	38.8	.35
Evaporated milk just after sterilizing	8.00	26.15	42.2	.38
Evaporated milk after being in cold storage one year	8.00	26.15	46.6	.42
Condensed skim-milk plain, freshly prepared	.60	25.50	55.5	.50
Sweetened condensed skim-milk		70.00	62.2	.56
Sweetened condensed whole milk	8.00	72.50	42.2	.38
Powdered skim-milk	1.50	97.50	205.5	1.85
Powdered whole milk	28.00	97.50	144.4	1.30
Powdered cream from cream testing 18 per cent fat	70.50	97.50	77.7	.70
Powdered buttermilk	5.00	97.50	866.6	7.80
Butter	83.00	85.50	27.7	.25
Cheese, American cheddar after ripening	34.00	63.00	222.2	2.00
Cheese, cottage, freshly prepared	3.70	27.20	233.3	2.10
Ice cream mix, freshly prepared	8.00	34.00	40.0	.26
Ice cream mix after aging at 40° F. for 24 hours	8.00	34.00	42.2	.28
Ice cream mix freshly prepared	12.00	36.00	31.1	.25
Ice cream mix after aging at 40° F. for 24 hours	12.00	36.00	32.2	.27

The Milk Sediment Test:—The sediment test is used for the purpose of collecting the insoluble dirt in milk. The test has some value as a factor in determining sanitary quality, and also makes it possible to demonstrate to careless dairymen the need for exercising constant vigilance in handling milk. The test is usually applied at the milk receiving station.

Fig. 146. Wizard Sediment Tester.

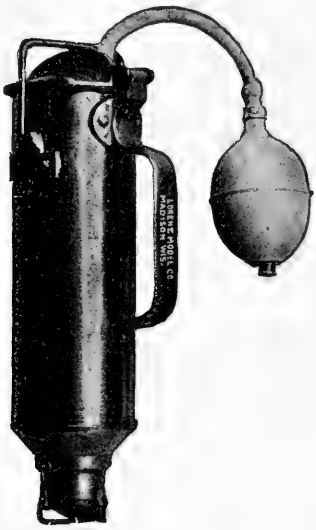


Fig. 147. Wisconsin Sediment Tester.

There are two different forms of apparatus on the market. In the "Wizard" instrument the essential part consists of a cotton disk one inch in diameter that rests on a wire strainer held in place by a metal band so constructed that it can be readily adjusted to the top of a milk bottle. The apparatus is also provided with a side tube and rubber bulb for passing air into a milk bottle when the apparatus is attached. In applying the test, the apparatus, with a cotton disk in place, is adjusted to the top of a milk bottle, or similar container which is full of milk. The bottle is then inverted and one pint of the milk is allowed to pass through the cotton disk. The insoluble substance in the milk collects on the white cotton disk where it is plainly visible. The

disk may be readily removed and replaced so that testing successive samples may proceed quickly. The disks containing the visible dirt may be attached to sheets of paper, dried and held for comparison and reference.

The Lorenz (Wisconsin) sediment tester is similar to the Wizard but is connected to a copper holder for the milk.

In the other form of apparatus some of the milk is placed in a test tube that is somewhat pointed at the bottom. The tube is then whirled for 10 minutes in a centrifuge at a speed that throws down the insoluble sediment and collects it in the bottom of the tube. The amount of sediment present may then be estimated and such further examination made as the case demands.

The Alcohol Test.—This test is used to some extent at milk receiving plants and condenseries to assist in distinguishing abnormal milk and milk that, after condensing, will not withstand temperatures high enough to insure sterilization without forming objectionable curd. The test is carried out by placing 2 cc. of the milk in a small test tube, adding an equal volume of 68 to 75 per cent alcohol, and mixing by inverting twice while closing the tube with the finger.

If a flakey white precipitate forms it is thought to indicate that the milk is abnormal. The amount of the precipitate and the size of the flakey particles forming it, indicate the degree of abnormality. When the mixture is shaken in a way that causes it to splash against the sides of the test tube for about an inch above the surface of the liquid, the flakey particles become attached to the wall of the test tube where their number and size may be noted.

Alcoholic solutions varying in strength may be used in making the test, but in practical work a 68 or 70 per cent solution gives good results. It is important to know definitely the strength of the alcoholic solution, since a difference of 3 or 4 per cent in concentration may have considerable effect on the result of the test. Experiments carried out by one of the authors indicate that milk which gives a negative test when fresh will give a positive test when between 0.015 per cent and 0.02 per cent of real acidity has developed, and that the result is independent of the "apparent" acidity of the fresh milk.

Dahlberg and Garner,[16] using a 75 per cent alcoholic solution on 90 samples of milk of varying acidity, 45 of which showed coagulation by the alcohol test, found that 43 of the 45, when evaporated and sterilized at 112.8° C. (235° F.) for 30 minutes, showed curdiness after shaking.

The 45 samples that gave a negative reaction with the 75 per cent alcohol, after evaporation and sterilization, showed only 3 curdy samples after shaking. The results of the experiment and comments by the investigators follow:

TABLE 104.

Comparison of Alcohol and Acid Tests at Grove City Creamery. Milk concentrated 2¼ to 1 and Sterilized at 235° F. for 30 minutes. Effect of Sterilization Noted After shaking for 1 minute.

ACIDITY	Coagulation with 75 Per Cent Alcohol			No Coagulation with 75 Per Cent Alcohol		
	Total Samples	Effect of Sterilization		Total Samples	Effect of Sterilization	
		Curdy	Not Curdy		Curdy	Not Curdy
Per cent						
0.14 to 0.15.....	3	3	0	.....	.....	.....
0.15 to 0.16.....	5	5	0	1	0	1
0.16 to 0.17.....	10	8	2	9	0	9
0.17 to 0.18.....	11	11	0	12	1	11
0.18 to 0.19.....	10	10	0	11	1	10
0.19 to 0.20.....	5	5	0	10	0	10
0.20 to 0.21.....	1	1	0	2	1	1
Total.....	45	43	2	45	3	42

"It seems quite certain that there is some condition of raw milk coagulating with 75 per cent alcohol, making it impossible to sterilize without getting a curdy finished product, for such milks when evaporated and sterilized give a much firmer coagulation than those showing a negative reaction with 75 per cent alcohol. In some instances the coagulation, even at the lower temperatures used, is such that the product turns to a hard cheesy mass incapable of improvement with long-extended shaking. Figure 1, showing the type of curd obtained in sterilization,

indicates clearly the difference which must exist in the condition of milk coagulated with 75 per cent alcohol. Only 6.7 per cent of the samples made from milk coagulating with alcohol gave a soft curd, the remainder giving either a firm or a hard curd, both of which are as a rule difficult to shake out to give a product showing no curdiness. With the evaporated samples from raw milk not coagulating with 75 per cent alcohol 88.9 per cent gave either a soft curd or no coagulation at all, the remaining 11.1 per cent giving a firm curd. The soft curds shake out very easily, giving a smooth-bodied product of good consistency showing no curdiness."

From the results obtained in the above experiment and further work along somewhat similar lines the investigators drew the following conclusions:

"1. The acid test as ordinarily used will reflect a portion of the unsatisfactory milks, but as a whole it is unreliable and inadequate as a means of determining the quality of milk for condenseries where evaporated milk is manufactured.

"2. There is no direct relation between the coagulation of milk with alcohol and its titratable acidity, but milks high in titratable acidity as a result of fermentation will in the large majority of cases show coagulation with alcohol.

3. The alcohol test shows good possibilities as a practical and reliable test for determining the quality of milk for condenseries making evaporated milk. How generally the test can be applied will require further investigation at other condenseries. It is believed that it can be used to advantage in a large majority of average factories."

Ayers and Johnson[17] state that "when the 68% alcohol test is positive with a sample of market milk, it is evident that there is some change in the milk from normal. In some cases it may be due to an increased acidity and in consequence a change in the casein of the milk, due to bacterial action. In other cases, it may be due to a pure rennet fermentation or there may be a combination of an acid-and-rennet fermentation. In such cases the bacteria count would undoubtedly be high. However, there still remains to be explained the reason for a positive alcohol test in samples of market milk with a low bacteria count and low acidity."

HEATED MILK, PRESERVATIVE AND COLOR TESTS

Heated Milk Test. Storch has shown that milk when heated to 79° C. (174°F.) loses its power to reduce peroxides, and he has devised a test for distinguishing between raw milk and milk that has been heated to the temperature named above. He used hydrogen peroxide and paraphenylenediamine hydrochloride. Calcium peroxide is quite stable and serves as well or better than hydrogen peroxide. To apply the test place about 5 cc. of the milk or cream in a test tube or other container, add from the point of a pen knife a little paraphenlyenediamine hydrochloride about the size of a kernel of wheat and an equal volume of calcium peroxide, shake thoroughly and in a very short time the mixture will turn to a blue color if the milk has not been heated. If an excess of calcium peroxide is used the milk develops a pink or red color.

The same test may be used to distinguish between butter made from raw or pasteurized cream provided the heated cream is raised to 79° in the process. In applying the test, fill a test tube with butter and place it in water at a temperaure near 130° F. until the fat melts and the water and casein in the butter settle to the bottom. Pour off most of the fat and then complete the test as directed for milk.

Evenson's Color Test[18] for "Remade Milk and Cream": Procedure for Milk. Place 25 cc. of milk in a 250 cc. beaker, add 25 cc. of distilled water, warm to 25 or 30° C. and precipitate the curd by adding 4 cc. of 10 per cent acetic acid. Add 200 cc. of distilled water, let settle for some time, decant the supernatent liquid through a 166 mesh bolting cloth. Wash back into the beaker any curd left on the cloth and fill the beaker with water, allow the curd to settle and decant as before. Repeat the washing 3 or 4 times, then transfer the curd to a 15 cm. rapid double filter and wash at least 3 times, filling the funnel nearly full each time and breaking the curd up with a glass rod to facilitate the washing. Remove the filter with contents from the funnel and squeeze out the water. Place the curd in vials of clear glass 17 by 100 mm., add 10 cc. of 5 per cent sodium hydroxide, and, using a glass rod, break up and mix the curd with the liquid.

The curd from remade milk will begin to develop a yellow color in about two hours; the final observation being made after

several hours. For comparison, make in like manner a test on a sample of pasteurized milk.

Procedure for Cream. Add 15 cc. of water to 15 cc. of cream and warm to 30 or 35° C., precipitate the curd with 2 cc. of 10 per cent acetic acid, filter and wash. Remove most of the fat by washing, first with 25 to 40 cc. of 95 per cent alcohol, then with 50 to 75 cc. of pure acetone, adding small amounts at a time and breaking up the curd with a glass rod after each addition. Wash thoroughly with water to remove acetone, drain, place in vials like those used for milk and add 10 cc. of sodium hydroxide. Make, in like manner, a comparative test on a sample of pasteurized cream.

Hener's Test for Formaldehyde. Place about 10 cc. of milk in a test tube or Babcock test bottle and add an equal volume of commercial sulphuric acid, but do not shake. A bluish violet zone forms where the acid comes in contact with the milk when formaldehyde is present. Leonard states that pure acid will not give the test and advises the addition of a few drops of a 10% solution of ferric chloride before adding the acid. The test is very delicate, showing one part of formaldehyde in 200,000 parts of milk. If a large amount of formaldehyde is present the color change may not take place, therefore, when testing suspected milk if a negative test is obtained, add a volume of water equal to the volume of milk and repeat the test.

Hener's test does not give the color change in the presence of a nitrite. For this reason nitrites are sometimes added to formaldehyde that is to be used surreptitiously for the purpose of preserving market milk. In making a test it is necessary to first remove the nitrite. In a report to the local Government Board (London) Monier-Williams advises the following procedure: Mix 5 c. c. of milk with 5 c. c. of water and add 0.5 c. c. of a 10% solution of urea, and 1 c. c. of a 5% solution of sulphuric acid. Heat the mixture in boiling water for 2 minutes, cool and apply the test as described above for formaldehyde in milk when nitrites are absent.

Vanillin also gives a color reaction similar to that produced by formaldehyde, therefore the test cannot be applied to cream flavored with vanilla.

Quantitative Determination of Formaldehyde in Solution. Robinson [19] states that he has found that the method for the determination of formaldehyde in formaldehyde solutions as outlined in the Journal of the Association of Official Agricultural Chemists, Numbers 1, Volume II, Part 11, page 17, gives erroneous results. He states that the errors are probably due to loss by volatilization or to incomplete oxidation. For accurate determinations he recommends the following method:

"Measure 25 c. c. of N/1 sodium hydroxide into a 200 c. c. Erlenmeyer flask and add 50 c. c. of hydrogen peroxide. Weigh out accurately 1.5 to 2.0 grams of the formaldehyde solution under examination, and add by means of a pipette, allowing the point to reach nearly to the liquid in the flask. Set aside for several hours, or preferably, over night. Titrate the excess sodium hydroxide with N/1 acid, using purified litmus solution as an indicator. One c. c. of N/1 sodium hydroxide is equivalent to 30.02 milligrams of formaldehyde."

It is important to use sufficient hydrogen peroxide solution, and if it is not neutral it should be made so with sodium hydroxide, using the litmus solution as an indicator.

Schmidt's Test for Sodium Carbonate: Mix 10 c. c. of milk with 10 c. c. of alcohol and add a few drops of a 1 per cent rosolic acid solution. Mix and in the presence of sodium carbonate a rose-red color develops. Pure milk develops a brownish-yellow color.

Detection of Boracic Acid or Borax. Place about 10 c. c. of milk or cream in a platinum dish, make alkaline with sodium hydroxide solution, evaporate to dryness and burn to an ash, add a few drops of concentrated hydrochloric acid to make strongly acid and about one cc. of water. Stir with a glass rod then place strips of tumeric paper in the dish so that one end of the strip extends up over the edge. After soaking for a few minutes remove the strips and allow to dry on clean porcelain or glass at a gentle heat. When dry the tumeric paper will take on a characteristic deep brown-red color which will turn to a dark olive-green when treated with a little alkali.

When an inexperienced operator is making the test on a suspected sample a comparative test should be run in like manner on a sample of known purity.

Boracic acid or borax in butter may be detected by melting about 25 grams of the butter in a test tube and allowing the curd and water to settle to the bottom. Using a pipette, draw off most of the aqueous portion and place it in an evaporating dish, make alkaline and evaporate to about one-third of original volume, acidify with concentrated hydrochloric acid and apply strips of tumeric paper, completing the test as for milk.

Salicylic Acid Test. Acidulate 50 c. c. of the milk with hydrochloric acid, and shake with 100 c. c. of ether. Do not shake vigorously enough to form an emulsion. Pour off ether extract, evaporate nearly to dryness, add a few drops of water and then a little ferric chloride solution. In the presence of salicylic acid a deep violet color develops.

Test for Nitrates in Milk: Since nitrates are not found in pure milk but are often present in water obtained from wells and springs, their presence in milk may indicate adulteration. The absence of nitrates is not proof that water has not been added to milk since water free from nitrates may have been added.

Nitrates in milk may be detected as follows: Dissolve one part of chemically pure diphenylamine in 100 parts of chemically pure sulphuric acid. Place about 6 c. c. of the milk in a test tube and add about 3 c. c. of the sulphuric acid-diphenylamine solution allowing it to run down the side of the tube and under the milk. In the presence of nitrates a blue color at the junction of the liquids indicates the presence of nitrates. The color may often be only transitory, owing to the action of the sulphuric acid on the milk. A very slight rotary motion usually causes the color to appear for an instant when nitrates are present, but the color quickly disappears in the liquid that is darkened by the action of the sulphuric acid on the milk solids.

Stoke's Method for Detecting Gelatin in Milk or Cream. Dissolve one part by weight of mercury in 2 parts by weight of concentrated nitric acid (Sp. Gr. 1.42), and add 25 times its volume of water. Place 10 c. c. of this solution in a test tube together with an equal volume of cream, and add 20 c. c. of water, shake well, let stand for 5 minutes and filter. The filtrate will be cloudy or opalescent if much gelatin is present. Pour some of the filtrate into a test tube and add an equal volume of a saturated solution of picric acid. If the solution remains clear gelatin is absent.

Small amounts of gelatin produce a cloudiness, and larger amounts a stringy yellow precipitate.

Detection of Foreign Color.[20] Leach's method: Add about 5 c. c. of acetic acid to 150 c. c. of milk in a porcelain dish and heat slowly nearly to the boiling point while stirring. With a stirring rod gather the curd into one mass or when the curd remains in small particles separate it from the whey by straining through a sieve. Press the whey from the curd, break it into small pieces and place in a flask, add 50 c. c. of ether, macerate thoroughly and allow to stand for several hours in a tightly stoppered flask, shaking at intervals.

Annatto: Pour off the ether extract into an evaporating dish and evaporate the ether on a water bath. Make the residue alkaline with sodium hydroxide, and pour upon a small wet filter while still warm. When the solution has passed through the filter, wash the fat from the filter with a stream of water and dry the paper. If the paper is colored orange the presence of annatto is indicated. Confirm the test by applying a drop of stannous chloride solution to the paper, which in the presence of annatto produces a characteristic pink on the orange colored paper.

Analin Orange. After extraction with ether the curd is perfectly white from uncolored milk, or milk that has been colored with annatto. If the extracted curd still has distinct orange or yellow color, it indicates the presence of analin orange. To confirm the presence of this color, place a lump of the extracted curd in a test tube and add a little strong hydrochloric acid. In the presence of analin orange, the curd turns pink at once.

Caramel. If the extracted curd has a dull brown color the presence of caramel is indicated. Treat a lump of the curd in a test tube with strong hydrochloric acid and heat gently. In the presence of caramel the acid solution will gradually turn blue, as will also the extracted curd from uncolored milk. It is only when this blue coloration of the acid solution occurs in connection with a brown colored curd, which itself does not change color, that the presence of caramel is indicated, as distinguished from the pink coloration produced at once under similar conditions by analin orange.

ANALYSIS OF BUTTER AND BUTTER SUBSTITUTES A. O. A. C. METHOD.

1. Preparation of Sample—Official. If large quantities of the butter are to be sampled, use a butter trier or sampler. Completely melt the portions thus drawn, 100 to 500 grams, in a closed vessel at as low a temperature as possible. When melted, cool the whole, and at the same time shake the mass violently until it is homogeneous and sufficiently solidified to prevent the separation of the water and fat. Then pour a portion into the vessel from which it is to be weighed for analysis. The sample should completely or nearly fill the vessel and should be kept in a cold place until analyzed.

2. Moisture—Official. Place 1.5 to 2.5 grams in a dish with a flat bottom having a surface of at least 20 sq. c. m. and dry at the temperature of boiling water until it ceases to lose weight, each drying being for only one hour. The use of clean dry sand or asbestos is admissible, and is necessary if a dish with a round bottom is employed.

Moisture. Mojonnier Method. See Chapter VIII.

3. Casein, Ash and Chlorin—Official. Cover the crucible containing the residue from the fat determination by the indirect method [see 4 (a) below] and heat gently at first, gradually raising the temperature to just below redness. The cover may then be removed and the heat continued until the contents of the crucible are white. The loss in weight represents casein, and the residue in the crucible, mineral matter. In this mineral matter, dissolved in water slightly acidulated with nitric acid, determine chlorin either gravimetrically or volumetrically.

4. Ether Extract. (a) Indirect Method. Official. From the dry butter obtained in determining the water, either with or without the use of an absorbent, extract the fat with anhydrous alcohol-free ether, receiving the solution in a weighed flask. Evaporate the ether and dry the extract at the temperature of boiling water until it ceases to lose weight, the dryings not to exceed one hour each in duration.

For another ether extraction method, see Mojonnier Test, Chapter IV.

5. Salt—Official. Weigh in a counterpoised beaker 5 to 10 grams of butter, using portions of about 1 gram from different parts of the sample. Add about 20 c. c. of hot water and after the butter is melted transfer the whole to a separatory funnel. Insert the stopper and shake for a few moments. Let stand until the fat has all collected on the top of the water, then draw off the latter into a flask, being careful to let none of the fat globules pass. Again add hot water to the beaker and repeat the extraction from 10 to 15 times, using each time from 10 to 20 c. c. of water. The washings will contain all but a mere trace of the

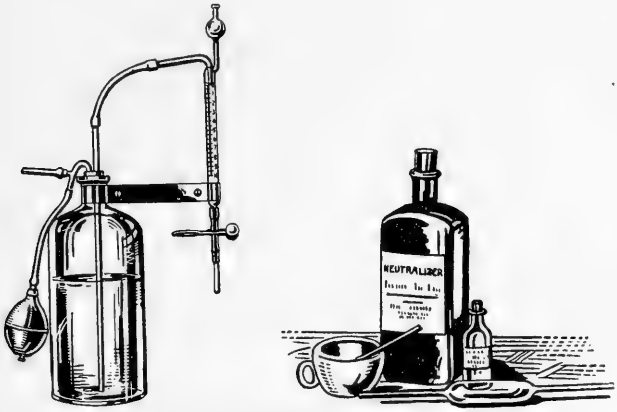


Fig. 148. Troy Salt Test Apparatus.

sodium chloride originally present in the butter. Determine its amount in the whole or an aliquot of the liquid by the volumetric silver-nitrate method, with potassium chromate as indicator.

Troy's Method for Determining the Percentage of Salt in Butter. Place three or four onces of a representative sample of the butter in a wide-mouthed jar or bottle. Soften the butter by warming, and mix it vigorously with a spatula until it is in a pasty condition and is homogenous throughout. Then weigh 10 grams into a flask and add 300 cc. of hot water (150° F.). Insert the stopper and shake the flask vigorously until all of the salt is in solution and evenly distributed. Let the flask stand for a few minutes until most of the fat rises to the surface, then draw a Babcock milk pipette full to the mark of the watery solution, and

run it into a white cup or similar container. Add 3 or 4 drops of a 10% solution of potassium chromate (K_2CrO_4), stir, and run in from a 10 cc. burette, tenth-normal silver nitrate solution with constant stirring until the color of the substance changes from a light yellow to a permanent light brown color. Then read on the burette scale the amount of standard silver nitrate solution used.

Each cc. of the silver nitrate solution required equals one per cent of salt in the butter.

Explanation: One cc. of tenth-normal silver nitrate solution contains 0.017 grams of silver nitrate and is chemically equal to 0.00585 grams of sodium chloride. Suppose it required 2.8 cc. of tenth-normal silver nitrate to neutralize the salt in the 17.5 cc. of solution delivered from the Babcock pipette.

$0.0585 \times 2.8 = 0.01638$, gram of salt in 17.5 cc. of solution.

But there are 17.14 pipette fulls in 300 cc.

$300 \div 17.5 = 17.14$.

Then: $0.01638 \times 17.14 = 0.280$, gram of salt in 10 grams of butter.

$0.280 \div 10 = 0.028$, gram of salt in 1 gram of butter.

$0.028 \times 100 = 2.80$, grams of salt in 100 grams of butter, or the per cent of salt present.

Hunziker's method[21] for determining salt in butter. (For factory use):

Equipment.—One salt tester. This is a copper container, 3½ inches deep, 2½ inches in diameter, and holding about 250 cc. It is equipped at its top edge with a heavy rubber ring on which the moisture evaporating dish is inverted, and with a lightning jar wire clamp for pressing the evaporated dish down on the rubber ring.

One 100 cc. glass cylinder (low style).

One 25 cc. pipette.

One or more 150 cc. flasks (cone shape) for titrating.

One 50 cc. burette with stand.

One large bottle, with glass tubing and clamps to connect with burette, for standard silver nitrate solution.

One small bottle for potassium chromate solution.

Chemicals.—Silver nitrate solution containing 7.265 grams silver nitrate in 1000 cc. water.

Potassium chromate solution.

Fig. 149. Hunziker Salt Test Apparatus.

Operation of test.—This test is intended to be a continuation of the moisture test in which an evaporating dish of a diameter of 2⅝ inches is used.

(1). At the conclusion of the moisture test fill the 100 cc. cylinder to the mark with warm water, temperature about 100° F., and pour this water into the salt tester.

(2). Invert moisture evaporating dish over rubber ring of salt tester and make the dish fast by means of wire clamp.

(3). Now shake the salt tester vigorously, giving it about 30 shakes. This causes the salt in the evaporating dish to be washed out by the warm water.

(4). Remove evaporating dish and transfer with pipette 25 cc. of the salt solution from the salt tester into the titrating flask.

(5). Add 1 cc. of potassium chromate solution to the titrating flask and from burette slowly add silver nitrate solution until a

permanent brick-red precipitate is obtained. The titrating flask must be constantly and thoroughly agitated by a rotating motion while the silver nitrate solution is added.

(6). If a 10-gram sample of butter is used in the moisture test, each cc. silver nitrate solution represents .1 per cent salt. Assuming that 35 cc. silver nitrate solution was used, the butter then contained 35/10=3.5% salt.

(7). If the sample of butter is not exactly 10 grams, but somewhat more or less, the per cent of salt is readily calculated by dividing the cc. silver nitrate solution required, by the exact weight of the sample of butter. Say the sample weighed 10.5 grams and required 35 cc. of silver nitrate solution, the butter then contained 35/10.5=3.3% salt.

(8). This salt test occupies about five minutes. It is exceedingly simple and accurate, when made in accordance with the above directions. It eliminates the weighing of the sample for the salt determination and it automatically washes the moisture evaporating cup. For uniformly reliable results the following precautions must be observed:

(a). Do not slobber the melted butterfat in the evaporating dish, over the outside of the salt tester. The butter must stay inside of the periphery of the evaporating dish, when the latter is inverted over the tester.

(b). Do not use water at a temperature lower, nor much higher, than 100° F. Water must be warm enough to melt the fat. If too warm it will generate pressure when shaking the tester, causing loss of contents.

(c). Strap the evaporating dish down to the tester, so that there is no leak around the rubber ring.

(d). Shake vigorously thirty (30) times.

(e). Give the titrating flask the proper rotating movement for vigorous and continuous agitation, while the silver nitrate solution runs from the burette.

(f). Stop titration when the desired color has been reached (brick-red).

(g). It is necessary to give the fat time to rise in the tester after shaking. This requires about one minute. For this reason,

the tester should be set down after shaking, and the aluminum cup taken off and wiped dry and gotten ready for the next weighing of butter. While this is done, the fat in the tester automatically rises to the surface.

(h). If the edges of the evaporating dish become uneven, due to wear, causing the cup to leak when inverted over the rubber ring of the tester, invert the cup over a piece of fine emery cloth, and wear down the edges until even.

10. The speed of the entire test will much depend on the proper planning and organizing of the work of both the moisture and the salt test, so as to avoid any waiting between steps, such as waiting for the evaporating dish to cool, or for the fat to rise to the surface in the tester. It has been found that the maximum speed is obtained by running the moisture and the salt tests of three samples together.

11. Use only evaporating dishes without lips.

Determination of the free fatty acids in butter A. O. A. C. Method:

Weigh 20 grams of the clear filtered fat into a flask, add 50 c. c. of 95% alcohol which has been neutralized with weak caustic soda, using phenolphthalein as indicator, and heat to the boiling point. Agitate the flask thoroughly in order to dissolve the free fatty acids as completely as possible. Titrate with tenth-normal alkali, agitating thoroughly until the pink color persists after shaking.

Express the result as cubic centimeters of tenth-normal alkali required to neutralize the free acids in 100 grams of the fat.

Halpen's test for cotton seed oil: A. O. A. C. Method. Dissolve one gram of sulphur in 100 grams of carbon disulphide and mix with an equal volume of amyl alcohol. Place about 8 cc. of the clear melted fat, or oil, in a test tube and add an equal volume of the above reagent. Mix and heat the test tube in a bath of boiling saturated salt solution for one hour. As little as one per cent of cotton seed oil produces an orange-red color.

Distinguishing butter, renovated butter and oleomargarine.[22]

Examination of the melted substance: Fill a glass test tube or similar transparent container with the fat and heat at a

temperature of 50° C. until the fat is completely melted and the water and curd has settled. The melted fat from butter will be clear and bright in appearance while that from renovated butter and oleomargarine will be cloudy and turbid.

Vega's test. —Filter some of the fat through a hot dry filter into a test tube, placing the tube in boiling water for 2 minutes. In another large test tube place 20 cc. of a mixture of 1 part glacial acetic acid, 6 parts ether and 6 parts alcohol.

Add about 1 cc. of the hot filtered fat to the reagents in the large test tube. Stopper the tube and shake well. Immerse in water at 15° C. (60° F.) and let stand 15 minutes. Pure butter will leave the contents of the tube almost clear while oleomargarine will give a marked deposit.

Foam test.[23]—Melt in a spoon a piece of the sample about the size of a hickory nut over a lamp or gas flame, heating slowly until the fat is nearly melted, then more rapidly to boiling. With butter, foam forms and remains for some time, usually filling the spoon heaping full. On the contrary, the bubbles from oleomargarine and renovated butter break almost immediately on forming, so that very little foam remains to obscure the surface of the melted fat.

The Waterhouse test.[24]—The Waterhouse test distinguishes between butter fat and foreign fat but does not distinguish between butter and renovated butter.

Operation: Half fill a pint tin cup or beaker with skim-milk and heat nearly to boiling, add about 10 grams of the fat and stir with a small wooden splinter about the diameter of a match until the fat is melted. Set the cup in a pan of ice water and stir briskly with the splinter. Continue the stirring until the milk is cold enough to congeal the fat. The latter may then be collected into a mass by means of the splinter if the fat is from oleomargarine. Butter fat on the other hand, from either genuine or process butter, will not gather in a lump but will float quite uniformly in small particles on the surface of the liquid.

CHEESE ANALYSIS. A. O. A. C. METHOD.

(a). Preparation of Sample.—When the cheese can be cut, a narrow, wedge-shaped segment reaching from the outer edge to the center of the cheese is obtained. This is to be cut into strips

and passed through a sausage-grinding machine three times. When the cheese cannot be cut, samples are obtained with a cheese trier. If only one plug can be obtained, this should be taken perpendicular to the surface at a point one-third of the distance from the edge to the center of the cheese. The plug should reach either entirely through or only half-way through the cheese. When possible, draw three plugs—one from the center, one from a point near the outer edge, and one from a point half-way between the other two. For inspection purposes, the rind may be rejected; but for investigations requiring the absolute amount of fat in the cheese the rind is included in the sample. It is preferable to grind the plugs in a sausage machine, but when this is not done they are cut very fine and carefully mixed.

(b). Determination of Water.—From 2 to 5 grams of cheese should be placed in a weighed platinum or porcelain dish which contains a small quantity of porous material, such as ignited asbestos or sand to absorb the fat which may run out of the cheese. This is heated in a water oven for ten hours and weighed; the loss in weight is considered as water. Or, if preferred, the dish may be placed in a desiccator over concentrated sulphuric acid and dried to constant weight. In some cases, this may require as much as two months. The acid should be renewed when the cheese has become nearly dry. See Chapter VIII for method for determining water in cheese, using the Mojonnier Tester.

(c). Determination of Fat.—Cover the perforations in the bottom of an extraction-tube with dry asbestos felt, and on this place a mixture containing equal parts of anhydrous copper sulphate and pure, dry sand to the depth of about 5 cm., packing loosely. Cover the upper surface of this material with a film of asbestos. On this are placed from two to 5 grams of the sample of the cheese. The tube is placed in a continuous extraction apparatus, and treated for five hours with anhydrous ether. The cheese is removed and ground to a fine powder with pure sand in a mortar. The mixed cheese and sand are replaced in the extraction-tube, the mortar washed free of all matter with ether, the washings being added to the tube, and the extraction is continued ten hours. See Chapter VII for method for determining the fat in cheese, using the Mojonnier Tester.

(d). Determination of Nitrogen.—Make a determination of nitrogen by the Kjeldahl method, using about 2 grams of cheese, and multiply the percentage of nitrogen by 6.25.

(e). Determination of Ash.—The dry residue from the water determination may be used for the ash. If the cheese be rich in fat, the asbestos will be saturated therewith. This may be ignited carefully, and the fat allowed to burn off, the asbestos acting as a wick. No extra heat should be applied during this operation, as there is danger of spurting. When the flame has died out, the burning may be completed in a muffle at low redness. When desired, the salt may be determined in the ash in the manner specified under butter analysis, page 614.

(f.) Determination of Other Constituents.—The sum of the percentages of the different constituents, determined as above, subtracted from 100 will give the amount of organic acids, milk sugar, etc. in the cheese.

(g). Provisional Method for the Determination of Acidity in Cheese.—To 10 grams of finely divided cheese, add water, at a temperature of 40° C., until the volume equals 105 cc.; agitate vigorously and filter. Titrate portions of 25 cc. of filtrate, corresponding to 2.5 gram of cheese, with standardized solution of sodium hydroxide, preferably one-tenth normal. Use phenolphthalein as indicator. Express amount of acid as lactic.

Troy's Cheese Moisture Test. This test provides a fairly rapid and accurate method for determining the percentage of moisture in cheese. It is practical for factory use and also serves well for the purpose of determining the percentage of moisture in butter. The high percentage of fat in butter permits rapid heating at a comparatively high temperature in an open dish without danger of loss by spattering or charring of the proteins until all of the moisture is driven off. But when cheese is treated similarly some of the solids will spatter out of the dish. There is not enough fat present to prevent the casein from sticking to the bottom and sides of the dish, charring and volatilizing some of the cheese solids. This test overcomes these difficulties by providing a double walled copper cup, space between the walls

for holding oil into which a thermometer may be inserted, thus providing a means of determining the temperature and permitting its control. A scale for weighing the cheese, and a flask for holding it while drying and a small alcohol lamp or gas flame for heating the cup are necessary. The Troy Moisture Tester is illustrated under Fig. 150.

Operation: In operating the test the alcohol lamp is first lighted, so that the oil bath may be warming while the test sample is under preparation. A representative sample of the cheese, which may be taken with a cheese trier and held in a glass stoppered sample jar, is then cut into particles about the size of kernels of wheat without removing it from the jar. This may be done with an ordinary table knife that has had the end squared and sharpened. The clean dry flask is then accurately balanced on the scales and a 5-gram weight is placed in the opposite scale pan. Particles of cheese from the prepared sample are put into the flask until the scales comes to an exact balance. Great care should be taken to avoid loss of moisture from the cheese during the preparation of the sample.

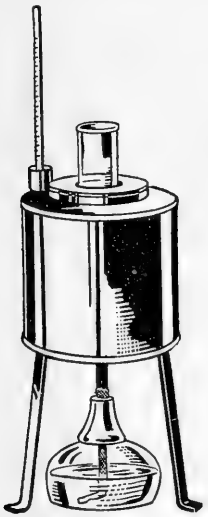


Fig. 150.
Troy Moisture Tester for Cheese.

With the thermometer in the oil bath registering a temperature between 140° and 145° C. (or between 284° and 293° F.), the flask is placed in the cup of the oil bath and the flat, disk-shaped cover is adjusted over the apparatus. The flask should remain in the bath for fifty minutes, the temperature being kept between 140° and 145° all of the time. The flask is then removed, covered, and allowed to cool to room temperature in a dry place. It is then weighed, and the quotient obtained by dividing the loss in weight by the original weight, multiplied by 100, gives the percentage of water in the cheese. The following shows the method of computation:

Problem: Five grams of cheese were heated until the moisture was evaporated. The remaining substance weighed 3.15 grams. What percentage of water did the cheese contain?

Answer:

5.00—3.15=1.85

1.85÷5 =0.37

0.37×100= 37, per cent of water in the cheese.

A butter moisture scales with an extra 5 grams weight may be used for weighing out the 5 grams of cheese. If the scales indicate the amount of moisture in 10 grams of butter by percentage graduations on its beam, or by percentage weights, then it is necessary to multiply by 2 the percentage indicated by such scales or percentage weights when only 5 grams of cheese are used.

Troy's Cheese Salt Test. Place a representative sample of the cheese in a half pint sampling jar or similar container. Using an ordinary table knife, or one that has had the end of the blade squared and sharpened, cut the cheese sample into particles as small as kernels of wheat. Mix thoroughly and weigh 10 grams into a crucible, or into a silica or platinum dish. Dry at a temperature of 100° C., or a few degrees higher and then ignite to a gray ash, preferably in a muffle. Wash the ash from the dish into a flask and make up with water to 300 cc. Stir thoroughly to bring all of the salt into solution and to make the solution homogeneous. Neutralize with dilute nitric acid. Draw a Babcock pipette full to the mark of the solution and run it into an evaporating dish or white cup, add two or three drops of a 10% solution of potassium chromate, and slowly run in tenth-normal silver nitrate solution from a 10 cc. burette graduated to 0.1 cc. until a permanent light brown color is obtained.

Each cc. of tenth-normal silver nitrate solution required equals one per cent of salt in the cheese.

THE MELTING POINT OF MILK FAT.

As milk fat is composed of a number of different fats having different melting points and the percentages of these fats vary in different samples, the melting point of the substance is not sharply defined. Determinations of the melting point of samples from many sources by different investigators place the range of

temperature within which the melting point should fall between 30 and 36.6° C. (87 and 98° F.). The solidifying points range between 19 and 25° C. (66 and 77° F.).

Where the quantity of the fat permits, the simplest method for determining the melting point is to immerse an accurate thermometer in the partly molten and partly solid mass.

In many instances, however, only a limited amount of the fat is available. Under these circumstances a drop of the melted fat is drawn into a thin walled glass tube about 1 mm. in diameter and cooled until completely solidified. The tube is then attached to the side of a thermometer, the part containing the fat being held on a level with the bulb. The thermometer and tube are then heated slowly in water or sulphuric acid until the fat begins to appear translucent, when the temperature is taken. The temperature should be taken again when the fat becomes nearly transparent.

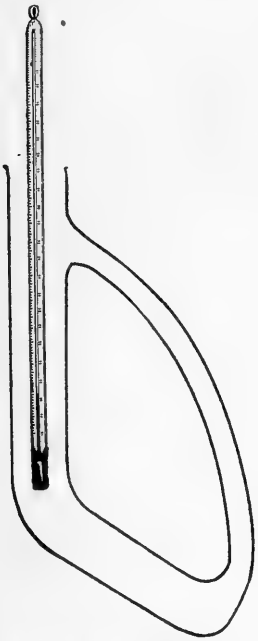


Fig. 151.
Melting Point Apparatus.

In order to avoid error due to the uneven heating of the immersion fluid, Dennis[25] advises the use of sulphuric acid in a tube like that shown in Fig. 151. When operating the test the tube may be attached to an ordinary burette support and sulphuric acid added until the tube is filled a little above the opening into the upper side arm. An Anschuetz thermometer with attached tube containing the slender column of solid fat is then immersed in the sulphuric acid until the top of the mercury column is below the opening into the upper side arm. The thermometer may be held in place by a burette support attachment, or by being fitted through a cork placed in the opening of the melting point apparatus. The lower arm of the tube is then slowly heated, by means of a flame, or electrically, from the lowest point to a point about midway between the lowest point and the perpendicular tube. The temperature

should be taken when the fat begins to become translucent and molten and again when it becomes transparent. The best results are obtained when the tube is heated electrically. To accomplish this it is directed that the portion, described above, of the tube to be treated is wrapped with a single layer of thin asbestos paper, and then wound with about 10 turns of michrome wire, No. 26, B and S gauge (about 0.016 in. in dia.). The wire is then covered with a layer of asbestos cement to a depth of about 5 mm. The melting point apparatus may be made of ordinary soft glass, but Pyrex glass is preferable.

DETECTING FOREIGN FATS IN MILK FAT.

The lower cost of most fats and oils compared with that of milk fat has led to their frequent substitution in a variety of dairy products. This practice gives special importance to methods used in the detection of such substitutes. The fat constants that will ordinarily enable the analyst to decide as to the purity of milk fat are (1) the refractive index, (2) the Reichert-Meissl number, and (3) the iodine number. If the evidence obtained by determining these constants is not sufficient, a more complete work on fat analysis should be consulted.

The figures given in the table that follows indicate the range within which these constants of the edible fats and oils named may be expected to fall.

TABLE 105.

Fat Constants.

	Refractive Index 25° C.	Reichert-Meisel Number	Iodine Number
Milk fat	1.459 to 1.460	25 to 34	26 to 38
Beet tallow	1.462* to 1.465	0.2 to 0.5	35 to 45
Cocoa butter	1.462* to 1.464	0.2 to 0.8	32 to 41
Cocoanut butter	1.452* to 1.456	6.0 to 8.5	8.0 to 9.5
Cottonseed oil	1.469 to 1.473	0.6 to 0.8	66 to 77
Lard	1.463* to 1.467	0.2 to 0.7	54 to 70
Corn oil	1.472 to 1.474	0.7 to 0.9	79 to 86
Olive oil	1.467 to 1.469	0.5 to 0.7	77 to 95
Peanut oil	1.468 to 1.471	0.4 to 0.6	83 to 105

* Reading at 60° C. calculated to 25° C.

The Refractive Index. Determination with the Abbe Refractometer.—The double prism of the instrument is opened by means of the screw head, then place three or four drops of the liquid to be examined on the stationary prism, clamp the prisms together firmly. While waiting for a few minutes to permit the liquid to come to the temperature of the instrument, turn the mirror to properly light the prism. By moving the upright arm

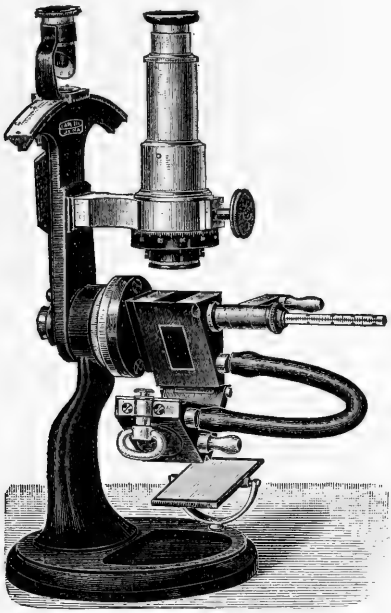


Fig. 152. Abbe-Zeiss Refractometer.
Courtesy Arthur H. Thomas Co.

slowly backward and forward, while looking through the sharply focused telescope, a light and dark portion of the field will be observed. The "border line" dividing the light and dark portions of the field is then adjusted until it rests on the point of intersection of the cross hairs. The refractive index is then read directly to the fourth decimal by looking through the magnifier in the movable arm over the scale. The temperature of the instrument at the time the reading is taken should also be recorded. During the determination running water, held at the desired temperature, is allowed to flow through and control the tempera-

ture of the instrument. The index of refraction may be taken at 25° C. for oils and fats that are liquid at that temperature. For other fats, readings may be made at 40° or 60° C.

Determinations by means of the Zeiss-Butyro-Refractometer. —Place 2 or 3 drops of the filtered fat on the surface of the lower prism. Close the prism and adjust the mirror until it gives the sharpest reading. If the reading be indistinct after running water of a constant temperature through the instrument for some time, the fat is unevenly distributed on the surface of the prism. As the index of refraction is greatly affected by temperature, care must be used to keep the latter constant. The instrument should be carefully adjusted by means of the standard fluid which is supplied with it. Convert the degrees of the instrument into refractive indices by use of the table that follows:

TABLE 106.

Butyro-Refractometer Readings and Indices of Refraction (A).

Reading	Index of Refraction	Reading	Index of Refraction	Reading	Index of Refraction	Reading	Index of Refraction
40.0	1.4524	50.0	1.4593	60.0	1.4659	70.0	1.4723
40.5	1.4527	50.5	1.4596	60.5	1.4662	70.5	1.4726
41.0	1.4531	51.0	1.4600	61.0	1.4665	71.0	1.4729
41.5	1.4534	51.5	1.4603	61.5	1.4668	71.5	1.4732
42.0	1.4538	52.0	1.4607	62.0	1.4672	72.0	1.4735
42.5	1.4541	52.5	1.4610	62.5	1.4675	72.5	1.4738
43.0	1.4545	53.0	1.4613	63.0	1.4678	73.0	1.4741
43.5	1.4548	53.5	1.4616	63.5	1.4681	73.5	1.4744
44.0	1.4552	54.0	1.4619	64.0	1.4685	74.0	1.4747
44.5	1.4555	54.5	1.4623	64.5	1.4688	74.5	1.4750
45.0	1.4558	55.0	1.4626	65.0	1.4691	75.0	1.4753
45.5	1.4562	55.5	1.4629	65.5	1.4694	75.5	1.4756
46.0	1.4565	56.0	1.4633	66.0	1.4697	76.0	1.4759
46.5	1.4569	56.5	1.4636	66.5	1.4700	76.5	1.4762
47.0	1.4572	57.0	1.4639	67.0	1.4704	77.0	1.4765
47.5	1.4576	57.5	1.4642	67.5	1.4707	77.5	1.4768
48.0	1.4579	58.0	1.4646	68.0	1.4710	78.0	1.4771
48.5	1.4583	58.5	1.4649	68.5	1.4713	78.5	1.4774
49.0	1.4586	59.0	1.4652	69.0	1.4717	79.0	1.4777
49.5	1.4590	59.5	1.4656	69.5	1.4720	79.5	1.4780

(A) Winton, Conn. Agr. Exper. Sta. Rpt., 1900, Part 2, p. 143.

The Reichert-Meissl Number. The Reichert-Meissl number is the number of cc. of tenth-normal alkali required to neutralize the volatile fatty acids distilled from 5 grams of fat when they are set free and the operation is carried out according to specified conditions. The method was developed by Reichert and modified by Meissl. Later Leffman and Beam modified the method slightly

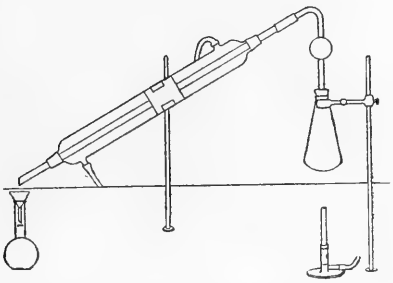


Fig. 153. Distilling Apparatus.

by saponifying the fat in a glycerol-soda mixture in place of an alcoholic potash mixture. The Leffman and Beam modification is quite generally used at present. It is carried out as follows:

Weigh 5 grams of the pure fat into a round bottomed flask and add 20 cc. of a mixture made by placing 10 cc. of a 50 per cent caustic soda, water solution, in 90 cc. of glycerine. Heat the contents of the flask over a small flame, with constant shaking, until the water is boiled off and the mixture which on boiling had a clouded appearance, becomes clear. Add 135 cc. of water slowly, to prevent foaming and a pinch of pumice stone powder, or a few pieces of pumice stone to prevent bumping during distillation. Add 5 cc. of dilute sulphuric acid (200 cc. of concentrated sulphuric acid in 1000 cc. of water). Connect the flask at once to a condenser, shake to mix the acid with the solution and heat to distill off the volatile acids. Distill off 110 cc. at a rate that will yield that volume in 30 to 40 minutes. Filter the distillate through a dry filter and titrate 100 cc. of it with tenth-normal alkali solution. The number of cc. of tenth-normal alkali used multiplied by 1.10 equals the Reichert-Meissl number.

The Reichert-Meissl number for milk fat is usually between 25 and 32, for cocoanut oil between 6 and 8, and for most other fats and oils less than 1.5.

Iodin Absorption Number of Fat and Oils.—The capacity of fats and oils to absorb iodin is sometimes used to advantage for the purpose of identifying them or determining their purity. The percentage of iodin that a given fat or oil will absorb under specified conditions is called its iodin number. A method for treating fats and oils with iodin was developed by Hubl.[26] It was improved and shortened by Hanus and is the method usually employed. The A. O. A. C. has adopted it as follows:

Hanus Method.—Official.—Reagents.—(a) Hanus iodin solution.—Dissolve 13.2 grams of pure iodin in one liter of glacial acetic acid (99.5 per cent) which shows no reduction with dichromate and sulphuric acid. Add enough bromin to double the halogen content as determined by titration (3 cc. of bromin are about the proper amount). The iodin may be dissolved by heating, but the solution should be cold when the bromin is added.

A convenient way to prepare the Hanus solution is as follows: Measure 825 cc. of acetic acid which has shown no reduction by the dichromate test and dissolve in it 13.615 grams of iodin with the aid of heat. Cool and titrate 25 cc. of this solution against the N/10 sodium thiosulphate. Add 3 cc. of bromin to 200 cc. of acetic acid and titrate 5 cc. of the solution against the N/10 sodium thiosulphate. Calculate the quantity of bromin solution required exactly to double the halogen content of the remaining 800 cc. of iodin solution as follows:

$$A=\frac{B}{C}$$ in which

A=cc. of bromin solution required.

B=800 $\times$ the thiosulphate equivalent of 1 cc. of iodin solution,

C=the thiosulphate equivalent of 1 cc. of bromin solution.

Example:—136.15 grams of iodin are dissolved in 8250 cc. of acetic acid. 30 cc. of bromin are dissolved in 2000 cc. of acetic acid. Titrating 50 cc. of the iodin solution against the standard thiosulphate shows that 1 cc. of the iodin solution equals 1.1 cc. of

the thiosulphate (0.0165 gram of iodin). Titrating 5 cc. of the bromin solution shows that one cc. of the bromin solution equals 4.6 cc. of the thiosulphate. Then the remaining quantity of bromin solution required to double the halogen content of the remaining 8200 cc. of iodin solution is equivalent to $\frac{8200\times1.1}{4.6}$ or 1961 cc. Upon mixing the two solutions in this proportion, a total volume of 10161 cc. is obtained, containing 135.3 grams of iodin. In order to reduce this solution to the proper strength (13.2 grams iodin per liter), $10.161\times13.2=134.1$; $135.3-134.1=1.2$ grams of iodin present in excess, or $\frac{1.2\times1000}{13.2}=91$ cc. of acetic acid which must be added.

(b). N/10 sodium thiosulphate solution.—Prepare a solution containing 24.82 grams of sodium thiosulphate ($Na_2S_2O_3 5H_2O$) in water and dilute to 1 liter. Standardize this solution as follows: Place in a glass stoppered flask 20 cc. of the N/10 potassium dichromate and 10 cc. of the 15 per cent potassium iodide solution. Add 5 cc. of strong hydrochloric acid. Dilute with 100 cc. of water and allow the N/10 sodium thiosulphate to flow slowly into the flask until the yellow color of the liquid has almost disappeared, add a few drops of starch indicator and, with constant shaking, continue to add the N/10 sodium thiosulphate until the blue color just disappears.

(c). Starch indicator:—Mix about 0.5 gram of finely powdered potato starch with cold water to a thin paste; pour into about 100 cc. of boiling water, stirring constantly, and discontinue heating immediately after the paste is added.

(d). Potassium iodid solution.—Dissolve 150 grams of potassium iodid in water and dilute to 1 liter.

(e). N/10 potassium dichromate.—Dissolve 4.903 grams of potassium dichromate in water and dilute to 1 liter. The strength of this solution should be checked against pure iron.

Determination.—Weigh about 0.500 gram of fat, or 0.250 gram of oil (0.1—0.2 gram in the case of drying oils which have a very high absorbent power), into a 500 cc. glass-stoppered flask or bottle. Dissolve the fat or oil in 10 cc. of chloroform. Add 25 cc.

of the Hanus iodin solution and allow to stand for 30 minutes, shaking occasionally.

This time must be adhered to closely in order to obtain good results. The excess of iodin should be at least 60 per cent of the amount added. Add 10 cc. of the 15 per cent potassium iodid solution, shake thoroughly and then add 100 cc. of water, washing down any free iodin that may be found on the stopper. Titrate the iodin with N/10 sodium thiosulphate, adding the latter gradually, with constant shaking, until the yellow color of the solution has almost disappeared. Add a few drops of the starch indicator and continue the titration until the blue color has entirely disappeared. Toward the end of the titration, stopper the bottle and shake violently, so that any iodin remaining in solution in the chloroform may be taken up by the potassium iodid solution. Conduct two blank determinations along with that on the sample. The number of cc. of the sodium thiosulphate solution required by the blank less the amount used in the determination gives the thiosulphate equivalent of the iodin absorbed by the fat or oil. Ascertain the iodin number by calculating the per cent by weight of iodin absorbed.

ESTIMATION OF MILK FAT IN MILK CHOCOLATE. A. O. A. C.—TENTATIVE METHOD.

Estimate the amount of milk fat in milk chocolate from the following formula based on a Reichert-Meissl number of 0.5 for cocoa butter:

$$C=\frac{24A+0.5B}{5}$$ in which

A=grams of butter fat in 5 grams of mixed fat,

B=5—A=grams of cocoa fat in 5 grams of mixed fat,

C=Reichert-Meissl number of extracted fat.

From which the

Weight of butter fat in 5 grams of mixed fat$=\frac{C-0.5}{4.7}$ and the

Per cent of butter fat=per cent of total fat$\times\frac{C-0.5}{23.5}$

DETECTING GUMS, GELATINIZING AGENTS AND THICKENERS.

In recent years a number of substances of colloidal nature have been used to give apparent "body" to a wide variety of food products. Most of them are able to absorb relatively large amounts of water and when mixed with diluted food emulsions impart properties that simulate the richness of the genuine product. Among the substances used are gelatin, sucrate of lime, gum tragacanth, gum arabic (acacia), agar-agar, starch, dextrin, glucose, and pepsin. Methods for detecting their presence in foods and for identifying them have been developed and while not wholly satisfactory serve their purpose fairly well.

Patrick's Method for Detecting Thickeners.—Add 25 cc. of water to 50 cc. of the sample and heat to boiling to dissolve thickeners that may be present, add 2 cc. of 10 per cent acetic acid, heat again to boiling and add 3 heaping tablespoonfuls of kieselguhr, mix thoroughly and pass, without delay, through a plaited filter. Add 12 cc. of 95% alcohol to 3 cc. of the clear filtrate and mix. This precipitates any of the milk proteids remaining, also the gums and some of the gelatin if much is present. To dissolve the milk proteids add 3 cc. of a mixture containing 5 cc. of concentrated hydrochloric acid in 95 cc. of 95% alcohol. If a clear liquid is obtained no gums or vegetable jellies are present, and turbidity or a precipitate does not necessarily indicate the presence of a thickener, as it may result from the use of eggs or the gelatin used in ice cream as a stabilizer. Add 3 cc. of water, if the mixture is turbid at this dilution any precipitate due to gelatin or eggs will be dissolved, a stringy and cohesive precipitate, especially after shaking, shows the presence of gum tragacanth, while agar-agar and other vegetable thickeners give a finely flocculent precipitate devoid of stickiness. When sour cream containing no thickeners is tested an insoluble precipitate may form and which does not dissolve when water is added. By adding formaldehyde to the sample while it is sweet, it appears that the formation of such a precipitate may be avoided.

Congdon's Method[27] for Detecting Thickeners and Similar Agents in Foods.—By this method the thickening materials are separated into six groups on the basis of reagents used. The reagents are added to the water soluble solutions of the materials

to obtain the reactions. While specific directions for applying the method to dairy products are not given in the original article the following table should be of assistance in identifying the different substances.—

"**Group 1.**—Group reagent—Iodine solution.

Blue coloration indicates starch. (Sometimes green apples made into jelly will give traces of starch.)

Purple coloration indicates Amylo-dextrin.

Red coloration indicates Erythro-dextrin.

No coloration may indicate neither starch nor dextrin, but may be Achro-dextrin.

Group II.—Group reagent—Million's or Stokes' reagent (acid nitrate of mercury).

Mixture, after shaking substance in solution with reagent, is cloudy, Yellow precipitate with picric acid solution indicates Gelatin.

Drop of this reagent. Gelatinous precipitate, soluble in excess of this reagent, indicates Acacia.

A slight white cloudy precipitate may indicate either Agar-agar or Tragacanth or both (test for Tragacanth as in group IV).

Group III.—Group reagent—Concentrated solution of sodium borate.

A white gelatinous precipitate indicates either Agar-agar or Acacia or both.

Acacia will give a gelatinous, opaque white precipitate with solution of basic lead acetate.

Acacia may be further tested for as in Group II or Group IV or by adding a solution of tannin which gives a bluish black coloration.

Group IV.—Group reagent—Solution of sodium hydrate.

A brownish yellow color on heating indicates Tragacanth.

A white cloudy precipitate indicates Acacia.

Group V.—Group reagent—Solution of mercuric chloride.

A slight turbidity may indicate Dextrin.

A white precipitate may indicate Albumin and Gelatin.

Group VI.—Group reagent—Schweitzer's reagent (solution of cupra-ammonia).

If a concentrated water solution of the unknown is treated with this reagent and placed on glass slide under microscope, a delicate framework of cupric pectate is evident, showing a pectin of fruit or vegetable origin present."

Cook and Woodman's Method[28] for the Detection of Vegetable Gums in Food Products.—In this method the tests are applied to the gums after they have been separated, in a relatively pure condition, from 50 to 200 grams of the sample as the case may

require. The proteins in the food mixture are precipitated by adding acetic acid and tannin, heating and filtering, then the gums are precipitated from the filtrate by the addition of acetone. The filtrate contains the sugars and other acetone soluble material. Soluble phosphates, derived from sources like milk, are removed by an extra precipitation with ammonia. Finally the gums are redissolved and precipitated relatively pure by alcohol.

In order to use the method successfully, before making a test on an unknown, the analyst should become familiar with the appearance and characteristic properties of the various gum

TABLE 107.
The Separation of Gums.

A—Elimination of Proteins.	B—Separation of Gums and Dextrin from Sugars.	C—Isolation of Pure Gum Substance.
1—Dilute sample to suitable concentration with water, add 5 cc. dilute acetic acid and 25 cc. of 10 per cent tannin solution, and heat mixture for 20 to 30 minutes. Centrifuge and filter. Discard precipitate. Note—Casein, coagulable proteins, and some of the gelatin precipitated. Fats and other insoluble substances included in precipitate. 2—Add 40 to 50 cc. more tannin solution to filtrate from A1 and heat for a short time. Centrifuge and filter. Discard precipitate. Note—Remainder of gelatin and soluble proteins precipitated.	1—Treat clear filtrate from A2 with twice its volume of acetone. Centrifuge and filter. Discard filtrate. Wash precipitate twice with acetone. Note—Precipitate includes gums and dextrin. No precipitate shows absence of gums, dextrin, and milk solids. 2—Dissolve precipitate from B1 in 50 cc. of warm water slightly acidified with acetic acid and add 10 cc. of ammonia (sp. gr. 0.90). Centrifuge and filter. Discard precipitate. Note—Calcium phosphate from milk solids precipitated.	Add acetic acid to filtrate from B2 until slightly acid. Add alcohol, one volume at a time, until a well defined precipitate appears. Note—Gums and dextrin precipitated in a fairly pure condition. No precipitate with 5 volumes of alcohol indicates absence of gums and dextrin.

precipitates by working on their solutions. The procedure is summarized in the following table:

TABLE 108.

Identification of Gums.

Approximate Volumes of Alcohol Necssary for precipitation		Characteristic Appearance of Gum Precipitate	Characateristics of Gum Precipitate After Standing for Some time in Air.
Vols. Alcohol	Vol. Gum Solution		
Agar ..3-4	1	Finely divided white precipitate; settles very slowly.	Usually remains soft and non-coherent.
Arabic ...2	1	White flocculent precipitate; settles quickly; neither sticky nor coherent.	Becomes dry and powdry.
Indian .2-3	1	Stringy precipitate; becomes very coherent after settling.	Becomes dark colored; tough coherent layer.
Tragacanth ...2	1	Coherent, jelly-like mass; floats in clots in upper part of solution.	Flattens down, becoming a semi-transparent coherent layer.
Dextrin ..3	1	White, fine precipitate, settles slowly; very sticky.	Tends to become hard on long standing.

It is claimed that, by the above procedure, amounts of gum as small as 0.1 per cent can be separated from ordinary food mixtures, but some gums are more readily detected than others. Tragacanth is easier to detect than either gum arabic or agar. Where the ratio of protein, and possibly some other precipitable matter is large there is danger of the gums bing carried down mechanically and lost.

Where more than one gum is present, and in mixtures containing pectin and commercial glucose, the identification of the gum is made more difficult.

Sucrate of Lime in Milk and Cream.—Sucrate of lime (viscogen) is sometimes added to cream in order to increase the viscosity, a quality that indicates richness. Determinations of

(1) the presence of sucrose, (2) the alkalinity of the water-soluble ash, (3) the alkalinity of the insoluble ash, and (4) the lime content may assist in detecting its presence.

Sucrose may be detected by means of Lythgoe's modification[29] of Baier and Neuman's test. The test is made according to the following directions:

Add 10 cc. of a 5 per cent solution of uranium acetate to 25 cc. of the sample, shake thoroughly, let stand for five minutes and filter. To 10 cc. of the filtrate (or all of it if less than 10 cc.) add a mixture of 2 cc. of saturated ammonium molybdate solution and 8 cc. of dilute hydrochloric acid (1 cc. of 25 per cent acid in 7 cc. of water) and place in a water bath at a temperature of 80° C. for 5 minutes. The solution will have a prussian blue color if sucrose is present. A comparative test should be run in like manner on a pure sample. The latter will sometimes give a pale blue color.

Alkalinity and Calcium Determinations.—Weigh into a platinum dish 25 grams of the sample, evaporate to dryness in a water bath, char and burn at a temperature so low that the fat will scarcely flame until it is burned off, then at a little higher temperature but not above a barely preceptible red until all of the carbon has disappeared and the ash is almost white. Cool in a desiccator and weigh.

To determine the alkalinity of the soluble ash add 25 cc. of water and heat nearly to boiling, filter through an ashless filter, wash with 25 cc. of hot water, dry the filter and contents and burn to a white ash. Weigh to obtain the insoluble ash, and subtract its weight from the total ash to obtain the weight of the soluble ash.

To determine the alkalinity of the water-soluble ash add 20 cc. of N/10 hydrochloric acid to the filtrate containing the soluble ash, heat nearly to boiling to expel carbon dioxide, cool, add a few drops of phenolphthalein indicator solution and neutralize the excess of hydrochloric acid with N/10 alkali. Determine the cc. of N/10 hydrochloric acid to neutralize the soluble ash, then calculate and record the result on the basis of 100 grams of the sample.

To determine the alkalinity of the insoluble ash place 25 cc. of N/10 hydrochloric acid in the dish containing it and heat

cautiously nearly to boiling, cool and neutralize the excess of hydrochloric acid with N/10 alkali, using phenolphthalein as indicator. Calculate the cc. of N/10 acid required to neutralize the ash and report the result as in the determination for the alkalinity of the soluble ash.

The total ash alkalinity of 100 grams of cream containing between 25 and 33 per cent of fat requires between 14 and 20 cc. of N/10 acid calculated to 100 grams of sample.

To determine the calcium.—Mix the neutral liquids from the soluble and insoluble ash, add 20 cc. of dilute hydrochloric acid, neutralize with ammonia, add one gram of ammonium chloride and an excess of ammonium oxalate. Boil for three or four minutes, filter through an ashless filter and wash with water. Dry the filter with the precipitate, burn the filter, allowing the precipitate and ash to fall into a weighed platinum crucible. Heat gently at first and then for 10 minutes at a very dull red. Avoid over heating, as some of the calcium carbonate may be converted to the oxide. Cool in a desiccator and weigh. From the weight of calcium carbonate obtained calculate the weight of calcium oxide.

The maximum amount of calcium oxide in milk should not exceed 0.212 per cent. In cream, as the percentage of fat increases, the percentage of calcium oxide decreases. The maximum percentage of calcium oxide that is likely to be obtained from pure cream may be calculated by applying the formula:

$$\text{Calcium oxide} = 0.212 \left(\frac{100 - F}{100} \right)$$

F=the per cent of fat in the cream.

A METHOD FOR ANALYZING SALT.[30]

Tests for Insoluble Matter.—After sampling well reduce the salt to a fine powder, and put into a glass-stoppered bottle. Weigh out 10 grams of this powder and dissolve in a beaker by digestion with hot water and filter the solution into a 500 cc. graduated flask. Wash the residue thoroughly, taking care that the residue contains insolubles only and not grains of the slowly soluble calcium sulphate. Fill the flask up to the mark with

distilled water, mix well and set aside for later determinations. Ignite and weigh the insoluble residue. This weight multiplied by 100 and divided by the weight of the sample (10 grams) gives the per cent of insoluble matter.

Test for Calcium:—Remove 150 cc. of the salt solution from the 500 cc. flask with a pipette and add a small quantity of ammonium chloride and a slight excess of ammonium hydroxide. The solution should be clear at this point, if not, more ammonium chloride should have been added. A considerable excess of ammonium oxalate solution is now added and the solution allowed to stand for some time, after which it is filtered and the residue washed well. The precipitate of calcium oxalate contains a slight amount of magnesium at this point and for a complete separation must be redissolved with hydrochloric acid, made alkaline with ammonium hydroxide and reprecipitated with ammonium oxalate. The calcium oxalate precipitate is then dissolved from the filter paper with 150 cc. dilute sulphuric acid and the paper washed well. About 6 or 8 cc. of strong sulphuric acid is then added and the solution warmed to 60° centrigrade and titrated with potassium permanganate solution to a slight pink color. The solution should be stirred during the titration. In order to obtain the percentage of calcium without calculation the potassium permanganate solution should be made up by dissolving 0.5254 gram of chemically pure potassium permanganate in one liter of distilled water accurately measured. It is best to make up at least five liters of this solution and use an automatic burette if very much work is to be done. Each 10 cc. of this solution will be equal to 1% calcium with the above method.

The potassium permanganate solution should be kept in a brown bottle or a bottle painted black. It is well to check the solution from time to time against a weighed sample of chemically pure sodium oxalate. Thirty cubic centimeters of the potassium permanganate solution will consume 0.03342 gram of the sodium oxalate. It is easier to weigh a larger quantity of the salt and several checks should be made at a time, so it is best to dissolve 0.3342 gram of sodium oxalate in 500 cc. of distilled water and take several portions of 50 cc. each. Titrate this with the permanganate solution after adding 5 or 6 cc. of strong sulphuric acid and warming to 60° Centigrade. If the permanganate is

found to be too weak it can be strengthened by adding a little of a stronger solution.

Test for Magnesium:—The combined filtrates from the calcium determination are acidified, evaporated to about 100 cc., 30 cc. of strong ammonia and 25 cc. of 10% solution of sodium arsenate added. This is best done in an Erlenmeyer flask, so that the solution may be vigorously shaken after the reagents have been added. The precipitate is filtered off, washed with the least possible amount of dilute ammonia, dissolved in 25 cc. dilute sluphuric acid (1 to 4) into the original flask. The filter is washed with 50 cc. hot water and 10 cc. sulphuric acid (1 to 1) added. After cooling, 3 to 5 grams of potassium iodide are added, the solution allowed to stand for five minutes, then the liberated iodine titrated with sodium thiosulphate solution to a faint straw color. A few cubic centimeters of starch solution are then added and the titration completed to a colorlessness. The standard sodium thiosulphate solution should be made up of 6.7863 gm. of chemically pure sodium thiosulphate crystals ($Na_2S_2O_3.5H_2O.$) per liter. Ten cubic centimeters of this solution is equal to 1% magnesium. Standardize this solution against 50 cc. samples of a solution of 0.4942 gm. of chemically pure magnesium sulphate crystals in 500 cc. of distilled water treated as for the analysis of magnesium. It should take exactly 30 cc. of the standard sodium thiosulphate solution to titrate these samples. The starch indicator solution is made by mixing 1 gm. of starch to a paste in a little cold water and then gradually pouring this into 200 cc. of boiling water. This solution should be boiled a little and put into a glass stoppered bottle with a few drops of chloroform when cool.

Test for Sulphate.—A sample of 100 cc. of the original salt solution is transferred to a 250 cc. beaker, made very slightly acid with hydrochloric acid, heated to boiling and an excess of barium chloride solution containing about 100 gms. of the salt per liter is added while rapidly stirring the solution. After allowing to stand a few moments the barium sulphate is filtered off on an ashless filter and washed well with water. The filter containing the precipitate is then placed in a weighed porcelain or platinum crucible and ignited, cooled and weighed.

Other Impurities.—Potassium, bromine and iodine are present in rock salt and brines in very small quantities, if present at all, so there is no need, except in the rarest cases, to analyze the salt or brine for them. It is customary to regard the balance of the material as sodium chloride or common salt.

VANILLA EXTRACT.

Pure vanilla extract is made from the vanilla bean. There are several varieties of this bean and the different varieties vary quite widely in flavoring value. The choicest extract is obtained from beans grown in Mexico. The Tonka bean, which is not a variety of the vanilla bean, is commonly used in making imitation or substitute vanilla flavoring. The Tonka bean contains coumarin, which subtance is not present in the vanilla bean. By extracting the Tonka bean and by mixing synthetic vanillin and other substances, such as caramel, prune juice, resinous material, glycerol and alcohol, a flavoring may be made that resembles pure vanilla extract, but the difference can be detected by the analyst. The pure extract possesses a delicacy of flavor and subtlety of aroma that cannot be obtained in the substitute or artificial product. The presence of coumarin, abnormal amount or deficiency of vanillin and resinous material, and peculiar reactions of the latter assist in distinguishing the fictitious from the pure extract.

The pure vanilla extract is usually made by cutting the vanilla beans into small pieces, then crushing them, adding sugar, alcohol and water; macerating the mixture for several hours, then placing it in a percolator and extracting it with 50 per cent alcohol.

Vanilla extract of U. S. Standard quality is the flavoring extract obtained from the vanilla bean with or without sugar or glycerine and contains in 100 cc. the soluble matters from not less than 10 grams of vanilla bean.

EXAMINATION OF VANILLA EXTRACT.

Total Solids, A. O. A. C. method.—Official. Digest pure quartz sand with strong hydrochloric acid, wash, dry and ignite. Preserve in a stoppered bottle.

Place 6-7 grams of the prepared sand and a short stirring rod in a flat bottomed dish. Dry thoroughly, cool in a desiccator and

weigh. Then add 3-4 grams of the extract, mix with the sand, dry in a water oven at the temperature of boiling water for 8-10 hours, stirring at intervals of an hour, cool in a desiccator and weigh. Stir, heat again for an hour, cool and weigh. Repeat the heating and weighing until the loss of water in an hour is not greater than 3 mg.

Alcohol determination: Place 25 cc. of the sample in a distilling flask and add 25 cc. of water. Distil almost 25 cc. and make up to 25 cc. with water. Determine the specific gravity of the distillate at 15.6° C. Obtain from an alcohol table the grams per 100 cc.

Vanillin and coumarin: A. O. A. C. Method—Official. (This method is not applicable to concentrated vanillin and coumarin preparations in which the amount of vanillin and coumarin present in 50 cc. exceeds the quantity dissolved by 100 cc. of water at 20° C. In such cases employ a smaller amount of sample and dilute to 50 cc.)

Preparation of solution: Measure 50 cc. of the extract at 20° C. into a 250 cc. beaker with marks showing volumes of 80 and 50 cc., dilute to 80 cc. and evaporate to 50 cc. on a water bath kept at 70° C. or below. Dilute again to 80 cc. and evaporate to 50 cc. Transfer to a 100 cc. flask, rinsing the beaker with hot water; add 25 cc. of 8 per cent neutral lead acetate solution; make up to the mark with water, shake and allow to stand 18 hours (overnight) at 37°-40° C. Decant into a small, dry filter, reserving the filtrate for the determination of vanillin and coumarin, the lead number, and the residual color.

Determination: Transfer a 50 cc. aliquot of the filtrate to a separatory funnel and extract with four successive portions of ether (previously washed twice with an equal volume of water to remove alcohol). Wash the combined ether solutions four or five times with 2 per cent ammonium hydroxide solution (2 per cent NH_3 by weight), using 10 cc. the first time and 5 cc. thereafter, and reserve the ether solution for the determination of coumarin. Slightly acidify the combined ammoniacal solutions with hydrochloric acid; cool and extract in a separatory funnel with four portions of washed ether, using about 40 cc. altogether. Evaporate the ethereal solutions at room temperature, dry over

sulphuric acid and weigh. If the residue is considerably discolored or gummy, re-extract in the dry state with boiling petroleum ether (b. p. 40° C. or below) not less than 15 times; evaporate the solvent, dry and weigh. The residue should now be white, crystalline vanillin, with a melting point of approximately 80° C. A small amount of this residue, dissolved in 2 drops of concentrated hydrochloric acid, should develop a pink color upon the addition of a crystal of resorcin.

Evaporate at room temperature the original ether extract of the sample, from which the vanillin has been removed by means of ammonium hydroxide, and dry over sulphuric acid. The residue, if pure coumarin, should melt at approximately 67° C. and should respond to Leach's test for coumarin as follows: A small portion of the residue, dissolved in not more than 0.5 c. c. of hot water, should yield a brown precipitate upon the addition of a few drops of N/10 iodin. This precipitate finally gathers in green flecks, leaving a clear, brown solution. The reaction is especially marked if the reagent is applied with a glass rod to a few drops of the solution on a white plate or tile.

Lead Number: A. O. A. C.—Official. To a 10 cc. aliquot of the filtrate from the lead acetate precipitate, as obtained under "Preparation of solution," add 25 cc. of water, 0.5-1.0 cc. of sulphuric acid, and 100 cc. of 95 per cent alcohol by volume. Let stand over night, filter on a Gooch crucible, wash with 95 per cent alcohol, dry at a moderate heat, ignite at low redness for three minutes, taking care to avoid the reducing flame, and weigh. Conduct a blank determination employing water containing 4 or 5 drops of glacial acetic acid in place of the sample. The lead number is calculated by the following formula:

$$P = \frac{100 \times 0.6831\ (S—W)}{5} = 13.66\ (S—W)$$ in which

P=lead number (grams of metalic lead in the precipitate obtained from 100 cc. of the sample);

S=grams of lead sulphate corresponding to 2.5 cc. of the lead acetate solution as determined in a blank analysis; and

W=grams of lead sulphate obtained in 10 cc. of the filtrate from the lead acetate precipitate, as obtained under "Preparation of solution."

Vanilla Resins

Qualitative Test: A. O. A. C.—Tentative. Place 50 cc. of the extract in a glass dish and evaporate the alcohol on a water bath. When the alcohol is removed, make up to about the original volume with hot water. If alkali has not been used in the manufacture of the extract, the resins will appear as a floculent red to brown residue. Acidify with acetic acid to free the resins from the bases, separating the resins completely and leaving a part decolorized, clear, supernatant liquid after standing a short time. Collect the resins on a filter, wash with water and reserve the filtrate for further tests.

Place a portion of the filter with the attached resins in a few cc. of dilute potassium hydroxide solution. The resins are dissolved, giving a deep red solution; acidify, and the resins are precipitated.

Dissolve a portion of the resins in alcohol. To one portion add a few drops of ferric chloride solution; to another portion, hydrochloric acid; neither produces any marked change in color. Most resins, however, in alcoholic solution give color reactions with ferric chloride or hydrochloric acid.

To a portion of the filtrate obtained above add a few drops of basic lead acetate solution. The precipitate is so bulky as to almost solidify, due to the excessive amount of organic acids, gums and other extractive matter. The filtrate from the precipitate is almost colorless.

Test another portion of the filtrate from the resins for tannin with a solution of gelatin. Tannin is present in varying but small quantities but should not be present in great excess.

Color value: A. O. A. C.—Tentative. Pipette 2 cc. of the extract into a 50 cc. graduated flask and make up to the mark with a mixture of equal parts of 95 per cent alcohol and water. Determine the color value of this diluted extract in terms of red and yellow by means of a Lovibond tintometer, using a one-inch cell. To obtain the color value of the original extract multiply the figures for each color by 25.

Residual Color After Precipitation With Lead Acetate: A. O. A. C. Method—Tentative. Determine the color value, in terms of red and yellow, of the filtrate from the lead acetate precipitate

as obtained under "Preparation of Solution," using a 1-inch Lovibond cell. Multiply the reading by 2 to reduce the results to the basis of the original extract. If the actual reading of the solution is greater than 5 red and 15 yellow, as may happen if the extract is highly colored with caramel, a ½ or ¼ inch cell should be employed, and the readings multiplied, respectively, by 4 or 8. Divide the figures for red and yellow, respectively, by the corresponding figures of the original extract and multiply the quotients by 100, to obtain the percentages of the two colors remaining in the lead acetate filtrate.

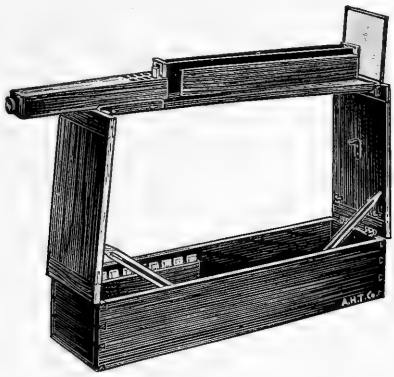


Fig. 154. Lovibond Tintometer.
Courtesy Arthur H. Thomas Co.

Calculate also the relation of the red to yellow in both extract and lead acetate filtrate.

GELATIN.

Gelatin is an albuminoid-like material extracted from bones and other animal parts by heating them in water. When hot water containing as low as one per cent of gelatin cools a jelly forms. The substance is used legitimately in preparing a number of palatable dishes and as a stabilizer in ice cream. When the substance is added surreptitiously to produce body and apparent richness in dairy products, as for example, to ordinary market cream, it is used for a deceptive purpose and is then classed as an adulterant.

The quality of gelatin may vary according to the material from which it is made, the methods of manufacture and the presence or absence of impurities. The pure food regulations of the United States Department of Agriculture specify that there shall be, per million parts of gelatin, not more than 350 parts of sulphurous acid, 100 parts of zinc, 300 parts of copper and 1.25 parts of arsenic.

Grading and Testing Gelatin: Place 30 grams of the granulated gelatin in a 250 cc. container and add 180 cc. of cold water, stir thoroughly and soak for 1 hour. Then place the vessel containing the soaked gelatin in a water bath at 60°C. (140° F.) until the gelatin is all dissolved. Let stand about ten minutes longer, then determine the color and odor.

Mojonnier Viscosity Test for Gelatin. T. Mojonnier. Add together dry gelatin and water in the exact proportions to make 200 cc. of solution containing .10, .25, .50, .60, .75, 1.00, and 1.50 per cent respectively, of the gelatin. Heat to 140° F. until the gelatin is all dissolved. Cool and hold in ice water for at least twelve hours. Determine the viscosity in each sample using the Mojonnier-Doolittle viscosimeter, described in this chapter. Read and record results in terms of degrees of retardation. For comparison make determinations using water only.

The best qualities of gelatin when made up into solutions containing one per cent or more of the gelatin, may yield a product that is too viscous to permit of the determination of the viscosity by the above method.

Frohring Gelatin Foam or Air Test. W. O. Frohring. Add together dry gelatin and water in the exact proportion required to make 100 cc. of solutions containing various percentages of gelatin. The most practical amounts are .20, .50, .60, .70, .80, .90, and 1.00 per cents respectively, of the gelatin. Heat to 140° F. until the gelatin is all dissolved. Cool and hold in ice water for at least twelve hours. Whip for one minute using electric soda fountain mixer. Read and record increase in volume, immediately after whipping and at end of half hour interval.

Jelly Value of Gelatin: A method that is practical and easily applied in determining the jelly value of gelatin has been developed by Clark and Dubois.[31] They make up from each sample

a series of gelatin solutions of known concentrations. These are allowed to cool and set, and are then heated to a predetermined temperature. The concentrations that go into solution are then noted. The sample having the lowest percentage concentration that does not go into solution has the highest jelly value.

Procedure: Number from 1 to 10 a series of 6-inch test tubes that are nearly equal in diameter, graduated at the 10 cc. mark and fitted with corks. Into tube No. 1 weigh 0.1 gram of the granulated gelatin, into tube No. 2 weigh 0.2 gram and so on, increasing the amount of gelatin in each successive tube by 0.1 gram. Add cool water until the tubes are full to the 10 cc. mark, place a glass rod in each tube and stir the contents occasionally during several hours, then stand the tubes in boiling water until the gelatin is completely dissolved. When complete solution is obtained remove the glass rods and cork the tubes tightly to prevent the formation of a skin on the surface when the gelatin cools. Cool the tubes considerably below 10° C. (50° F.) if that is to be the observation temperature. Next place the tubes in water and warm it up very gradually to the temperature at which the observation is to be made (10 C. is advised for making the observation). Observation of the "set" is then made by tilting the tubes and noting which contain the gelatin in solution and which do not.

The observation may be made at other temperatures, but 10° C. is considered as a good average working temperature. After experience has been obtained by working with the method it may be found that it is not necessary to make up a series of as many as 10 tubes in order to cover the concentrations that go into solution or remain set at the observation temperature.

GUM ARABIC.

McMillan's Method for Analyzing Gum Arabic.[32] **Reagent**: Dissolve 50 grams of copper acetate in water, add an excess of ammonia and make the solution up to 1000 cc., using alcohol and water in such proportion that the final solution contains 50 per cent of alcohol.

Determination: Place 50 cc. of a 5 per cent solution of the original sample in a beaker, add an equal volume of alcohol and

25 cc. of the copper reagent, stirring constantly. Filter through a weighed paper. Wash the precipitate with 50 per cent alcohol containing ammonia, then with 70 per cent and finally 95 per cent alcohol. Dry to constant weight at 105° C., ignite and weigh the ash.

Moisture: Determine the percentage of moisture in some of the original sample by drying in a current of hydrogen at 105° C.

Add the weight of the moisture to the weight of the ash and subtract the sum thus obtained from the weight of the substance obtained by precipitation with the copper reagent. The difference is the "net gum arabic."

GUM TRAGACANTH.

At present methods have not been completed which satisfactorily determine the relative merits of different samples of gum tragacanth, or, for readily distinguishing the presence of all adulterants and substitutes. The most common adulterant and substitute is Indian gum, but Peru gum, and nourtoak root mixed with gypsum have also been used. The adulterant may be less soluble than gum tragacanth, or after bringing it into solution with difficulty, it may liquefy so far that it is of little value. The A. O. A. C. gives the following method for measuring the purity of gum tragacanth.

Volatile Acidity (Tentative).—The quantity of volatile (acetic) acidity developed in the acid hydrolysis of gum tragacanth (Astragalus gummifer) affords a valuable index of the purity of this commodity when compared with results obtained by similar treatment of so-called "Indian gum" (Cochlospernum gossypium and Sterculia urens). The term "volatile acidity" expresses the number of cc. of N/10 potassium or sodium hydroxid required to neutralize the volatile (acetic) acid obtained by distilling with steam the products of the action of boiling aqueous phosphoric acid on 1 gram of the gum.

Treat 1 gram of the whole or powdered sample in a 700 cc. round-bottomed, long-necked flask for several hours in the cold with 100 cc. of water and 5 cc. of sirupy phosphoric acid until the gum is completely swollen. Boil gently for 2 hours under a

reflux condenser. A very small amount of cellulose substance will remain undissolved. Now distill the hydrolyzed product with steam, using a spray trap to connect the distillation flask with the condenser and continue until the distillate amounts to 600 cc. and the acid residue to about 20 cc. Do not concentrate too far, as this would scorch the non-volatile, organic decomposition products and possibly contaminate the distillate. Titrate the distillate with N/10 potassium hydroxid, using 10 drops of phenolphthalein as an indicator, finally boiling the liquid under examination until a faint pink color remains. Correct the result by a blank determination and express the final results in terms of the number of cc. of N/10 alkali required, as in the above definition.

While tragacanth yields a practically colorless solution when boiled with aqueous phosphoric acid, Indian Gum, on the other hand, gives a pink or rose solution. This reaction may be used as a preliminary test for the detection of Indian gum.

THE SPECIFIC HEAT OF DAIRY PRODUCTS.

In recent years processes for heating and refrigerating have become important economical factors in the manufacture and preservation of dairy products. The production of high or low temperatures in large masses of material involves considerable expense and, unless the methods employed in obtaining them are properly controlled, when applied to the products of the dairy there is always present the danger of further loss through damaging the materials. Different substances vary in the amount of heat required to raise their temperature through a given range. The causes of these differences are both physical and chemical, and the capacity of a substance to absorb heat may vary considerably as changes occur in its physical and chemical status.

The unit of heat measurement or thermal unit is the calorie. It is the amount of heat required to raise the temperature of one gram of water one degree centigrade. As the amount varies slightly with changes in temperature, the temperature at which measurements are made should always be given. It should be stated that the large calorie is used in engineering practice. It is the amount of heat required to raise one kilogram of water one

degree C. The British thermal unit (B. T. U.) is the heat required to raise one pound of water one degree Fahrenheit, while in most European continental countries the kilogram is substituted for the pound, as the unit of weight.

When substances having different temperatures are brought together the temperature of the warmer material falls on account of a transference of heat to the colder material. The amount of heat that is transferred in this way by unit mass of a substance while cooling 1° C. is called the specific heat of that substance. As this amount is equal to the number of calories required to raise unit mass of the substance 1° C., the specific heat of a substance may be defined as the number of calories required to raise the temperature of 1 gram of the substance 1° C.

Methods for studying the specific heat of different substances have been in process of development during the past century. Recently Hammer and Johnson[33] designed special apparatus and made a study of the specific heat of several dairy products. A description of one of the forms of apparatus developed, their method for making specific heat determinations, and some of the results obtained follow.

Apparatus Design.—"In apparatus No. 1, for variable voltage, Fig. 155, the outer insulating walls (1) of the apparatus consists of pressed cork, such as is used in the construction of refrigerators and thermostats. In the cylindrical cavity (2), which may be gouged out with a sharp paring knife, is the copper (or glass) calorimeter vessel (3) (Dia.=6.25 cm. Height=8.75 cm.) for holding 100 gms. of sample; (4) is another copper vessel (D= 4.7 cm., H=8.1 cm.) with a capacity of 100 gms. of water, in which is immersed an electric light bulb and a thermometer to which a stirrer is attached. The vessel is arranged with a tight fitting cap having a bayonet catch. Leads from the electric lamp pass up through a fibre or glass tube (5) which also serves as a handle for the whole vessel and its contents which we may call the "heater." The upper portion (6) of the cork insulating vessel has cut through it a cylindrical hole just a trifle greater in diameter and deeper than the heater. Between the upper and lower portions of the cork container is a heavy asbestos board partition (7) the middle third of which is a slide that may be readily inserted or withdrawn.

Operation of the Apparatus.—The operation of the apparatus is as follows: . 100 grams of milk is weighed in the vessel (3) which is placed in the cork thermostat. A thermometer (8) reading .1 degree C. is then inserted. The electric current is turned on the heater (4) and this is allowed to come to a suitable temperature outside of the thermostat. If the temperature of the milk is 20 degrees C. it will be sufficient to heat the heater to about 45° C. It is then placed in the cavity (9) and allowed to come to a condition such that radiation takes place regularly, the thermometer (8) is read, and when the mercury of the thermometer (10) comes to a chosen mark the heater is dropped down

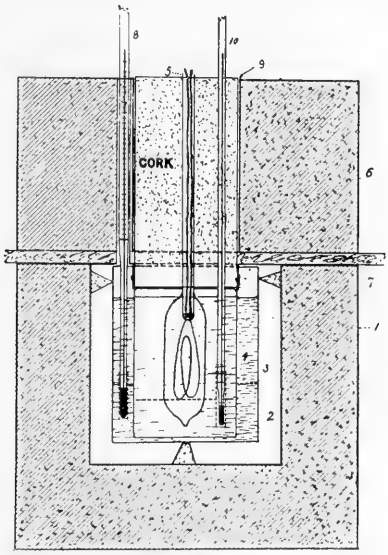


Fig. 155.
Specific Heat Determination Apparatus.

into the liquid in the calorimeter vessel. The liquids of both vessels are agitated regularly until the thermometer (8) shows the maximum rise of temperature. Results are gotten for water and the substance in hand for the same range of temperature. The specific heat of the substance is inversely proportional to the temperature rise, the rise being compared with that of water

under like conditions. Corrections for radiation and the water equivalent of the calorimeter must of course be applied.

Specific Heat of Whole Milk. The samples of milk used in the tests were from the composite milk delivered at the College creamery. The fat content varied from 3.4 per cent to 4.9 per cent, most samples having about 4.3 per cent. About 15 hours elapsed between the time the milk was drawn from the cows and the time of the tests. After the milk was delivered at the creamery the samples were kept in the refrigerator.

The averaged results for the various temperatures have been plotted in the form of a curve. See Fig. 156.

Though the changes in the specific heat of milk between 15.0° C. and 60.0° C. are not great, still there is shown by our data a fairly pronounced maximum at about 30.0° C.

Specific Heat of Skim-milk. Samples of sweet, skim-milk varying in fat content from 0.30 to 0.38% were obtained from a small separator immediately after running through the machine. The average 15 determinations on 4 different samples made beween approximately 20 and 40° C. gave an average value of 0.949 Over the pasteurizing range of 60°-70° C. the average value of 0.963 was obtained.

Specific Heats of Cream. The creams used were sweet and were separated from composite milk in the morning and kept in a refrigerator until evening when the measurements were carried out. A series of determinations were made on each sample over quite a wide range and generally up to aout 60° C.

In the course of the measurements on creams it was found that apparent specific heats considerably above 1,000 were often encountered. This peculiarity of cream was also noted by Fleishmann. The authors' data for 33.5 per cent, 30 per cent, 27 per cent, 15 per cent and 60 per cent creams have been obtained under very definite conditions and the results averaged; from the averages the curves shown in Fig. 156 have been plotted and these will be discussed later. The 60% cream was first heated, as it was very viscous at room temperature.

TABLE 109.

Specific Heat of Skim-Milk.

SAMPLE No. 1		SAMPLE No. 2		SAMPLE No. 3	
Temp. C.	Sp. H.	Temp. C.	Sp. H.	Temp. C.	Sp. H.
18.80°		15.35°		21.00°	
	0.951		0.941		0.942
24.00°		20.72°		26.20°	
	0.948		0.941		0.940
29.70°		25.88°		31.20°	
	0.957		0.937		0.948
34.54°		30.90°		36.00°	
	0.955		0.958		
39.32°		35.70°			
	0.957				
43.95°					
Av.	0.954		0.944		0.943

SAMPLE No. 4		SAMPLE No. 5		SAMPLE No. 6	
Temp. C.	Sp. H.	Temp. C.	Sp. H.	Temp. C.	Sp. H.
20.30°		61.90°		58.55°	
	0.946		0.977		0.942
25.80°		65.68°		62.55°	
	0.960		0.974		0.948
31.09°		68.20°		65.20°	
	0.957		0.972		0.952
36.14°		70.60°		68.10°	
					0.966
				70.66°	
Av.	0.954		0.974		0.952

Specific Heat of Whey. The whey used was from composite milk and was obtained from the cheese vat. There was present from 0.25 to 0.30 per cent fat and the samples were opalescent. The values obtained for two samples taken at different times were very near one another. The average specific heat between 23° and 33° C. was 0.975.

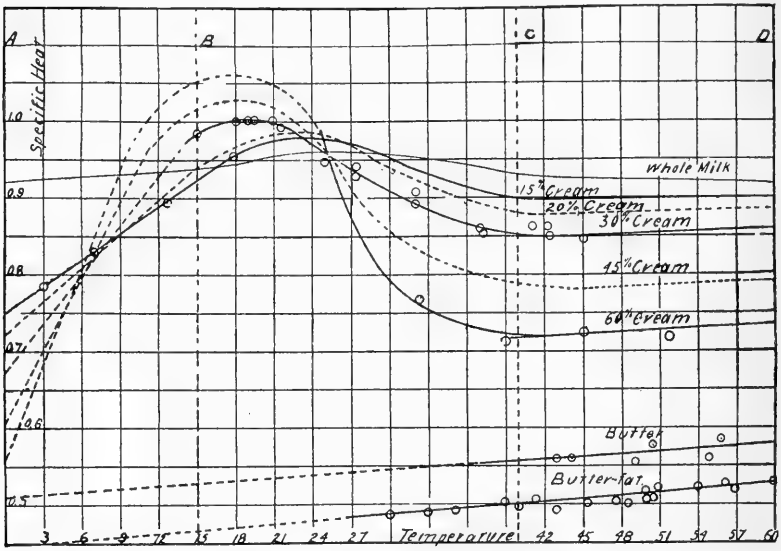


Fig. 156. Specific Heat of Several Dairy Products at Various Temperatures.

TABLE 110.

Specific Heat of Whey.

SAMPLE NO. 1.		SAMPLE NO. 2.	
Temp. Range C.	Sp. H.	Temp. Range C.	Sp. H.
22.99	....	22.93	....
28.38	0.977	28.32	0.977
33.60	0.974	33.55	0.975
Average.....	0.975	Average.....	0.975

Specific Heat of Butter. Three samples of butter taken from the churning on three different occasions, and containing the ordinary amounts of curd, salt, water and fat gave the following results:

TABLE 111.

Specific Heat of Butter.

No.	% Salt	% Curd	% Water	% Fat	Av.-Sp. Heat 30-60° C.
I.....	2.2	0.60	14.20	83.0	0.688
II.....	1.02	0.48	13.50	85.0	0.557
III.....	1.14	0.76	13.60	84.5	0.574

The values for ordinary butter are considerably higher than for pure fat. This is in part due to the presence of considerable quantities of water.

Specific Heat of Butter Fat. Butter fat carefully prepared in accordance with the specifications of the official method gave the following results:

No. 1 Average from 30°-60° C. equals 0.532
No. 2 Average from 30°-60° C. equals 0.510

Average 0.521

Samples of practically pure butter fat were also prepared by taking freshly churned butter, placing it in a large separatory funnel, and keeping it in a thermostat at 43° C. so as to allow the fat, curd and water to separate by gravity. Water was added several times, shaken with the melted fat and allowed to separate and then drawn off. Next fused calcium chloride was added and the melted fat thoroughly dried, then filtered. The average value between 30° C. and 60° C. for four samples thus treated was 0.507. At 30° C. it was 0.485 and at 60° C. 0.530."

The results obtained by Hammer and Johnson on milk agree fairly well with the results obtained by previous investigators, but they point out that, heretofore, results obtained on cream and

butter varied widely due to making no allowance for influencing factors such as the temperature range over which the substances were to be heated or cooled. A more detailed discussion of results may be found in the original publication.

TABLE 112.

Specific Heat Values for Milk and Milk Derivatives.

Material	Conditions		Specific Heat	Investigator	Reference
	Temperature C.	% Fat			
Whole Milk	16—17°		.9406 .0523	Chanoz & Vaillant	Grimmer-Chemie and Physiologie der Milch. Orig. Journ. de Phys. et de Pathol Generale 8, p. 413.
Whole Milk	14—16°	3.17	.9457	Fleischmann	Jour. Landwirtschaft 50, p. 33.
Whole Milk	27.5 up to 40 and return		.9351	Fleischmann	Jour. Landwirtschaft 50, p. 33.
Whole Milk			.94	Fjord	McKay & Larsen, Principles and Practices of Butter Making.
Skim-Milk	14—16°	.20	.9388	Fleischmann	See above.
Skim-Milk	27.5 up to 40 and return		.9455	Fleischmann	See above.
Cream	14—16°	19.18	.9833	Fleischmann	See above.
Cream	27.5 up to 40 and return		.8443	Fleischmann	See above.
Cream			.7	Fjord	McKay & Larsen. See above.
Butter			.4	Fjord	McKay & Larsen. See above.
Butter	31.15		.5207	Fleischmann	See above.
Butter			.55	King	Siebel's Compend. Mech. Ref. & Eng.

THE FREEZING POINT OF MILK.

As the freezing point of milk is one of its least variable factors, it has been used with considerable success in determining the presence of added water. The followng temperatures of the freezing point of milk are given by different investigators.

Richmond[34], about 0.55° C. (31° F.); Barthel[35], between 0.55° and 0.57° C.; Atkis[36], 0.55 and further states that it never varies more than 0.03° C.; Stocking[37], 0.55° C.; Grimmer[38], gives 0.54 to 0.57° C.; Heineman[39], 0.54 to 0.57 and further states that

dilutions with water below 10 per cent cannot be detected with certainty by freezing point determinations. Others state that as little as 5% of added water can be detected with certainty, and the Chem. Bulletin[40], volume 7, No. 4, University of Minnesota Section, states that the method is reliable to a minimum of 3 per cent of added water and gives the results shown in Table 113.

TABLE 113.

Detection of Water Added to Milk by Freezing Point Method.

No. of Sample	Specific Gravity at 60° F.	Fat	Tota Solids	Solids Not Fat	Freezing Point— 0 Deg. C.	Added Water Found	Water Added
		%	%	%		%	%
1	1.029	4.6	12.92	8.32	0.475	13.6	12.0
2	1.0312	4.8	13. 7	8.9	0.490	10.9	10.0
3	1.0339	5.2	14.85	9.65	0.544	none	none
4	1.0346	52	15.03	9.83	0.549	none	none
5	1.0319	5.0	14.12	9.12	0.518	5.8	4.0
6	1.0314	4.8	13.75	8.95	0.505	82.	8.0
7	1.0311	3.7	12.35	8.65	0.518	5.8	market
8	1.0328	3.7	12.77	9.07	0.524	4.7	market sample
9	1.0339	3.7	13.03	9.33	0.541	none	market sample

Different forms of apparatus have been devised for the purpose of determining freezing points. The best known are Beckmann's freezing point apparatus and Hortvet's Cryoscope illustrated under Fig. 157. By means of the latter apparatus the freezing point determination of milk may be made in less than 10 minutes. The directions for making determination are given as follows:

Insert a small caliber thistle-tube or funnel tube into the vertical portion of the T-tube at one side of the apparatus and pour in about 400 cc. of ether previously cooled to 15° C. or lower. Close the vertical tube by means of a small cork and

connect the pressure bulb or pump to the air inlet tube of the air drying attachment on the opposite side of the apparatus.

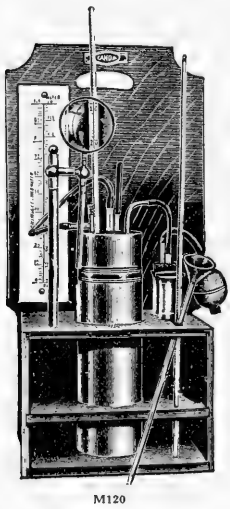


Fig. 157.
Hortvet Cryoscope.

Measure into the inner test tube 30 to 35 cc. of boiled distilled water, previously cooled to 10° C. or lower. Enough water should be measured in to fairly submerge the thermometer bulb. Insert the thermometer, which together with the stirring device is mounted in a sound stopper, and lower the test tube into the larger tube, which is tightly fitted into the apparatus. A small quantity of alcohol, sufficient to fill the space between the two test tubes, will serve to complete the conducting medium between the interior of the apparatus and the liquid to be tested. A sufficiently tight connection between the inner and outer tubes is afforded by means of a narrow section of thin walled tubing. The thermometer and stirring device should fit accurately in the stopper and the entire arrangement should be in a vertical position.

By means of the pressure pump maintain a steady current of air through the apparatus, thereby vaporizing the ether at a fairly rapid rate. Arrangement may be made so as to conduct the ether vapors away from the operator and the apparatus should not be used in the vicinity of a flame. Keep the stirring device in a steady up-and-down motion at a rate of approximately one stroke each two or three seconds, or even at a slower rate providing the cooling proceeds satisfactorily. Maintain passage of air through the apparatus until the temperature of the ether cooling bath approaches 3° below zero, as indicated on the control thermometer, or until the top of the mercury thread in the special freezing point thermometer recedes to a point in the neighborhood of the probable freezing point of water. Continue the manipula-

tion of the stirring device until a supercooling of sample from 1.2 to 1.3° is observed. Also note the temperature recorded on the control thermometer in order to guard against excessive supercooling and a consequent too low convergence temperature. As a rule, by this time the liquid will begin to freeze, as may be noted by the rapid rise of the mercury thread. Manipulate the stirring device slowly and carefully two or three times while the mercury column approaches its highest point. By means of a suitable light weight mallet tap the upper end of the thermometer cautiously several times in order to insure a permanent position of the top of the mercury column. Observe the exact reading on the thermometer scale and estimate to 0.001° C. After a few minutes' time the mercury may begin to recede owing to the cooling effect of the ether in the interior of the apparatus. When the above observation has been satisfactorily completed make a couple of duplicate determinations, then remove the thermometer and stirring device and empty the water from the inner tube.

Rinse out the test tube with about 20 cc. of the sample of milk to be tested, measure into the tube about 35 cc. of the milk, or enough to fairly submerge the thermometer bulb, and insert the tube into the apparatus. In the meantime by lowering a narrow tube into the ether bath, then closing the top end by means of the forefinger and raising to a suitable height, a judgment may be obtained as to whether an additional supply of ether is necessary for the next determination. Usually an additional 50 to 75 cc. of cold ether should be poured in at this stage. When the apparatus has once cooled down to low temperature an additional 50 cc. of ether is sufficient on an average for every four or five succeeding determinations.

Make the determination on the sample of milk, following the same procedure as that employed in determining the freezing point of water. As a rule, however, it is necessary to start the freezing action in the sample of milk by dropping in a small

fragment of ice (approximately 0.05 gram) at the time when the mercury column has receded to a place from 1.2 to 1.3° below the probable freezing point. A rapid rise of the mercury column results almost immediately. Manipulate the stirring device slowly and carefully two or three times while the mercury column approaches its highest point. Complete the adjustment of the mercury column in the same manner as in the preceding determination, then observe the exact reading on the thermometer scale and estimate to 0.0001°. The algebraic difference between the reading obtained on the sample of water and the reading obtained on the sample of milk represents the freezing point of the milk.

For deducing the proportion of added water from the determined freezing point use Winter's Table as published in extended form in the Chemical News, Vol. 110, 1714, pages 283-284, or use the porcelain scale accompanying the cryoscope. The percentage of added water (W) may also be calculated as follows:

$$W = \frac{100\ (T—T^1)}{T}$$

in which T represents the average freezing point of normal milk (—0.550) and T^1 the observed freezing point on a given sample.

THE PREPARATION OF PURE MILK CONSTITUENTS.

Milk Fat:—Place in a tall cylinder fresh unsalted butter obtained by churning pure sweet cream, hold at a temperature of 60° C. (140° F.) until the water and curd settles. Filter most of the melted fat without allowing any of the water to get onto the filter. Dry the filtered fat carefully and preserve in air tight glass stoppered jars in a cool place away from the light.

Pure Casein. Van Slyke and Baker Method[41].—The aim of this method is to introduce an acid into the milk in a manner that approaches that of natural souring, and then to separate the casein from the serum while all of the calcium and inorganic phosphorous are in solution.

Description of Apparatus.—The apparatus used in coagulating casein in milk by adding acid under the surface with rapid stirring consists of four main parts: the milk container, the burette, the acid-carrying tube, and the stirrer (see Fig. 158).

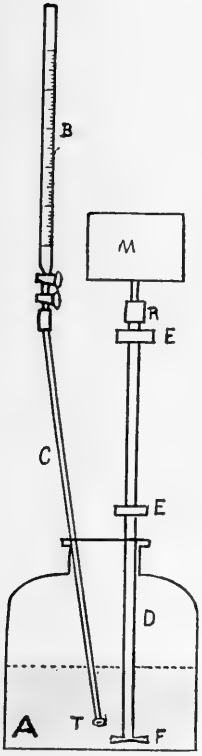


Fig. 158. Casein Coagulating Apparatus.

(1). Milk container:—A wide mouthed, broad, low form container (A) of the desired capacity permits the best stirring with least vibration.

(2). Burette:—Use a burette with two stop cocks, one for regulating the flow of acid and another to serve as a shut-off.

(3). Acid tube:—Diameter of bore 1.5 to 2 mm., the tip of the tube is bent upward, with opening (T) in the form of a narrow slit. A rubber joint connects the tube to the burette. A pinch-cock must not be used on the rubber connection in place of the second stop cock or milk and casein may be drawn into, and clog the tip opening.

(4). Stirring-rod (D):—This is made of rigid glass tubing about 1 cm. in diameter mounted on ball bearings. It must revolve rapidly at a speed sufficient to stir the milk thoroughly and without excessive foam. The connection with the motor (M) is made by means of rubber tubing (R). A rheostat connection controls the speed of the stirrer.

Placing the stirrer at one side of the container prevents the formation of a whirlpool and drawing air into the milk which would cause foaming. The acid delivery tube is so placed that the whirling milk washes the tip but is not thrown against it, thus avoiding clogging the opening.

Milk Used.—One liter of fresh undiluted skim-milk from a centrifugal separator is used.

Acids Used.—Normal lactic acid or a mixture of 1 part normal hydrochloric acid and 1 or 2 parts of normal acetic acid is preferred.

Addition of Acid and Coagulation of Casein.—With the stirrer revolving at 2000 to 3000 revolutions per minute, the acid is allowed to flow so slowly into the milk that no sediment is found at the bottom of a sedimentation tube after centrifuging a few cc. of the milk. About 45 cc. of the acid may usually be added in 30 minutes. When 60 cc. has been added the rate is decreased until the coagulation point is nearly reached, as shown by the following tests:—

Titrate a sample of the original milk to the coagulating point, then calculate and add the right amount of acid slowly, with constant stirring as described above, after the milk in the apparatus has stood about 3 hours, with stirrer revolving at about 500 revolutions, or less, per minute. Brom-cresol purple may also be applied as an indicator.

As the casein precipitation approaches, foaming may be controlled either by adding a few drops of octyl alcohol, or by using a stirrer free from vibration, or by using a container large enough to accommodate the foam.

When a portion of the mixture on centrifuging in a sediment tube yields a definite supernatant layer of solution the addition of acid is stopped. About 90 cc. of the normal lactic acid or of a mixture of 1 part of normal hydrochloric acid and 2 parts of normal acetic acid is ordinarily required. About 75 cc. of normal hydrochloric acid usually is sufficient. The mixture is then allowed to stand 2 to 4 hours with gentle stirring.

Treatment of Casein Coagulum.—The casein is centrifuged in two or four containers at 1000 revolutions per minute, the super-

natant liquid decanted, and the casein washed with distilled water 4 or 5 times, centrifuging between the washings and breaking up the coaglum to a smooth paste with a rubber tipped glass rod. Wash with 95 per cent alcohol twice and with ether three times, adding the liquids gradually with vigorous beating. The alcohol removes alcohol soluble material and water. The water would cause the casein to cake on drying. The ether removes any fat present.

Spread the washed casein on a smooth, flat surface to dry and work the mass gently with a spatula while drying in order to obtain a finely divided product.

Control of Ash and Phosphorus Content.—A product low in phosphorus, about 0.80%, results from holding the casein in an uncoagulated condition for about 3 hours at a degree of acidity just below the coagulation point. A casein with low ash, 0.05 to 0.15 per cent, is obtained by holding the casein after coagulation in the slightly acid solution for 2 to 4 hours. The acid combines with the calcium after decomposing the calcium caseinate, thus yielding a casein of low ash content. It does not appear possible to remove completely the inorganic prosphorus that remains after coagulation once occurs as shown in the table that follows.

Albumin.—Add sufficient acid to skim-milk to make the solution 0.1 per cent acid. The acid must be added very slowly with vigorous constant stirring. Warm the milk, if necessary to cause casein precipitation, to about 40° C. Stir until the liquid is clear, filter through cheese cloth. Refilter the portion that comes through first until a filtrate is obtained that is perfectly clear and free of casein. Boil the filtrate for about 15 minutes. Filter through cheese cloth, wash the precipitate several successive times with distilled water, squeezing out as much of the water as possible after each washing. Rub the albumin in a mortar with 80 per cent alcohol, pour off the alcohol and press out as much as possible, and repeat the treatment several times. Finally

extract with ether 2 or 3 times and dry at as low a temperature as possible.

TABLE 114.

Time of Standing Before Coagulation	Time of Standing After Coagulation	Ash	Phosphorus
Hours	Hours	Per Cent	Per Cent
0	6	0.15	0.85
0	24	0.14	0.86
0	24	0.15	0.83
3	0	0.46	0.81
4	0	0.43	0.81
1	12	0.15	0.85
3	15	0.05	0.80
3	18	0.11	0.81
4	4	0.10	0.81
16	4	0.10	0.81
30	10	0.10	0.80

Milk Sugar.—Use the filtrate from the albumin. Make it slightly alkaline with lime water and add 5 grams (more if necessary) of alum solution for each original 100 pounds of milk. Evaporate to one-sixth of original bulk. Add an equal volume of wood alcohol and let stand. Filter off the sugar crystals, redissolve in distilled water and filter over animal charcoal. Evaporate and if necessary dissolve again and repeat the purification process. Dry thoroughly to prevent mold growth and keep in glass stoppered bottles.

Ash.—Evaporate skim-milk to dryness in a large evaporator over a free flame. Incinerate the residue to whiteness in a muffle using porcelain dishes or crucibles for the purpose.

Citric acid. (Method of T. Mojonnier).—Remove the granules of calcium citrate from the bottom of evaporated milk cans. Wash thoroughly with water. Dry. Grind to a fine powder. Add 5 per cent sulphuric acid in quantity slightly under that required to combine with all the calcium contained in the above salt. The reaction takes place according to the following equation:—

$$Ca_3(C_6H_5O_7)_2+4H_2O+3H_2SO_4=3CaSO_4+2C_6H_8O_7+3H_2O$$

570.144 : 294.228=1.0 : .5161

Therefore add the sulphuric acid in the proportion of one part calcium citrate to .5161 part sulphuric acid calculated upon the water free basis.

Heat the mixture carefully, not to exceed 140° F.

Filter hot through bone black. Evaporate to small bulk, and allow to stand in evaporating dish until the citric acid crystals have separated. Separate the crystals from the motor liquor. Recrystalize until pure white crystals are obtained.

HYDROGEN ION CONCENTRATION AND ITS DETERMINATION.

The theory of electrolytic dissociation announced by Arrhenius[42] in 1887 has been the subject of study and investigation for several years. While, at present, there is not a clear conception of all of the phenomena connected with it, the results already obtained may be applied to advantage especially in the different branches of chemistry and biology. In those fields many workers apply it daily and a reasonable understanding of the theory of electrolytic dissociation, and ability to apply it, by workers in bacteriology and certain branches of dairying is already, or rapidly becoming, a necessity. For example, in making culture media the amount of dissociated hydrogen must be controlled on account of its influence on the growth of bacteria. In the dairy industry, in addition to its application in dairy bacteriology, a knowledge of the amount of dissociated hydrogen present in milk may be used to advantage in milk inspection work and in selecting and allotting milk to be manufactured into different dairy products. In the food processing industry it is known that the temperature necessary to employ and the duration of its application to a given food substance, in order to obtain sterilization, is affected by the nature, condition and especially, in a large measure, by the acidity of the substance. The acidity was formerly measured by its degree of concentration, but at present it is known that a part of some of the acid elements may be present in acid solution in a condition which enables them to act more intensely than the remainder of the acid. An acid contains hydrogen, and when in solution has the property of dissociating into two components, namely hydrogen ions and a reserve quantity of acid capable of producing them. The hydrogen ions act more intensely than the remainder of the acid and

in the processing of food play an important part in the destruction of bacteria. Therefore, a means of measuring the acidity due to dissociated hydrogen in food liquids may be used to great advantage in the food processing industry.

The relative amounts of dissociated hydrogen present in acid solutions are expressed by the terms "hydrogen ion concentration" or "pH" value. In order to bring out clearly the meaning of these terms Bigelow and Cathcart's[43] excellent description is given here.

Explanation of pH Value and Hydrogen Ion Concentration.—

"Water has the property of dissociating or separating into its components to a very slight extent as shown in the equation: $HOH = H^+ + OH^-$. The symbol H^+ is that of the hydrogen ion and OH^- that of the hydroxyl ion. The $^+$ and $^-$ signs signify that these ions carry respectively a positive and a negative charge of electricity. Only about one one-hundred-millionth of one per cent of pure water is dissociated into hydrogen ions and there are an equal number of hydrogen and hydroxyl ions.

All acids contain hydrogen in combination and, dissolved in water, dissociate to yield hydrogen ions; whereas all alkalis contain hydrogen and oxygen in the proportion found in the hydroxyl ion and, dissolved in water, dissociate to yield hydroxyl ions. All the properties common to acids are due to the hydrogen ions. When we say that an acid tastes sour we mean in reality that the hydrogen ions present taste sour, for it is these that give the sensation of sourness. When we speak of an acid attacking the tin on tin plate, we should think of the hydrogen ions as the active agent. In like manner all properties common to alkalies are due to the hydroxyl ions. The brackish taste, the smooth feeling on the fingers, are properties of the hydroxyl ions. The hydrogen ion and the hydroxyl ion neutralize each other. Therefore water has neither acid nor alkaline properties to our usual senses.

The different acids, and also the alkalies, vary in the degree of dissociation and therein lies the strength or weakness of an

acid or alkali. When we find that a one per cent solution of hydrochloric (muriatic) acid is much more sour than an equivalent solution of acetic acid, it is because a much greater proportion of the former is dissociated to yield hydrogen ions."

Baker and Van Slyke[44] explain clearly some of the fundamental facts bearing on hydrogen ion concentration and its relation to titration methods used in determining the acidity and alkalinity of solutions. Extracts from their work, which follow, are simple enough to enable those with some knowledge of chemistry to understand the principles involved.

In explaining neutrality, acidity and alkalinity in terms of ions of hydrogen and hydroxyl, they point out that:

"(1). A solution is neutral when the number of free hydrogen ions is the same as that of the free hydroxl ions ($H^+ = OH^-$).

(2). A solution is acid when the number of free hydrogen ions is greater than that of the free hydroxyl ions ($H^+ > OH^-$).

(3). A solution is alkaline when the number of free hydrogen ions is less than that of the free hydroxyl ions ($H^+ < OH^-$).

It is not necessary for our purpose to describe here the method used in making measurement of the number of free hydrogen ions or hydrogen ion concentrations. It is, however, essential to consider the method of expressing quantitatively the results of such measurements.

Hydrogen ion concentration can be expressed quantitatively in two ways: (1st) In terms of normal solution or hydrogen ion normal C_H, and (2nd) in the form of the symbol, pH. Each of these expressions has its advantages and objectionable features. For those who have always been accustomed to express acidity and alkalinity in terms of the normal solution, it is extremely awkward to interpret pH values in relation to the reactions of solutions. This is owing to the fact that the mathematical method of obtaining the values of pH is such that the higher the figure representing the value of pH, the lower is the hydrogen ion concentration. Thus, an increase in the value of pH indicates a decrease in the hydrogen ion concentration. It is, therefore,

important to understand the meaning of the value of pH more fully in relation to neutrality, acidity and alkalinity as commonly expressed.

In pure water, the concentration of hydrogen ions is equal to that of hydroxyl ions. Therefore, as a starting point, pure water is regarded as a really neutral solution, or, stated in another way, the hydrogen ion concentration of pure water is believed and is taken to be that of true or absolute neutrality. Consequently, the concentration of hydrogen or of hydroxyl ions in pure water is called the true or absolute neutral point. Now, by actual measurement, the hydrogen ion concentration of pure water, expressed in terms of normal solution (C_H) is known to be .000,000,1 N, or, expressed more conveniently in abbreviated form 1×10^{-7} N; and this value represents quantitatively the true or absolute neutral point. On this basis, solutions are acid when they contain hydrogen ion concentrations greater than, or hydroxyl ion concentrations less than, 1×10^{-7} N; and solutions are alkaline when they contain hydrogen ion concentrations less than, or hydroxyl ion concentrations greater than, 1×10^{-7}.

Further, when expressed in terms of pH, the hydrogen ion concentration of pure water (1×10^{-7} N) has a value of 7. In the scale of pH values, 7 is therefore the true neutral point, and all values greater than 7 indicate alkaline solutions, while all values less than 7 indicate acid solutions.''

In order to enable one to compare easily the values furnished by these two methods of expressing hydrogen ion concentration, we have prepared Table 115, giving the equivalent values of hydrogen ion concentration for pH values varying from 1 to 13 and also of hydroxyl ion concentrations for pH values varying from 7 to 13.

The first column in the table gives figures for pH values varying from 1 to 13; the second and third columns show the equivalent values of hydrogen ion concentrations expressed in terms of the hydrogen ion normal (C_H) or normal solution, the abbreviated form being given in the second column and the full form, expressed decimally, in the third column. In the fourth column the character of the reaction is stated. In case of pH

values higher than 7, the equivalent values are given for hydroxyl normal (C_{OH}) or normal solution in columns six and seven.

In order to bring out a simple relation existing between the pH values and their equivalent expressd in terms of hydrogen ion and hydroxyl ion normal, pH values are taken at intervals of 0.3 in most cases. It will then be observed that the following rules apply with close approximation when we take any two points in the range of pH values differing by 0.3:

(1) A decrease of 0.3 in the value of pH at any point is equivalent to doubling the C_H value at that point.

(2) An increase og 0.3 in the pH value at any point is equivalent to halving the C_H value and doubling the C_{OH} value, at that point.

For example when the pH value equals 2, the equivalent C_H value is 0.01; when pH decreases 0.3, that is, to 1.7, C_H equals 0.02. Again, when the value of pH equals 7.1 the C_H value is 0.8×10^{-7}; when pH increases 0.3, that is, becomes 7.4, the C_H value is 0.4×10^{-7}. At the same point (pH, 7.1), the C_{OH} value is $.125\times 10^{-6}$; when the value of pH increases to 7.4, the equivalent C_{OH} value is $.250\times10^{-6}$.

It is obvious that the use of the simple numbers representing pH values is more convenient than the numbers representing C_H or C_{OH} values. It is evident also that when one desires to plot hydrogen ion concentration figures upon co-ordinate paper, the pH values possess a marked advantage over the other form of expression, especially when the range of differences in values is large.

Table 115 will be found useful for those who have been accustomed to think, not in terms of pH values, but only in those of hydrogen or hydroxyl ion normal. It can be seen that the pH value of 1 is approximately represented, for example, by tenth-normal (0.1N) hydrochloric acid; while the pH value of 13 is represented by tenth-normal sodium hydroxide.

Many are accustomed to express the concentration of solutions only in fractional form, as, for example, N/10 instead of the decimal form, .1N. For such, the relations of pH values to the various

TABLE 115.

Hydrogen Ion Concentration Expressed in Form of

Values of pH.	Values of C_H (the hydrogen ion normal or normal solution).		Reaction.	
	Abbreviated form.	Full form.		
1.0	0.1×10^{-0}	=.10 N	Acid	
1.1	0.8×10^{-1}	=.08 N	"	
1.4	0.4 " "	=.04 N	"	
1.7	0.2 " "	=.02 N	"	
2.0	0.1 " "	=.01 N	"	
2.1	0.8×10^{-2}	=.008 N	"	
2.4	0.4 " "	=.004 N	"	
2.7	0.2 " "	=.002 N	"	
3.0	0.1 " "	=.001 N	"	
3.1	0.8×10^{-3}	=.000,8 N	"	
3.4	0.4 " "	=.000,4 N	"	
3.7	0.2 " "	=.000,2 N	"	
4.0	0.1 " "	=.000,1 N	"	
4.1	0.8×10^{-4}	=.000,08 N	"	
4.4	0.4 " "	=.000,04 N	"	
4.7	0.2 " "	=.000,02 N	"	
5.0	0.1 " "	=.000,01 N	"	
5.1	0.8×10^{-5}	=.000,008 N	"	
5.4	0.4 " "	=.000,004 N	"	
5.7	0.2 " "	=.000,002 N	"	
6.0	0.1 " "	=.000,001 N	"	

6.1	0.8×10^{-8}	=.000,000,8N	"	Hydrogen Ion Concentration Expressed in Form of		
6.4	0.4 " "	=.000,000,4N	"			
6.7	0.2 " "	=.000.000,2N	"			
7.0	0.1 " "	=.000,000,1N	Neutral	Values of pH	Values of C_{OH} (the hydrogen ion normal or normal solution)	
7.1	0.8×10^{-7}	=.000,000,08N	Alkaline	7.1	0.125×10^{-6}	=.000,000,125 N
7.4	0.4 " "	=.000,000,04N	"	7.4	0.250 " "	=.000,000,25N
7.7	0.2 " "	=.000,000,02N	"	7.7	0.500 " "	=.000,000,5N
8.0	0.1 " "	=.000,000,01N	"	8.0	1.000 " "	=.000,001N
8.1	0.8×10^{-8}	=.000,000,008N	"	8.1	0.125×10^{-5}	=.000,001,25N
8.4	0.4 " "	=.000,000,004N	"	8.4	0.250 " "	=.000,002,5N
8.7	0.2 " "	=.000,000,002N	"	8.7	0.500 " "	=.000,005N
9.0	0.1 " "	=.000,000,001N	"	9.0	1.000 " "	=.000,01N
9.1	0.8×10^{-9}	=.000,000,000,8N	"	9.1	0.125×10^{-4}	=.000,012,5N
9.4	0.4 " "	=.000,000,000,4N	"	9.4	0.250 " "	=.000,025N
9.7	0.2 " "	=.000,000,000,2N	"	9.7	0.500 " "	=.000,05N
10.0	0.1 " "	=.000,000,000,1N	"	10.0	1.000 " "	=.000,1N
10.1	0.8×10^{-10}	=.000,000,000,08N	"	10.1	0.125×10^{-3}	=.000,125N
10.4	0.4 " "	=.000,000,000,04N	"	10.4	0.250 " "	=.000,25N
10.7	0.2 " "	=.000,000,000,02N	"	10.7	0.500 " "	=.000,5N
11.0	0.1 " "	=.000,000,000,01N	"	11.0	1.000 " "	=.001N
11.1	0.8×10^{-11}	=.000,000,000,008N	"	11.1	0.125×10^{-2}	=.001,25N
11.4	0.4 " "	=.000,000,000,004N	"	11.4	0.250 " "	=.002,5N
11.7	0.2 " "	=.000,000,000,002N	"	11.7	0.500 " "	=.005N
12.0	0.1 " "	=.000,000,000,001N	"	12.0	1.000 " "	=.01N
12.1	0.8×10^{-12}	=.000,000,000,000,8N	"	12.1	0.125×10^{-1}	=.012,5N
12.4	0.4 " "	=.000,000,000,000,4N	"	12.4	0.250 " "	=.025N
12.7	0.2 " "	=.000,000,000,000,2N	"	12.7	0.500 " "	=.05N
13.0	0.1 " "	=.000,000,000,000,1N	"	13.0	1.000 " "	=.10N

concentrations of solutions can be brought out more clearly by the following illustrations, using HCl and NaOH and assuming that they are completely ionized.

TABLE 116.

pH Values	HCl Concentrations Expressed		pH Values	NaOH Concentrations Expressed	
	Decimally	Fractionally		Decimally	Fractionally
1.0	.1 N	$\frac{N}{10}$	8	.000,001 N	$\frac{N}{1,000,000}$
1.4	.04 N	$\frac{N}{25}$	9	.000,01 N	$\frac{N}{100,000}$
1.7	.02 N	$\frac{N}{50}$	10	.0001 N	$\frac{N}{10,000}$
2.0	.01 N	$\frac{N}{100}$	11	.001 N	$\frac{N}{1,000}$
2.1	.08 N	$\frac{N}{125}$	11.1	.00125 N	$\frac{N}{800}$
2.4	.004 N	$\frac{N}{250}$	11.4	.0025 N	$\frac{N}{400}$
2.7	.002 N	$\frac{N}{500}$	12.0	.01 N	$\frac{N}{100}$
3.0	.001 N	$\frac{N}{1,000}$	12.1	.0125 N	$\frac{N}{80}$
4.0	.0001 N	$\frac{N}{10,000}$	12.4	.025 N	$\frac{N}{40}$
5.0	.000,01 N	$\frac{N}{100,000}$	12.7	.05 N	$\frac{N}{20}$
6.0	.000,001 N	$\frac{N}{1,000,000}$	13.0	.1 N	$\frac{N}{10}$

In Table 117 we give the pH values and their equivalent C values for each 0.01 pH, ranging between 1 and 2. By the use of this table one can readily ascertain values intermediate between those given in Table 116. These intermediate figures can be used for any part of the range of values given in Table 116 by

adapting the decimal properly. By the use of Tables 116 and 117 in combination, one can convert pH values into C_H values, or vice versa, simply by inspection and without calculation.

TABLE 117.

Intermediate pH and C_H Equivalents for Use with Table 116.

pH Values	C Values	pH Values	C Values	pH Values	C Values	pH Values	C Values	pH Values	C Values
1.00	.1000	1.20	.0632	1.40	.0400	1.60	.0251	1.80	.0159
1.01	.0980	1.21	.0619	1.41	.0392	1.61	.0246	1.81	.0156
1.02	.0959	1.22	.0606	1.42	.0384	1.62	.0241	1.82	.0152
1.03	.0939	1.23	.0592	1.43	.0375	1.63	.0236	1.83	.0149
1.04	.0918	1.24	.0579	1.44	.0367	1.64	.0231	1.84	.0146
1.05	.0898	1.25	.0566	1.45	.0359	1.65	.0226	1.85	.0143
1.06	.0877	1.26	.0553	1.46	.0351	1.66	.0220	1.86	.0139
1.07	.0856	1.27	.0540	1.47	.0343	1.67	.0215	1.87	.0136
1.08	.0836	1.28	.0526	1.48	.0334	1.68	.0210	1.88	.0133
1.09	.0815	1.29	.0513	1.49	.0326	1.69	.0205	1.89	.0129
1.10	.0795	1.30	.0500	1.50	.0318	1.70	.0200	1.90	.0126
1.11	.0779	1.31	.0490	1.51	.0311	1.71	.0196	1.91	.0123
1.12	.0762	1.32	.0480	1.52	.0305	1.72	.0192	1.92	.0121
1.13	.0746	1.33	.0470	1.53	.0298	1.73	.0188	1.93	.0118
1.14	.0730	1.34	.0460	1.54	.0291	1.74	.0184	1.94	.0116
1.15	.0714	1.35	.0450	1.55	.0285	1.75	.0180	1.95	.0113
1.16	.0697	1.36	.0440	1.56	.0278	1.76	.0175	1.96	.0110
1.17	.0680	1.37	.0430	1.57	.0271	1.77	.0171	1.97	.0108
1.18	.0665	1.38	.0420	1.58	.0264	1.78	.0167	1.98	.0105
1.19	.0648	1.39	.0410	1.59	.0258	1.79	.0163	1.99	.0103
1.20	.0632	1.40	.0400	1.60	.0251	1.80	.0159	2.00	.0100

There are two points in connection with the determination of hydrogen ion concentration to which it is desirable to call attention briefly: (1) Buffer effects and (2) the relation of hydrogen ion concentration to titration values.

(1) Buffer effects. It has been found that many compounds have the property of affecting the results of the determination of the hydrogen ion concentration. When acid or alkali is added to a solution containing such compounds, the change in hydrogen ion

concentration is found to be less than would be expected for the known amount of acid or alkali added. Any substance which tends to prevent change in the original hydrogen ion concentration of its solution, when an acid or base is added, is called a buffer or regulator. Proteins, salts, etc., may exercise such an effect. These effects must be determined for individual cases under specific conditions of concentration, temperature, etc. In the case of milk, the compounds acting as buffers are proteins, phosphates, citrates and carbonates.

(2) Relation of hydrogen ion concentration to titration values. We have seen that hydrogen ion concentration is a quantitative measure of the true acidity or alkalinity of a solution. The following question suggests itself to those who have used only titration methods for such measurements: What relations have the values determined by the measurement of the hydrogen ion concentration to those determined by titration? Without going into the full details, it is sufficient for our purpose to state that the neutral point of a solution, as determined by the use of an indicator, varies according to the indicator used and rarely coincides with the true neutral point shown by the hydrogen ion concentration. For example, phenolphthalein under favorable conditions gives the neutral point of solutions as being somewhere between pH, 8 (C_H, 1×10^{-7}) and pH, 10 (C_H, 1×10^{-9}), instead of at pH, 7 (C_H, 1×10^{-6}); methyl red, between pH, 4(C_H, 1×10^{-3}) and pH, 6(1×10-5). It should be stated also that the determination of hydrogen ion concentration shows extremely minute changes in the reaction of a solution, degrees of change which are not appreciable or measurable by the use of an indicator.

ELECTROMETRIC TITRATIONS OF SOLUTIONS CONTAINING PROTEIN.

Before attempting hydrogen ion concentration determinations upon which conclusions of importance may be based the operator should consult the available literature on the subject, and by study and experiment become, as far as possible, familiar with methods and the many conditions and influences that are likely to affect results. This should be done no matter which

method is used. The nature of the interferences will vary according to the problem but there is now available a large amount of material that may serve as a guide. The book, "The Determination of Hydrogen Ions," by Clark, is one that no worker should fail to consult.

Baker and Van Slyke's Method.—This method provides a means for making electrometric titrations of solutions containing

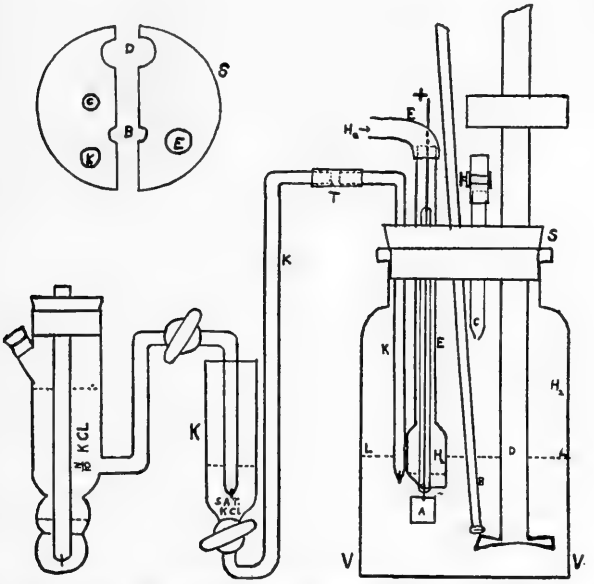


Fig. 159. Apparatus for Making Electrometric Titrations of Solutions Containing Protein.

proteins which is shorter and less complicated than methods previously used. A cut of the apparatus used in the test is shown in Fig. 159. It consists of a 400 cc. wide mouthed bottle (V) calibrated in units of 50 cc. and provided with a cork stopper (S) which is divided into two equal halves that may be easily adjusted in the neck of the bottle. The tube (E) for carrying the hydrogen electrode, and through which hydrogen may be passed into the bottle, is made by cutting a 10 cc. pipette in two in the

middle, then cutting one side of the lower edge off diagonally. The upper end of the tube is fitted through a hole in the stopper so that it may be raised and lowered as desired. A close fitting piece of pure gum rubber tubing attached to the upper end of the glass tube permits hydrogen to be passed into the apparatus when necessary. The hydrogen electrode (A) is about 1 cm. square and is made from platinum foil and welded to a piece of platinum wire about 15 cm. long. A slender piece of glass tubing extending down close to the electrode and annealed at each end around the wire covers the lower half of the wire. The upper end of the platinum wire is passed through a pin hole made through one side of the rubber tube after bending it across the top of the hydrogen tube. This makes a gas tight joint that permits the hydrogen electrode to be raised and lowered within the bell shaped lower end of the hydrogen tube and avoid having the electrode touch the inside wall. The electrode is prepared for use by cleaning it in hot chromic acid, washing with water, then giving it a uniform coating of platinum black. It is again dipped in hot chromic acid, washed and electrolyzed according to Clark's directions [45]. All points on the electrode should give off bubbles with equal uniformity.

The titration reagent is carried into the solution, from a burette 30 cm. long and holding 10 cc., by means of the capillary glass tube (B). The capillary tube should fit snugly in the hole through the cork. The stirring apparatus (D) is the same as that described in Fig. 158, page 661. The opening through the cork should be just large enough to permit the rod to revolve freely. The tube (C) permits the addition of any special reagent, such as caprilic alcohol when necessary to prevent foaming. It may also serve, when made long enough, to siphon off a solution. It should then be located near the side wall away from the stirrer. The tube (K) contains saturated KCl solution. A roll of filter paper is placed in the small opening in the tip that enters the protein solution, and also, the upper surface of the KCl solution in the funnel is held slightly below the level of the protein solution in the bottle, in order to retard flow and diffusion. When the apparatus is used with a water bath the stop-cock in the KCl tube may be placed near the rubber connection at the top.

The following additional pieces of apparatus are used: (a) A Leeds and Northrup potentiometer, type K; (b) a Leeds and Northrup galvanometer, type R, for zero instrument; (c) a one cell storage battery to supply the working current, which is checked with a Weston standard cell kept at constant temperature. The current being measured originates in the chain, Hg|HgCl|0.1 N KCl| solution|H_2|Pt,|kept at constant temperature during each titration.

Operation. The solution to be titrated is poured into the bottle or vessel (V) and water is added to make the desired volume. If a thermostat is used, the temperature of the solution should now be adjusted. Any bubbles present should be removed, which can be done by pricking them with a greased pin or by touching them with a fine capillary tube containing ether. The burette must be previously filled and all bubbles carried out of the delivery tube (B), the tip of which should be rinsed before it is put into the vessel. The filled delivery tube and the stirrer are placed in position within the vessel or bottle. The two halves of the cork stopper are placed in position together with the other parts. Care is taken to have the electrode drawn up within the protecting bell so that it does not touch the apparatus or solution. Hydrogen is now permitted to flow rapidly in until the air is displaced, after which the stirrer is set in motion. This precaution is necessary because any bubbles of air that are stirred into the solution greatly retard the attainment of equilibrium.

The electrode is now quickly lowered until it is entirely under the surface of the solution, and connections are then completed for the electrolytic circuit. Equilibrium is quickly reached ordinarily, usually in 2 to 5 minutes after introducing the electrode. During the period approaching equilibrium, the stirrer should be run fast enough to kep a few bubbles of hydrogen constantly in suspension in the solution. Equilibrium is indicated by a constant E. M. F. for 2 minutes or more. When the E. M. F. is satisfactory, the desired amount of reagent is slowly introduced from the burette, during which the stirrer may be slightly accelerated to prevent coagulation but not fast enough to produce foam. After introduction of the reagent, readings are made once a minute until constant. When the amount of reagent introduced

is 0.5 cc. or less, equilibrium should be immediate. Titration is now continued until the desired number of values is obtained.

In order to avoid marked dilution of the protein solution, titrations are made with use of N solutions of reagents, and thus the need of making corrections is avoided since the hydrogen ion concentration of the buffered solutions is inappreciably changed by the small degree of dilution under such conditions. The speed of the stirrer must be carefully regulated so as to cause little or no foam; consequently, the addition of the reagent must be moderately slow; for example, about 1 cc. in 2 minutes in the case of N HCl with solutions containing 1 per cent of casein.

The accuracy of the electrometric titration can be checked, when completed, by redetermining the final E. M. F. value of the titration of the solution with a Clark electrode. If agreement is not close, the results of the titration should be discarded and the operation repeated. In our work agreement is nearly always obtained.

Baker and Van Slyke's Colorimetric Method[46] for Determining Hydrogen Ion Concentration in Milk: Preparing the indicator: Dissolve finely ground crom-cresol purple in water using 0.1 g. for 100 cc. of water. Heat on a water bath to hasten solution to saturation. Cool to room temperature and filter. The saturated solution contains about 0.09 per cent of the dye.

Apparatus: (a) A burette with delivery so controlled that each drop measures 0.05 cc. of indicator. (b) Test tubes made of Pyrex glass, flat-bottomed, and about 4 inches long and ½ inch in diameter. The tubes hold about 8 cc. and should be uniform in color and thickness of wall. (c) Test tube rack so constructed that the tubes may be held in a line side by side without concealing any of the milk column. (d) Pipettes graduated at 3 cc. for measuring the milk into the test tubes.

Operation: Place the test tubes in the holder, fill the burette with the brom-cresol solution and adjust the stop-cock to deliver about 1 drop in 2 seconds, each drop measuring 0.05 cc. Allow 1 drop of the indicator to flow from the burette into each tube without touching the side walls while it is falling. Place 3 cc. of milk from the first sample in the first tube. Mix the milk thoroughly with the indicator, then measure 3 cc. of the second sample

into the second tube, mix and proceed in a similar way for all samples.

Compare the shade of color obtained with each sample with a color standard made up as follows: Select a sample of normal milk containing between 3 and 4 per cent of fat and having an acidity that requires nearly, but not more than, 1.8 cc. of tenth-normal alkali for 10 cc. of the milk, using 0.5 cc. of a neutral alcoholic phenolphthalein solution as indicator.

Arrange 8 test tubes and place 10 cc. of the normal milk in each. Run tenth-normal NaOH solution into them as follows:

Tube No.	1	2	3	4	5	6	7	8
Drops of tenth-normal NaOH	0	2	4	6	8	10	12	14

In adding the alkali from the burette take all of the precautions that were observed in measuring the brom-cresol purple into the first set of test tubes. Mix the alkali and milk thoroughly. Arrange another set of 8 test tubes like the smaller ones used in the first instance and number them from 1 to 8. From each test tube containing the milk and alkali mixture measure 3 cc. into the smaller test tube that is numbered correspondingly, and add to each, one drop of the brom-cresol purple solution and mix well. Compare the color of each tube containing the unknown milks with the standard set of tubes containing the milk, alkali and brom cresol mixture.

The reaction color in each tube corresponds approximately to the following pH values.

TABLE 118.

No. in series	1	2	3	4	5	6	7	8
cc. of 0.1 N NaOH used	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7
	6.5	6.6	6.67	6.75	6.82	6.90	6.98	7.05
	to	to	to	to	to	to	to	to
	6.6	6.67	6.75	6.82	6.90	6.98	7.05	7.13
Symbol for reaction color	N	N-1	N-2	N-3	N-4	N-5	N-6	N-7

As a matter of convenience in tabulating results, we append a series of symbols to indicate the pH values, N standing for nor-

mal reaction and N followed by the minus sign and figures ranging from 1 to 7, indicating decreased acidity corresponding to increasing pH values.

Such samples as appear to be abnormal by showing a deeper blue shade of color, indicating decreased acidity, are open to the suspicion of being watered, or skimmed, or treated with alkaline salts, or containing excessive numbers of leucocytes as in milk from diseased udders. Which of these suspicions is justified can be ascertained by the determination (1) of the freezing-point, (2) of the percentage of milk-fat or the ratio of fat to proteins, (3) of the specific gravity, (4) of the total solids, (5) of the presence of alkaline salts, especially sodium bicarbonate and borax, (6) of the numbers of leucocytes by direct microscopic examination by Breed's method, and (7) of CO_2 by Van Slyke's method[47] modified by us for use in connection with milk.

In the case of samples showing a color lighter than normal with the brom-cresol purple solution, indicating an abnormal degree of acidity, there is awakened the suspicion of bacterial acid production, the presence of formaldehyde, overheating, or the presence of added acid salts; or the lighter color may be due to a high percentage of milk-fat. Which of these indications is correct is determined as follows: A direct count of the number of bacteria is often sufficient. If this fails to show the presence of excessive numbers of bacteria, then a test should be made for the presence of formaldehyde, and if this is not present, the percentage of milk-fat is determined; and, further, in order to see if the light color is due to overheating, the determination of carbon dioxide should be made and Storch's test may also be applied.

McCrudden's[48] Colorimetric method for determining hydrogen ion concentration.—This method is primarily for use in bacteriological work.

Standard solutions: Prepare "tenth molecular solutions of KH_2PO_4 (13.62 grams potassium phosphate, monobasic, anhydrous, Merck's reagent, to the liter) and Na_2HPO_4 (14.21 grams sodium phosphate, anhydrous, Merck's reagent, per liter). From these the following twelve standard solutions are prepared:

TABLE 119.
pH of Phosphate Solution.

c. c. $\frac{M}{10}$ Na_2HPO_4	c. c. $\frac{M}{10}$ KH_2PO_4	pH
8	92	5.8
12	88	6.0
19	81	6.2
27	73	6.4
37	63	6.6
49	51	6.8
61	39	7.0
73	27	7.2
82	18	7.4
89	11	7.6
94	6	7.8
97	3	8.0

The Reading.—To determine the hydrogen ion concentration of an unknown solution coming within the limits of P_H=6.8 to 8.2, add to it five drops of a 0.03 per cent solution of phenol red and compare the resulting color with that obtained by adding the same amount of indicator to 5 cc. of each of the standard phosphate solutions diluted with 10 cc. of water. Between the limits P_H= 5.8 to 6.8 the indicator brom-cresol purple—five drops of a saturated solution—should be used. (The standard solutions with indicator in them will keep several weeks if tightly stoppered.)

The Comparator.—The color comparison can be made in large clear glass test tubes. To overcome the effect of turbidity, such as occurs in bacteriological media, the unknown solution is diluted to a moderate extent, say to three times its volume, and the test tubes are arranged in a device called a comparator. The device consists of a block of wood containing 6 perpendicular holes large enough to carry the test tubes. Three other holes are then bored horizontally through the block from side to side, so that one can look right through each pair of test tubes in series. When the solutions are arranged as indicated in each case the light reaching the eye has passed through solution containing indicator and solution containing turbidity. In the case of the unknown, one solution contains both turbidity and indicator; in the case of the standards the turbidity and indicator are in separate solutions.

Adjusting reaction of culture media. Most bacteria grow best in media whose p_H lies between 7.2 and 7.6. To adjust media to any desired hydrogen ion concentration N/10 alkali is added drop by drop to five cc. of the somewhat diluted media containing indicator until, as shown by comparison with the standards, the desired hydrogen ion concentration is reached. From the amount of alkali required for five cc. the amount needed for the whole batch of media can then be calculated. Sterilization of the media shifts the p_H about 0.2 toward the acid side. Allowance should be made for this.

Clark and Lubs Table.[49]

	Range pH
Thymol blue (acid range)	1.2—2.8
Thymol blue (alkaline range)	8.0—9.6
Brom phenol blue	2.8—4.6
Methyl red	4.4—6.0
Propyl red	4.8—6.4
Brom-cresol purple	5.2—6.8
Brom-thymol blue	6.0—7.6
Phenol red	6.8—8.4
Cresol red	7.2—8.8
Cresol phthalein	8.2—9.8

The indicators in either powdered form or stock solution may be purchased from chemical supply houses.

Thymol blue may be made up for use in .04% solution. Its color change is from red to yellow in the acid range and from yellow to blue in the alkaline range.

Brom-Phenol blue is made up to .04% solution. Its color change is from yellow to blue.

Methyl red is made up to .02% solution. Its color change is from red to yellow.

Brom-cresol purple is made up to .04% solution. Its color change is from yellow to purple.

Brom-thymol blue is made up to .04% solution. Its color change is from yellow to blue.

Phenol red and cresol red are made up to .02% solutions. Their color change is from yellow to red.

Cresol phthalein is made up to .02% solution. Its color change is from colorless to red.

REFERENCES.

[1] U. S. Dept. of Agri., Bul. 134, 1911.
[2] McInerney, Prof. T. J., Cornell Univ., Ithaca, N. Y.
[3] Association of Official Agricultural Chemists.
[4] Walker, W. O. A Rapid Method for Determining the Percentage of Casein in Milk. Jour. Ind. Eng. Chem. Vol. 6, No. 2, 1914.
[5] Hart, E. B., A Simple Test for Casein in Milk and its Relation to the Dairy Industry, Wis. Exp. Sta. Bul. 156, 1907.
[6] Butterman, S. The Influence of the Method of Manufacture on the Use of Casein in Glue Making. Jour. Ind. and Eng. Chem., Vol. 12, No. 12, p. 141, 1920.
[7] Dahlberg, A. O. The Manufacture of Casein from Buttermilk or Skimmilk. U. S. Dept. of Agri. Bul. No. 661, Bu. Ani. Ind. 1918.
[8] Van Slyke, L. L. N. Y. Agri. Exp. St. Bul. 215, 102.
[9] White, W. B., Chemist, Ithaca Laboratory, Division of Foods and Markets, N. Y. Unpublished results, Cornell University.
[10] Analyst, 1910, 29, 248.
[11] Bigelow and McElroy. Jour. Am. Chem. Soci. 15, p. 668.
[12] Rothenfusser. Zeitz. Nahr. Genussm., 16, 51, 1906.
[13] Compt. rend. de l'Acad. des Sciences, vol. CXXXIV, p. 1592.
[14] Supplee, G. C., Bellis, B., Citric Acid Content of Milk and Milk Products J. Biol. Chem. 48, 2, 1921.
[15] Beau M. (Revue Generale du Lait, 1903-4 P. 385) as modified by Dobbie. (Reports of the Local Gvt. Board on Public Health and Medical Subjects. New series No. 116, p. 184, London 1918.
[16] Dahlberg, A. O. and Garner, H. S., Bul. 944, Bu. An. Ind., U. S. Dept. Agr 1921.
[17] Ayers, S. H. and Johnson, W. T. Jr. The Alcohol Test in Relation to Milk. U. S. Dept. Agri. Bul. 202, p. 35, 1915.
[18] Evenson, O. L. A Color Test for "Remade Milk and Cream." Jor. Dairy Sci., Vol. V, No. 1, 1922.
[19] Robinson, R. H. The Determination of Formaldehyde in Solution. Chemist-Analyst. No. 29. Apr. 1919.
[20] Wilcox, E. V. Production and Inspection of Milk. Hawaii. Agri. Exp. Sta. Bul. 1912.
[21] Hunziker, Otto F. The Butter Industry, 1920.
[22] Methods of A. O. A. C. Bul. No. 107. (Revised) 1912.
[23] Chem. Zeit. 1899, 23, 312, Abs. Analyst, 24, p. 206.
[24] Patrick, G. E. Household Tests for the Detection of Oleomargarine and Renovated Butter, Farmer's Bulletin 131.
[25] Jour. Ind. Eng. Chem. 12. 366-8, 1920.
[26] Dingler's Polyt. Jour., 25, 1884, p. 281. Zeits. Unters. Nahr. Genussm., 4, 1901, p. 913.
[27] Congdon, L. A. Jour. Ind. Eng. Chem. Vol. 7, No. 7, 1915.
[28] Cook, A. A. and Woodman, A. G. Jour. Ind. Eng. Chem. Vol. 10, No. 7, 1918.
[29] Bur. of Chem., Bull. 122, p. 52., 132, p. 122.
[30] Am. Food Jour. Dec. 1916. P. 621.
[31] Clark, A. W. and DuBois, L. "Jelly Value" of gelatin and glue, Jour. Ind. Eng. Chem. Vol. 10, No. 9, 1918.
[32] Jour. Ind. Eng. Chem. Vol. 8, No. 8, 1916.
[33] Hammer, B. W. and Johnson, A. R. The Specific Heat of Milk and Milk Derivatives. Agri. Exp. Sta., Iowa State College of Agriculture and Mechanic Arts, Research Bul. No. 14, 1913.
[34] Richmond. Dairy Chemistry, 1914, London, Charles Griffin and Company, Limited.
[35] Barthel, translated by Goodwin. Milk and Dairy Products, 1910, London. MacMillan and Co., Limited.
[36] Atkins. Chem. News, 1908, 97, 241.
[37] Stocking. Manual of Milk Products. 1917, N. Y. McMillan Co.
[38] Grimmer. Chemie and Physiologie der Milch, 1910.
[39] Heineman. Milk, 1919, Philadelphia, W. B. Saunders Company.
[40] Chem. Bul. Vol 7, No. 4, 1920.
[41] Van Slyke, L. L. and Baker, J. C. Studies Relating to Milk Tech. Bul. No. 65, N. Y. Agr. Exp. Sta. 1918.
[42] Arrhenius, S. Ueber die Dissociation in Wasser geloesten Stoffe. Z. physik. Chem. 631, 1887.
[43] Bigelow, W. D. and Cathcart, P. H.; Bul. 17-L, 1921. Nat. Canners Assn.
[44] Baker, J. C. and Van Slyke, L. L. N. Y. Agri. Exp. Sta., Geneva, N. Y. Tech. Bul. No. 65, 1918.
[45] Clark, W. M. Jor. Biol. Chem. 23; 475, 1915.
[46 47] Baker, J. C. and Van Slyke, L. L. J. Biol. Chem. 2, 337, 357, 1919.
[48] McCrudden, F. H., U. S. Public Health Rpt. Vol. 37, No. 7, 1922.
[49] Clark, W. M. and Lubs, H. A., J. Bact. 2, 1, 109, 191.

CHAPTER XVIII

THE PURPOSE AND ADVANTAGE OF THE VACUUM PAN IN THE DAIRY INDUSTRY

The use of the vacuum pan in the dairy industry dates back to the invention of Gail Borden to whom patent was granted in 1856. The historical side of the milk condensing industry is ably discussed by Prof. O. F. Hunziker, in "Condensed Milk and Milk Powder," to which the reader is referred.

The purpose of the vacuum pan in the dairy industry is primarily to remove water from dairy products, thus making it possible to manufacture a new class of products. The advantages derived by evaporating in vacuo as against evaporating in the open air are numerous, the principal of which are the following:

(a). **The Economic Advantage.** To evaporate one pound of water from milk in the open air, starting with a temperature of 60° F. and calculating the specific heat of milk at 0.93 requires the expenditure of 1107 B. T. U. To remove the same amount of water under vacuo at 140° F. requires the expenditure of only 1040 B. T. U., or a saving of 6.4 per cent in heat units.

(b). The rate of evaporation in vacuo is very much greater than in the open air, due to the fact that the boiling point decreases with lowering pressures. This is illustrated best by reference to Table 120, which is based upon the table by Hunziker[1] entitled: "Boiling points of water at different vacua." The last column in Table 120 is based upon a careful experiment the object of which was to determine the rate of evaporation under different vacua. Under good conditions of practical operation it is usually possible to evaporate about 30 pounds per hour, per square foot of heating surface in the vacuum pan. Under the vacuum usually obtainable in practice, namely, about 26 inches of mercury as shown in Table 120 and upon the

TABLE 120. Relation Boiling Points Vacuo and Rate of Evaporation.

Absolute pressure per square inch	Vacuum inches of mercury column	Vacuum millimeters of mercury column	Boiling points of water at degrees F.	Boiling points of water at degrees C.	Pounds of water evaporated per hour, per sq. ft. of heating surface. Approximate values
14.720	.....	.....	212.00	100.00	8.2
14.010	1.42	36	209.55	98.5	9.4
13.015	3.45	88	205.87	96.8	11.0
12.015	5.40	139	201.96	94.3	13.0
11.020	7.52	191	197.75	91.9	14.7
10.020	9.56	243	193.22	89.5	16.5
9.020	11.60	295	188.27	86.75	18.2
8.024	13.63	346	182.86	83.7	20.0
7.024	15.67	398	176.85	80.5	21.7
6.024	17.70	450	170.06	76.8	23.4
5.029	19.74	502	162.28	72.5	25.2
4.029	21.78	553	153.01	67.2	27.0
3.034	23.81	605	141.52	60.8	28.7
2.034	25.85	657	126.15	52.3	30.2
1.040	27.88	708	101.83	38.7	Not determined
.980	28.00	712	100.00	37.8	"
.735	28.50	724	90.00	32.2	"
.544	28.89	734	80.00	26.7	"
.402	29.18	741	70.00	21.1	"
.294	29.40	747	60.00	15.6	"
.216	29.56	751	50.00	10.0	"
.162	29.67	754	40.00	4.4	"
.127	29.74	756	32.00	.....	.....

graph under Fig. 160, the quantity of water possible to evaporate per square foot of heating surface, decreases rapidly with a decrease in the vacuum. In other words, it would take nearly four times as long to evaporate the same amount of water at air pressures than under 25.85 inches of mercury vacuum.

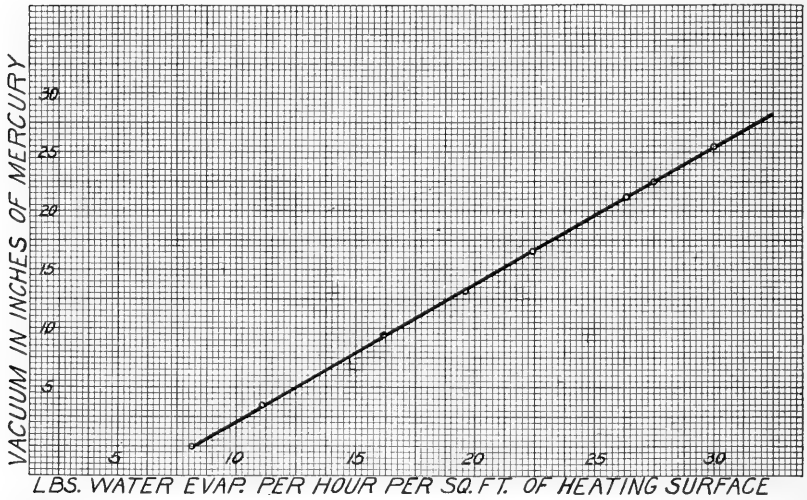


Fig. 160. Pounds of Water Evaporated per Hour per Square Foot of Heating Surface, Under Different Pressures in the Vacuum Pan.

(c). The greatest advantage is probably the fact that under vacuum the various constituents of milk undergo no changes in flavor, color or chemical composition, owing to the low temperatures employed, and the short time necessary to hold the milk under heat during the condensing operation. It is these advantages that have made it possible to manufacture and market many new products of great commercial importance, that were unknown before the advent of the vacuum pan in the dairy industry.

DESCRIPTION OF THE VACUUM PAN.

Many different types of vacuum pans are upon the market, and in use. The reader is referred to "Condensed Milk and Milk Powder" by Prof. O. F. Hunziker,[1] for a description of

these various types. For the purpose of enunciating principles the Mojonnier type of vacuum pan is the only one explained herewith, and illustrated under Fig. 161.

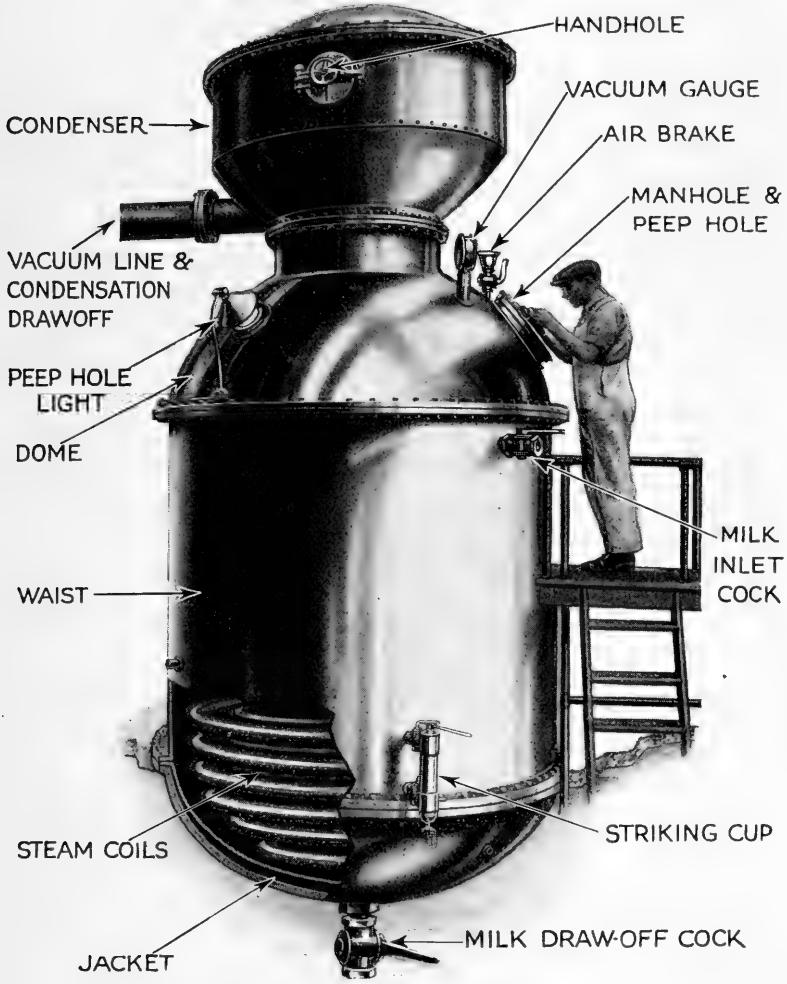


Fig. 161. Mojonnier Type Vacuum Pan.

All vacuum pans consist essentially of five principal parts, together with the necessary control devices. The design of each

of these parts has a large bearing upon the subsequent operation of the pan itself. These various parts are as follows:

(a). **The Condenser.** It is here that the vapors which are evaporated from the milk are condensed to the liquid form. This should be so designed and proportioned as to remove the incoming vapors in the least time and with the use of the least possible amount of water.

(b). **The Dome.** This supports the condenser, and upon it are usually fastened the majority of the accessories such as the manhole, vacuum gauge thermometer, eye glasses, and buttercup valve. It should be sufficiently strong to support the condenser, and the atmospheric pressure. The opening into the condenser should be large enough to permit of the free and ready passage of the expanded vapors from the pan into the condenser. One pound of saturated steam at 126.27° F. under 25.88 inches of mercury vacuum will occupy 173.6 cubic feet as against 26.36 cubic feet for an equal weight of saturated steam at 212° F. The shape of the dome is also a factor in helping to prevent entrainment of milk solids into the condenser. The oval dome as shown upon the illustration under Fig. 161 is of the proper design to help prevent such losses.

(c). **The Waist.** This part requires the use of heavy copper, in order that it may stand up properly under the work that is required of it. A frequent mistake is to make this part too low thus making a condition that favors entrainment losses.

(d). **The Jacket.** This is supplied either with double copper jacket or with the outside jacket made of cast iron. The double copper jacket helps to prevent water leakage at the coil joints. This is the cause of considerable trouble in the case of pans fitted with cast iron jackets, owing to the unequal coefficient of expansion of the two metals,—that of copper being nearly 50 per cent larger than that of cast iron. A deeply dished jacket presents many advantages over the shallow type. It makes for greater strength, and it also makes it possible to set the coils low, and thus begin the evaporation in a minimum of time. This also helps to prevent entrainment losses.

(e). **The Coils.** The proper size, quantity and design of the coils in a large measure determine the success of the pan. The

openings into the coils should be large enough to permit of the use of exhaust steam. Coils of the basket type help to keep the level of the milk low, thus preventing entrainment losses. The spiral shape of basket type coils also permits the water which is condensed from the steam to flow out rapidly to the outlet.

COMMERCIAL SIZES, AND CAPACITIES OF VACUUM PANS IN TERMS OF BOTH RAW AND FINISHED PRODUCTS.

Various sizes of vacuum pans are obtainable, the choice of size being governed by the quantity of product that it is desired to handle. Table 121 lists the most commonly used sizes. Likewise it gives the approximate hourly rating of the various sizes in terms of both raw and finished products. The list is confined to the most common of the commercial condensed milk products. The ratings are very conservative, and under the most efficient operation these can be increased as much as 20 to 25 per cent.

One example will serve to illustrate the method of calculation used.

Example:—What is the capacity of a vacuum pan, diameter 3 feet, making sweetened condensed whole milk? Whole milk tests 3.43 per cent fat, and 12.0 per cent total solids. Finished product tests 8.0 per cent fat, 20.0 per cent milk solids not fat, and 46.0 per cent sugar. Pan has capacity to remove 1000 lbs. water per hour.

Solution:—

$28.0 \div .12 = 233.2$, lbs. whole milk required for every 100 lbs. finished product.

$233.2 + 46 = 279.2$, lbs. total products required for every 100 lbs. finished product.

$279.2 - 100 = 179.2$, water removed for every 100 lbs. finished product.

$1000 \div 179.2 \times 100 = 558$, lbs. finished product per hour.

$$\frac{558 \times .28}{.12} = 1302, \text{ lbs. whole milk per hour.}$$

Proof:—

$558 \times .466 = 256$, lbs. sugar.

$1302 + 256 = 1558$, lbs. total raw products.

$1558 - 558 = 1000$, lbs. water removed per hour.

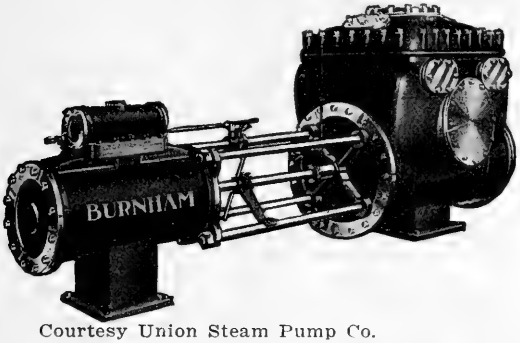
TABLE 121.

Capacity per Hour of Various Sizes of Vacuum Pans of Both Raw and Finished Products.

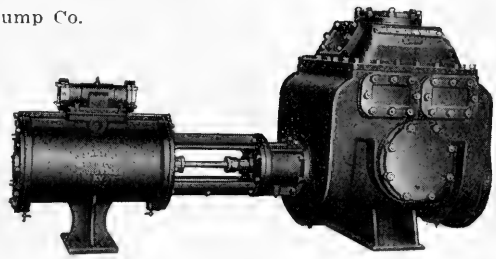
Diameter of vacuum pan	Pounds water evaporated per hour	Pounds Raw Products Used, and Finished Products Manufactured per Hour											
		Sweetened Condensed Skim-Milk		Sweetened Condensed Whole Milk		Plain Condensed Whole Milk		Plain Condensed Skim-Milk		Condensed Buttermilk		Ice Cream Mix	
		Skim-milk testing 8.8 per cent total solids	Finished product testing 28.0 per cent milk solids and 70.0 per cent total solids	Whole milk testing 3.43 per cent fat and 12 per cent total solids	Finished product testing 28.0 per cent milk solids and 74.0 per cent total solids	Whole milk testing 3.6 per cent fat and 12.00 per cent total solids	Finished product testing 8.00 per cent fat and 26.15 per cent total solids.	Skim-milk testing 8.80 per cent total solids	Finished product testing 26.40 per cent total solids	Buttermilk testing 8.80 per cent total solids	Finished product testing 25.0 per cent total solids	Whole Milk testing 3.67 per cent fat and 12.00 per cent total solids	Finished product testing 10.0 per cent fat 14.0 per cent sugar .5 per cent gelatin 11.5 per cent milk solids not fat 36.0 per cent total solids
3′0″	1000	1223	385	1302	558	1848	848	1500	500	1543	543	2358	1707
4′2″	1850	2262	711	2410	1033	3419	1569	2775	925	2855	1005	4363	3160
5′0″	2650	3240	1018	3450	1478	4998	2248	3975	1325	3939	1439	6250	4525
6′0″	4750	5809	1825	6186	2650	8778	4038	7125	2375	7330	2580	11190	8112
6′6″	5300	6482	2037	6900	2958	9794	4494	7950	2650	8178	2878	12480	9054
7′0″	6000	7337	2306	7810	3348	11088	5088	9000	3000	9260	3260	14140	10240

THE VACUUM PUMP.

Two different classes of vacuum pumps are available: namely, the dry vacuum and the wet vacuum. In the dry vacuum pump the condensed vapors do not discharge through the pump as in the case of wet vacuum pump. In the milk condensing industry the wet vacuum pump is now almost universally used, probably the only exception being experimental plants that desire to study the condensation.



Courtesy Union Steam Pump Co.



Courtesy J. J. Reilly Co.

Fig. 162. Straight Type Wet Vacuum Pumps

In turn, there are several types of the wet vacuum pump, namely the straight type as illustrated under Fig. 162; the crank and fly wheel type, and types that are either belt driven or driven by direct attached motors. The choice of type is governed entirely by local considerations, the principal of which is the unit power cost. The crank and fly wheel type is the most efficient from the standpoint of steam consumption, but its first cost is the largest of any of the common types, and it is bulky and occupies much floor space. When the exhaust steam is used in the pan, in the end the straight line pump is equally economical, and that is the type that is by far the most commonly used.

The correct sizes of vacuum pumps to use upon various sizes of pans, is indicated in Table 122. This comprises only pumps of the straight line type. In the case of 3 feet diameter and 7 feet diameter pans a choice of sizes is given. At low altitudes the smaller sizes will render good service, while at higher altitudes, the larger sizes will usually prove to be the more satisfactory.

TABLE 122.

Sizes of Vacuum Pumps Recommended for Various Sizes of Vacuum Pans.

Size of vacuum pan	SIZE OF VACUUM PUMP			Size of vacuum pan	SIZE OF VACUUM PUMP		
	Diameter of steam cylinder	Diameter of water cylinder	Length of stroke		Diameter of steam cylinder	Diameter of water cylinder	Length of stroke
3′ 0″	7″	10″	10″	5′ 0″	10″	16″	20″
3′ 0″	8″	10″	12″	6′ 0″ 6′ 6″ and 7′ 0″	12″	18″	20″
3′ 0″	8″	12″	12″	7′ 0″	14″	20″	20″
4′ 2″	10″	14″	16″	.....	.....	.....	.....

STEAM PIPING UPON VACUUM PAN TO USE EITHER LIVE OR EXHAUST STEAM.

Numerous methods are employed to introduce steam into the coils and jackets of vacuum pans, and likewise to remove the condensation from the same. Wherever any exhaust steam is available this should be used, and the deficiency made up with live steam.

In Fig. 163 a complete scheme of piping is shown whereby either live or exhaust steam can be used to operate the vacuum pan. The scheme is the simplest and at the same time the most satisfactory one possible. Exhaust steam can be utilized to the extent of the quantity available. If more exhaust steam is available than the pan can utilize, the relief valve will operate and permit the escape of the surplus exhaust steam either into the open air, or into the feed water heater. If no exhaust steam is available, the lower end of the low pressure header can be closed with a blank flange. If exhaust steam is used, the coil openings

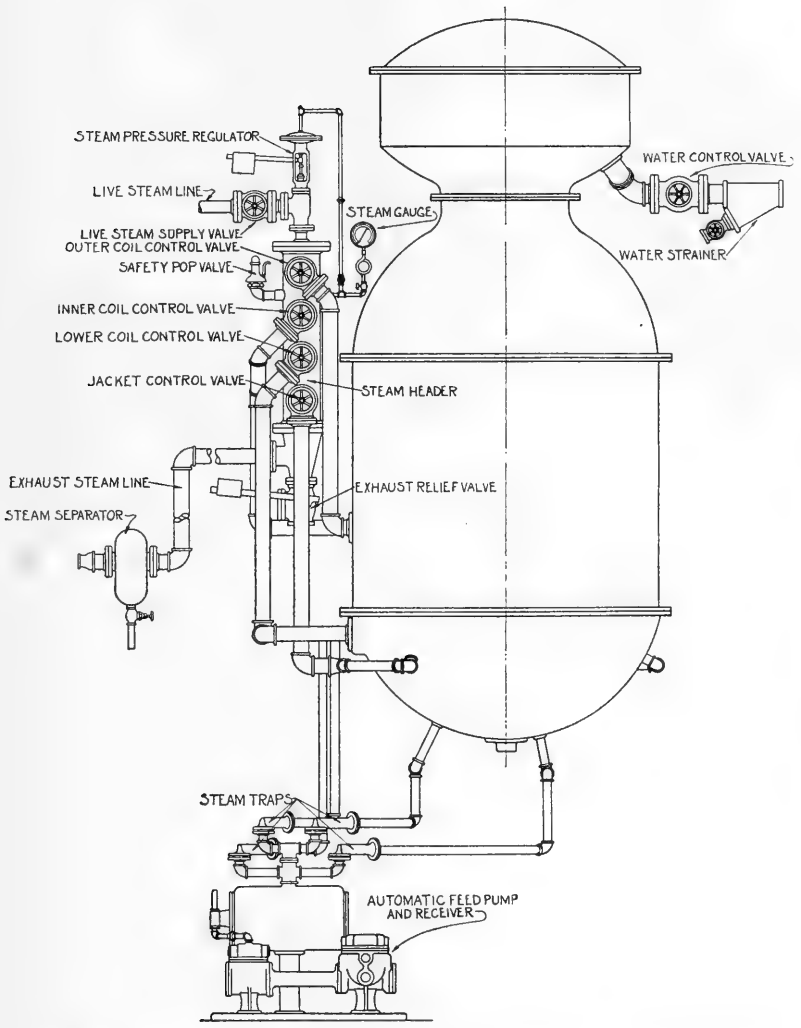


Fig. 163. Piping Scheme Suggested for Connecting a Vacuum Pan to Operate Upon Either or Both Live and Exhaust Steam.

should be large enough to admit the increased volume due to the low pressure of the steam. Equal weights of saturated steam will occupy about five times more space at 5 pounds than at 100 pounds pressure.

At the discharge from the pan single traps are provided for each coil and the jacket. Good makes of either thermostatic or gravity traps will operate with equal satisfaction.

The condensation from the trap, in turn, discharges into a receiver which is connected to a boiler feed pump, which pumps the condensation directly into the boilers as fast as it accumulates.

The suggested scheme of piping makes it possible to condense the milk with the smallest number of heat units, and with the expenditure of the smallest amount of labor.

Suggested Location of Control Devices.

The location of all the control devices is also indicated in Fig. 163. The proper selection and location of these several devices will do much to promote the efficient operation of the pan. Local conditions frequently make it necessary to modify the locations shown.

RELATION OF WATER REQUIRED IN THE CONDENSER, TO THE WATER REMOVED FROM THE MILK IN THE VACUUM PAN.

The quantity of water required to condense the steam vapors arising from the milk in the vacuum pan, varies under several different conditions. Table 123 gives the number of pounds of water required in the condenser for every pound of water evaporated in the vacuum pan under many different conditions of operation. The values given are the theoretical values. In practice the total requirements under the same conditions as named under Table 123 are about five per cent higher than the values given. This statement is based upon the results of carefully conducted experiments made to determine this point.

The method of calculation used is illustrated by the following example:—

Example:—How many pounds of water, temperature 55° F., will be required to condense one pound steam in vacuum pan. Water vapors 140° F. Condensation 130° F.?

TABLE 123.

Pounds of Water at Different Temperatures Required to Condense One Pound of Water Vapor, Evaporated in a Vacuum Pan, Under Different Conditions of Operation.

Temperature of Water Entering Condenser F.	Water Vapors in Pan at 120° F.			Water Vapors in Pan at 125° F.			Water Vapors in Pan at 130° F.			Water Vapors in Pan at 135° F.			Water Vapors in Pan at 140° F.		
	Water Discharging from Condenser at Different Temp. F.			Water Discharging from Condenser at Different Temp. F.			Water Discharging from Condenser at Different Temp. F.			Water Discharging from Condenser at Different Temp. F.			Water Discharging from Condenser at Different Temp. F.		
	100°	105°	110°	105°	[illegible]	115°	1[illegible]°	110°	120°	105°	115°	125°	105°	120°	130°
35°	15.2	14.0	13.0	14.1	13.1	12.2	14.2	13.1	11.5	14.2	12.3	10.8	14.3	11.6	10.3
45°	17.9	16.4	15.0	16.4	15.1	13.9	16.5	15.2	13.0	16.6	14.1	12.2	16.7	13.1	11.5
55°	21.9	19.6	17.7	19.7	17.8	16.3	19.8	17.9	15.0	19.9	16.4	13.9	20.0	15.2	13.0
65°	28.1	24.5	21.7	24.7	21.8	19.5	24.8	21.9	17.7	24.9	19.7	16.3	25.0	17.9	15.0
75°	39.4	32.7	27.9	32.9	28.1	24.4	33.0	28.2	21.7	33.2	24.7	19.5	33.4	21.9	17.7
85°	65.7	49.0	39.0	49.3	39.2	32.5	49.6	39.4	27.9	49.8	32.9	24.4	50.0	28.1	21.7
95°	197.2	98.0	65.1	98.6	65.4	48.8	99.1	65.7	39.0	99.6	49.3	32.5	100.0	39.4	27.9
105°	.....	.....	195.2	.....	196.2	97.6	.....	197.2	65.1	.....	98.6	48.8	.....	65.7	39.0

Solution:—

(a). $140 - 130 = 10$, B.T.U. required to cool vapors to temperature of condensation.

966 B.T.U. required to evaporate one pound of water in the pan.

$966 + 10 = 976$, B.T.U. required for evaporation of one pound of water.

(b). $130 - 55 = 75$, B.T.U. available per pound water supplied in the condenser.

$\frac{976}{75} = 13.0$, pounds water required per pound steam evaporated in the pan.

The percentage increase in the volume of water required under various conditions of operation, as compared with water at a temperature of 35° F. is given in Table 124. This table is based upon the values given in Table 123. One example will serve to illustrate the derivation of the table.

Example:—With the water vapors in the pan at 140° F., and the condenser water at 130° F., 10.3 pounds of water at 35° F. are required for each pound of water vapor removed. Using water at 55° F., 13.0 pounds are required, per pound of water. What percentage increase in volume of water is required at 55° F.?

Solution:—

$13.0 - 10.3 = 2.7$, pounds increase.

2.7 divided by $.103 = 26.21$, per cent increase.

The following conclusions are based upon the values given in Tables 123 and 124.

(a). The warmer the water entering the condenser, the larger the volume required. The most efficient use is made of the condenser water, when the temperature of the water vapors in the pan is maintained at about 140° F.

(b). The greater the difference between the temperature of the water vapors in the pan, and the outgoing water temperatures in the condenser, the greater will be the volume of water required.

TABLE 124.

Percentage Increase in Volume of Water Required, With Incoming and Outgoing Condensing Water at Different Temperatures. Incoming Water 35° F. Taken as Unity.

Temperature Incoming Water F.	Water Vapors in Pan at 120° F.		Water Vapors in Pan at 125° F.		Water Vapors in Pan at 130° F.		Water Vapors in Pan at 135° F.		Water Vapors in Pan at 140° F.	
	Water Discharging from Pan at Temp. (F.) of		Water Discharging from Pan at Temp. (F.) of		Water Discharging from Pan at Temp. (F.) of		Water Discharging from Pan at Temp. (F.) of		Water Discharging from Pan at Temp. (F.) of	
	100°	110°	105°	115°	110°	120°	115°	125°	120°	130°
35°	Unity	Unity	Unity	Unity	Unity	Unity	Unity	Unity	Unity	Unity
45°	Per Cent 17.76	Per Cent 15.38	Per Cent 16.31	Per Cent 13.93	Per Cent 16.03	Per Cent 13.04	Per Cent 14.63	Per Cent 12.96	Per Cent 12.93	Per Cent 11.65
55°	44.08	36.92	39.72	33.67	36.64	30.43	33.33	28.70	30.95	26.21
65°	84.87	66.92	75.18	59.84	67.18	53.91	60.16	50.92	54.31	45.63
75°	158.21	114.62	133.33	100.00	115.27	88.70	100.81	80.55	88.79	71.84
85°	332.23	200.00	249.64	197.08	200.77	142.61	167.48	135.93	142.24	110.68
95°	1197.37	323.85	582.76	300.00	401.53	239.13	300.81	200.92	239.66	170.87
105°	.....	1401.52	.....	700.00	1405.34	466.09	701.63	351.85	466.38	278.64

The increase in the volume of water required due to the decrease in the temperature of the water vapors in the pan is indicated in Table 124. This table is based in large part upon the results given in Table 123. One example will suffice to illustrate the method of calculation used.

Example:—With the water vapors in the pan at 140° F.; the incoming condenser water 35° F.; and the outgoing condenser water 130° F., 10.3 pounds of water are required for each pound of water vapor removed.

How much more water will be required if the temperature of the water vapors is 135° F. and the outgoing condenser water 125° F.?

Solution:

10.8 — 10.3 = .5, pounds more water required.

.50 ÷ 10.3 = 4.85, per cent more water required.

Table 125 shows that the higher the temperature of the water vapors in the pan (not exceeding 140° F.) the less the quantity of water required in the condenser. This rule applies regardless of the temperature of the incoming water.

TABLE 125.

Percentage Increase in Volume in Excess of Water Required When the Pan Temperature is 140° F. In All Cases the Difference Between the Incoming and the Outgoing Condenser Water Temperature is 10° F.

Temperature (F) water entering condenser	Temperature (F) Steam Vapors in Pan			
	135°	130°	125°	120°
	Per cent	Per cent	Per cent	Per cent
35°	4.85	11.65	18.44	26.21
45°	6.09	13.04	20.87	30.43
55°	6.92	15.38	25.38	36.15
65°	8.67	18.00	30.00	44.66
75°	10.17	22.60	37.85	57.63
85°	12.44	28.57	49.77	79.72
95°	17.20	39.78	74.91	133.33
105°	25.13	66.92	152.82	400.51

STEAM REQUIRED TO CONDENSE MILK IN THE VACUUM PAN.

The total heat units required to condense milk is the sum of the heat units required to forewarm the milk in the hot wells,

plus the heat units required to evaporate the water in the vacuum pan. This will vary under several different conditions, the principal factors causing variations being, (a) the type of hot wells, or method of preheating used; (b) the type, efficiency, and general operating condition of the pan used; (c) the temperature and the composition of the product that is to be condensed; (d) the temperature of the steam used both at the hot wells and in the vacuum pan.

Type of hot well. As described in Chapter XIX, the two types of hot wells in general use are the plain and the jacketed. In the plain type the heating of the milk is accomplished by introducing live steam directly into the milk. In the jacketed type the heat is transmitted to the milk through the jacket, in which case no steam needs to be condensed directly into the milk. It is sometimes the practice however, to heat the milk through the jacket up to about 180° F., and then to complete the heating up to 210° F. by means of both the jacket and live steam introduced directly into the milk.

Table 126 shows the amount of steam condensed into milk at various initial temperatures, heated to both 140° F. and 210° F., and using steam of various pressures, in plain type hot wells. The percentages indicated in the table prove plainly that this is a considerable factor in the efficient operation of a vacuum pan. The figures given apply only to whole milk of the test indicated. The values will vary with the specific heat of the product that is being heated in the hot well. In the case of the fresh milk covered by the table, the specific heat was calculated at 0.935.

Table 127 gives the pounds of steam required both to forewarm and condense the raw materials necessary to make one pound of various condensed milk products. The values are given covering various conditions of operation, particularly with regards to method of forewarming employed. The table also gives the pounds of steam required, per pound of water evaporated out of the fluid milk, together with the percentage increase in the use of steam when using plain type, instead of jacketed type of hot wells.

TABLE 126.

Pounds of Steam at Various Pressures, Condensed Into One Pound of Whole Milk Testing 3.50 Per Cent Fat and 12.0 Per Cent T. S. of the Various Temperatures, and Each Heated to 140° F. and 210° F., Respectively, Using Plain Hot Wells. Also Percentage Increase in Water Content of Milk.

Temp. of whole milk F.	Milk heated to 140° F.						Milk heated to 210° F.					
	Steam pressure						Steam pressure					
	5 lbs.		10 lbs.		100 lbs.		5 lbs.		10 lbs.		100 lbs.	
	Lbs. steam condensed in one lb. milk	Percentage increase in water content of milk	Lbs. steam condensed in one lb. milk	Percentage increase in water content of milk	Lbs. steam condensed in one lb. milk	Percentage increase in water content of milk	Lbs. steam condensed in one lb. milk	Percentage increase in water content of milk	Lbs. steam condensed in one lb. milk	Percentage increase in water content of milk	Lbs. steam condensed in one lb. milk	Percentage increase in water content of milk
35°	.094	10.68	.093	10.57	.091	10.34	.168	19.09	.168	19.09	.163	18.30
60°	.72	8.02	.072	8.02	.070	7.95	.144	16.36	.144	16.36	.139	15.80
80°	.54	6.14	.053	6.02	.052	5.91	.125	14.20	.125	14.20	.121	13.75

The method of calculation employed, to arrive at the values given in the table, was as follows:—

(1). To find steam required to forewarm using plain hot wells:—

[(210 — 60) × 0.935] × 2.179 = .144, pounds steam to forewarm in plain wells.

(forew. temperature F.) (milk temp. F.) (sp. heat milk) (condensation)

$$\frac{1151.5 \text{ (B. T. U. in steam at 5 lbs.)} - 179 \text{ (B. T. U. in water at 210° F.)}}{}$$

(2). To find steam required using jacketed wells:—

Added 10 per cent to value obtained under (1), for radiation.

(3). To find steam required to condense using plain wells:—

$\frac{26.65}{12.00} = 2.179$, pounds whole milk required per pound finished product.

$(2.179 - 1.00) + .144 = 1.323$, pounds water evaporated.

$1.323 \times 966 = 1278$, B. T. U. required.

$[(210—140) \times .935] \times 2.323 = 152$, B. T. U. in milk after forewarming.

$\frac{1278 - 152}{1151.5 - 151.5} = 1.126$, pounds steam required to condense using plain hot wells.

(4). To find steam required to condense using jacketed hot wells.

$\frac{26.65}{12.00} - 1.00 = 1.179$, pounds water to be evaporated.

$1.179 \times 966 = 1139$, B. T. U. required.

$\frac{1139 - (2.179 \times 65.45)}{1151.5 - 151.5} = .996$, pounds steam required to condense using jacketed hot wells.

TABLE 127.

Pounds of Steam Required Both to Forewarm and Condense Raw Materials Necessary to Make One Pound of Various Dairy Products. Also Expressed per Pounds of Water Evaporated.

Raw Materials and Finished Products a. Initial temperature (F.) raw product. b. Forewarming temperature (F.). c. Temperature milk in pan (F.).	Pounds of 5 lb. Pressure Steam per Pound of Finished Product Required to:—						Pounds of 5 lb. Pressure Steam Required per Pound of Water Evaporated from the Fluid Milk:—		
	Forewarm only using Plain Hot Wells	Forewarm only using Jacketed Hot Wells	Condense only using Plain Hot Wells	Condense only using Jacketed Hot Wells	Both Forewarm and Condense Using Plain Hot Wells	Both Forewarm and Condense Using Jacketed Hot Wells	Using Plain Hot Wells	Using Jacketed Hot Wells	Percentage Increase Plain over Jacketed
Plain condensed whole milk testing 8.00 per cent fat and 26.15 per cent T.S. Made from whole milk testing 3.67 per cent fat and 12.00 per cent T. S. a = 60° b = 210° c = 140°	.314	.345	1.126	.996	1.440	1.341	1.221	1.137	7.38
Plain condensed skim-milk testing 26.40 per cent T. S. Made from skim-milk testing 8.80 T. S. a = 60° b = 140° c = 140°	.213	.234	2.144	2.070	2.357	2.304	1.179	1.153	2.30
Sweetened condensed whole milk testing 28.0 per cent milk solids and 46.0 per cent sugar. Made from whole milk testing 3.43 per cent fat and 12.00 per cent total solids. a = 60° b = 210° c = 140°	.405	.445	1.911	1.547	2.316	1.992	1.292	1.111	16.27
Sweetened condensed skim-milk testing 28.0 per cent milk solids and 42.0 per cent sugar made from milk testing 8.80 per cent total solids. a = 60° b = 210° c = 140°	.536	.590	2.862	2.380	3.398	2.976	1.251	1.094	14.41
Condensed buttermilk testing 25.00 per cent total solids. Made from buttermilk testing 8.80 per cent total solids. a = 60° b = 140° c = 140°	.228	.241	1.792	1.588	2.020	1.828	1.097	.993	10.50
Ice cream mix testing 8.00 per cent fat, 12.50 per cent M. S. N. F. 13.00 sugar .50 per cent gelatin. Made from whole milk testing 3.75 per cent fat, 8.50 per cent M. S. N. F., butter, sugar and gelatin. a = 60° b = 140° c = 140°	.121	.133	.460	.350	.581	.483	1.233	1.025	20.29

RELATION OF GAS, OIL AND COAL CONSUMPTION TO STEAM PRODUCTION.

It is frequently desirable to know the relation between the fuel supply, and the steam produced in the boiler. Obviously this is open to wide fluctuations, the principal factors causing variations being the kind of fuel; type of boiler used; quality of the water supply, and especially the efficiency of the methods of firing employed. Due to these variables there is a wide gap in practice between the theoretical and the actual steam production. Table 128 shows the above relations in the case of several of the most common American fuels, giving the steam produced at pressures of 5, 10 and 100 lbs. each respectively. Obviously the practical values given are only approximate, but yet they are accurate enough to serve as a practical guide.

TO CALCULATE THE WATER, STEAM AND FUEL REQUIRED TO OPERATE A VACUUM PAN.

It is frequently necessary to know, both for purposes of figuring costs, and for properly coordinating equipment capacities, the water, steam and fuel necessary to condense milk into various products. The information given in this chapter is sufficient to permit anyone to arrive at these values quickly and easily.

The following example will illustrate the principle of the calculation, and the same can be applied to any dairy product.

Example:— Wanted to condense 10000 lbs. skim-milk testing 8.80 per cent total solids, into sweetened condensed skim-milk testing 28.00 per cent milk solids and 42.00 per cent sugar.

Pan vapors 140° F. Condenser water 120° F. Plain hot wells used. Water at 55° F. costing 6 cents per 1000 gallons. One U. S. gallon of water weighs 8.345 pounds. Hocking Valley bituminous coal used costing $6.50 per ton. Find quantity of water and coal required.

Solution:—

(a). $10000 \times 8.80 = 880$, pounds total solids in skim-milk.

$880 \div .28 = 3143$, pounds finished product possible to make.

TABLE 128.

Relation of Fuel Consumption to Steam Production.

KIND OF FUEL	Unit	B. T. U.	Pounds of steam produced by one unit of fuel starting with water at 32° F. and ending with steam at pressure indicated.			
			Theoretical	Practical		
			100 lbs.	100 lbs.	10 lbs.	5 lbs.
Natural gas, Ohio	Cu. ft.	1020[3]	.86	.65	.67	.67
Natural gas, Pa.	Cu. ft.	1073[3]	.91	.68	.70	.67
Producer gas	Cu. ft.	145[4]	.12	.09	.09	.09
Coal gas	Cu. ft.	599[3]	.51	.38	.39	.39
Crude Oil, Calif.	Pound Sp. Gr. 0.966	18667[5]	15.75	11.81	12.11	12.15
Crude Oil, Texas	Pound Sp. Gr. 0.924	19060[5]	16.09	12.06	12.37	12.41
Crude Oil, residium	Pound Sp. Gr. 0.860	19200[5]	16.20	12.15	12.47	12.50
Anthracite, Northern field	Pound	13160[6]	11.11	7.78	7.96	8.01
Semi-anthracite, Loyalsack	Pound	13920[6]	11.75	8.23	8.44	8.57
Semi-bituminous, Pocahontas, W. Va.	Pound	15070[6]	12.70	8.89	9.12	9.15
Bituminous, Pittsburgh, Pa.	Pound	13410[6]	11.31	6.79	6.97	6.99
Bituminous, Hocking Valley, Ohio	Pound	12130[6]	10.24	6.14	6.30	6.32
Lignites, Utah	Pound	11030[6]	9.31	5.12	5.25	5.27

$3143 \times .42 = 1320$, pounds sugar required.

$10000 - (3143 - 1320) = 8177$, pounds water removed from skim-milk.

(b). $8177 \times (15.2 \div 8.345) = 14896$, gallons water required.

$14.896 \times .06 = \$.89$, cost of water.

(c). $3143 \times 3.398 = 10679$, pounds of 5 lb. pressure steam required.

$10679 \div 6.32 = 1690$, pounds, or .845 ton of Hocking Valley coal required.

(d). $.845 \times \$6.50 = \$5.49$, cost of coal.

THE OPERATION OF THE VACUUM PAN.

The operation of the vacuum pan and its practical application in the manufacture of various condensed milk products is considered here. The discussion includes methods recommended in forewarming as well as other steps comprised in the complete condensing operation.

1. TO FOREWARM AND CONDENSE WHOLE MILK AND SKIM-MILK, BOTH PLAIN AND SUPERHEATED.

(a). Forewarming or Heating in the Hot Wells.

The forewarming operation is of very great importance as affecting the finished product. The influence of this operation is frequently neither properly understood nor properly appreciated in practice.

In the manufacture of sterilized evaporated milk the forewarming operation requires constant daily watching. The physical properties of the finished product are influenced very largely by the heat treatment given to the whole milk in the hot wells. At certain seasons too high a temperature in the hot wells raises the coagulating point of the finished product in the sterilizers, and thus makes it difficult, if not impossible, to produce a product of the proper viscosity. Upon the other hand, insufficient forewarming lowers the coagulating point to such an extent as to make it difficult, if not impossible, to properly sterilize the finished product, on account of the excessive viscosity produced. The application of the above principles in practice, gives the processor one means for keeping the finished product under control.

The above principles are also applied in the manufacture of superheated products, where the aim is to obtain all the viscosity possible up to the point where the product still remains smooth, and free from lumps.

The range of forewarming temperatures in the case of sterilized evaporated milk, either whole or skim, is from 140° F. to 210° F. When as low a temperature as 140° F. is used, care must be taken to provide a safe sterilizing record. Under some conditions heating to 210° F., shutting off the steam, and heating again to 210° F. after a lapse of two to five minutes, may prove beneficial, but when this practice is followed, there is danger of producing a product too high in color. This latter trouble can be prevented to a considerable extent by reducing the sterilizing time and temperature to a minimum.

The range of forewarming temperatures in the case of superheated products is from 140° F. to 160° F. Obviously in these products the aim is to control the operations in such a way as to produce a high final viscosity.

When using the plain type of hot well, the steam should be introduced into the milk at a pressure not to exceed ten pounds. Higher steam pressures are liable to cause chemical changes in the finished product. The steam line leading into the hot well should be fitted with an oil separator to remove any oil or water that might be contained in the steam.

The forewarming should be so timed that the pan will be ready to receive the milk as soon as it has reached the desired temperature, in the hot wells.

(b). **To Start and Operate the Vacuum Pan.**

Before starting the operator should see that the pan is clean and thoroughly steamed; that the water spray in the condenser is free from obstructions and that the stop valves upon the coils and jackets do not leak steam.

The air vents are now all closed, and the vacuum pump is started up slowly, increasing the speed to 25 or 30 single strokes per minute. Open the water valve to the condenser as soon as 15″ to 20″ of vacuum are obtained, and the milk in the hot wells has reached the desired temperature. The milk inlet valve is now opened wide. The milk always rises due to the air in the

same when first introduced into the pan. The operator must be upon the alert at this point and by means of the vacuum break introduce just enough air into the pan to hold the milk down to a safe limit. It will take only a few seconds for the pump to expel the air, and to obtain the proper vacuum. This result can be accomplished by the time the lower coils are covered with milk. In addition to introducing air in the pan to reduce the milk level, it may sometimes be necessary to close off the milk supply, and to shut off the steam for a few moments, until the proper vacuum has been reached.

Sufficient milk should be in the pan, to cover one set of coils before turning on the steam. To arrive at the proper amount to introduce into the pan, it is suggested to fill one of the hot wells with water, to the level at which it is usually filled with milk. The water is now drawn into the pan until the lowest set of coils are all covered, and the new level upon the hot well is suitably marked for subsequent guidance. The above procedure will insure knowing just when the right amount of milk is in the pan to permit turning on the steam without danger of baking milk upon the coils. There is no other satisfactory way of doing this, owing to the foamy condition of the milk, in the pan.

When turning on the steam, open the jacket valve first; then the lowest coil, and the remaining coils after a lapse of three or four minutes.

Whenever possible the condensing should be done with exhaust steam. If insufficient exhaust steam is available to do all the condensing, the amount available should be utilized, and the shortage made up with live steam. Every well installed pan should be fitted to use either exhaust steam, live steam, or a combination of the two, when both are available.

Simple devices are available for controlling automatically the pressure upon the steam header.

The efficiency of exhaust steam for condensing purposes is due to its latent heat, thereby giving it a large number of available heat units, with a relatively low temperature. The higher the steam pressure the higher the temperature of the steam, without an increase in heat units proportional to the increase in temperature. These facts are of great moment in condensing milk. The higher the steam temperature, the greater the danger of the

milk baking upon the coils, and also the greater the danger of the product being dark in color. It is not good practice to crowd the capacity of the pan by increasing the steam pressure inside the coils and jacket. The correct practice is to operate at moderate pressures, and within the ratings of the pan.

Table 129 gives the available heat units and the temperature of exhaust steam, and of steam at various pressures.

TABLE 129.

Available Heat Units, Volume and Temperature of Steam at Various Pressures.[2]

Pressure in pounds per square inch above sea level	Temperature of steam Degrees F.	Volume in cu. ft. occupied by one pound	Normal heat expressed as B. T. U. in liquid form 32° F.	Latent heat expressed as B. T. U.	Total heat expressed as B. T. U. from water at 32° F.
.....	212.00	26.36	180.9	965.7	1146.6
.3	213.03	26.14	181.8	965.1	1146.9
2.0	219.00	23.65	187.8	960.9	1148.7
3.5	223.47	21.78	191.9	957.8	1149.7
5.	227.05	19.54	196.0	954.0	1150.0
10.	239.32	15.90	208.4	945.5	1153.9
25.	266.65	10.29	235.9	926.3	1162.2
40.	286.53	7.66	255.9	912.8	1168.7
100.	337.66	3.76	398.5	876.1	1184.6

It is evident from the data contained in the above table that with a pan of proper design,—that is, one that contains the necessary heating surface, and amply large openings into the coils and jacket, every advantage is gained by using low pressure steam. Five pounds should be the maximum under proper operating conditions.

The same pressure should be carried upon the coils and the jacket. The steam in the jacket causes the milk to "kick up". That in the coils causes it to "roll", and to drop back towards the center of the pan.

The level of the boiling milk should be not more than half way up the waist. The milk intake cock should be so adjusted that the milk will condense about as fast as it is drawn into the pan.

The milk should test near the end of the run, and before lowering the steam pressure, from 5 to 10 points lower upon the hydrometer than the striking point desired. Also all the milk from the hot wells should be in the pan before turning off the steam. This will help to obtain a more correct hydrometer reading.

The best pan temperature to maintain upon plain condensed milk is from 122° to 140° F. The best method is to maintain the temperature near 140° F., throughout the run until the finishing point is nearly reached. At this point the temperature can be dropped to about 120° F. by reducing the steam pressure. This will make for greater accuracy in arriving at the end point. Below 122° F. the evaporation becomes too slow, while above 140° F. the evaporation also becomes slower, and the higher temperature tends to produce a dark colored product. While the evaporation is proceeding rapidly, the temperature of the water vapors in the pan will be the same as that of the milk itself. Near the end of the run there may be a considerable difference between the two, so that the temperature of the milk itself should be the proper guide for the operator, especially when striking the batch.

If the pan temperature should drop under the point at which it is desired to be carried, in order to raise it, the water supply should be decreased, and sometimes the steam supply can be increased to advantage. A drop in pan temperature as above may be due to a decrease in the steam supply, to water being carried over from the boilers, or to the condensation being improperly removed from the coils and jacket.

If the pan temperature should rise above 140° F., the water supply should be increased, and the steam pressure decreased. A condition of this kind may be caused by air leaks into the pan, increase in the steam pressure, without any corresponding increase in the water supply to the pan, or to the spray pipe in the condenser becoming clogged.

(c). **To Strike the Batch.**

The reader is referred to Chapter XI for detailed information as to the specific gravity of evaporated milk under different conditions, and as to suggestions for striking the batch. This is an operation that requires both skill and care. The steam should be kept upon the coils and jacket as long as possible, in order not to reduce the capacity of the pan. And upon the other hand, it should not be kept on long enough to over-condense the milk.

Usually the time method can be used to good advantage to aid in arriving at the striking point. Under this method the operator ascertains by experiment just how long it takes to increase the hydrometer reading one-tenth degree after the milk from the batch is all in the pan, and while the full steam pressure remains upon the coils and the jacket at a certain pan temperature.

Example:— Test desired 6.35 degrees Baume at 140° F. Test increases at rate of .10° B. for every minute.

Preliminary test found to be 6.05° Baume at 140° F.

Solution: 6.35 — 6.05 = .30, degrees short.
.30 ÷ .10 = 3, minutes additional necessary to operate pan before turning off the steam.

(d). **To Finish the Pan Batch.**

The first step after reaching the striking point is to close off the steam valves. If plenty of cold water is available, leave the water valve to the condenser open, with the vacuum on, for two or three minutes. This will cool the milk in the pan to about 100° F., and thus it will assist greatly with the subsequent cooling of the batch. The vacuum break is now opened; the water valve to the condenser is closed, and the vacuum pump is shut down. Do not open the draw off valve until the vacuum has been reduced to two or three inches. If opened sooner, the manhole cover may be blown off, or some milk may be lost.

The proper handling of the milk immediately after it leaves the pan, is of prime importance. Equipment should be on hand to cool the product from the pan rapidly and efficiently.

(e). **To Superheat the Batch.**

Superheating both condensed, whole and skim-milk is an old established trade custom. Possibly with but few exceptional

cases there is but little merit or advantage to this practice, in so far as it may improve the quality of the product. The superheating coagulates part of both the albumin and the casein, thus greatly increasing the viscosity without increasing the total solids in the product. It frequently happens that superheating may give an entirely false impression as to the total solids content of the product. The modern tendency is to buy milk products upon the basis of their fat and total solids contents, together with the necessary specifications regarding their essential physical properties. The method of superheating given herewith is inserted for the benefit of those called upon to furnish such products.

As already noted, when making superheated products, the fluid milk in the hot wells, should not be heated to exceed 160° F.

Condense the milk in the pan as described above. Strike the batch about two degrees Baume higher then necessary to produce the total solids desired. The steam condensed into the milk in superheating should not dilute the milk under the standard desired. Keep the temperature up to 140° F. at the time of striking. The steam from the coils and the jacket is now turned off, and the vacuum pump is shut down, but the vacuum is allowed to remain in the pan. The superheating steam valve is now opened wide, using full boiler pressure up to 100 pounds. Lower pressures will unduly prolong this operation. Obviously as the temperature of the milk rises, the vacuum in the pan decreases. The superheating is continued until the milk reaches a temperature of 180° F., and the vacuum has reached about 13″. The end temperature has to be varied depending upon the concentration, and the condition of the milk. Obviously milk of higher concentration will reach the desired viscosity in superheating at a lower temperature than milk of lower concentration. Likewise milk of high acid content will superheat much more rapidly, and at lower temperatures, than milk of low acid content, or than milk with low coagulating point due to causes other than the acidity of the same. Likewise milk with high coagulating point, has to be superheated at times, as high as 190° F., before obtaining the desired viscosity.

The end point in superheating is found by sampling at the striking cup. If the superheating is carried too far there is danger of "cracking" the product. That is, of coagulating the

casein in lumps, so that the product loses its smooth, velvety appearance. This can be avoided by care and experience, and if by chance the superheating has been carried too far, the lumpy condition thus produced can be overcome by running the product through the homogenizer. But of course the preventative is better than the cure. The superheating operation consumes considerable time, requiring about 30 minutes for about 5000 pounds of finished product, upon the proper size of pan.

When the desired viscosity has been obtained, the superheating valve is closed; the vacuum pump is started; and the water is turned on in the condenser, very slowly at first. The batch is now cooled in the pan to at least 140° F., — preferably to 120° F. before dropping it out of the pan.

On account of its viscous condition, superheated condensed milk is one of the most difficult of all dairy products to cool. The proper cooling of this product requires the use of equipment well designed for this work, and the use of cooling mediums of low temperature.

The product should be tested for fat and total solids while the batch is being cooled, and the materials necessary to use for standardizing should subsequently be added, cooled and mixed with the balance of the batch.

(f). **Precautions in Pan Operation.**

The efficient operation of a vacuum pan is influenced by several conditions that should be well understood by every pan operator.

The following are the most important of these conditions:

Condition of Heating Surfaces. Two conditions may exist to decrease the efficiency of the heating surfaces.

The outside of the coils and the jacket may become coated with coagulated milk. This condition is caused by the use of too high steam pressure; by the presence of water inside of the coils; by condensing milk too high in acidity; by turning on steam before the heating surfaces are all covered; by condensing too many batches before cleaning the pan, and by careless, improper cleaning of the pan. The layer of milk acts as an insulator, and greatly hinders the transmission of the heat from the steam to the milk. Under good operation the above difficulties can be readily eliminated.

The inside of the coils and the jacket may become partly or completely filled with water, due to improper methods of trapping off the condensation; improper coil or jacket construction, or the use of steam containing much water condensed into it. The coils should be designed to completely and rapidly carry off the water as soon as it forms. The water also acts as an insulator, and prevents the transmission of the heat from the steam to the milk.

The two conditions described above are graphically illustrated under Fig. 164. These conditions greatly reduce the capacity of vacuum pans, and to a lesser extent cause the use of increased amounts of both steam and water.

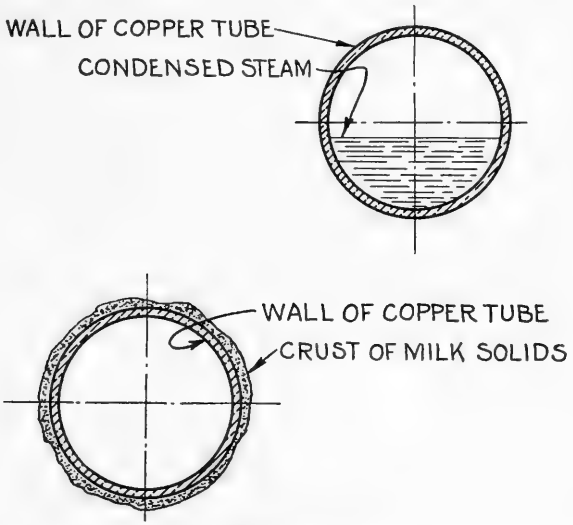


Fig. 164. Factors That Influence Heat Transmission.

Air Leaks Into Pan. If any considerable amount of air should get into the pan, while under operation, the milk intake valve should be immediately shut off. As soon as the air enters the pan, the milk will cease boiling, and it will appear motionless upon the bottom of the pan. Just as soon as the vacuum pump begins again to remove the air and to form vacuum, the milk will immediately get very wild and foamy. Great care must be

exercised by the operator at this moment. Just enough air should be introduced through the vacuum break to keep down the milk in the pan until the proper vacuum has been regained. The steam can be then gradually turned on the coils and jacket. The steam should be shut off from the coils and the jacket just as soon as the above condition is discovered. If this is not done, the heating surfaces will soon become coated with milk.

Large air leaks into the pan are caused principally by the water supply tank becoming dry; to the accidental breaking of an eye glass; to the emptying of a hot well without closing the milk intake valve; or when jacketed hot wells are used, to air being drawn in through the "whirlpool". This last named condition can be simply and easily prevented by a small device used for that purpose.

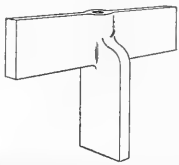


Fig. 165. Device for Breaking Whirlpool in Jacketed Hot Well. To Be Inserted in Discharge Opening.

Influence of Bicarbonate of soda.

If bicarbonate of soda is added to the last portions of milk remaining in the hot wells, and just before drawing into the pan, this will cause the milk in the pan to become very wild and foamy, due to the excessive amount of carbon dioxide generated. Under these conditions great care must be exercised by the operator, and the milk should be drawn into the pan only as fast as the vacuum pump can expel the gas.

When necessary to use bicarbonate of soda, this should be added to the milk in the hot wells before any steam has been introduced into the milk. Under these conditions a large part of the gas will be eliminated as the milk is being heated, and before it enters the pan.

Cleaning the Pan. After the day's run has been completed draw enough water into the pan to submerge all the coils. Allow to stand for at least 15 minutes, or if time is available, as much as several hours. Empty and clean the pan, taking care that the milk is completely removed.

The cleaning of vacuum pans and hot wells can be greatly facilitated by the use of caustic alkali, properly applied. The use of caustic alkali for this purpose originated in Europe, and full report upon the subject was made by Dr. Hamilton.[7] In order to obtain proper results it is necessary to use the right concentration of the alkali, and to apply it hot. Devices are available for accomplishing this result simply and efficiently.

The merit of this method is owing to the solubility of coagulated casein and albumin in even very dilute solutions of caustic alkali. Soon after applying the alkali, it becomes possible to remove the coagulated products, which under the action of the alkali, have been converted into slimy substances, that are easily removed from the heating surfaces.

In using caustic alkali good judgment must be exercised. It should be applied only a few minutes before the cleaning of the pan is started, and it should be applied only to the surfaces containing coagulated milk. Under no condition should the alkali be added for any considerable time before cleaning the pan. These precautions are necessary owing to the solubility of tin in caustic alkali, causing decomposition of the solder, and thus weakening the seams of the pan.

The final step in cleaning a pan is to rinse the pan freely with water, and then in turn to follow up the rinsing with a thorough steaming. The pan will thus soon become thoroughly dry, without any verdigris forming in it. The rinsing and steaming should be repeated before starting the pan, the following morning.

Entrainment Losses. By this is meant the solid portions that are mechanically carried over into the condenser. These losses are caused by improper pan design; by carrying the milk too high in the waist of the pan; by careless operation, or by large air leaks. The same may be reduced to small proportions by careful operation. A good index of entrainment losses is the color of the water discharging from the vacuum pump. Even slight coloration is an indication of milk solids being carried over into the condenser.

There is also a small loss due to stickage, which is caused by conditions already named, all of which can be very largely prevented, under careful operation.

(2). TO FOREWARM AND CONDENSE BOTH SWEETENED CONDENSED WHOLE MILK AND SWEETENED CONDENSED SKIM-MILK.

(a). Forewarming or Heating in the Hot Wells.

The forewarming of the fluid milk in making the above products is subject to many differences in practice. In some cases the heating is carried only to 140° to 160° F. This method has the advantage of giving the finished product a minimum amount of color. It has the disadvantage of not reducing the bacterial flora as much as is usually desirable. It may have the further disadvantage of not dissolving the added sugar, as completely as it should be. The more common and the preferable practice is to heat the fluid product up to 200° to 210° F. If the heating is done carefully, a finished product can be produced that is of very satisfactory color, and at the same time the disadvantages of the first method named can thus be largely overcome.

It is recommended that no sugar be added to the first hot well in making up a batch. The total sugar making up a batch can be divided between the remaining hot wells, except that the final addition of sugar necessary for standardizing the batch can be added to the last hot well.

Both the plain and jacketed type of hot wells are used in making sweetened condensed milk. The operating advantages are in favor of the jacketed type, as in the case of unsweetened condensed milk. The disadvantage is in the first cost of the latter.

(b). The Operation of the Vacuum Pan Upon Sweetened condensed milk.

The operation of a vacuum pan upon sweetened condensed milk, is in all essential respects, the same as in the case of unsweetened products. The principal difference is in the concentration of the two products.

(c). Striking the Batch, in the Case of Sweetened Condensed milk.

Chapter XII contains detailed information as to the specific gravity of different kinds of sweetened condensed milk. Several methods for ascertaining the end point, and which depend for their success upon the judgment of the operator, are sometimes

used, but none of these are reliable, and the same should be depended upon only as an aid, and not as a means. The most satisfactory method devised up to this time, is by means of hydrometers, suitably graduated and properly used.

The striking operation requires skill, speed and care. A vacuum pan seven feet in diameter removes water at the rate of about 100 pounds per minute. Near the end of the run, the removal of this amount of water per minute in a batch of about 15000 pounds of whole milk, would increase the total solids at the rate of one per cent per minute.

(d). **To Finish the Pan Batch when Making Sweetened Condensed Milk.**

Proceed as in the case of unsweetened condensed milk. The practice of cooling the product in the pan may be advantageously followed, but the temperature is seldom lowered here, under 120° F.

Sweetened condensed milk should not be allowed to remain in the pan under heat after the batch is done. This will superheat and thicken the product, and in many cases render it unsalable. The method of handling the condensed product, after it leaves the pan, is fully described in Chapter XII.

The precautions in pan operation are the same as in the case of unsweetened condensed milk, and the operator should thoroughly familiarize himself with every condition requisite for successful operation.

(e). **To Forewarm and Condense Liquid Dairy Products, Other Than Unsweetened and Sweetened Condensed Milk**

The vacuum pan can be used to condense any liquid dairy product, as well as unsweetened and sweetened condensed milk, many of which are of great commercial and economical importance. These products can be reduced to a liquid, semi-liquid, or solid state.

Ice cream mix is the most recent product to be added to the list, and the process for making this in the vacuum pan is subject to patents now pending by one of the authors[8] and one of his brothers By this process a superior quality of product can be obtained, besides the numerous economic advantages. The temperatures during no part of the operation are allowed to exceed

140° F., so that the natural flavors are fully retained. The temperature used in condensing the mix is the same as that used in pasteurizing, therefore the pasteurizing and condensing are combined in one operation. The principles involved are the same as in the case of other dairy products. The whole milk, butter or cream, sugar and the gelatin are all added in the hot wells, and condensed together in the vacuum pan. The striking point varies obviously with the composition of the product being manufactured. The specific gravity of different ice cream mixes is given in Chapter XIII.

Condensed buttermilk is a product of growing commercial importance. It is condensed to a semi-paste condition. The heavy viscosity is due both to its concentration, and to slightly superheating before drawing it out of the pan. The usual method is to heat the buttermilk in the hot wells at 145° F., to condense at the pan temperatures usually used in the case of unsweetened condensed milk products, and finally to superheat in the pan to 160° F. It is run while hot, directly into shipping barrels, and it is cooled after being barreled. The specific gravity of this product at various concentrations is given in Chapter XIV.

Malted milk is an American product of world wide distribution and of considerable commercial importance. It is finished in a special pan wherein it is reduced to a dry state, before removing it from the pan.

Whey used to make milk sugar can frequently be condensed to a semi-liquid or dry state before shipping to a central refining plant. The advantage is in the superiority of the product, and the saving in transportation charges.

REFERENCES.

[1] Hunziker, O. F., La Grange, Ill. "Condensed Milk and Milk Powder," p. 87, 3rd edition.
[2] Snow & Leland. "The Steam Engine," 1908, p. 88.
[3] Poole. "The Calorific Power of Fuels."
[4] Gill, A. H. "Engine Room Chemistry," p. 72.
[5] Report, U. S. "Liquid Fuel," Board 1904.
[6] Babcock and Wilcox Co. "Steam."
[7] Hamilton, Molkerie-Zeitung, No. 16, 1901.
[8] Mojonnier. T.

CHAPTER XIX

EVAPORATED MILK

ITS STERILIZATION AND PHYSICAL AND CHEMICAL CONTROL.

In plants manufacturing evaporated milk, the proper sterilization of the product is one of the most important of the operations. Conditions that affect sterilizing time and temperature vary greatly over the course of the year, and frequently from day to day. Unless the factors that affect sterilization are properly understood and in turn applied in daily practice, the product will be irregular in its physical properties or it will be both irregular and develop spoilage after manufacture.

The ideal aimed at in this chapter is to recommend methods and processes for sterilizing evaporated milk whereby the physical properties of this product, namely the viscosity, flavor and color, can be kept uniform at all times and under all conditions; and at the same time insure proper sterilization so that spoilage will be entirely eliminated. To insure these results operations going back to the farms need to be understood and closely watched from day to day, and the knowledge thus gained applied in daily practice. The two-fold purpose of sterilization should be kept in mind at all times. First, to insure the keeping qualities of the product; and second to impart to the product the physical properties referred to above that are demanded by trade, custom, or personal preference.

The Choice of Sterilizer.—Several makes of sterilizers are upon the market, most of which if properly operated can be used with success. These are offered in a large range of sizes to suit all ranges of production. Two common types of sterilizers that are extensively used are illustrated under Figs. 166 and 167. Many of the problems involved in the operation of the sterilizers are purely mechanical, and must be determined by local conditions. Other phases of the subject will be discussed in this chapter.

The Sterilizing Process.—The time and temperatures used in sterilizing, and the mechanical manipulations of the sterilizers during the sterilizing process are subject to many needless fluctuations in practice. Space will not be consumed to discuss

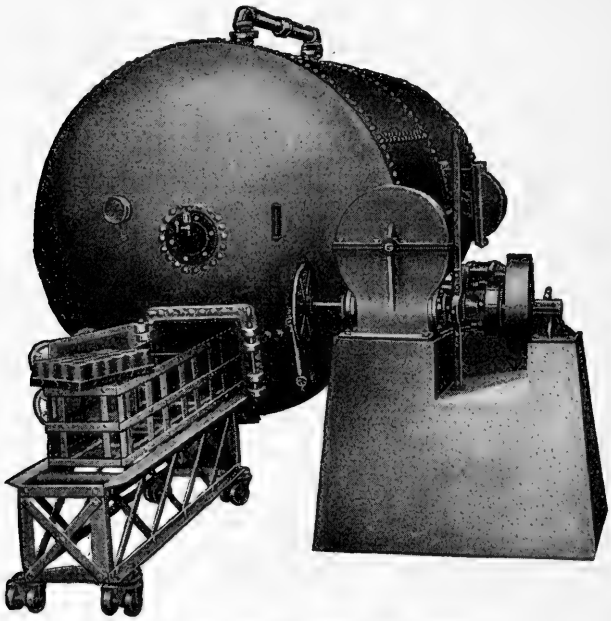


Fig. 166. Fort Wayne Sterilizer.
Courtesy The Engineering Co.

the relative merits of these different methods, but the discussion will concern only the process that the authors know from wide experience to give satisfactory results at all times. Furthermore the modern tendency is to standardize the sterilizing process not only as between the plants of the same manufacturer, but in a larger sense, as between the plants of different manufacturers. The process in brief is as follows:—

Coming-up time.—A minimum of 15 minutes, and a maximum of 20 minutes should be taken to raise the temperature in the sterilizer from room temperature, to the temperature at which the milk is to be sterilized. This is commonly known as

the "coming-up time." Where water is used in the sterilizers during the processing uniform results may be obtained with 15 minutes coming up time. When live steam is used, the best results are obtained when 20 minutes elapse. The relation between minutes in coming up and the temperature in the sterilizer is indicated both for the 15 and 20 minute intervals in Table 130.

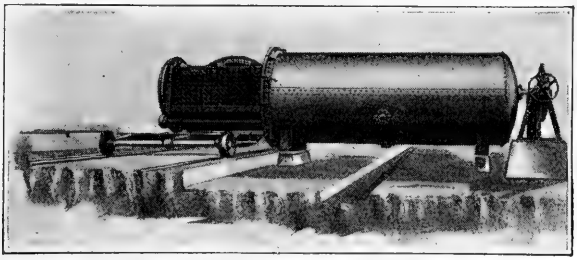


Fig. 167. Berlin Sterilizer.
Courtesy Berlin Canning Machinery Works.

As indicated in the table the temperature should be at 190° F. at the end of 5 minutes when 15 minutes is the coming up time used, and at the end of 10 minutes when 20 minutes is used. The rate of increase is more rapid between the initial temperature and 170° F., than it is from 170° F. to 240° F. During the last 10 minutes of the coming up time the increase should be at the rate of 5° F. for every minute.

Influence of Speed of Sterilizer Reel.—The speed at which the sterilizer reel is operated has a very important bearing upon the sterilizing operation. The faster the reel is operated the more rapidly the milk will heat inside of the can, and also the more rapidly it will cool at the end of the run. Too rapid reeling tends to destroy the viscosity, and to produce a grainy finished product. Too slow reeling produces a clabbery product—one that is sterilized with difficulty, and that cools very slowly.

The proper speed of the reel is from six to ten turns per minute depending upon the diameter of the sterilizer. A sterilizer of 96 case capacity produces the best results at six turns per minute. A 30 case sterilizer at ten turns per minute.

TABLE 130.

Relation Between Temperature and Time When Coming Up in Sterilizers.

Minutes after turning on steam.		Temperature in sterilizer at corresponding minute. Degrees F.	Minutes after turning on steam.		Temperature in sterilizer at corresponding minute. Degrees F.
	1	70	6	11	195
1	2	90	7	12	200
	3	110	8	13	205
2	4	130	9	14	210
	5	150	10	15	215
3	6	170	11	16	220
	7	175	12	17	225
4	8	180	13	18	230
	9	185	14	19	235
5	10	190	15	20	240

The Addition of Water to the Sterilizers.—Adding water to the sterilizers before turning on the steam usually helps to produce more uniform sterilization, but the practice is not a universal one. The proper spacing of the cans in the trays and in the crates is a factor that influences uniformity of sterilization. The spacing and the placing of the cans should be such as to facilitate the transmission of the heat equally to all of the cans in the batch.

When water is added just enough should be used to cover all of the cans in one position of the reel. Savings in coal can be affected by storing the hot water between the sterilizer runs in a suitable tank, so placed that the water will run by gravity back into the sterilizer at the beginning of the succeeding run. The above points are illustrated under Fig. 168.

Holding temperature.—The minimum temperature recommended is 240° F., and the maximum 245° F., with the proper holding time.

Holding time. The holding time never should be less than 15 minutes with the temperature never under 240° F.

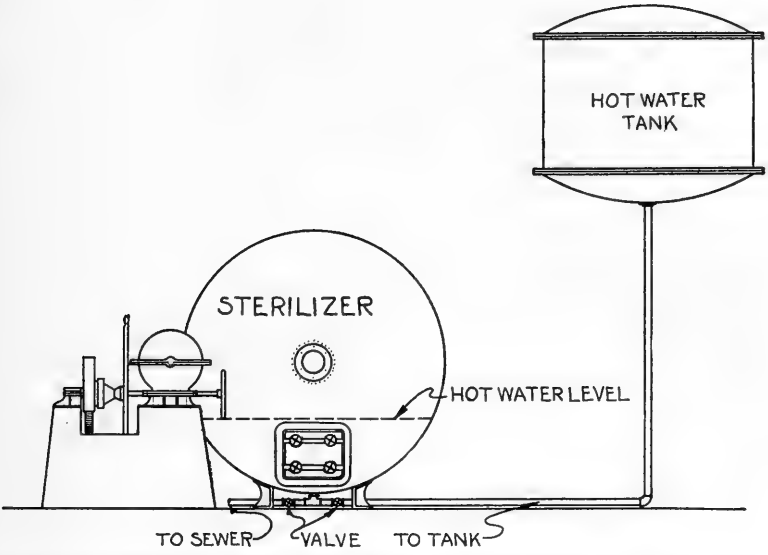


Fig. 168. Sterilizer Arrangement When Using Hot Water in Sterilizing.

Cooling time.—From 15 to 20 minutes, depending upon the temperature of the water. The cooling should be continued until the temperature of the milk throughout the batch is between 70 and 80° F., or about room temperature. If all the factors affecting sterilization are properly controlled the sterilizing process can be kept between the following limits at all times:—

Coming up time { 15 minutes minimum
20 minutes maximum

Holding temperature { 240° F. minimum
245° F. maximum

Holding time { 15 minutes minimum
20 minutes maximum

Cooling time { 15 minutes minimum
20 minutes maximum

The sterilizing process, as recommended above, from the time the steam is introduced until the cooling of the batch has been completed is shown in the graph represented over Fig. 169.

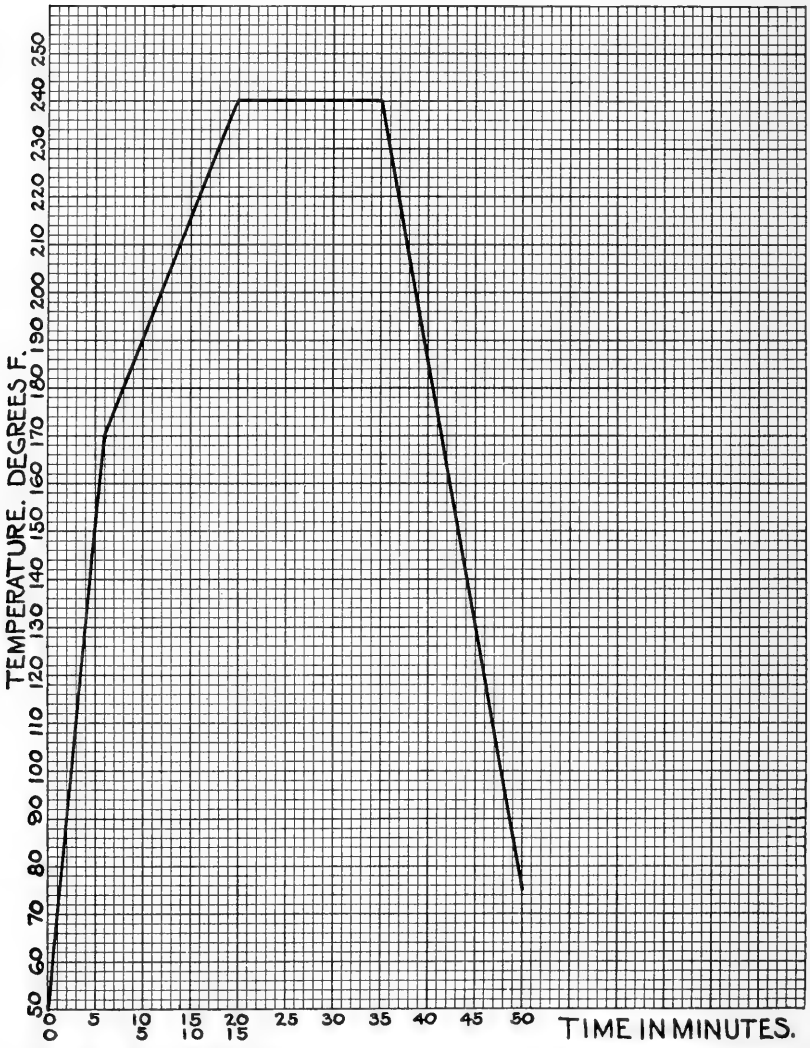


Fig. 169. The Relation Between Coming Up Time, Holding Temperature, Holding Time, and Cooling Time in Sterilizing Evaporated Milk.

MOJONNIER EVAPORATED MILK CONTROLLER.

This apparatus was designed especially to provide a means for controlling all the factors that affect the sterilization of evaporated milk. It is illustrated under Fig. 170. To O. W. Mojonnier was granted U. S. patents covering the fundamental processes underlying its operation. Its application will be described further in this chapter.

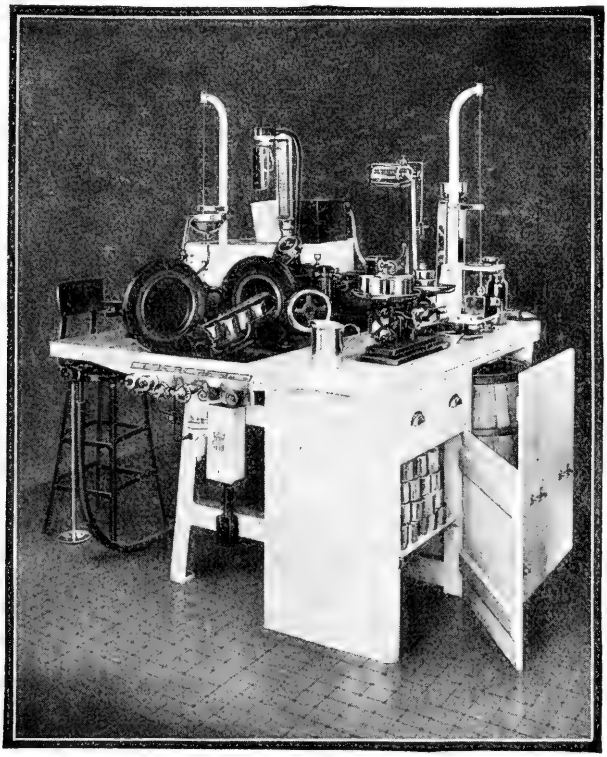


Fig. 170. Mojonnier Evaporated Milk Controller.

Factors That Influence the Heat Coagulation of Milk.—The starting point of a good finished product is a good supply of fresh milk. The acid content should be kept as low as possible at all times. At certain seasons the processing is very difficult even

with a milk supply of low acid content. This is due to the several factors that influence the coagulating point of casein and albumin as follows:

(a). Effect of acid content upon the coagulating point of milk. —The ease with which sour milk curdles when heated is a fact of common knowledge. Advantage of this fact is taken in the manufacture of cottage cheese. The difficulties encountered in sterilizing evaporated milk as a rule increase as the content of titratable acidity increases. This is particularly true if the titratable acidity is due in part, at least, to the decomposition of the milk sugar into lactic acid by bacterial growth.

It has been proved by several investigators (among whom can be mentioned Rice,[1] and Sommer and Hart[2]) that the percentage of titratable acidity in milk as drawn from the cow, varies between rather wide limits. Sommer and Hart found no definite relation between the titratable acidity in freshly drawn milk, and the heat coagulation of the same. The summary of their interesting experiments are contained in Table 131.

TABLE 131.

Summary of Results. Sommer and Hart Upon Relation of Titratable Acidity and Heat Coagulation.

Date	No. of cows tested	Titratable acidity in per cent.			No. samples that tested over .18 per cent	No. samples testing over .18 per cent that coagulated within 20 minutes	No. samples that tested under .18 per cent	No. samples testing under .18 per cent that coagulated within 20 minutes
		Min. imum	Max- imum	Aver- age				
May 8, 1919	26	.120	.257	.185	15	5	11	6
May 10, 1919	30	.131	.241	.196	14	7	16	7
May 16, 1919	30	.102	.203	.167	16	11	14	6
Total.....	86	.....	.....	.178	45	23	41	19

In the above experiment 51.2 per cent of the samples testing above .18 per cent of acid coagulated under 20 minutes when heated in a sealed glass tube held in a xylene vapor bath at a temperature of 136° C. Likewise 46.4 per cent of the total samples testing under .18 per cent of acid, coagulated in less than 20 minutes.

These results show that when an acidity test is depended upon entirely when grading milk that is to be used for making evaporated milk, an entirely false criterion of its value may be obtained.

The quantity of acid required to influence the coagulating point of milk is too small to permit of its control by titration methods. High titratable acidity in fresh milk cannot be detected by the senses of taste or of smell. To a trained person even small quantities of acid produced by bacterial growth can be readily detected by the senses of taste or of smell or by both. The most concealing factor to the sense of smell is the temperature of the milk—the colder the milk the more difficult it becomes to detect any acid development in the milk.

In practice unquestionably the best method of grading milk at the factory's intake is by means of the senses of taste and smell, both intelligently applied by a trained person. This in turn should be supplemented by careful observation of the behavior of the milk accepted, under the processes to which it is to be subjected. Any indication of milk taken which reacts unfavorably under heat, should lead at once to increased vigilance at the intake.

If it should be desired to determine the coagulability of the milk from individual cows, cans or herds this can be done by using the method devised by Sommer and Hart, or by means of one or more of the methods given in Chapter XVII of this book. A means is thus available for tracing trouble to the original source.

The acid content of the fresh product increases in direct proportion to the degree of condensation. Obviously the higher the degree of condensation the greater will be the acid content of the evaporated milk before sterilizing the same.

McInerney [3] made a careful study of the influence of the acid content upon the coagulating point of milk. To 100 cc. of milk there was added sufficient N/10 lactic acid to build up the total acidity to the test desired. "The mixture of milk and acid was then heated in the steam bath until the milk coagulated, and the temperature was noted. The amount of acid required to coagulate the milk decreased as the temperature increased from 70 to 180° F."

The composition of the milk studied is not reported. Typical results covering these kinds of milk are given in Table 132.

TABLE 132.

Influence of Acid Content Upon the Coagulating Temperature of Milk.

Skim-milk testing .145 per cent acid		Whole milk testing .140 per cent acid		Pasteurized whole milk testing .150 per cent acid	
Total acid Per cent	Coagulating temperature °F	Total acid Per cent	Coagulating temperature °F.	Total acid Per cent	Coagulating temperature °F.
.580	70	.530	73	.560	66
.480	104	.480	87	.500	85
.430	145	.440	110	.480	83
.390	150	.400	110	.450	95
.340	155	.350	147	.410	96
.280	170	.310	162	.400	104
.250	185	.270	175	.390	110
....	...	....	...	.370	140
....	...	....	...	.360	150
....	...	....	...	.320	160

"These experiments show that milk containing 0.57 per cent acid (in terms of lactic acid) will, on the average, precipitate at a temperature between 60° to 65° F. Milk containing 0.50 per cent acid will curdle at 75° to 80° F., 0.40 per cent at 100° to 110° F., 0.35 per cent at about 150° F. and 0.25 per cent acid in milk will not cause coagulation until heated to 180° F. As shown in Table 132 the small drop in acidity between 0.40 to 0.35 per cent makes a greater range of temperature than between any other two points of acidity studied. As shown in the experiments, a decrease of 0.05 per cent acid at this particular stage requires nearly a 50° F. range in temperature to produce coagulation as 0.40 per cent acid in milk will curdle at about 100° F. while 0.35 per cent acid in milk will not produce curdling until heated to at least 150° F."

(b). Influence of the nitrogenous constituents upon the coagulating point of milk.—From the standpoint of the manufacture of evaporated milk all of the nitrogenous constituents of milk are of interest and divide themselves into three separate and distinct substances or groups of substances, as follows: (1) Casein which coagulates in the cold in the presence of acid only. It also coagulates under pressure at temperatures above the boiling point of water, in either alkaline, neutral, or slightly acid mediums. (2). Albumin which coagulates in part under heat in normal milk, and completely in an acid medium. (3) Other nitrogenous constituents which are not precipitated either by acids or by heat. This group probably includes quite a number of different chemical en-

tities. All of the above substances dissolve in weak alkaline solutions, after having been coagulated.

In processing evaporated milk the casein and albumin are the products of the greatest importance. These two substances vary in milk both in the total percentages of the two present, as well as in their relative percentages.

Albumin predominates especially in colostrum milk, which accounts for the ease with which such milk is curdled by heat. Hunziker [4] reports the composition of the nitrogenous constituents of the milk from three cows at monthly intervals during an entire lactation period, as shown in Table 133.

The influence of egg albumin upon the coagulating point of evaporated milk is illustrated by the following experiment. To one six ounce can of unsterilized evaporated milk there was added one cc. and to a second can four cc. of fresh egg albumin. After sterilizing under standard time and temperature along with a control can to which nothing had been added, both were compared with the blank can. The can to which one cc. of the egg albumin had been added showed a considerable increase in viscosity, and that to which five cc. had been added showed a very large increase in viscosity over that of the blank can. This indicated a large decrease in the coagulating point due to the added egg albumin.

TABLE 133.

Effect of Period of Lactation on the Percentages of Albumin, Casein and Total Proteid in the Milk of Three Cows.

Period of Lactation	Cow No. 1			Cow No. 2			Cow No. 3		
	Albumin	Casein	Total Proteids	Albumin	Casein	Total Proteids	Albumin	Casein	Total Proteids
First 14 milkings	.98	3.18	4.16	1.59	3.81	3.40	1.72	4.46	6.18
1st month	.57	2.55	3.12	.55	2.47	3.02	.58	2.88	3.40
2nd month	.53	2.27	2.80	.47	2.37	2.84	.51	3.06	3.57
3rd month	.52	2.54	3.06	.48	2.28	2.76	.55	3.25	3.80
4th month	.56	2.51	3.07	.50	2.36	2.86	.60	3.05	3.65
5th month	.55	2.62	3.17	.48	2.26	2.74	.60	3.05	3.65
6th month	.53	2.65	3.18	.54	2.30	2.84	.73	2.96	3.69
7th month	.86	2.62	3.48	.76	2.50	3.26	.62	2.99	3.61
8th month	.75	2.79	3.54	.60	2.66	3.26	.64	2.94	3.58
9th month	.73	2.84	3.57	.56	2.73	3.29	.72	3.30	4.02
10th month	.77	3.02	2.79	.59	2.73	3.32	.82	3.39	4.21
11th month	.91	3.08	3.99	.61	2.88	3.49	....	....	....

It becomes obvious from the above facts that milk high in colostrum when made into evaporated milk will very likely have

a low coagulating point, and therefore it will be very difficult to sterilize properly. Sterilizing difficulties due to the above causes are of comparatively rare occurence where the proper control is maintained over the milk supply. In the mixed milk from many herds the variations in the percentages of the nitrogenous constituents are relatively small, especially where colostrum milk is completely rejected.

(c). Influence of the mineral constituents.—It has been long known that the addition of certain mineral salts, and other substances, exert a marked influence upon the coagulating point of evaporated milk. In some cases the coagulating point is lowered. In others it is increased.

One of the authors[5] by careful experiment determined the influence of the addition of various substances upon the coagulating point of evaporated milk. These substances were added in known amounts to six ounce cans of evaporated milk before sterilizing. The influence of the added substance was noted immediately after sterilizing. The results are given in Table 134.

TABLE 134.

Influence of Added Salts on the Coagulating Point of Evaporated Milk.

Name of substance added to evaporated milk before sterilizing.	Percentage of substance after adding to the evaporated milk.	Influence of the added substances upon the coagulating point of the evaporated milk.
Lactic acid.....	.03	Large decrease in coagulating point
Sodium chloride....	.03	Large decrease in coagulating point.
Calcium chloride...	.15	Large decrease in coagulating point. Impossible to sterilize properly.
Magnesium chloride.	.15	Large decrease in coagulating point. Impossible to sterilize properly.
Sodium sulphate....	.15	Slight decrease in coagulating point.
Sodium acid phosphate, NaH_2PO_4	.15	Large decrease in coagulating point. Impossible to sterilize properly.
Ammonium chloride	.15	Large decrease in coagulating point. Impossible to sterilize properly.
Tri sodium phosphate Na_3PO_4	.03	Large increase in coagulating point.
Sodium ammonium acid phosphate...	.03	Large increase in coagulating point.
Ammonium phosphate.....	.03	Large increase in coagulating point.
Sodium bicarbonate.	.006	1 oz. per 1000 lbs. raised coagulating point 1° F.

All the chlorides tested greatly decreased the coagulating points. Sodium sulphate also decreased the coagulating point. Sodium acid phosphate decreased the coagulating point, while other phosphates increased it. Sodium bicarbonate increased it greatly. The small amounts required to influence the coagulating point shows how delicate is the balance, and how great is the influence of the content of mineral salts.

Sodium bicarbonate is in most respects the best product to use when it may be necessary to add some substance to the milk after other means have failed, in order to reduce the coagulating point. It is dependable, and of low cost. Its principal objection is the fact that it produces a large volume of carbon dioxide gas when it decomposes. This retards the condensing operation, since it makes it necessary for the vacuum pump to remove the gas that is formed. If the sodium bicarbonate is added to the evaporated milk after condensing, the gas is released during the sterilizing operation, and this causes the ends of the cans to bulge, giving the appearance of the cans being "swells" due to spoilage.

Carbon dioxide is very soluble in cold water, so that moderate amounts that may be released during the sterilizing process are soon absorbed after the evaporated milk has cooled to room temperature. The practical limit of sodium bicarbonate to add after condensing is four ounces per 1000 pounds of the condensed product. When the sodium bicarbonate is added to the milk in the hot wells before condensing the practical limit should not exceed twelve ounces per 1000 pounds of finished product. The best plan is to add the greater part of the total amount required to the hot wells before condensing and to add only the final small amount required to standardize the coagulating point, to the condensed product before filling it into the cases, and therefore before sterilizing.

The use of an excessive amount of sodium bicarbonate also increased the color of the finished product after sterilizing. Every argument is in favor of its moderate use.

Tri-sodium phosphate has the disadvantage of greater cost, but it does not produce any gases when added to milk. There may be conditions under which it can be used to advantage.

Theoretically it would appear possible to utilize the above facts in standardizing the coagulating point of evaporated milk

during the process of manufacture. This is only partially possible. Lactic acid cannot be used because its action is too violent, and its use is attendant with too many dangers. All the chlorides named cannot be used principally because of their bitter taste. More satisfactory means are known for decreasing the coagulating point than by adding foreign substances. These means will be discussed elsewhere in this chapter. The use of sodium bicarbonate affords a very satisfactory means for increasing the coagulating point. This will be further described in this chapter.

Sommer and Hart[2] made a careful study of the influence of the mineral constituents upon the coagulating point of milk, and draw the following conclusions which in the main confirm the results reported above:—

"In most cases coagulation can be prevented by the addition of citrates or phosphates, the coagulation being due to an excess of calcium and magnesium. However, in a few cases the addition of citrates or phosphates did not prevent coagulation, but rather hastened it. In these cases the addition of the proper amounts of calcium salts prevents coagulation, or at least raises the coagulating point."

"From the data in Tables 135 and 136 we see that the calcium and magnesium are balanced by the phosphates and citrates of the milk practically in gram equivalent amounts. The balance of the four constituents, calcium, magnesium, citrates and phosphates, largely determine whether a milk will coagulate or not. If calcium and magnesium are in excess, the milk will coagulate upon heating. If calcium and magnesium are properly balanced with the phosphates and citrates, the optimum stability obtains. If posphates and citrates are in excess, coagulation will also result."

"Thus the coagulation of a milk sample on heating may be due either to an excess or a deficiency of calcium and magnesium. We may explain this in the following manner. The casein of the milk is most stable with regards to heat coagulation when it is in combination with a definite amount of calcium. If the calcium combined with the casein is above or below this optimum the casein is not in its most stable condition. The calcium in the milk distributes itself between the casein, citrates and phosphates chiefly. If milk is high in citrate and phosphate content more

calcium is necessary in order that the casein may retain its optimum calcium content after competing with the citrates and phosphates. If the milk is high in calcium there may not be sufficient citrates and phosphates to compete with the casein to lower its calcium content to the optimum. In such a case the addition of citrates or phosphates makes the casein more stable by reducing the calcium content. The magnesium functions by replacing the calcium in the citrates and phosphates."

"In most cases the coagulation is due to an excess of calcium and magnesium. It is possible to balance this even by citrates, phosphates, carbonates and other salts. It is also stated that danger of coagulation may be avoided in the actual practice of condensing milk by controlling the preheating period, using higher temperatures. This may have the effect of lowering the soluble calcium content by precipitating part of it as insoluble calcium phosphate."

In the experiments of Sommer and Hart twenty-five out of thirty which coagulated contained an excess of calcium and magnesium over citrates and phosphates. Those which had the lowest excess did not coagulate.

TABLE 135.

Balance Between Calcium and Citrates.

25 cc. milk plus			Coagulation time
M/2 calcium acetate	M/2 sodium citrate	H_2O	
cc.	cc.	cc.	Min.
0.0	0.0	1.6	4
0.4	0.0	1.2	½
0.4	0.2	1.0	40.
0.4	0.4	8	40.
0.4	0.6	6	2¼
0.4	0.8	4	2

TABLE 136.

A Sample in Which Calcium Prevents Coagulation.

25 cc. Milk Plus			Coagulation time
M/2 calcium acetate	M/2 sodium citrate	H_2O	
cc.	cc.	cc.	Min.
0.0	0.0	0.8	1½
0.2	0.0	0.6	20
0.2	0.1	0.5	1¼
0.2	0.2	0.4	1
0.2	0.3	0.3	¾
0.2	0.4	0.2	¾

(d). Influence of concentration.—The degree to which the fresh milk is condensed has a large influence upon the coagulating point of the evaporated milk. This is illustrated by the experiment reported by Hunziker[6] as shown in Table 137.

TABLE 137.

Showing the Increase of the Per Cent of Acid as the Concentration of the Evaporated Milk Increases and Its Effect on the Curdling of the Casein.

Lot No.	Concentration	Per cent acid	Condition of casein
1	1.58:1	.34	Not precipitated
2	1.74:1	.34	Not precipitated
3	1.9 :1	.40	Not precipitated
4	1.99:1	.43	Not precipitated
5	2.11:1	.48	Small lumps of curd
6	2.25:1	.54	Large lumps of curd

In normal evaporated milk at a concentration around 7.80 per cent of fat and 25.50 per cent of total solids, every 20 pounds of water added or removed per 1000 pounds of the condensed product, lowers or raises, as the case may be, the coagulating point 1°F. This is an important factor that can be used in controlling the sterilizing process.

In normal evaporated milk the influence of concentration has been a large determining factor in establishing the present standards which control the manufacture and sale of this product.

The factor of concentration was studied by Sommer and Hart[2]. They concluded from their experiment that "not only the concentration of the casein influences the coagulating point, but also the concentration of the serum."

The intricacy of the above reactions is well illustrated by the case of the salts of sodium. Sodium chloride and other sodium salts when added to evaporated milk greatly lowers its coagulating point, while sodium bicarbonate and certain other sodium salts have exactly the opposite effect. Much remains to be learned regarding the influence of both basis and acidic radicals upon the coagulating point of milk by heat.

(e). Influence of products of bacterial growth, other than acid.—A considerable number of bacteria are known that have the power to produce rennet or rennet like substances, which have the power to curdle milk. The action of rennet upon milk forms the basis of the cheese industry, since this makes it possible to coagulate the casein at a low temperature, and in the presence of a low acid content.

Rogers[7] reports interesting experiments that prove the above statements. He states: "Milk, inoculated with a small amount of bacteria known to produce rennet actively, was held at room temperature for three hours. With this was held part of the milk without inoculation which, when evaporated to the standard concentration, curdled at a temperature of 240 degrees F. That inoculated and held three hours before evaporating, curdled at 226 degrees F., although the acidity was identical with the uninoculated fraction." The results of his experiments are shown in Table 138.

The presence of rennet producing type of bacteria is largely favored by unsanitary conditions either at the farms where the milk is produced, or in the plant where the fresh milk is manufactured into evaporated milk. Unclean milk pails and milk cans are the most prolific cause of trouble upon the farm. Unclean utensils, milk pumps and milk pipe lines are the most prolific cause of trouble in the plant. The rigid enforcement of

TABLE 138.
Effect of Rennet Forming Bacteria on Curdling Temperatures.

Inoculation	Time of action (hours)	pH	Coagulation temperature degrees F.
None	3	6.33	240.4
Rennet-forming bacteria, 10 cc.	1½		226.4
	3	6.33	226.4
None	2		246.2
Rennet .0175	1		226.4
gms.	2		213.6

sanitary rules at all points will do more than anything else to eradicate a trouble of this kind in an evaporated milk plant.

(f). Influence of method of forewarming in the hot wells.— The method of forewarming the milk in the hot wells exerts a large influence upon the coagulating point of the finished product. This fact is of large practical value in the manufacture of various condensed milk products, and mention is made of it in different chapters of this book.

The exact cause of this action is not fully understood because of lack of experimental proof.

Sommer and Hart, just quoted, state that this may be caused by the precipitation of part of the soluble calcium content into the insoluble calcium phosphate, but no experimental proof is submitted.

Tricalcium citrate when freshly prepared is readily precipitated upon heating, probably due to decreasing solubilities at increasing temperatures, and the theory is frequently advanced that this is the cause of the changes produced in milk by forewarming. Experimental proof is lacking here also, and practical evidence is contrary to this view. Further reference will be made to this matter in another part of this chapter.

The action of heat upon the coagulation of the albumin in the milk may very readily be the most important factor controlling this action. It has long been known that the extent of the coagulation of albumin by heat varies with both the temperature and the time of exposure of the milk to the heat. The higher the temperature and longer the time of heating, the more of the albumin will become insoluble by heat.

Cavanaugh and Latzer[8] report the following amount of albumin precipitated under different conditions of heating, the results being the average for ten experiments.

When heated to boiling .37 per cent albumin precipitated.

When boiled for five minutes .42 per cent albumin precipated.

When heated at 15 lbs. pressure for 30 minutes .44 per cent albumin precipitated.

The above results were obtained by difference from their published results.

When milk is heated no apparent separation or coagulation of the albumin takes place, but it undergoes a change that causes that part of it which has changed to separate with the casein when acid is added. The values given above represent the amount of albumin which separated along with the casein when acid was added in making the determination of acid insoluble protein.

The preponderance of evidence at the present time is that the changes in the albumin content of the milk by heating may be largely responsible for the differences in the behavior of evaporated milk in sterilizing, which milk had been previously heated differently in the hot wells.

Heating of the Milk in the Hot Wells.—As already noted, when milk is properly heated in the hot wells, it undergoes certain changes which play an important part in the sterilization of evaporated milk.

Unless the milk is properly heated in the hot wells, there is every opportunity for the milk to undergo certain other chemical changes, which will have a very bad effect upon the ultimate product. The reasons for these other changes are not definitely understood at the present time, but all the evidence is in favor of the view that when the heat is improperly applied to the milk in the hot wells, certain chemical changes occur in the casein and albumin molecules. The extent of these changes follow closely the law of mass action. That is, when the steam is introduced into the milk at a high pressure, or in large volumes, the agitation of the milk at the point of the introduction of the steam is not rapid enough to transmit the heat uniformly to all parts of the milk in the hot well. The result is that the local

action of the steam upon the milk is sufficiently great to overheat the milk beyond the coagulating temperature of the casein itself.

The above unfavorable effect is almost negligible where jacketed hot wells are used, and the worst effect manifests itself where plain hot wells are used—that is, where the milk is heated in the hot wells by live steam. By using the proper care, it is possible to heat the milk in plain hot wells, using live steam only, without causing any injury to the milk. It has been learned by experience that no bad results follow when eight minutes are taken to forewarm one thousand pounds of fresh milk to the desired temperature in the hot wells. The only safe method to follow is to place a pressure reducing valve upon the steam feed line which is used to supply the hot wells. This valve should be set to operate at a pressure not in excess of 10 pounds per square inch.

Where the jacketed hot wells are used, it is best to bring the milk up to about 170° F., and then to complete the heating from that point up to the right temperature by means of live steam, introduced directly into the milk. In a number of cases, the milk is passed through special heaters on the way to the hot wells and forewarming is then completed in the hot wells with live steam. As a rule, this is a very satisfactory method.

Steam Distribution in the Sterilizer.—Even distribution of steam in the sterilizer is necessary, no matter what style of sterilizer is used, or whether superheated water or steam alone is used for sterilizing. A frequent cause of uneven sterilization lies in the fact that the perforations in the steam distributing pipes become enlarged, due to the wearing effect of the steam while passing through the perforations. This is especially likely to be the case where the steam distributing pipes are made of thin brass tubing. It is recommended as far as practical, that brass pipe, iron pipe size, be used for this purpose. There is much less danger from enlarging of the perforations when this pipe is used, than when the thin brass tubing is used. It is especially suggested that iron pipe never be used for this purpose, although some makes of sterilizers are now furnished with the distributing pipe of iron. When iron is used, the openings are likely to become enlarged not only from the action of the steam, but also from the rusting of the iron.

It frequently happens that the cap may come off of one of the steam pipes, or the pipes may become disconnected at the inlet, so that for all of the above reasons, it is very desirable to check up the different sterilizers very carefully from time to time.

The Evaporated Milk Controller affords a particularly efficient means for checking up the evenness of sterilization. This is accomplished by means of the viscosimeters which accompany the Controller. Detailed instructions for making the viscosity tests will follow further in this chapter.

When checking up by means of the viscosimeter, it is suggested that at least three sets of cans be taken out of each sterilizer. The first set is to be taken from the top of one section in the case of a Fort Wayne Sterilizer, and from the top of the cage in the case of a Berlin Sterilizer. The second set is to be taken from the middle of the section or cage, and the third set from the bottom of the section or cage, in the two respective sterilizers. In each case, one sample is to be taken from near each of the two ends, and one from the center of the section or cage, making a total of nine samples in all. By following this method, it becomes possible to get an accurate check upon the distribution of the steam in the different parts of the sterilizer.

TABLE 139.

Determining Steam Distribution in the Sterilizer.

Location of Sample in Sterilizer	Viscosity retardation
Right end 4 cans from end, top row of cans	115°
Right end 4 cans from end, center row of cans	100°
Right end 4 cans from end, bottom row of cans	120°
Middle of cage, top row of cans	132°
Middle of cage, center row of cans	175°
Middle of cage, bottom row of cans	265°
Left end 4 cans from end, top row of cans	150°
Left end 4 cans from end, center row of cans	65°
Left end 4 cans from end, bottom row of cans	170°

As the figures show in the above example, the sterilizer in question cooked the milk considerably heavier in the center of the cage than at the two ends, particularly the inside cans at the two ends. By changing the steam circulation, and particularly by watching the level of the water in the sterilizers, it was possible to improve the uniformity of the sterilization.

Standardization for Fat and Total Solids.

After the milk has been condensed and cooled, the next step is to test the milk for butter fat and total solids. If the plan is followed of standardizing the finished product, both for fat and total solids, this should be done before the samples are taken out for the tests upon the Controller. In case that the plant follows the plan of standardizing with water only, the milk should be standardized down with the water to the required basis, and the samples then taken out for the tests upon the Controller. It is very important to coordinate the tests upon the Mojonnier Tester for butter fat and total solids with the tests upon the Evaporated Milk Controller. If this is done, it will be possible to obtain uniform results both from a chemical and physical sfandpoint upon the finished product.

Ten Per Cent Sodium Bicarbonate Solution.

Prepare as follows:

(1). Weigh bottle empty, upon Torsion Balance to .01 ounce.
(2). Add 3 ounces bicarbonate of soda to the bottle.
(3). Add 27 ounces warm water to the bottle.

Shake thoroughly until the bicarbonate is all dissolved. Draw out as needed into the dispensing bottle, filling the same not over half full. Keep remainder tightly corked in the stock bottle until needed. Should the bicarbonate crystallize out, prepare a new lot.

If prepared according to the above directions, the solution will contain exactly 10% sodium bicarbonate.

How to Add Sodium Bicarbonate to the Sample Cans.—Arrange in a row five open-top cups, marked—X-1-2-3-4. These cups are furnished with the Controller. Cup marked X is blank, to which nothing is added. To cup marked No. 1 add one charge of sodium bicarbonate from the dispensing burette. This is the amount contained between the upper two graduations on the burette.

To cup marked No. 2 add two charges, to cup No. 3 add three charges. To cup No. 4 add four charges. Examination of the dispensing burette furnished with the Controller will indicate how the above quantities are to be added; that is, the burette is graduated into four separate charges. The unit with one

single charge contains the equivalent of one ounce of sodium bicarbonate, to one thousand pounds of evaporated milk. Each successive charge is a multiple of this unit. In dispensing the bicarbonate solution, it is best not to fill the bottle more than half full. When filling the burette, the solution should be allowed to flow into it slowly in order not to trap in the air. If air is trapped into the burette, it is difficult to remove it, and in such a case it is best to run out whatever solution may be in the burette, and to put in a new supply.

Whenever the quality of the milk is bad, it may be necessary to add more than the above indicated number of charges of bicarbonate solution to the sample cans. In such cases any multiples of the above number of charges may be added. The ratio of ounces of bicarbonate to one thousand pounds of milk will remain the same, being increased simply by the number of charges added to each sample can.

Preparing the Five Sample Cans for the Sterilizer.—After the five open-top cups have been treated with bicarbonate as indicated in the preceeding section, they are transferred to the Torsion Balance and exactly six ounces of milk are weighed into each cup. This can be done by taring the entire set of empty cups, and then weighing six ounces of evaporated milk into each separate cup.

One set of five empty cans are now marked in the same manner as the cups to which the bicarbonate solution was added, namely, as follows: X= can containing no bicarbonate; 1=can containing equivalent of one ounce bicarbonate per thousand pounds of evaporated milk; 2=can containing equivalent of two ounces to one thousand pounds of evaporated milk; 3=can containing equivalent of three ounces to one thousand pounds of evaporated milk and 4= can containing equivalent of four ounces to one thousand pounds of evaporated milk.

The cans are now placed in pairs under the two can vent hole filler, furnished with the controller, and the cups with the milk and bicarbonate marked corresponding to the empty cans are now emptied into the filler. Care must be taken to keep the cans in the proper order.

After filling. the cans are to be tipped, using preferably rosin solder. Should none of this solder be available, then great care

must be exercised not to let any of the flux from the zinc chloride solder enter the cans. Zinc chloride flux has a very bad effect upon the milk, and will completely change the results.

Sterilizing the Five Sample Cans.—The five sample cans prepared as above are now ready for the sterilizer. Place these in the cage and fasten the lid securely, and also turn down the screws in order to hold all of the cans securely in place. Adjust the cage in the sterilizer by means of the thumb screw upon the right hand side in order to keep them from having end play. Close the sterilizer door securely so that no steam escapes during the sterilizing process.

Be sure to provide circulation of the steam through the vent upon the pipe surrounding the thermometer. This little vent should be kept open during the entire sterilization operation. Fill the small pilot sterilizer to a point half way upon the gauge glass. Turn on the switch to start the motor in operation. Open the "steam start valve" and take five minutes to let the heat reach 190° F. or 3 upon the sterilizer scale. Then let the heat come up gradually from 190 to 240° F. or from 3 to 8 upon the thermometer, taking one minute for each 5° as indicated in the following table:

TABLE 140.

Relation Temperature, Scale Reading, and Coming-Up Time.

Actual temperature in Fahrenheit degrees	Actual reading upon thermometer scale	Point at which mercury should be at any given time coming up.
		Minutes
240	8	20
230	7	18
220	6	16
210	5	14
200	4	12
190	3	10

Where sterilizing is done with steam only, without using superheated water, it is recommended twenty minutes be taken for coming up. The above table is arranged upon this basis. The table, however, can be readily adapted to a system requiring fifteen minutes for coming up, by taking five minutes to come up to the point marked 10 upon the table, or to 190° F.

It is also recommended that in the pilot sterilizer, the samples be cooked to 243° F. and that the jump from 230 to 243° be made in two minutes. It is very important to know the exact second when the mercury column reaches 243°. The milk should be held at this temperature for fifteen minutes to the exact second.

How to Cool the Five Sample Cans.—The instant that the clock indicates that the samples have been sterilized as indicated above, both discharge valve and cold water valve should be opened simultaneously. It is best to cool the five samples to about 75° F. This should take not to exceed five minutes, depending upon the temperature of the water available. This is something each operator will have to judge for himself.

How to Test Sample Cans for Viscosity.—As soon as the sample cans are cooled in the sterilizer, as indicated above, the outside of the cans are dried; and the cans are then opened and each can is placed in the proper position in the Mojonnier-Doolittle viscosimeter rack. It will be noted that the same scheme of marking the spaces upon the viscosimeter rack has been observed as in the case of marking the cans. It is very desirable to cool the samples to as nearly 75° F. as possible. If this is not done, the viscosity should be corrected for temperature, using the scale of corrections given in Table 141. Make the viscosity tests as follows:

(a). Different sizes of balls are furnished, corresponding to the product that it may be desired to test for viscosity. A special viscosity ball is furnished in the case of evaporated milk, and this is not interchangeable with any other ball for this purpose.

(b). Fasten one end of the wire in the knurled nut upon the top of the bent support, and the other end in the dial. Adjust the vertical position of the dial by raising or lowering, until the small lug on the bottom of the dial is in the proper position to engage the trip upon the right and side of the stand.

(c). Adjust the horizontal position of the dial until zero degrees is in a line with the pointer upon the front of the frame when the dial is balanced in the air. Center the dial in the open circle by means of the adjusting screws on the under side of the frame. Make a test for viscosity directly in the small size cans.

Properly center the can by means of the automatic arrangement provided for that purpose.

(d). Lower the ball into the can of milk; turn the dial clockwise one revolution; stopping when zero degrees upon the dial is in line with the pointer upon the front of the frame. Hold the dial in place by means of the lug and trip. When ready, sharply release the trip, note the degree where the dial stops, just before it starts upon the return round. This will occur after the dial has made one complete, and part of the second revolution. The degree at which the dial stops will represent the viscosity of the sample. The greater the viscosity, the larger the degree reading will be. The observed viscosity should always be reduced to a standard temperature. The higher the temperature the lower the viscosity will be or vice versa. The proper corrections to apply either above or below 75° F. are given in Table 141. A different correction applies upon freshly sterilized evaporated milk, than upon the same product after it has reached the packing room, in the usual methods of handling, as shown in the two tables.

TABLE 141.

Correcting Viscosity of Evaporated Milk to 75° F.

STERILIZING ROOM						PACKING ROOM					
Temp. Deg. F.	Take off Deg. R.	Temp. Deg. F.	Add. on Deg. R.	Temp. Deg. F.	Add. on Deg. R.	Temp. Deg. F.	Take off Deg. R.	Temp. Deg. F.	Add. on Deg. R.	Temp. Deg. F.	Add. on Deg. R.
65	25	76	2	89	24	60	15	75	0	88	10.0
66	22	77	4	90	25	61	14	76	1	89	10.5
67	19	78	6	91	26	62	13	77	2	90	11.0
68	16	79	8	92	27	63	12	78	3	91	11.5
69	13	80	10	93	28	64	11	79	4	92	12.0
70	10	81	12	94	29	65	10	80	5	93	12.5
71	8	82	14	95	30	66	9	81	6	94	13.0
72	6	83	16	96	31	67	8	82	7	95	13.3
73	4	84	18	97	32	68	7	83	7.5	96	13.6
74	2	85	20	98	33	69	6	84	8.0	97	13.9
75	0	86	21	99	34	70	5	85	8.5	98	14.2
		87	22	100	35	71	4	86	9.0	99	14.5
		88	23			72	3	87	9.5	100	14.8
						73	2				
						74	1				

Record the viscosity of each of the sample cans tested, as indicated above. Further instructions will follow as to the method of applying information thus obtained.

How to Test Cans for Color.—Just as soon as the samples have been tested for viscosity, they are to be moved under the colorimeter. The can that has been picked out as the standard

should now be compared with another can from a run that was selected as being of the proper color, or it can be compared to any other standard that may be desired. If the milk is standardized for fat and total solids, and if the sterilization is kept within narrow limits as regards time and temperature of sterilization, the fluctuation from batch to batch should be very small. The above are the largest factors that control the color. The color of evaporated milk also increases gradually with age, so that in selecting the standard, it is desirable to choose freshly prepared goods.

Correlations That Can be Used to Establish the Proper Sterilizing Method.—A number of very important relations have been correlated by careful experiment, and the facts thus known are used as a basis for establishing the exact temperature and time upon which any batch of evaporated milk may be sterilized, in order to obtain the best possible product. These relations are as follows:

A retardation of 40° in the viscosity=(a) 1 ounce solid sodium bicarbonate per 1000 pounds of unsterilized evaporated milk, standardized to 7.8 per cent butter fat and 25.50 per cent total solids; (b) or 1° F. in the sterilizing temperature, at the holding point of 240° F. with the same coming up time; (c) or one minute of time at a holding temperature of 240° F.; (d) or 2° F. upon the temperature to which the milk is heated in the hot wells under 212° F., (e) or 20 lbs. water per 1000 lbs. evaporated milk.

The above viscosity relation holds only with viscosities above 50° or below 300°, upon the Mojonnier-Doolittle Viscosimeter.

The above are most important and fundamental facts to bear in mind, and when once understood they will greatly simplify the adjusting of the correct process for sterilizing evaporated milk. This is best illustrated by the following example:

A batch of milk has been standardized to 7.8 per cent butter fat and 25.50 per cent total solids. Total weight of evaporated milk in the batch equals 24,000 lbs. The five sample cans from the pilot sterilizer tested for viscosity as follows:

Can X=235° retardation
Can 1=190° retardation
Can 2=150° retardation
Can 3=105° retardation
Can 4= 70° retardation

Now, it has been found by experience that 150° retardation is the proper viscosity for evaporated milk, just as it comes from the sterilizers. This refers to evaporated milk made for domestic consumption. Evaporated milk intended for export purposes should have a viscosity considerably higher than this, namely, around 200° retardation. It is not desirable to send out evaporated milk upon the market which contains as much as 150° retardation of viscosity. A considerable part of the viscosity which the milk has, when it comes from the sterilizers, is lost during the handling to which the milk is subjected from the time it leaves the sterilizers until it is ready to leave the shipping department. It is believed that the proper viscosity that the milk should have upon leaving the shipping department during the spring and summer months should be between 80° and 100° retardation. In the early fall and winter months, it should not be over 80°. The warmer the milk is during the handling operations, either before it leaves the plant, or after it passes into the hands of the retailer, the less will be the viscosity of the milk by the time it reaches the consumer. Upon the other hand, it is equally important over the winter months to avoid excessive viscosity, as in that case the evaporated milk is likely to appear curdled when used in coffee, or even when diluted with water in the home.

Referring back to the viscosity tests of the five cans, it will be seen that the can marked No. 2 is the one that most nearly approaches the standard aimed for, since this is found to have a viscosity of exactly 150° retardation.

It is always desirable to eliminate the use of sodium bicarbonate as much as possible. In this particular case it will be possible to eliminate its use entirely, as indicated by referring back to the above correlations. That is, can No. 2 could be adjusted to have a sterilizing record of 243° F. at a holding time of fifteen minutes by adding two ounces of sodium bicarbonate per thousand pounds of evaporated milk. Upon the other hand, since it is more desirable to get along without using any bicarbonate, very nearly the same results can be obtained by sterilizing the batch at 241° F. for fifteen minutes holding time. It is not recommended that the holding time be reduced under fifteen minutes, as this is as short as it is desirable to make it. Under

the circumstances, the two alternatives in the above problem are first to add 2 ounces of bicarbonate per thousand pounds of finished product, or to reduce the sterilizing temperature 2°.

The milk in the tank is now ready to be filled into the cans. It is important to know that the filling of the milk should not be started until all of the tests upon the Controller have been completed.

How to Add Sodium Bicarbonate to Milk Before Sterilizing.— In case that it is necessary to add sodium bicarbonate as might have been done in the preceeding problem, this should be done as follows:

The amount to be added is to be determined entirely by the viscosity tests of the milk upon the five sample cans. In the above example it was noted that can No. 2 showed a viscosity of 150° retardation. Since this is the standard of viscosity that it is desired to reach, bicarbonate should be added in the amounts indicated, being in the case of the milk under question, 2 ounces per each one thousand pounds of vaporated milk on hand. Since the batch contained 24,000 pounds, it will now be necessary to weigh out 48 ounces of the solid bicarbonate upon the Torsion Balance. This is then dumped into a ten gallon milk can, a small amount of water, with a little evaporated milk, usually just the sample cans, is then added to the bicarbonate in the can. The entire mixture is brought to a vigorous boil, by means of the steam hose attached to the Controller. The boiling should be continued until the gas has been fairly well expelled. This will not eliminate all the gas which is contained in the bicarbonate, but it will eliminate the greater part of it, since sodium bicarbonate is not a stable compound, and is partly broken up by heat under these conditions. The solution may now be added to the evaporated milk in the holding tank. The milk should be agitated while the bicarbonate solution is being added, and the bicarbonate solution should be poured in very slowly. As the amount used is usually small, it is not necessary to cool it back before adding it to the milk, as the amount is not sufficiently large to increase the temperature of the milk in the hold-over tank.

It is very important to allow the agitators to run for from ten to twenty minutes before starting the fillers. The time neces-

sary here depends upon the efficiency of the agitators, and it can be determined accurately only by careful experiment.

How to Adjust the Sterilizing Records Upon Different Sizes of Cans.—Different sizes of cans require different sterilizing temperatures to produce the same viscosity. Tall size cans require 1° more heat upon a 15 minutes' run that does baby size. For example, upon the same batch of milk, the record would be 240° F. for 15 minutes for baby size, and 241° F. for 15 minutes upon tall size.

How to Change the Temperature of Heating the Milk in the Hot Wells.—The method of changing the temperature necessary to heat the milk in the hot wells is indicated by the following example:

Sample can marked X cools 70° retardation.
Sample can marked 1 cools 40° retardation.
Sample can marked 2 cools 30° retardation.
Sample can marked 3 cools 20° retardation.
Sample can marked 4 cools 15° retardation.

As the results indicate, the blank can marked X which contains no bicarbonate shows viscosity under the standard desired, namely 150° retardation. This is short in viscosity to the extent of 80° retardation, which is equal to 4° F. upon the temperature to which the milk is heated in the hot wells under 212° F. upon the above mentioned correlated values. Granting that the milk has been brought to a temperature of 212° in the hot wells, it develops from the results of the viscosity tests that the milk in this batch had been forewarmed 4° more than should have been the case, that is, it should have been forewarmed at 208° F. Assuming that the milk in this particular case is now all in the tank, it is, of course, impossible to go back to correct the forewarming of the milk in the hot wells. All that can be done is to increase the sterilizing temperature from 243 to 245° F. at the standard holding time of fifteen minutes.

It is always recommended that a preliminary test be made of the milk before the condensing is all completed. In the above problem, it is recommended that the forewarming of the milk of the succeeding day be modified upon the basis of results obtained with the batch in question, that is, granting that climatic conditions and the general milk supply remain the same. In that

case, it is suggested that with a plant having four batches of raw milk, each containing about twelve thousand pounds, that immediately after three of the batches are condensed and cooled, and well mixed together in the hold-over tank, that a preliminary sample of these batches be run. If it is found that the milk from these three batches is of too low viscosity, the last batch can be forewarmed at a sufficiently low temperature to increase the viscosity of the three preceding batches to the desired point. It is possible to condense the milk at as low a forewarming temperature as 140° F. However, when this is done, care must be taken to see that a good sterilizing record is used, as otherwise there may be danger of spoilage of the milk.

It is not recommended that the milk taken for these preliminary tests be standardized for fat and total solids. If the tests of the milk at the strike is carefully watched, the product will be near enough to chemical standard so as not to affect greatly the physical properties. If this plan is followed, plenty of time is available to make the tests upon the Controller before the forewarming of the last batch is completed for the day. If necessary, the last batch can always be held up for a little while in order to complete this test, and it is recommended that this be done rather than sacrifice on the physical properties of the finished product.

Why Evaporated Milk Sometimes Fails to React with Sodium Bicarbonate.—Conditions are very frequently encountered in evaporated milk plants under which it is impossible to improve the quality of the product by adding bicarbonate of soda. This is illustrated by the following set of viscosity tests made upon one batch of milk that was standardized to exactly 25.50 per cent total solids.

TABLE 142.

Evaporated Milk That Failed to React to Bicarbonate of Soda.

Ounces sodium bicarbonate added per thousand pounds evaporated milk.	Viscosity after sterilizing 240° F. for fifteen minutes.
0	112° retardation
2	180° retardation
4	280° retardation
6	280° retardation
10	Too heavy to get viscosity.

As the above results indicate, the addition of the bicarbonate had just exactly the opposite effect to that when added to milk that was handled in the way that was recommended above. That instead of reducing the viscosity of the milk it increased the viscosity. This plainly indicated that the milk had undergone chemical changes in the casein molecule. The factors that will bring about the above mentioned conditions are as follows:

(1). Improper forewarming of the milk in the hot wells. This point has already been mentioned.

(2). Homogenizing the milk at too high a pressure. The trouble that may result from this cause can be determined experimentally under the conditions which exist at each particular plant. It is seldom desirable to homogenize the milk much above 2,000 pounds pressure.

(3). Handling of the milk by the so-called "wash process." Under this process the milk is condensed to about ¼ its original volume. It is then cooled, and an amount of water added slightly in excess of that required to bring the milk back to the desired consistency, and finally recondensing the surplus of water added to the milk. This is a wasteful process, which exerts a very bad effect upon the milk.

(4). Brine leaks from the cooling coils at the condensed milk cooler. This is a frequent cause of trouble.

If care is taken in the plant, all of the above conditions that tend to change the chemical composition of the milk can be avoided, thereby making it psssible for the milk to react to sodium bicarbonate in a perfectly normal way.

How to Reduce the Amount of Bicarbonate Necessary to Add.—It is always very desirable to keep the amount of bicarbonate down to the very lowest minimum. The indiscriminate use of this product may lead to several serious consequences. In the first place, the gas from the bicarbonate is released during the sterilizing process, and this will cause the ends of the can to bulge. If an excess is used, it becomes impossible to again press the ends back into normal position, so that they may be bulged when sent to the consumers. In the second place, an excess of bicarbonate is bound to increase greatly the color of the milk, making the milk much darker than it would be normally.

The following steps can be taken to reduce the use of bicarbonate. Observation that the proper methods of handling the milk are practiced upon the dairy farms. It is particularly necessary to have the milk well cooled and kept in well cleaned cans. Also, that all utensils in which the milk is handled are kept clean and sterile at all times. Colostrum milk should be rejected. Changes in the chemical composition of the milk are responsible more than anything else for the use of bicarbonate. In localities where summer dairying predominates, the change in the composition will become apparent more in the fall of the year. Upon the other hand, where winter dairying predominates, the same trouble may be encountered at other seasons. The trouble is, however, very much more prevalent in the fall of the year and during the winter months than during all of the other seasons combined. It is possible that the fact that the cows are being placed upon dry feed exerts some influence upon this condition. This is by far the most important of all conditions which compel the use of bicarbonate. No means are known to science at the present time whereby these conditions can be successfully overcome except by means of sodium bicarbonate.

Milk that is too long in transit to the factory is likely to develop an excess of acid, and may, therefore, require bicarbonate.

Milk that is held in storage at the factory at too high temperatures, or for too long a time before it is heated in the hot wells, also develops excessive acid. This is a very frequent cause of trouble, and frequently such milk is changed too much to make it possible to handle it at all.

Improper cooling of the milk after it leaves the vacuum pan, and holding the milk in the storage tanks too long before it goes to the fillers are all contributing causes.

Unsanitary methods in the plant itself, that is, improper cleaning of the vacuum pan, or of the hot wells, or homogenizer, or storage tanks, or filling machines, can all become contributing causes to this trouble.

The handling of two days' milk, sometimes practiced over the winter months, is also responsible for a great deal of trouble along these lines. There are very few dairies that are equipped to hold milk over in good condition for two days. The milk, therefore, is exposed to all kinds of unfavorable conditions and this, of course, affects the quality of the finished product.

SEASONAL VARIATIONS IN THE COAGULATING POINT OF EVAPORATED MILK.

The seasons do not in themselves directly influence the coagulating point of evaporated milk, but indirectly they are a large factor, and year after year changes in the coagulating point follow closely the changing seasons. Paralleling the changing seasons, and probably the direct causes of the variations in the coagulating points can be mentioned:

(1). The changes in the milk due to the lactation period.—If the cows supplying a given plant, always freshen at about the same time of the year, then more marked will be the influence of the lactation period. These differences can be considerably equalized by arranging for the cows to freshen at different months, thus making possible, both summer and winter dairying, which is an added advantage in plant operation.

(2). Variations caused by changes in the feed of the cows.—Particular reference is made here to the influence of such changes upon the components of the milk as affect the coagulating point. Relatively little exact information is now available upon this subject. It is well known that as soon as cows change from dry to green feed, or vice versa, that a change in the coagulating point of the milk is at once apparent.

(3). Variations caused by temperature and other climatic changes.—It is well known that immediately following storms, the coagulating point of the milk usually decreases several degrees. This has reference to the mixed milk from a large number of herds. Part of this decrease may be caused by the increased acidity which is usually produced because of the conditions favorable to acid development that exist at the time of a storm. Changes in the temperature itself surrounding the cow, aside from other factors, may cause changes in the composition of the milk, such as would influence its heat coagulation, but as yet relatively little is known upon this subject.

Fig. 171 illustrates the average of several seasonal variations in the coagulating point of evaporated milk. This refers to evaporated milk produced at plants located in the temperate zone, where both summer and winter dairying are practiced. It is assumed that the coagulating points indicated would be those

obtained by forewarming the milk all alike in the hot wells; condensing it to the Federal standard of butter fat and total solids; sterilizing it for 15 minutes at the various temperatures indicated, and in all cases obtaining a viscosity of 150° retardation. Under

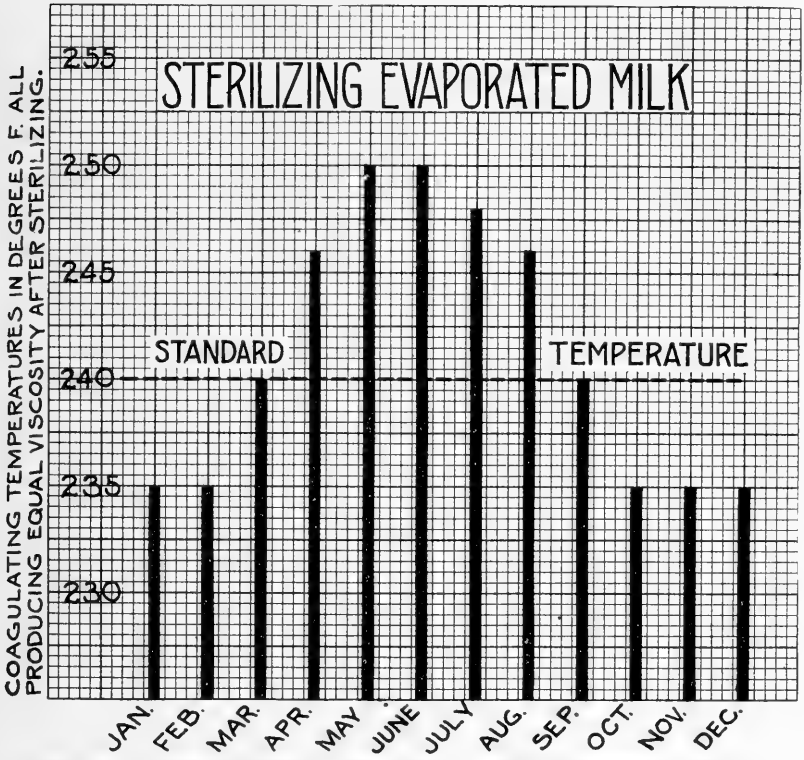


Fig. 171. Average Seasonal Variations in the Coagulating Point of Evaporated Milk.

intelligent management, and by applying our acquired knowledge the variations indicated can be correctly increased or decreased to the standard desired, as the case might require. Granting the milk to be of good, normal quality, and all other conditions properly standardized except the coagulating point, two general methods of control are available as follows:

(1). To raise the coagulating point increase the forewarming time and temperature in the hot wells, or add bicarbonate of soda. Usually it is necessary to do both.

(2). To decrease the coagulating point decrease the forewarming time and temperature, or increase the sterilizing temperature. It is frequently necessary to do both.

SOME EFFECTS OF STERILIZING TEMPERATURES UPON THE NITROGENOUS CONSTITUENTS OF EVAPORATED MILK.

Samples were obtained from six different batches each containing the milk from approximately 100 cows. These samples were carefully tested for casein, albumin and total protein, using the official methods of analysis as given in Chapter VII. In turn samples from the finished product, just after sterilizing, were likewise tested for casein (which included the albumin which had been coagulated by heat, and which in turn was precipitated along with the casein when making the determination of acid insoluble protein), albumin and total protein. The percentage of the various constituents was shown in Table 143.

TABLE 143.
Percentage of Each Protein Constituent.

Product	Percentage of each Constituent of the total Protein Content			
	Casein (including acid-insoluble Protein)	Albumin	Other Protein	Total
Fresh milk before heating....	Per cent 77.84	Per cent 13.12	Per cent 9.04	Per cent 100.00
Evaporated milk after sterilizing.....	86.97	4.12	8.91	100.00

In the above experiments 68.60 per cent of the total albumin contained in the fresh milk was precipitated in the evaporated milk after sterilizing. In the case of the protein called "other protein" only 14.38 per cent was coagulated by the sterilizing process. This group includes all the nitrogenous substances excepting the casein and albumin, some of which no doubt are not members of the protein group. The majority of these substances apparently are not affected by the sterilizing temperatures.

No exact data is available to show what percentage of casein itself is coagulated during the sterilizing operation. It must be

remembered that only a fraction of the total casein should be coagulated, as otherwise the product would not be a salable one. Probably in normal evaporated milk of correct viscosity the casein coagulated does not exceed ten per cent of the total present. In the acid solution used to determine the total casein, the part coagulated by heat, apparently, is all precipitated along with that not coagulated by the heat.

Changes in Viscosity at Various Stages in the Manufacture of Evaporated Milk.—The viscosity was determined in eight batches of fresh milk before heating, and after heating twice to the boiling point, allowing the milk to stand a few minutes between the two heating intervals. Upon four of the batches the viscosity was determined in the condensed product just as soon as cooled after condensing, and finally after sterilizing. In all cases the various products were all reduced to equal temperatures before determining the viscosity. The average results are given in Table 144.

TABLE 144.

Viscosity Changes in Products Used to Make Evaporated Milk.

Name of product and stage in process of manufacture	No. of samples tested	Viscosity at 75° F. in terms of degrees of retardation.
Fresh milk before heating	8	15.24
Fresh milk after heating	8	15.26
After condensing and cooling. Before sterilizing.	4	20.20
Evaporated milk just after sterilizing	4	150.00

The above results show that there is no practical or measurable difference in the viscosity between the fresh milk before and after heating in the hot wells when reduced to the same temperature and composition basis. The viscosity is only slightly increased by condensing, taking into consideration the increased total solids. The large gain in viscosity occurs in the sterilizing operation. This is closely associated with the coagulation of the casein and albumin.

VARIATIONS IN VISCOSITY OF EVAPORATED MILK.

The viscosity of a considerable number of cans of evaporated milk, of the same and of different brands as found upon the Chicago market was determined by one of the authors[9] using the Mojonnier-Doolittle viscosimeter. The results of these determinations are given under Fig. 172.

The viscosity is expressed in terms of degrees of retardation, as indicated upon the left hand column. The round spots indicate the tests of the respective samples. Where more than one sample of the same brand was tested, they are connected with the straight lines. A total of fourteen brands was tested, and the same are indicated by the number upon the top of Fig. 172.

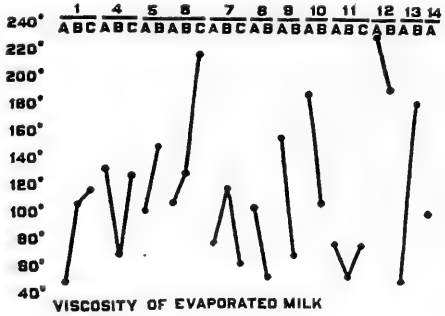


Fig. 172. Viscosity of Evaporated Milk.

The above results indicate a considerable variation in viscosity in most cases as between both the same and different brands. This fact obtained notwithstanding a close agreement in composition. The majority of the samples had a viscosity that was well within the ranges that constitute a good commercial product. Several of the samples had such excessive viscosity that the product would have curdled when added to coffee. Viscosity is a physical condition that can be influenced in several ways. Shaking the milk will reduce it. This is purely a mechanical result, whereby the large coagulated masses are disintegrated into

smaller particles. Viscosity is also greatly reduced by age, especially if the product is stored at a comparatively high temperature. In this case the change is caused by chemical action the nature of which is not understood, but it is probably based upon the fact that some substances contained in the milk react upon the coagulated casein and albumin, and cause them to return into solution.

The Function of Shaking and its Influence Upon the Viscosity in the Manufacture of Evaporated Milk.—The practice of shaking evaporated milk after sterilizing is as old as the industry. The two most common types of evaporated milk shakers are illustrated under Figs. 173 and 174.

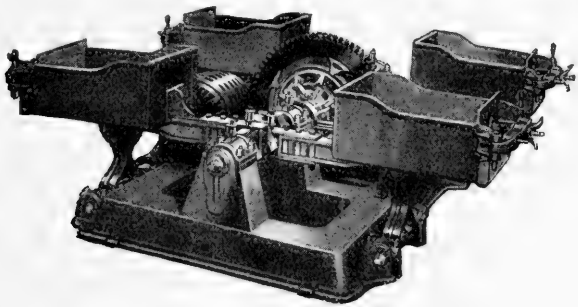


Fig. 173. Fort Wayne Shaker.
Courtesy The Engineering Co.

Evaporated milk after sterilizing frequently has a wide range of viscosity, especially in plants where the sterilizing operation is not carefully standardized. The purpose of the shaking operation is to destroy the excess of viscosity over that desired, and to reduce it all to certain standard, with the aim of making the entire output of the plant of uniform viscosity and of a homogeneous appearance.

The shaking operation is one of great importance, and one that needs to be well understood, and intelligently applied in practice.

The influence of excessive shaking upon the viscosity is shown by the following experiment, as given in Table 145.

TABLE 145.

No. of Samples	Viscosity after Shaking to Correct Standard	Viscosity after Shaking half Minute too Much	Viscosity after Shaking Three Minutes too Much	Viscosity after Shaking Nine Minutes too Much
2	80	57	45	38

The above results show plainly how viscosity is destroyed by shaking. The higher the temperature of the evaporated milk at the time of shaking the more viscosity will be destroyed, and the greater will be the danger of excessive shaking. Evaporated milk that is very cold is much more difficult to shake properly than that at ordinary or at warm temperatures. The best results in shaking are obtained and the danger of overshaking is more easily avoided if the shaking is done at ordinary temperatures.

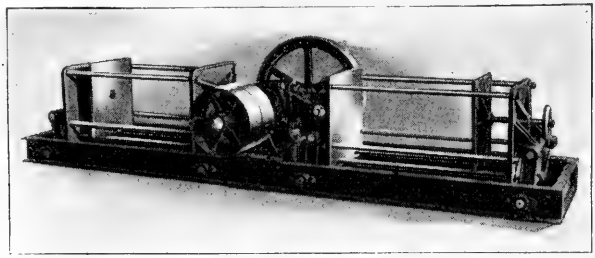


Fig. 174. Berlin Shaker.
Courtesy Berlin Canning Machinery Works.

Influence of Resterilization in Restoring Lost Viscosity.—Viscosity is a physical property that can be produced, destroyed and reproduced in several ways. The simplest method is by resterilization whereby the milk is subjected to only a fraction of the heat applied in the original process.

The average results of ten careful tests were as follows, in terms of degrees of retardation:—

Viscosity after goods were first finished.....80
Viscosity after destroying part of original viscosity by shaking, and before resterilizing.....30
Viscosity after resterilizing.....64

The original viscosity was not completely restored, due largely to the failure in not resterilizing the milk at a temperature high enough to restore it.

Influence of Storage Temperatures and of Immediate and Subsequent Shaking Upon the Viscosity of Evaporated Milk.—The handling of evaporated milk after sterilization varies in many particulars in practice. When shaking is necessary this is usually done soon after the product leaves the sterilizer. Also the temperatures at which the milk is handled between the time of sterilizing and the time of shipping, as well as between the time of shipping and the time when the product reaches the consumer, range between wide limits. The plan of holding the freshly sterilized product in a so-called hot room is a practice that is still being followed. Likewise the shaking is not a standardized operation.

A series of very careful experiments were performed to study the influence of the above factors upon the viscosity of evaporated milk. The results are given in Table 146.

TABLE 146.

Changes in Viscosity of Evaporated Milk Under Different Storage Temperatures.

Storage Conditions	No. of Samples Averaged	Viscosity in Degrees Retardation		Percentage Loss in Viscosity Due to Storage Temperatures
		Before Storing	After Storing	
In hot room 14 days at 79° F	8	80	63	20.25
In hot room 28 days at 79° F	8	80	54	32.50
In hot room 110 days at 79° F	8	80	33	58.75
In hot room one week, and then at ordinary temperatures, 69° F. for 7 days	8	80	68	15.00
In hot room one week, and then at ordinary temperatures, 69° F. for 21 days	8	80	60	25.00
In hot room one week, and then at ordinary temperatures, 69° F. for 103 days	8	80	48	40.00
In hot room one week, and then in cold room at 45° F. for 7 days	8	80	73	8.75
In hot room one week, and then in cold room at 45° F. for 21 days	8	80	75	6.25
In hot room one week, and then in cold room at 45° F. for 103 days	8	80	71	11.25

The results in Table 146 show clearly the large influence that storage temperatures play upon the viscosity of evaporated milk. The average percentage loss in viscosity at the end of 110 days was as follows:

When stored at 79° F.....58.75 per cent.
When stored at 69° F.....40.00 per cent.
When stored at 45° F.....11.25 per cent.

The above facts are of great practical significance since viscosity is so important a factor in the merchandising of evaporated milk.

In view of the fact that evaporated milk loses so much in viscosity upon aging unless it is stored at low temperatures the most uniform final results can be obtained if the shaking is done at the end rather than at the beginning of the storage period. The length of the shaking period can be reduced to allow for the viscosity that was destroyed due to storage influences.

THE DETECTION OF SPOILS IN EVAPORATED MILK.

Spoilage that develops in evaporated milk after condensing and before sterilizing is caused almost entirely by the use of too high holding temperatures. Evaporated milk that is to be promptly sterilized after filling the same day that is is condensed should be cooled to at least 60° F. When held for 24 hours it should be cooled to 44° F. For 48 hours to 40° F. It is never advisable to hold it more than 48 hours between the time of condensing and the time of sterilizing, but if this should ever be necessary the holding temperature should be reduced to about 34° F.

Spoilage after sterilizing evaporated milk divides itself into three main classes as follows:—

(1). Spoilage due to leaky cans.—This is caused by defective tin plate, or by improper soldering of the seams. Spoilage of this kind is almost invariably attended with lactic acid development and it can be thus readily recognized. It is universally recognized that the optimum temperature of growth of the great majority of lactic acid is about 68° F. Large leaks will manifest themselves in from 24 to 48 hours at room temperatures. Minute pin holes, that can be detected with the naked eye only with great difficulty, will show spoilage only after a considerably

longer time regardless of whether the storage temperature is 68 or 97° F. When the cans used are manufactured by a responsible concern, and if the same are well sealed after filling, the spoilage due to defective cans may be reduced to a minimum, and it should not exceed two cans per 1000 packed.

Granting that the can supply is of high quality, spoilage due to leaky cans is most readily detected if the sterilized product is kept at room temperatures. Nothing can be gained in helping to develop spoilage if higher storage temperatures are used.

(2). Spoilage due to under-sterilization.—This is caused by errors in processing, or by the use of unsafe sterilizing records. At the present state of knowledge of this science, spoilage losses due to under-sterilization are completely avoidable. By following the recommendations contained in this chapter, losses due to under-sterilization, barring accidents, can be completely prevented.

Spoilage of this kind manifests itself at ordinary temperatures in from four to seven day after the sterilizing operation. The use of higher storage temperatures will not, as a rule, expedite spoilage of this nature.

(3). Spoilage due to all other causes.—None of these are influenced by the temperatures at which the sterilized milk is held. Included under this heading can be mentioned a number of kinds of spoilage occasionally encountered. Coagulated lumps or balls of casein—this is usually due to the presence of zinc chloride flux inside of the can. Coagulated specks or masses of casein scattered more or less throughout the entire can—this is caused by improper shaking; uneven or excessive sterilization, and improper methods of forewarming the milk in the hot wells. Fatty separation sometimes develops after the milk has aged—this is due to the improper homogenization of the unsterilized product. With the homogenizer in good condition, and under operating pressures of 2000 to 3000 pounds, spoilage of this nature should be completely avoided.

FACTORS THAT INFLUENCE THE QUALITY OF EVAPORATED MILK.

The separation of calcium citrate in evaporated milk.—After evaporated milk has aged for a considerable time there appears

upon the bottom of the cans, white, gritty sand-like particles, which are lime salts of citric acid or tricalcium citrate, $Ca_3(C_6H_5O_7)_2+4H_2O$. It is more easily soluble in cold than in hot water; and it, therefore, precipitates from dilute, boiling solutions. Much remains to be learned regarding this substance in milk, and many conflicting statements regarding it appear in the literature. It is illustrated under Fig. 175.

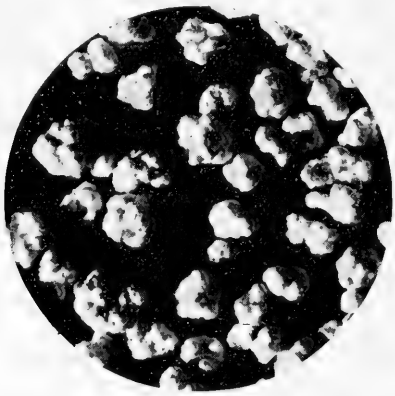


Fig. 175. Calcium Citrate Taken From Cans of Evaporated Milk.

A sample of unheated skim-milk was condensed over sulphuric acid about three volumes into one volume, without applying any heat. A lump of thymol was added, and the condensed product sealed and stored at about 85° F. for about three months. A considerable amount of calcium citrate was found deposited upon the bottom of the container at the end of the observation period. This proves that the separation of the calcium citrate is independent of the temperature used in sterilizing.

There are several factors that influence the separation of calcium citrate in evaporated milk. The principal ones are as follows:

(1). Variations in the calcium and citric acid content of milk.—It is well established that both calcium and citric acid (probably all combined with a base) vary in their content in milk

between relatively wide limits. The increase in mineral constituents is especially marked as the period of lactation advances. This is one explanation as to why the deposits of calcium citrate in evaporated milk cans vary so much, there being considerable differences in the total quantities found in different cans of very similar total solids content.

(2). Degree of condensation.—Obviously the larger the amount of total solids, especially milk solids not fat, the greater will be the quantity of lime salts available for separation. This is a strong argument in favor of a reasonable total solids standard.

(3). Storage temperatures.—The separation of lime salts in evaporated milk under different temperatures of storage was very carefully studied. Twenty seven samples were kept under observation for about four months. Evaporated milk stored at about 85° F. for one month or more, showed large amounts of fine particles and many large particles of grit. At about 68° F. at the end of from 78 to 110 days there was a considerable amount of large particles. At 45° F. there was no separation whatever at the end of four months. The above findings are in keeping with the fact that the solubility of calcium citrate decreases as the temperature increases. After precipitation has once occurred the particles do not return into solution even when the temperature is dropped under the usual conditions of handling. The product usually reaches the consumer with the largest part of the calcium citrate that separated out at any time still present in it.

(4). Affect of viscosity.—This factor was also studied by means of many careful experiments. Viscosity was found to have no effect upon the separation of calcium citrate in evaporated milk stored at 45° F. or less. Samples from the same batch in which the viscosity had been reduced about 57 per cent by excessive shaking were as free from precipitation at the end of four months as the samples which had not been shaken, and which contained excessive viscosity. Upon the other hand, samples of evaporated milk which had been stored at either 68° of 85° F., in all cases those samples which possessed the lowest viscosity were the ones which showed the most separation. The lower viscosity apparently favored the growth of the particles.

It follows from the above that the temperature of storage is one of the most important factors controlling the separation of calcium citrate. The higher the storage temperature the more will separate or vice versa.

FACTORS THAT INFLUENCE COLOR IN EVAPORATED MILK.

The color of evaporated milk is important as affecting its commercial value. Too little color is usually a sign of under-sterilization. Too much color may greatly impair its commercial value. The principal factors that influence color are the following:—

(1). The color of the fresh milk.—The color of fresh milk is normally subject to many fluctuations throughout the course of a year. Palmer and Eckles[10] have proved that this is due to distinct pigments dissolved in both the milk fat and in the milk serum. The pigments causing coloration in the fat, are the same as those found in green plants, and are known as carotin and xanthophylls, and their presence in milk is due to the fact of their absorption in the body of the cow, and their subsequent secretion in the milk. The coloration of the milk fat is largely a feed characteristic.

The pigment causing coloration of the milk serum is known as lactochrome, and its general characteristics are identical to the pigment contained in normal urine. The researches of Palmer and Coolidge[11] prove this to be a breed characteristic—the milk of Jerseys and Ayrshires containing it much more abundantly than that of Shorthorns or Holsteins.

The coloration due to the milk fat is by far the more important. In the manufacture of evaporated milk it is during the spring and summer months that the color of the finished product is increased because of the color of the fresh milk. The sterilizing time should be kept at a minimum, and the cooling promptly finished in the sterilizers.

(2). Concentration.—The more the fresh milk is condensed, the more color the freshly condensed product will contain. The increase in color due to concentration is very slight.

(3). Sterilization.—The sterilization process exerts a great influence upon the color of evaporated milk. The higher the

temperature and the longer the time, the greater will be the color. The increase in color is due to the action of the heat upon both the protein and the milk sugar. The exact changes that occur are not clearly understood at present.

(4). Storage temperatures.—In careful experiments it was ascertained that evaporated milk stored at 85° F. increased in color very rapidly and very greatly. At the end of four months at 68° F. there was also a marked increase in color, while at the end of the same time at 45° F. the increase in color was very much less marked. A satisfactory color can therefore be maintained much longer if the evaporated milk is stored at a low temperature.

The Titratable Acidity in the Various Stages of the Manufacture of Evaporated Milk.—The acid content as measured in terms of titratable acidity varies in several interesting particulars in all stages of the manufacture of evaporated milk. The cause of these changes are not fully understood. The average results of 13 very careful tests are given in Table 147.

TABLE 147.

Titratable Acidity in Evaporated Milk at Various Stages. Average Results.

Name of product	Percentage of titratable acidity
In fresh milk before heating	.14
In fresh milk after heating in the hot wells	.13
In freshly evaporated milk before sterilizing	.32
In evaporated milk after sterilizng	.39
In evaporated milk after storing for four months at 45° F.	.39
In evaporated milk after storing for four months at 68° F.	.40
In evaporated milk after storing for four months at 85° F.	.43
In evaporated milk after storing for one year at room temperatures	.45
In evaporated milk after storing for two years at room temperatures	.50
In evaporated milk after storing for three years at room temperatures	.55

As the above typical results show, there is first a decrease in titratable acidity upon forewarming the milk in the hot wells. In the evaporated product there is a gradual increase at every stage. High storage temperatures are especially favorable to the production of an increase in the titratable acidity. Dr. H. S. Grindley and his associates at the University of Illinois in their researches upon the cooking of meat proved that the coagulation of the protein constituents of meat by heat is accompanied by a considerable increase in the titratable acidity. In the case of evaporated milk an increase in titratable acidity during the sterilizing process is no doubt closely associated with the coagulation of the protein constituents. Why the acidity should increase with age, or the kind of acidity that is produced under the conditions named, are both unsolved problems.

The Influence of Freezing Temperatures Upon Evaporated Milk.—It occasionally happens that during transportation or in warehouses evaporated milk becomes frozen. A careful experiment was made to determine the effect of freezing. Duplicate samples from fourteen different batches of evaporated milk were taken. In one set the viscosity was determined at once. The second set was kept frozen continuously for sixteen days and nights, at temperatures ranging from 10 to 34° F. The samples were then kept at room temperature of about 69° F. for twenty-two days, at which time they were tested for viscosity and their physical condition carefully examined.

The average viscosity before freezing was 80° retardation. After freezing and thawing as above it was 81° retardation, showing practically no change in viscosity.

There were no traces of fat separation, but all the cans contained small amounts of brownish watery separation upon their bottoms. This watery part was readily reincorporated upon shaking the can. The texture of the milk was normal in all respects. Evaporated milk which has been frozen if handled as described in the above experiment can be restored to a completely normal condition, without loss or detriment.

VISCOSITY AS RELATED TO THE FEATHERING OR CURDLING OF EVAPORATED MILK IN COFFEE.

The practice of adding evaporated milk to coffee to study its solubility in the latter is an old one. The conclusion usually reached being that if the milk curdles, either the milk has too much acidity, or that something is wrong with the coffee itself. Upon the other hand, if the milk dissolves smoothly in the coffee, it is assumed that the milk does not contain an excess of acid and that nothing is wrong with the coffee.

The following experiment was made to establish the exact facts in the case. Samples were taken from each of two batches of evaporated milk. The samples from both batches varied greatly in viscosity. This was owing in part to the fact that the sterilizer in which these samples had been sterilized did not cook the milk uniformly, due to one of the end plugs being out of one of the steam distributing pipes, and also to the fact that some of the samples were purposely shaken in order to reduce the viscosity thereof. Batch No. A tested 7.99 per cent butter fat and 26.26 per cent total solids. Batch No. B tested 7.89 per cent butter fat and 25.65 per cent total solids.

The viscosity was determined upon each can by means of the viscosimeter illustrated under Fig. 140. The viscosity is expressed in degrees of retardation as indicated upon the dial which is graduated from 0 to 360. The greater the viscosity, the larger numerically is the degree of retardation.

Three cups were filled with hot coffee, hot water and cold water respectively. The spoonful of milk from each sample was added in turn to each cup. The results obtained are given in the following table.

The following conclusions are drawn from the above experiment:—

1. Hot coffee has no merit over cold or hot water as far as indicating the tendency of evaporated milk to curdle. The amount of curd formed was practically alike in all cases.

2. The formation of curd when evaporated milk is added to coffee is due entirely to an excess of viscosity. In the same and in different samples of evaporated milk where all factors were alike excepting viscosity, the tendency to curdle was always evident in the presence of excessive viscosity.

TABLE 148.

Comparison of Curdling Effect of Coffee and of Water on Evaporated Milk.

Date	Batch No.	Sample No.	Viscosity at 75° F. retardation	Results after adding one tablespoonful evaporated milk to 1 pint:—			REMARKS
				Hot coffee	Hot water	Cold water	
2-24-19...	A	1	173	Curdled badly	Curdled badly	Curdled badly	Heavy viscosity from sterilizer.
2-24-19...	A	2	59	No curd	No curd	No curd	Light viscosity from sterilizer.
2-24-19...	A	3	68	No curd	No curd	No curd	Light viscosity from sterilizer.
2-24-19...	A	4	70	No curd	No curd	No curd	Shook to reduce viscosity.
2-25-19...	B	5	53	No curd	No curd	No curd	Light viscosity from sterilizer.
2-25-19...	B	6	201	Curdled badly	Curdled badly	Curdled badly	Heavy viscosity from sterilizer.
2-25-19...	B	7	117	Curdled slightly	Curdled slightly	Curdled slightly	Shook slightly.
2-25-19...	B	8	84	No curd	No curd	No curd	Shook just right amount.
2-25-19...	B	9	15	No curd	No curd	No curd	Not sterilized.

3. The tendency to curdle can be entirely prevented by destroying the excess of viscosity by shaking the evaporated milk in the cans after sterilizing.

Influence of the Method of Cooling Upon the Color and Viscosity of Evaporated Milk.—The method of cooling employed at the sterilizers at the end of the sterilizing operation is most important as affecting the physical properties of the finished product. When water is used in the sterilizers a standard method should be followed in forcing the water out of the sterilizer at the end of the run. If the sterilizer outlets are sufficiently large the water should be all forced out within two or three minutes after shutting off the steam. The cooling water should be turned on as soon as the hot water is all out, or within two or three minutes after the steam has been turned off. When steam only is used, the cooling water should be turned on the instant that the steam is turned off. The hot water produced during the first stage of the cooling period should be allowed to run immediately into the sewer. The sewer valve can be closed after about five minutes, and the cooling completed in a total of about fifteen minutes, or until the milk attains a temperature of about 75° F.

The influence of the method of cooling as studied by careful experiments. Samples from the batch immediately after steril-

izing were cooled as indicated in Table 149. The color and the viscosity were noted in all cases.

TABLE 149.

Color and Viscosity of Evaporated Milk Under Different Methods of Cooling.

Number of batches tested	Method of cooling	Average color at 75° F.	Average viscosity at 75° F. retardation
9	Cooled in 6 to 10 minutes to 52° to 59° F.	Excellent color	80
9	Cooled in 20 to 25 minutes to 92° to 142° F.	Color much darker than above	70

The above results prove that slow and incomplete cooling in the sterilizers greatly increases the color. Batches that show excessive viscosity when sterilized may be further damaged by incomplete cooling, since they will take much longer to air-cool than the batches that are of low or of proper viscosity. This is due to the fact that coagulated milk is a poor conductor of heat.

The small differences in viscosity were in favor of the milk which had been rapidly cooled. In the majority of cases this difference was still apparent after the goods had been kept in storage for about four months.

GASES IN EVAPORATED MILK CANS.

Baker[12] studied the gases in the air space of hermetically sealed cans containing various sterilized foods including evaporated milk. He never found more than three gases,—"Carbon dioxide, nitrogen and hydrogen. Very often no hydrogen is found. Oxygen is practically never found. Changes in temperature of these cans produce changes in gas pressure. At 85° F. we may have a well puffed can, at 60° F. one in which there is practically no pressure, and at 45 to 50° there will be a vacuum. These changes occur with a decrease of temperature because the gas itself contracts, the solid and liquid contents of the can contracts and the solubility of the gas increases."

"The oxygen disappears in at least the three following manners. (1). By combining with the metals forming tin and iron oxides. (2). By oxidizing tin or iron salts. (3). By combining with nascent hydrogen when organic acids act on the metallic container." It is also probable that oxygen combines directly with the fat contained in evaporated milk, and some of it may be taken up during the carmelizing that occurs when processing evaporated milk.

The solubility of carbon dioxide at various temperatures is shown in Table 150.[13] This has an interesting application in connection with evaporated milk, whenever sodium bicarbonate is added to reduce the coagulating point. The more carbon dioxide that may be contained in the milk, the greater will be the danger from bulged can ends, especially during the summer months.

TABLE 150.

Solubility of CO_2 in Water. 1 Volume H_2O at T° and 760 mm. Dissolves V Volumes CO_2 Gas Reduced to 0° and 760 mm.

T°			T°			T°		
C	F	V	C	F	V	C	F	V
0	32	1.7967	7	44.6	1.3339	14	57.2	1.0321
1	33.8	1.7207	8	46.4	1.2809	15	59.0	1.0020
2	35.6	1.6481	9	48.2	1.2311	16	60.8	0.9753
3	37.4	1.5787	10	50.0	1.1847	17	62.6	.9519
4	39.2	1.5126	11	51.8	1.1416	18	64.4	.9318
5	41.0	1.4497	12	53.6	1.1018	19	66.2	.9150
6	42.8	1.3901	13	55.4	1.0653	20	68.0	.9014

REFERENCES.

[1] Rice, F. E. Abstract of paper on apparent acidity of milk. Science new series, Vol. L., No. 1296, October, 1919.

[2] Sommer, H. H, and Hart, E. B. The heat coagulation of milk. Journal of Biological Chemistry, Vol. XL., 1919, pp. 137 and 152.

[3] McInerney, T. J. Jour. of Dairy Science, Vol. 3, 1920, p. 220.

[4] Hunziker, O. F. Purdue University, Bul. 143, Vol. XV., May, 1910.

[5] Mojonnier, T.

[6] Hunziker, O. F. Purdue University, Bul. 143, Vol. XV., May, 1910, p. 489.

[7] Rogers, L. A. The Canner. March 5, 1921, p. 165.

[8] Latzer, R. L. The Effect of Pasteurization and Sterilization on the Solubility of Milk Proteids. Thesis, Department of Agricultural Chemistry, Cornell University.

[9] Mojonnier, T. Controlling the Chemical and Physical Properties of Evaporated Milk. The Canner, Convention number, 1917.

[10] Palmer, Leroy S, and Eckles, C. H. Carolin, the principal natural yellow pigment of milk fat, its relation to plant carotin and the carotin of body fat corpus luteum and blood serum. Jour. Biol. Chem., Vol. 17, 1914, p. 191.

[11] Palmer, Leroy S. and Coolidge, Leslie H. Lactochrome, the yellow pigment of milk whey, its probable identity with urochrome, the specific yellow pigment of normal urine. Jour. Biol. Chem., Vol. 17, 1914, p. 251.

[12] Baker, H. A. 8th International Cong. App. Chem., Vol. 18, pp. 35 and 49.

[13] Bunsen's Gasometry, pp. 289 and 141.

CHAPTER XX

SCORE CARDS FOR THE DAIRY INDUSTRY

INTRODUCTION.

For a number of years it has been customary in judging butter and cheese to print on a card the factors that contribute towards quality in these products and to give a numerical value to each factor. The cards also contain space for other necessary data, and are called score cards. They have contributed toward systematic work in scoring and help to bring into prominence the factors that control quality. In this way score cards have been of considerable educational value. They also form a concise record that may be filed for reference.

The score cards are now also used in judging milk, cream, and to a limited extent ice cream, and they have been applied to the scoring of dairies and market milk plants. Their proven merit make it appear that they will be of similar value in judging all the other newer milk derivatives. Examples of score cards now in use are given in this chapter and others are devised for use in scoring products where they have not heretofore been applied.

DEVELOPMENT OF THE DAIRY SCORE CARD.

MILK: The first public attention given to the quality of milk in this country was in reference to its chemical composition. It resulted in the enactment of laws against adulteration, the first of which was passed by the state of Massachusetts in 1856[1]. Other states later enacted similar legislation and systems of inspection were developed and laws enforced. When the science of bacteriology demonstrated that disease was largely due to pathogenic organisms and that milk, if not properly safe-guarded, might serve as a carrier of them, regulations controlling the sanitary quality of milk during its production and distribution were

developed and enforced by state and local communities, especially the larger cities.

The enforcement of these regulations was difficult when the work was in the period of development and few persons were properly trained to serve as efficient inspectors. Fortunately from the beginning, the methods of enforcement aimed to be educational and constructive, rather than arbitrary and oppressive.

The leaders in dairy schools and officials responsible for the enforcement of regulations established by Boards of Health, soon recognized the need of a synopsis of the salient points that govern the sanitary production and distribution of milk. Much thought and study was given to the development of such an outline which finally resulted in bringing forth the dairy score card.

The score card for the dairy is a systematic arrangement and rating of the points and conditions of importance in the production of clean milk. It is detailed in character giving credit to each condition according to its merit, a total score of 100 indicating perfect.

In making an inspection it is sometimes preferable to record on a question sheet the data necessary for determining the score. The inspector may then make out the score card from the record on the inspection sheet after returning to his office. The use of this method assists in avoiding arguments with proprietors who may be inclined to take exceptions to the score allowed when it is recorded in their presence.

The following milk inspection question sheet used by the Department of Dairy Industry of the New York State College of Agriculture, and score cards from other sources, for the farm dairy and milk distributing plants serve as illustrations.

New York State College of Agriculture at Cornell University

DEPARTMENT OF DAIRY INDUSTRY

MILK INSPECTION QUESTION SHEET.

Dairyman ..... Date.....

P. O. .....Location.....

No. cows in herd.....Milking.....No. stalls.....Qts. milk.....Cans or bottles.....

Name of family physician.....

Milk sold to.....License No.....

Report by.....At milking time?.....Hour.....M.

EQUIPMENT.

I. Cows.

Do all cows appear healthy?.....

What signs are there of disease?.....

Are udders sound?.....

Are cows tuberculin tested?.....

Date of last test.....By whom tested?.....

Number of cows added to herd since last test.....

Kinds of feeds used, { Roughage..... / Concentrates.....

Are they of good quality?.....

Method of watering.....Cleanliness of trough and surroundings.....

Is water supply abundant?.....

II. Stables.

Is stable well located?.....

Construction of ceiling....Walls....Are ceiling and walls smooth and tight?

Construction of floor.....State of repair.....

Size of stable, length.....Width.....Height.....

Size of stall, length.....Width.....

Kind of stanchion.....Kind of mangers.....

Kind of bedding used.....

Cubic feet of air space per cow.....

Number and size of windows.....

Are windows hinged or sliding?.....

Distribution of light.....Sq. feet of light per cow.....

How is stable ventilated?.....

Any special provision for controlling temperature?.....

III. Utensils.

Are all utensils well constructed and comparatively easy to clean?.....

Kind of milk pail used.....

Is any cooler used?..... Kind?.....

Are there any facilities for sterilizing utensils?.....

What are they?.....

Where are they?.....

IV. Milk Room or Milk House.

Location .....

Is milk house near any source of contamination, such as pig sty, privy?..

Is milk house well drained?.....

Construction, Floor..... Walls..... Ceiling.....

State of repair.....

Is house well lighted?..... Ventilated?.....

Are windows provided with screens?.....

Are there separate rooms for handling milk and washing utensils?.....

METHOD.

1. Cows.

Where are cows kept when sick?.....

Are cows free from dirt?.....

How are cows cleaned?.....

How often are cows cleaned?.....

How long before milking are cows cleaned?.....

Are udders washed or wiped with damp cloth before milking?.....

Are udders and flank clipped?..... How often?.....

II. Stable.

Is stable clean?.....

Is there dust or cobwebs on ceiling?..... Ledges?.....

Is there old dried manure on floor?.... Walls?.... Mangers or partitions?....

Is stable whitewashed?..... How often?.....

Is stable air free from dust and dirt?.....

Is stable free from flies?.....

Is feeding done before or after milking?.....

Has the stable any bad odors?.....

No. and kind of other animals in stable.....

Is bedding clean?.....

Is barnyard clean?..... Well drained.....

How often is manure removed from stable?.....

How far is manure removed from stable?.....

Is pasture free from mud-holes or stagnant water?.....

III. Milk Room.

Is milk room clean?.....

Has it any bad odors?.....

IV. Utensils and Milking.

Are utensils clean?.....Sterilized?.....How?.....

How are utensils cared for after milking?.....

Are milkers healthy?.....

Do they milk with clean, dry hands?.....

Do they wear special over-all suits?.....

How often are suits washed?.....

Where are suits kept when not in use?.....

Is stable floor dampened before milking?.....

V. Handling the Milk.

Where is milk strained?.....

Are attendants in milk room clean?.....

Is milk room free from flies?.....

What kind of a strainer is used?.....

How soon after milking is milk cooled.....

To how low a temperature is milk cooled?.....

To how low a temperature is milk stored?.....

How is milk protected during transportation to market?.....

SCORE

EQUIPMENT	SCORE Perfect	SCORE Allowed
COWS		
Health	6	
Apparently in good health	1	
If tested with tuberculin within a year and no tuberculosis is found, or if tested within six months and all reacting animals removed	5	
(If tested within a year and reacting animals are found and removed, 3.)		
Food clean and wholesome	1	
Water, clean and fresh	1	
STABLES		
Location of stable	2	
Well drained	1	
Free from contaminating surroundings	1	
Construction of stable	4	
Tight, sound floor and proper gutter	2	
Smooth, tight walls and ceiling	1	
Proper stall, tie, and manger	1	
Provision for light: Four sq. ft. of glass per cow	4	
(Three sq. ft., 3; 2 sq. ft., 2; 1 sq. ft., 1. Deduct for uneven distribution.)		
Bedding	1	
Ventilation	7	
Provision for fresh air, controllable flue system	3	
(Windows hinged at bottom, 1.50; sliding windows 1; other openings .50).		
Cubic feet of space per cow, 500 feet	3	
(Less than 500 ft., 2; less than 400 ft., 1; less than 300 ft., 0).		
Provision for controlling temperature	1	
UTENSILS		
Construction and condition of utensils	1	
Water for cleaning	1	
(Clean, convenient and abundant.)		
Small-top milking pail	5	
Milk cooler	1	
Clean milking suits	1	
MILK ROOM, OR MILK HOUSE		
Location free from contaminating surroundings	1	
Construction of milk room	2	
Floor, walls and ceiling	1	
Light, ventilation, screens	1	
Separate rooms for washing utensils and handling milk	1	
Facilities for steam (Hot water 0.5)	1	
Total	40	

METHODS	SCORE Perfect	SCORE Allowed
COWS		
Clean	8	
(Free from visible dirt, 6)		
STABLE		
Cleanliness of stable	6	
Floor	2	
Walls	1	
Ceiling and ledges	1	
Mangers and partitions	1	
Windows	1	
Stable air at milking time	5	
Freedom from dust	3	
Freedom from odors	2	
Cleanliness of bedding	1	
Barnyard	2	
Clean	1	
Well drained	1	
Removal of manure daily	2	
To 50 feet or more from stable.		
MILK ROOM OR MILK HOUSE		
Cleanliness of milk room	3	
UTENSILS AND MILKING		
Care and cleanliness of utensils	8	
Thoroughly washed	2	
Sterilized in steam for 15 minutes	3	
(Placed over steam jet or scalded with boiling water, 2.)		
Protected from contamination	3	
Cleanliness of milking	9	
Clean, dry hands	3	
Udders washed and wiped	6	
(Udders cleaned with moist cloth, 4; cleaned with dry cloth or brush at least 15 minutes before milking, 1.)		
HANDLING THE MILK		
Cleanliness of attendants in milk room	2	
Milk removed immediately from stable without pouring from pail	2	
Cooled immediately after milking each cow	2	
Cooled below 50° F.	5	
(51° to 55°, 4; 56° to 60°, 2.)		
Stored below 50° F.	3	
(51° to 55°, 2; 56° to 60°, 1.)		
Transportation below 50° F.	2	
(51° to 55°, 1.50; 56° to 60°, 1.)		
(If delivered twice a day allow perfect score for storage and transportation.)		
Total	60	

Equipment _____ + Methods _____ = _____ **Final Score**

NOTE 1—If any exceptionally filthy condition is found, particularly dirty utensils, the total score may be further limited.

NOTE 2—If the water is exposed to dangerous contamination, or there is evidence of the presence of a dangerous disease in animals or attendants, the score shall be 0.

ITHACA BOARD OF HEALTH

SANITARY INSPECTION OF DAIRY FARMS

MARKET MILK PRODUCTION

SCORE CARD

Indorsed by the Official Dairy Instructors' Association.

Owner or lessee of farm.....

P. O. address..... State.....

Total number of cows..... Number milking.....

Gallons of milk produced daily.....

Product is sold by producer to families, hotels, restaurants, stores,

to.....dealer

For milk supply of.....

Permit No..... Date of inspection.....192.....

Remarks: .....

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(Signed).....

Inspector

THE SCORE CARD SYSTEM OF DAIRY INSPECTION.

DAIRY SCORE CARD—DISTRIBUTION.

Place: .....Date: .....Name of dealer: .....Score as a producer

Gallons sold daily: .....

.....Inspector.

EQUIPMENT.	Perfect	Allowed
Items from "Dairy Score Cards" common to production and distribution with rating given thereon to the person named above:		
Milk room location	2	
Surroundings	1	
Convenience	1	
Milk room construction	2	
Floor, walls, ceiling	1	
Light, ventilation, screens	1	
Water for cleaning (Clean, convenient, abundant).	1	
Facilities for hot water or steam. (Should be in milk house, not kitchen.)	1	
Utensils, construction and condition	1	
ADDITIONAL ITEMS:		
Arrangement of milk room	3	
Milk bottled	4	
Kind and quality of machinery, fixtures and utensils (other than facilities for heating water) bottles, bottle washer, sterilizer refrigeration facilities, racks, cases, etc.	4	
Proper wagons in good repair	2	
	20	
Multiply by 2 for uniformity and to reduce to decimal basis	40	

METHODS.	Perfect	Allowed
Items from "Dairy Score Cards" common to production and distribution with rating given thereon to the person named above:		
Cleanliness of milk room		
Care and cleanliness of utensils	3	
Thoroughly washed and sterilized in live steam for 30 minutes	8	
(Thoroughly washed, and placed over steam jet, 4; thoroughly washed and scalded with boiling water, 3; thoroughly washed, not scalded, 2.)	5	
Inverted in pure air	3	
Cleanliness of attendants	1	
Efficient cooling and storage, below 50° F. (51° to 55°, 6; 56° to 60°, 3.)	8	
Transportation		
ADDITIONAL ITEMS:		
Methods of handling milk—promptness in bottling and capping, avoiding exposure to air, flies, etc.	3	
Cleanliness of additional equipment	2	
Cleanliness of wagons	2	
	30	
Multiply by 2 for uniformity and to reduce to decimal basis	60.	

Score for equipment..... + score for methods..... = ...final score.

VETERINARIAN'S SCORE

Date.....

Producer..... Phone.....

Address.....

Total number Cows.....

Number Milking.....

Number not Milking..... Cause.....

Number Tuberculin Tested..... Date.....

General Conditions { Coat ..... / Flesh..... / Attitude.....

Respiratory System—

Cough .....

Respiration .....

Percussion .....

Auscultation .....

Lymphatic System .....

Udder .....

Animal has symptoms suspicious of.....

Remarks .....

.....

.....

Rating of Herd—Excellent, Good, Fair, Poor.

Signed..... Veterinarian.

UNITED STATES DEPARTMENT OF AGRICULTURE

BUREAU OF ANIMAL INDUSTRY

DAIRY DIVISION

SANITARY INSPECTION OF CITY MILK PLANTS

SCORE CARD

Owner or manager.....

Street and No.....

City..... State.....

Trade name .....

Number of wagons..... Gallons sold daily { Milk..... / Cream.....

Permit or License No.....

Date of inspection....., 192.....

Remarks: .....

.....

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....., Inspector.

D. D. 331.—10-8-15—5,000.

8—2475

[OVER]

EQUIPMENT	SCORE. Perfect.	SCORE. Allowed.	METHODS.	SCORE. Perfect.	SCORE. Allowed.
BUILDING:			BUILDING	14	
Location: Free from contaminating surroundings	2		Cleanliness:		
			Floors 3		
			Walls 2		
Arrangement	7		Ceilings 2		
Separate receiving room 1			Doors and windows 1		
Separate handling room 2			Shafting, pulleys, pipes, etc 1		
Separate wash room 1			Freedom from odors 2		
Separate sales room 1			Freedom from flies 3		
Separate boiler room 1			APPARATUS	7	
Separate refrigerator room 1			Cleanliness:		
Construction	12		Thoroughly washed and rinsed 3		
Floors tight, sound, cleanable 2			Milk-handling machinery 2		
Walls tight, smooth, cleanable 1			Pipes, cans, etc 1		
Ceilings smooth, tight, cleanable 1			Sterilized with live steam 3		
Drainage 2			Milk-handling machinery 2		
Floors 1			Pipes, cans, etc 1		
Sewer or septic tank 1			Protected from contamination 1		
Provision for light 2			BOTTLES	7	
(10 per cent of floor space.)			Thoroughly washed and rinsed 3		
Provision for pure air 2			Sterilized with steam 15 minutes 3		
Screens 1			Inverted in clean place 1		
Minimum of shafting, pulleys, hangers, exposed pipes, etc 1			HANDLING MILK	22	
APPARATUS	15		Received below 50° F 3		
Boiler 2			(50° to 55°, 2.)		
(Water heater, 1.)			(55° to 60°, 1.)		
Appliances for cleansing utensils and bottles 2			Rapidity of handling 2		
Sterilizers for bottles, etc 2			Freedom from undue exposure to air 2		
Bottling machine 1			Cooling 5		
Capping machine 1			Promptness 2		
Wash bowl, soap, and towel in handling room 1			Below 45° F 3		
Condition 6			(45° to 50°, 1.)		
Milk-handling machinery 3			Capping bottles by machine 2		
Pipes, couplings, and pumps 2			Bottle top protected by cover 1		
Cans 1			Storage; below 45° F 4		
LABORATORY AND EQUIPMENT	2		(45° to 50°, 3; 50° to 55°, 1.)		
			Protection during delivery 2		
WATER SUPPLY	2		(Iced in summer.)		
Clean and fresh 1			Bottle caps sterilized 1		
Convenient and abundant 1			INSPECTION	6	
			Bacteriological work 3		
			Inspection of dairies supplying milk 3		
			(2 times a year, 2; once a year, 1.)		
			MISCELLANEOUS	4	
			Cleanliness of attendants 2		
			(Personal cleanliness, 1; clean, washable clothing, 1.)		
			Cleanliness of delivery outfit 2		
Total	40		Total	60	

Score for equipment ____ plus score for methods ____ equals TOTAL SCORE ____

NOTE.—If the conditions in any particular are so exceptionally bad as to be inadequately expressed by a score of "0" the inspector can make a deduction from the total score.

(United States Department of Agriculture, Bureau of Animal Industry, Dairy Division.)

SANITARY INSPECTION OF STORES HANDLING BULK MILK.

Operator: ..... Address ..... Gallons sold daily: ..... Permit No. .....

Date: ..... Remarks: .....

Signed ..... Inspector.

(Back of Card.)

DETAILED SCORE.

EQUIPMENT.	Score: Perfect	Score: Allowed
Building:		
Location: Free from contaminating surroundings	2	
Separate room for milk handling	5	
Construction:	8	
Floors, tight, smooth, cleanable....1		
Walls, tight, smooth, cleanable....1		
Ceilings, tight, smooth, cleanable....1		
Show cases, smooth, free from ledges and crevices....1		
Provision for light (10 per cent of floor space)....1		
Provision for air....1		
Screens....2		
Utensils	15	
Construction: Easily cleaned; free from open seams and complicated parts....5		
Condition: Free from rust, dents, etc....2		
Facilities for cleaning:		
Water, clean, convenient and abundant..2		
Hot water or steam....3		
Brushes and washing powder....1		
Protected from flies and when not in use....2		
Ice box	10	
Separate ice box for milk....5		
(Milk kept in separate compartment, 2.)		
Construction:		
Tight and cleanable....1		
Non-absorbent lining....1		
Good drainage....1		
Protected from flies and dust....2		
Total	40	

METHODS.	Score: Perfect	Score: Allowed
Building:		
Cleanliness	10	
Floor....3		
Wall....2		
Ceiling....2		
Show cases, shelves, etc....3		
Freedom from flies	3	
Freedom from rubbish	2	
Air:		
Freedom from dust	2	
Freedom from odors	2	
Utensils	20	
Thoroughly washed and rinsed....10		
Steamed....10		
(Scalded, 5)		
Ice box:		
Cleanliness of ice box	3	
Handling:		
Placed on ice as soon as received	5	
(Protected, put on ice inside of an hour, 2.)		
(Unprotected, but put on ice inside of an hour, 1.)		
Temperature of milk, below 50° F. (51°-55°, 8; 56°-60°, 5; 61°-65°, 2.)	10	
Freedom from undue exposure to air	2	
Cleanliness of attendants	1	
Total	60	

Equipment ..... — Methods ..... = Total .....

THE SCORE CARD FOR DAIRY PRODUCTS.

The score card for dairy products aims to give an orderly arrangement of the points which a good product possesses. It places a numerical value on each point and allows space for recording the grade assigned in scoring each point. There is also provided space for the name and address of the producer or exhibitor, necessary dates, name of inspector or judge and remarks.

The advantages of a good score card are (1) its educational feature, (2) its influence toward improving quality, (3) it is an orderly record that may be filed for reference, (4) it tends to eliminate error.

In marketing and manufacturing, the score of a product in itself is usually of prime importance since it is a large factor in fixing the market or price value. The score card here serves as a record that gives in mathematical terms the credits allowed on each factor that influences value. This record may be of considerable importance when studied for the purpose of improving quality, when used as a basis for trading, and in settling disputes as to quality.

The sanitary quality of milk is the most important factor affecting its value, as milk cannot be used as a food if it contains pathogenic organisms or filth. Its chemical composition comes next in importance as it governs the nutrient value. Taste and odor come next in order, with color, appearance and other details last. The following score card illustrates the arrangement of points and method of assigning credits for retail bottled milk.

Certified milk: The scoring of certified milk is carried out in essentially the same manner as in the case of market milk, but the bacteria count is limited to a narrower range and credits assigned accordingly. Also any special guarantees in regard to composition must be recognized and the container should comply with the regulations for certified milk.

UNITED STATES DEPARTMENT OF AGRICULTURE,

BUREAU OF ANIMAL INDUSTRY,

DAIRY DIVISION.

SCORE CARD FOR MILK.

Place .....

Class ..... *Exhibit No.* .....

ITEM.	PERFECT SCORE.	SCORE ALLOWED	REMARKS.
Bacteria	35		Bacteria found per cubic centimeter .....
Flavor and odor	15		Cowy, bitter, feed, flat, strong .....
Sediment	10		
Fat	15		Per cent .....
Solids not fat	15		Per cent .....
Temperature (street samples) *or* Acidity (prepared samples)	5		Degrees ..... *or* Per cent .....
Bottle and cap	5		Bottle ..... Cap .....
TOTAL	100		

Exhibitor .....

Address .....

(Signed) .....

.....

.....

Judges.

Date .....

DIRECTIONS FOR SCORING.

BACTERIA PER CUBIC CENTIMETER—PERFECT SCORE, 35.

	POINTS.		POINTS.
500 and under	35	25,001–30,000	29
501–1,000	34.9	30,001–35,000	28
1,001–1,500	34.8	35,001–40,000	27
1,501–2,000	34.7	40,001–45,000	26
2,001–2,500	34.6	45,001–50,000	25
2,501–3,000	34.5	50,001–55,000	24
3,001–3,500	34.4	55,001–60,000	23
3,501–4,000	34.3	60,001–65,000	22
4,001–4,500	34.2	65,001–70,000	21
4,501–5,000	34.0	70,001–75,000	20
5,001–6,000	33.8	75,001–80,000	19
6,001–7,000	33.6	80,001–85,000	18
7,001–8,000	33.4	85,001–90,000	17
8,001–9,000	33.2	90,001–95,000	16
9,001–10,000	33.0	95,001–100,000	15
10,001–11,000	32.8	100,001–120,000	12.5
11,001–12,000	32.6	120,001–140,000	10.0
12,001–13,000	32.4	140,001–160,000	7.5
13,001–14,000	32.2	160,001–180,000	5.0
14,001–15,000	32.0	180,001–200,000	2.5
15,001–20,000	31.0	Above 200,000	0
20,001–25,000	30		

NOTE.—When the number of bacteria per cubic centimeter exceeds the local legal limit the score shall be 0.

FLAVOR AND ODOR—PERFECT SCORE, 15.

Deductions for disagreeable or foreign odor or flavor should be made according to conditions found. When possible to recognize the cause, it should be described under "Remarks."

SEDIMENT—PERFECT SCORE, 10.

Examination for sediment may be made by means of a sediment tester, and the resulting cotton disks compared with standards; or the sediment may be determined by examination of the bottom of the milk in the bottle. In the latter case the milk should stand undisturbed for at least an hour before the examination. Raise the bottle carefully in its natural upright position until higher than the head. Tip slightly and observe the bottom of the milk with the naked eye or by the aid of a reading glass. The presence of the slightest movable speck makes a perfect score impossible. Further deductions should be made according to the quantity of sediment found. When possible, the nature of the sediment should be described under "Remarks."

FAT IN MILK—PERFECT SCORE, 15.

	POINTS.		POINTS.
4.0 per cent and over	15	3.3 per cent	8
3.9 per cent	14	3.2 per cent	7
3.8 per cent	13	3.1 per cent	5
3.7 per cent	12	3.0 per cent	3
3.6 per cent	11	2.9 per cent	1
3.5 per cent	10	Less than 2.9 per cent	0
3.4 per cent	9		

NOTE.—When the per cent of fat is less than the local legal limit the score shall be 0

SOLIDS NOT FAT—PERFECT SCORE, 15.

	POINTS.		POINTS.
8.7 per cent and over	15	8.2 per cent	5
8.6 per cent	13	8.1 per cent	3
8.5 per cent	11	8 per cent	1
8.4 per cent	9	Less than 8 per cent	0
8.3 per cent	7		

NOTE.—When the per cent of solids not fat is less than the local legal limit the score shall be 0.

TEMPERATURE (STREET SAMPLES)—PERFECT SCORE, 5.

	POINTS.		POINTS.
50 degrees F. and below	5	57 to 60 degrees	1
51 to 53 degrees	4	Above 60 degrees	0
54 to 56 degrees	3		

ACIDITY (PREPARED SAMPLES)—PERFECT SCORE, 5

	POINTS.		POINTS.
0.2 per cent and less	5	0.23 per cent	2
0.21 per cent	4	0.24 per cent	1
0.22 per cent	3	Over 0.24 per cent	0

BOTTLE AND CAP—PERFECT SCORE, 5.

Deductions in score should be made for dirty or chipped bottles; for caps which do not cover the lips of the bottles, or do not fit properly in the cap seats.

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The American Dairy Science Association (2) recommends the following score card for whole milk:

Bacteria	35
Flavor and odor	25
Fats	10
Solids not fat	10
Sediment	10
Acidity	5
Bottle and cap	5
	100

Skim-milk. The scoring of skim-milk has heretofore received very little consideration. The greater value now placed upon skim-milk as a food and the larger application of skim-milk products as a food and in the arts, makes it very desirable to have a score card that gives in a systematic way the respective points that good skim-milk should possess and provide space for recording the necessary data relating to samples scored.

The score card need not differ in principle from that used for whole milk but the credits allowed for the different points may vary somewhat in proportion to their influence upon the value of the skim-milk in the use that is to be made of it. The explanation of scores given for whole milk may be applied also for skim-milk.

SCORE CARD FOR SKIM-MILK.

Owner ..... Date .....
Address ..... Exhibit No. .....
Class .....

Item	Score		Remarks:
	Perfect	Allowed	
Bacteria	35		
Flavor and odor.....	20		
Sediment	10		
Solids not fat.....	15		
Temperature (street sample	5		
Acidity	5		
Fat	5		
Container	5		
Total.....	100		

Date scored.....

Judges { .... }

UNITED STATES DEPARTMENT OF AGRICULTURE,

BUREAU OF ANIMAL INDUSTRY,

DAIRY DIVISION.

SCORE CARD FOR CREAM.

Place .....

Class ..... *Exhibit No.* .....

ITEM.	PERFECT SCORE.	SCORE ALLOWED.	REMARKS.
Bacteria	35		Bacteria found per cubic centimeter
Flavor and odor	25		Cowy, bitter, feed, flat, strong
Sediment	10		
Fat	20		Per cent
Temperature (street samples) *or* Acidity (prepared samples)	5		Degrees *or* Per cent
Bottle and cap	5		Bottle / Cap
TOTAL	100		

Exhibitor .....

Address .....

(*Signed*) .....

.....

.....

Judges.

Date .....

DIRECTIONS FOR SCORING.

BACTERIA PER CUBIC CENTIMETER—PERFECT SCORE, 35.

	Points.		Points.
500 and under	35	25,001–30,000	29
501–1,000	34.9	30,001–35,000	28
1,001–1,500	34.8	35,001–40,000	27
1,501–2,000	34.7	40,001–45,000	26
2,001–2,500	34.6	45,001–50,000	25
2,501–3,000	34.5	50,001–55,000	24
3,001–3,500	34.4	55,001–60,000	23
3,501–4,000	34.3	60,001–65,000	22
4,001–4,500	34.2	65,001–70,000	21
4,501–5,000	34.0	70,001–75,000	20
5,001–6,000	33.8	75,001–80,000	19
6,001–7,000	33.6	80,001–85,000	18
7,001–8,000	33.4	85,001–90,000	17
8,001–9,000	33.2	90,001–95,000	16
9,001–10,000	33.0	95,001–100,000	15
10,001–11,000	32.8	100,001–120,000	12.5
11,001–12,000	32.6	120,001–140,000	10.0
12,001–13,000	32.4	140,001–160,000	7.5
13,001–14,000	32.2	160,001–180,000	5.0
14,001–15,000	32.0	180,001–200,000	2.5
15,001–20,000	31.0	Above 200,000	0
20,001–25,000	30		

NOTE.—When the number of bacteria per cubic centimeter exceeds the local legal limit the score shall be 0.

FLAVOR AND ODOR—PERFECT SCORE, 25.

Deductions for disagreeable or foreign odor or flavor should be made according to conditions found. When possible to recognize the cause of the difficulty it should be described under "Remarks."

SEDIMENT—PERFECT SCORE, 10.

Examination for sediment should be made only after the cream has stood for at least an hour undisturbed in any way. Raise the bottle carefully in its natural upright position until higher than the head. Tip slightly and observe the bottom of the cream with the naked eye or by the aid of a reading glass. The presence of the slightest movable speck makes a perfect score impossible. Further deductions should be made according to the quantity of sediment found. When possible the nature of the sediment should be described under "Remarks."

FAT IN CREAM—PERFECT SCORE, 20.

	Points.		Points.
25 per cent and above	20	19 per cent	17
24 per cent	19.5	18 per cent	16
23 per cent	19	17 per cent	12
22 per cent	18.5	16 per cent	8
21 per cent	18	15 per cent	4
20 per cent	17.5	Less than 15 per cent	0

NOTE.—When the per cent of fat is less than the local legal limit the score shall be 0.

TEMPERATURE (STREET SAMPLES)—PERFECT SCORE, 5.

	Points.		Points.
50 degrees F. and below	5	57 to 60 degrees	1
51 to 53 degrees	4	Above 60 degrees	0
54 to 56 degrees	3		

ACIDITY (PREPARED SAMPLES)—PERFECT SCORE, 5.

	Points		Points.
0.2 per cent and less	5	0.23 per cent	2
0.21 per cent	4	0.24 per cent	1
0.22 per cent	3	Over 0.24 per cent	0

BOTTLE AND CAP—PERFECT SCORE, 5.

Deductions in score should be made for dirty or chipped bottles; for caps which do not cover the lips of the bottles, or do not fit properly in the cap seats.

Cream: The method of scoring cream is essentially the same as that applied in scoring milk. It is not ordinarily scored for solids not fat. Whether it should receive such a score or not, is a debatable question. Where the minimum percentage of fat in cream is fixed by legislative or similar enactments, full credit may be allowed if the composition conforms to such fat standard. It is customary, however, to require the presence of at least 20 per cent of fat in cream in order to be entitled to the full score.

SCORE CARD FOR BUTTER.

The systematic scoring of butter is carried out in commercial transactions between producers and dealers and between the dealers themselves. It is also practical in scoring butter at butter exhibitions and in giving instruction in dairy schools. The practice does not extend to any great extent to the commercial transactions taking place between the ultimate retailer and consumer. As the practice of scoring butter has continued over a long period of years, the system has become fairly well fixed, and the factors that affect quality satisfactorily established.

Butter score cards may vary somewhat in form according to the use that is to be made of the score. In general they include the factors and take the general form of the card shown here as an example.

Flavor: This is the most important factor in fixing the score, and perfect flavor is rarely if ever given.

Body: The ideal butter is firm, hard and waxy which properties prevent it from softening or melting too easily. Poor body is described as weak, greasy, leaky, short-grained and sticky. The "body" of butter is not of such importance to the consumer as that of flavor, and recent methods of manufacture have not contributed toward improving it.

Color: The shade of yellow color in butter varies in different markets. All require that it be uniform, that is, free from streaks, mottles, waves and specks. Where there is too much color it is said to be too high and where the yellow is too pale the color is said to be too light.

Salt: The percentage of salt also varies according to the demands of the trade, which in turn, is governed by the likes and dislikes of the consumer. If the salt is not all in solution or is not evenly distributed the score is reduced.

Package: The package is controlled by market requirements. In any case it must be substantial, attractive, neat and clean. The interior wrapper should be free from wrinkles, properly folded and the workmanship good throughout.

SCORE CARD FOR BUTTER.

Owner ..... Date .....
Address .....
Class ..... Exhibit No. .....

Quality factors	Perfect score	Score Allowed	Remarks:
Flavor	45		
Body	25		
Color	15		
Salt	10		
Package	5		
Total	100		

Fat .....per cent
Moisture .....per cent
Salt .....per cent
Casein .....per cent

Date scored .....
Judges { .....
.....

Butter is graded on the market according to the score it receives.

The grade given by the New York Mercantile Exchange corresponds with the score as follows:

Grade:	Higher scoring	Extras	Firsts	Seconds	Thirds
Score:	93 or above	92	91 to 88	87 to 83	82 to 76

Other classifications sometimes are "Packing stock", "renovated", and to butter of inferior quality "cooking butter", "ladels" and "grease".

While different judges may check closely on the score, butter that satisfies the best trade in one market may not do so in another, thus the same butter might receive a different score and grade on two different markets, like, for example, Boston and New York. Also, when the supply is short and demand strong, butter that would ordinarily go into one grade may be raised a grade higher, and when the opposite conditions prevail it might be dropped a grade lower. This practice is confusing until trade customs are learned.

Flavor: It consists of those properties that affect the senses of taste and smell. Nearly every one can become proficient in judging butter by intelligently using the senses of sight, taste and smell, although such physical tests are very difficult to describe. A number of terms are used in describing flavor as it varies widely and is due to many causes. Those tastes or odors which are pleasing and which develop in one an appetite or desire to eat more of the butter receive credit while those that have the opposite effect reduce the score. Such terms as clean, creamy, pleasant, delicate, and sweet are favorable, while the following are unfavorable: cowey, barney, old, strong, tallowy, rancid, fishy, fruity, and weedy.

CULTURE SCORE CARD.

Culture or starter, as the term applies in dairying, is an active culture of bacteria that are used for the purpose of developing lactic acid fermentation in milk and milk derivatives. It finds its greatest application in the manufacture of butter, cheese and milk beverages. Quality in starter is of first importance as it transmits its properties to the material to which it is added and when the quality is poor it may be the cause of considerable loss.

The factors that contribute to quality in a good culture are not unlike those for buttermilk. The score cards proposed usually follow the same general outline. The one used by the Dairy Department of the N. Y. State College of Agriculture at Cornell University will serve as an example:

CORNELL CULTURE SCORE CARD.

	Score		
	Perfect	Allowed	
Flavor	50	.....	Clean, desirable acid.
Aroma	20	.....	Clean, agreeable acid. No undesirable aroma.
Acidity	20	.....	0.6 per cent—0.8 per cent.
Body	10	.....	Before breaking up: Jelly like, close, absence of gas holes. No free whey. After breaking up: smooth, creamy, free from granules or flakes.
Total	100		

THE BUTTERMILK SCORE CARD.

The value of good buttermilk as a food and healthful stimulating beverage is generally acknowledged but in the past methods for regularly producing the desired flavors and aroma were lacking. Recent improvement in methods of handling milk combined with a better understanding of the principles that control fermentation is rapidly overcoming these difficulties and it is now possible by the use of proper methods and improved equipment to regularly produce buttermilk of high quality having the same desirable properties from day to day.

There is need for a better general knowledge of the factors that produce quality in buttermilk since quality must be depended upon to increase the demand. The use of a score card will be a help in gaining this desirable end in the same way that it has been of so much service in improving the quality of market milk. The following score card may be adapted to the purpose:

BUTTERMILK SCORE CARD.

Owner ..... Date .....
Address ..... Exhibit No. .....
Class .....

Quality factor	Score		Remarks:
	Perfect	Allowed	
Flavor	45		Clean, delicate, pleasant, desirable acid.
Aroma	15		Clean, agreeable, attractive, delicate, mild.
Body	15		Smooth, even, jelly-like, close, creamy.
Acid	15		0.7 per cent to 0.9 per cent.
Container	10		Clean, neat, substantial, noncorrosive. Oderless.
Total	100		

Date scored.....

Judges { .... }

CHEESE SCORE CARDS.

The quality of cheese is affected by (1) the quality of the milk that enters into it, (2) the method applied in its manufacture and (3) by the fermentation that takes place during the making process, curing and storage. The defects may be many and varied and it requires practice, study and experience to become skilled in detecting them, and especially to assign proper credits to the points of merit which will correctly indicate commercial value. The properties that have been adopted as a basis for scoring cheddar cheese are (1) flavor, (2) body and texture, (3) color and (4) finish.

The flavor of high quality cheese is very characteristic yet so unlike other substances that it is difficult to describe. It is slightly salty, mingling the flavor of fat with acid and protein substances in a way that yield a very attractive rich flavor sometimes described as mildly nutty. Unpleasant and offensive odors and tastes should be absent.

Flavors: Volatile substances from the feed of the cows producing milk are sometimes transmitted to the cheese. They are known as weedy or feedy flavors. They vary according to the flavor of feed. "Cowey" flavor remind one of the odor of the breath of a cow. Sweet flavors characteristic of some of the common fruits are described as fruity. They may be derived from fermentations caused by organisms found in decomposing milk substance and indicate that the milk from which the cheese was made came in contact with unsanitary conditions. Cheese that has a pronounced sour smell or taste is described as acid. It is due to the presence of an excess of acid. Flat flavor indicates an absence or reduction in the flavors present in high quality cheese. Other terms are bitter, rancid, tallowy and mouldy.

Texture and Body: When the texture of the cheese is good there should be no holes and the broken ends of a plug should appear close, solid, compact and well annealed, yet flakey and somewhat like broken flint. When pressed and rubbed between the thumb and finger it should feel smooth, silky and waxy. Body refers to the firmness or consistency of the substance. It is judged at the same time and in the same manner as the texture.

When the body is good it will feel somewhat firm under pressure, but not too firm, and when pressure is applied it should not

break or crumble but yield in form like cold butter. It should not feel harsh or gritty nor soft and pasty. Stiff, corky, curdy, weak-bodied, salvy, and watery are self explanatory terms used in describing cheese body.

Color: Color is ordinarily considered perfect if it is uniform. The depth of the shade of yellow is not important as long as it satisfies the demands of the market in which it is sold. The fancy or whim of different markets vary in respect to the shade of yellow color.

Finish: Finish is important as it is likely to be taken as an index of the workmanship put into the manufacturing process which in turn has so much to do with quality in cheese. Finish may or may not include the package or box—but a dirty, dilapidated and untidy container should never be used. The surface of the cheese should be clean, smooth and free from cracks. The edges should be even and the bandages neatly arranged, giving an impression of value and quality.

SCORE CARD FOR CHEDDAR CHEESE.

Owner ..... Date .....
Address ..... Exhibit No. .....

Item	Score		Remarks
	Perfect	Allowed	
Flavor	45		
Body and texture	30		
Color	15		
Finish	10		
Total	100		

Date scored .....

Judges { .....
.....

SCORE CARD FOR COTTAGE CHEESE.

Cottage cheese is one of our most wholesome food products. With the large surplus of milk solids not fat always available its use should greatly increase. Good quality will do much to stimulate consumption. The authors are suggesting the following score card in grading this product.

SCORE CARD FOR COTTAGE CHEESE.

Owner ..... Date .....
Address .....

Item	Score	66	Remarks:
	Perfect		
Flavor	50		Mild, clean, acid flavor.
Viscosity and texture	20		Body or viscosity fairly firm. Smooth to the taste.
Color	5		Creamy cast. A little odor enhances its commercial value.
Appearance of package	5		Neat, clean with every evidence of careful workmanship.
Composition	20		Sufficient total solids to give good food value to the product.
Total.....	100		

Date scored.....

Judges { .....
.....

SWISS CHEESE.

In scoring Swiss Cheese special attention is given to its typical nutty flavor and slightly sweet, pleasing taste. Off flavors, derived from the milk or undesirable fermentation, should be wholly absent. The characteristic "eyes" or holes should be rather evenly distributed from one to three inches apart. They are normally from one-half to three fourths of an inch in diameter. The substance between the eyes should be compact, and free from small holes which indicate that undesirable gas producing fermentation has occurred.

The salt should have passed well through the cheese. The body should be firm and the rind smooth, clean and free from cracks.

SCORE CARD FOR SWISS CHEESE.

Owner ..... Date .....
Address ..... Exhibit No.....
Class .....

Item	Score		Remarks:
	Perfect	Allowed	
Flavor	40		
Holes and appearance...	25		
Texture	20		
Salt	10		
Style	5		
Total	100		

Date scored.....

Judges { .... }

LIMBURGER CHEESE SCORE CARD.

Limburger cheese is subject to most of the defects that are common to other kinds. Its peculiar flavor is not easy to obtain without defect, as in the process of manufacture it is difficult to control some of the common undesirable forms of bacteria when they once gain entrance to the milk from which the cheese is made. Gassy cheese is a common defect due to the presence of gas forming bacteria. The body of the cheese is filled with gas holes and bloats until the sides are more or less bulged and rounded. Too much acid development results in sour cheese that cures slowly and develops a bitter taste. Other defects are dryness which causes the cheese substance to be hard and to cure slowly, while too much moisture results in a pasty, rapidly curing cheese that will not hold its shape well. The cheese should keep its regular shape, the substance should be uniform throughout and the rind free from cracks.

SCORE CARD FOR LIMBURGER CHEESE.

Owner ..... Date received.....
Address ..... Exhibit No.....
Class .....

Item	Score	
	Perfect	Allowed
Flavor	40	
Texture	40	
Color	10	
Salt	5	
Style	5	
Total	100	

Date scored.....

Judges { ....

SCORE CARD FOR ICE CREAM.

The scoring of ice cream does not differ materially from the scoring of other dairy products excepting that in judging quality in added flavor the ideal for the flavor used should be the standard of comparison. The principal factors that have an influence on quality in ice cream are usually described under the following headings: Flavor, body, texture, appearance, and package.

Flavor: Flavor may be described under two headings, (1) that derived from added flavoring, (2) that derived from other materials. If the added flavoring is not of high quality it may introduce "foreign" flavors and leave the cream "low" in the desired flavor. If too much flavoring is added it may be so pronounced as to taste too "sharp" or slightly "bitter", leaving a sensation that is slightly unpleasant. There should be just sufficient flavoring present to enable the consumer to identify it but not enough to smother or detract from the pleasant taste of other high grade materials present. "Rancid", "mouldy" and "stale" flavors may be derived from carelessly sorted nut meats and fruits. Sweetness should not be too pronounced, nor lacking to such an extent as to produce a "flat" taste.

The flavors imparted to ice cream by milk products are numerous and variable in strength. The highest quality yields to

the tongue and palate the delicate aroma and sensation of richness that is so pleasing in sweet, fresh, clean cream. Some believe that a slightly acid development, hardly enough to be recognized, tends to liven the flavor and improve it. All of the flavors that appear in milk or cream of poor quality may be carried into the frozen product. The common ones are sour, old, cowey, bitter, metallic, oily, muddy, barn, unclean, burned and overheated flavors.

Other defects in flavor may be due to other ingredients added. Milk powder, condensed milk, gelatin and starch when added, each impart at times, particularily if these products are not of first quality, defects in flavor characteristic of the products themselves.

Body or Viscosity.—Ice Cream should be firm and yet not sticky.

Texture. Smooth and velvety to the taste. No large water crystals. No milk sugar crystals causing "sandiness".

Defects in texture are described as icy, coarse, sticky, buttery or soft. Allowance must always be made for fruits or nuts added in manufacturing.

Composition.—The ice cream should not fall under the legal or trade standards. Both the fat and total solids should be taken into consideration. Increased importance is being attached to composition when scoring ice cream.

Bacteria. The bacterial content is frequently overlooked, and more importance should be attached to it. Baer[5] states: "The bacterial content of a perfect ice cream should be not more than 20,000 to the cc. One point should be deducted for every increase of 10,000 bacteria to the cc, until 100,000 is reached, when two points should be deducted for every increase of 50,000 to the cc".

Appearance. The color should be characteristic of the fruit or flavor used. The general appearance should be clean.

Package. Container to be clean, free from rust and from all evidences of slovenly workmanship. Brick ice cream should be neatly packaged.

Several ice cream cards have been proposed, but none have been generally accepted. The four best known are as follows:

(1.) Vermont Score Card.[3]

Flavor	45
Texture	20
Richness	20
Appearance	10
Color	5
	100

(2.) Iowa Score Card.[4]

Flavor	45
Body	20
Texture	20
Permanency	10
Package	5
	100

(3.) Wisconsin Score Card.[5]

Flavor	40
Bacteria	20
Texture and body	20
Fat	10
Appearance & color	5
Package	5
	100

(4.) California Score Card.[6] Approved by Dairy Division, University of California, Davis, Calif.

Items	Possible Score	Amount Allowed
Flavor and palatability	50	
Texture and body	25	
Appearance (color)	10	
"A" butterfat	5	
"B" total solids	10	
Total	100	

Analysis:

Per cent	Remarks:
Butterfat	
Total solids	

"A"—A perfect score shall be allowed ice cream containing 10-12 per cent butterfat, inclusive.

Deduct 1 point for each ½ per cent above 12 per cent. Less than 10 per cent score is 0.

"B"—A perfect score shall be allowed ice cream containing 36 per cent total solids or above.

For each per cent less than 36 per cent, deduct 2 points.

Judges { .....
.....

While the manuscript for this chapter was being set up there appeared the "Report of the Committee on Legal Standards and Score Cards for Dairy Products" of the American Dairy Science Association.[2] The following is taken from the above report:

(5). Score card for ice cream tentatively recommended by the above committee:

Flavor	40
Body and texture	25
Fat and solids	10
Bacteria	20
Package	5
	100

SCORE CARD FOR PLAIN SUPERHEATED CONDENSED WHOLE OR SKIM-MILK.

The authors are suggesting the following score card for plain superheated condensed whole or skim-milk. Explanation accompanies each item to be scored. Products of this class are practically always marketed in bulk.

Suggested Score Card for plain superheated whole or skim-milk.

Item	Score	Allowed	Remarks
Viscosity	15		Heavy viscosity. Product to flow freely from container.
Homogeneity.....	15		Smooth, velvety appearance. No visible specks or lumps.
Color	10		Light, white, milky color.
Flavor	30		Good, clean milk flavor. No foreign flavors.
Odor	5		No appreciable odors of any kind.
Appearance container	5		Container to be neat, clean and with all evidences of good workmanship.
Fat	10		No foreign fats. Fat content to conform to legal or trade requirements.
Total solids	10		No preservatives of any kind. Total solids to conform to legal or trade requirements.
Total	100		

SCORE CARD FOR EVAPORATED MILK.

No score cards for evaporated milk are known to have been published. The authors are suggesting the following score card, which takes into consideration the physical properties, appearance of the container, composition and net weight. Explanation is made of each item to be scored.

Among the more common defects encountered when scoring evaporated milk to determine its commercial value, the following can be mentioned:

(1). Viscosity either too light or too heavy, due to improper processing, or to incorrect handling after sterilizing.

(2). Fat separated due to improper homogenization.

(3). Color either too light due to insufficient sterilization, or too dark due to excessive sterilization or to the age of the product.

(4). Off flavor caused by foreign substances, or by decomposition due to bacterial development when the product is not properly sterilized. The use of raw milk products of poor quality may cause off flavors.

(5). Off odors caused usually by bacterial development as a result of improper sterilization.

(6). Sediment upon bottom of cans, caused by the crystallization of the lime salt of citric acid. This appears only in products of considerable age. Particles of foreign matter and lumps of coagulated casein, are sometimes found.

(7). Evaporated milk is usually served at the table out of the original container. For this reason defects in the package should be carefully noted. Soiled and poorly applied labels and dirty or rusty cans all deduct from the score.

(8). The composition and net weight of the cans are of great commercial importance. If under the advertised claims, it detracts from the commercial value of the product, and the score should be very liberally cut. No foreign fats or preservatives of any kind should be present.

SUGGESTED SCORE CARD FOR EVAPORATED MILK.

Owner ..... Date .....

Address..... Brand..... Size.....

Plant where manufactured.....

Item	Score		Remarks:
	Perfect	Allowed	
Viscosity	15		Good viscosity, but not enough to flake in water or coffee. Sufficient to convey correct impression of its value.
Homogeneity..	15		No fat separated. No specks or lumps. Product smooth and homogeneous throughout.
Color	5		Medium color like heavy cream. Neither too white nor too dark. Sufficient color to insure safe sterilization.
Flavor	30		Rich, nutty flavor. Cooked taste not too pronounced. No foreign flavors.
Odor	2		No appreciable odors of any kind.
Sediment	3		No lumps of coagulated casein. No foreign matter. No precipitate of calcium citrate.
Appearance container	5		Neat labels properly applied. Ends of cans well polished, and not bulged.
Fat	10		No foreign fats. No preservatives. Fat content to conform to legal requirements.
Total solids ..	10		Total solids content to be not under legal requirements.
Net weight ...	5		Net weight to be not under amount specified upon the label.
Total	100		

The following score card for evaporated milk is taken from the "Report of the Committee on Legal Standards and Score Cards," cited above:[2]

Tentative Score Card for Evaporated Milk recommended by above committee:

Flavor and odor	40
Body and texture	35
Color	5
Fat content	10
Total solids	10
Adulterants and preservatives must be absent	
	100

The following comments are made by the committee upon the various points in the above score:

Flavor and odor. Perfect: Must be fresh, sweet and free from off flavors. Deduct 1 to 10 points if metallic, rancid and stale. Deduct 40 points if sour, bitter, putrid, gassy or otherwise fermented.

Body and texture. Perfect: Must be creamy, of uniform emulsion, smooth. Deduct 1 to 10 points each for curdy milk, separated or churned milk.

Color. Perfect: Must be creamy. Deduct 1 to 3 points if brown.

Fat content. Perfect: Must contain not less than 9 per cent milk fat. Deduct one point for each one-half per cent less than 9 per cent. Deduct 10 points if less than 7.8 per cent, the present Federal Standard.

Total solids. Perfect: Must contain not less than 28 per cent solids. Deduct 1 point for each 1 per cent or fraction thereof, less than 28 per cent. Deduct 10 points if below 25.5 per cent, present federal standard.

Adulterants and preservatives. Perfect: Must be free from all adulterants or preservatives. If it contains animal or vegetable fats, or other ingredients foreign to the composition of normal milk, or any preservatives deduct 100 per cent.

SCORE CARD FOR SWEETENED CONDENSED MILK

The authors are suggesting the following score card for sweetened condensed skim-milk. It takes into consideration the phys-

ical properties, appearance of the container, composition and net weight. The same score card can be applied with slight modification to both the whole and skim-milk. The various physical properties are the same in either case. In the case of the sweetened condensed skim-milk, the score allowed under fat can be included with the total solids, since composition is of equal importance in either case, and upon it depends to a large extent the commercial value of the product. Brief explanation follows each item in the score.

Large quantities of sweetened condensed milk are sold in bulk, being marketed either in barrels or in milk cans. Bulk sweetened condensed milk can be judged by using the same scale of points as in the case of the canned milk. The appearance of the container is of importance whether the product is marketed in bulk or in cans.

The more common defects encountered in scoring sweetened condensed milk, are the following:

(1). Viscosity either too light, or too heavy.

(2). Fat separated upon the top of the milk or milk sugar separated upon the bottom of the container. These defects occur in varying degrees. Lumps and specks rendering product not homogeneous.

(3). Product slightly or badly discolored, caused by improper manufacturing processes.

(4). Off flavors caused by mould development. Too much cooked or burned taste. Yeasty flavors.

(5). Bad odors described as manurial, tallow, rancid or yeasty.

(6). Container lacks neatness. Too much air space on top of the milk in the container.

(7). Composition and net weight under standard claimed, which detracts considerably from the score.

SUGGESTED SCORE CARD FOR SWEETENED CONDENSED MILK

Owner ..... Date .....
Address..... Brand..... Size.....
Plant .....

Item	Score	Allowed	Remarks:
Viscosity	10		Neither too light nor too heavy in viscosity. Sufficiently fluid to pour from container.
Homogeneity...	10		No fat separated. No milk sugar settled upon bottom of container. Product smooth to taste and free from foreign matter.
Color	5		Slight yellowish cast. Neither too light nor too dark.
Flavor	25		Clean milk flavor without any foreign flavor other than the sugar added.
Odor	2		No appreciable odors of any kind. No signs of yeast development.
Solubility	5		Product to dissolve freely in water, without showing any undissolved matter.
Appearance of container ...	3		Neat label, properly applied. No rust spots upon tin surfaces. If bulk container, should be neat and attractive.
Bacteria.....	10		Bacteria to be present in amounts not to exceed the limits found in properly pasteurized milk. No yeast cells to be present.
Fat	10		Fat to be not under legal or trade standards. Score for fat to be added to total solids in the case of the skimmed product. No foreign fats allowed.
Sugar	5		For sweetened condensed skim-milk, sugar to be about 42.00 per cent, and for whole milk about 44.50 per cent.
Total solids .	10		Milk solids to conform to legal standards. Total solids to conform to trade standards. No adulterants.
Net weight ...	5		To be not under amount specified upon the label.
Total	100		

The following score card for sweetened condensed milk is taken from [2] cited above.

Tentative score card for sweetened condensed milk, recommended by the above committee:

SCORE CARD FOR SWEETENED CONDENSED MILK.

Properties.	Perfect score, per cent.
Flavor and odor	30
Body and texture	25
Color	5
Fat content	10
Milk solids	10
Bacteria	10
Sugar	10
Adulterants and preservatives (must be absent)	...
Total score	100

SUGGESTIONS FOR USE OF SCORE CARD.

Flavor and odor. Perfect; must be fresh, sweet and free from all flavors. Deduct one to ten points each if metallic, rancid, stale, cheesy. Deduct one to thirty points if sour, yeasty or otherwise fermented.

Body and Texture.—Perfect: Must be viscous, smooth and free from lumps of curd, sugar sediment and foreign impurities. Deduct one to five points if rough and sandy, from one to five points if sugar sediment in bottom, from one to five points if fat separation, one to five points if white and yellow buttons, 15 to 25 points if lumps of curd.

Color.—Perfect: Rich cream to yellow. Deduct one to five points if brown.

Fat Content.—Perfect: Must contain not less than 10 per cent milk fat. Deduct one point for each half per cent less than 10 per cent. If below 8 per cent, deduct ten points. Deduct ten points if below 8 per cent, present Federal Standard.

Total Milk Solids.—Perfect: Must contain not less than 32 per cent. Deduct one point for each per cent or fraction thereof below 32 per cent. If below 28 per cent, deduct ten points.

Sugar.—Perfect: The concentration shall be from 60 to 62 per cent. Deduct two points for each per cent concentration below 60 or above 62 per cent. The concentration shall be determined by dividing per cent of sugar by the sum of per cent of sugar and water.

Bacteria.—Make reduction for excessive number of bacteria. Importance of bacterial counts have not as yet been sufficiently considered by the committee to warrant definite recommendations

SCORE CARDS FOR WHOLE MILK, SKIM-MILK AND CREAM POWDERS.

The authors are suggesting the following score card for various powdered milk products. Explanations follow the various items that go to make up the score.

Flavor.—This largely determines the commercial value of all milk powders. The first signs of decomposition usually manifest themselves in the flavor. The principal defect in flavor is caused by rancidity. Any considerable amount of rancidity renders the powder unfit for human food. No method of treatment has yet been found that will completely eliminate rancidity after it has been once developed. The flavor should be very similar to that of the fluid products from which the powders were made.

Odor.—No bad odors of any kind should be noticeable. Bad odors usually indicate either improper manufacturing processes, or decomposition of the product.

Solubility.—The importance of solubility depends upon the use to which the powder is to be placed. Powder made by the spray process is usually more soluble than that made by the roller process. If the powder is to be reconstituted or used for making ice cream, it is very important that it be completely soluble. If it is used for making milk chocolate and other food products, its solubility is relatively not important.

Appearance.—White to slightly yellowish cast. No dark lumps or specks. Powder is to be homogeneous throughout.

Composition.—Water content not to exceed the Federal Standard of 5 per cent. The less water the better, since the presence of water is the most common cause of spoilage. The fat and total solids are to conform to the legal or trade requirements.

SCORE CARDS FOR WHOLE MILK, SKIM-MILK AND CREAM POWDERS.

Item	Score	Allowed	Remarks:
Flavor	50		Fresh, clean flavor resembling that of the fluid products. No signs of rancidity.
Odor	5		Clean, agreeable odor. Suggestion of good milk products.
Solubility	10		For certain uses, powder should be completely soluble. For other uses. solubility is relatively unimportant.
Appearance ...	10		Pleasing appearance. Homogeneous and free from lumps or specks.
Composition	15		Not to exceed 5 per cent of water.
Bacteria	10		Not to exceed limits usually found in properly pasteurized milk.

REFERENCES.

[1] Whitaker, G. M. The Score Card System of Dairy Inspection. Bu. Am. Ind. U. S. Dept. Agri. Cir. 199,122.

[2] Frandsen, J. H. Chairman "Report of Committee on Legal Standards and Score Cards for Dairy Products." Journal of Dairy Science, March 1922, p. 164.

[3] Washburn, R. M. Vermont Station, Bulletin 155, 1910.

[4] Mortensen, M. Iowa Station, Bulletin 123.

[5] Baer, A. C. Wisconsin Station, Bulletin 262, 1916.

[6] California and Southwestern States Ice Cream Manufacturers Ass'n. 1921.

CHAPTER XXI

DEFINITIONS AND STANDARDS FOR DAIRY AND RELATED PRODUCTS

Standards for dairy products group themselves into three subdivisions: namely, federal, state and municipal standards. Obviously these are continuously undergoing changes, and the marked lack of uniformity is very evident.

STANDARDS OF THE U. S. DEPARTMENT OF AGRICULTURE.

The following definitions and standards are taken verbatim from the federal regulations as promulgated by the U. S. Secretary of Agriculture down to the time of going to press.[1] These definitions and standards are all a result of the labors of the "Joint committee on Food and Drug definitions and standards" of which Dr. Julius Hortvet is chairman. The definitions have been adopted in whole or in part by many of the state authorities.

Milk and Milk Products

Milk.—1. Milk is the whole, fresh, clean lacteal secretion obtained by the complete milking of one or more healthy cows, properly fed and kept, excluding that obtained within fifteen days before and five days after calving, or such longer period as may be necessary to render the milk practically colostrum-free.

2. Blended milk is milk modified in its composition so as to have a definite and stated percentage of one or more of its constituents.

3. Pasteurized milk is milk that has been subjected to a temperature not lower than 145 degrees Fahrenheit for not less than thirty minutes. Unless it is bottled hot, it is promptly cooled to 50 degrees Fahrenheit, or lower.

4. Sterilized milk is milk that has been heated at the temperature of boiling water or higher for a length of time sufficient to kill all organisms present.

5. Homogenized milk is milk that has been mechanically treated in such a manner as to alter its physical properties with particular reference to the condition and appearance of the fat globules.

6. Skimmed milk is milk from which substantially all of the milk fat has been removed.

7. Buttermilk is the product that remains when fat is removed from milk or cream, sweet or sour, in the process of churning. It contains not less than eight and five-tenths per cent (8.5%) of milk solids not fat.

8. Goat's milk, ewe's milk, et cetera, are the fresh, clean, lacteal secretions, free from colostrum, obtained by the complete milking of healthy animals other than cows, properly fed and kept, and conform in name to the species of animal from which they are obtained.

9. Condensed milk, evaporated milk, concentrated milk, is the product resulting from the evaporation of a considerable portion of the water from the whole, fresh, clean lacteal secretion obtained by the complete milking of one or more healthy cows, properly fed and kept, excluding that obtained within fifteen days before and ten days after calving, and contains, all tolerances being allowed for, not less than twenty-five and five-tenths per cent (25.5%) of total solids and not less than seven and eight-tenths per cent (7.8%) of milk fat.

In the case of the standard upon evaporated milk, a tentative standard, wherever standardization is being practiced, of 8.00 per cent fat and 26.15 per cent total solids is the one that applies.

10. Sweetened condensed milk, sweetened evaporated milk, sweetened concentrated milk, is the product resulting from the evaporation of a considerable portion of the water from the whole, fresh, clean, lacteal secretion obtained by the complete milking of one or more healthy cows, properly fed and kept, excluding that obtained within fifteen days before and ten days after calving, to which sugar (sucrose) has been added. It contains, all tolerances being allowed for, not less than twenty-eight per cent (28.0%) of total milk solids, and not less than eight per cent (8.0%) of milk fat.

11. Condensed skimmed milk, evaporated skimmed milk, concentrated skimmed milk, is the product resulting from the evapo-

ration of a considerable portion of the water from skimmed milk, and contains, all tolerances being allowed for, not less than twenty per cent (20%) of milk solids.

12. Sweetened condensed skimmed milk, sweetened evaporated skimmed milk, sweetened concentrated skimmed milk, is the product resulting from the evaporation of a considerable portion of the water from skimmed milk to which sugar (sucrose) has been added. It contains, all tolerances being allowed for, not less than twenty-eight per cent (28.0%) of milk solids.

13. Dried milk is the product resulting from the removal of water from milk, and contains, all tolerances allowed for, not less than twenty-six per cent (26.0%) of milk fat, and not more than five per cent (5.0%) of moisture.

14. Dried skimmed milk is the product resulting from the removal of water from skimmed milk, and contains, all tolerances allowed for, not more than five per cent (5.0%) of moisture.

15. Malted milk is the product made by combining whole milk with the liquid separated from a mash of ground barley malt and wheat flour, with or without the addition of sodium chloride, sodium bicarbonate, and potassium bicarbonate in such a manner as to secure the full enzymic action of the malt extract and by removing water. The resulting product contains not less than seven and one-half per cent (7.5%) of butter fat and not more than three and one-half per cent (3.5%) of moisture.

Cream. 1. Cream, sweet cream, is that portion of milk, rich in milk fat, which rises to the surface of milk on standing, or is separated from it by centrifugal force. It is fresh and clean. It contains not less than twenty per cent (20.0%) of milk fat and not more than two-tenths per cent (0.2%) of acid-reacting substances, calculated in terms of lactic acid.

2. Whipping cream is cream which contains not less than thirty per cent (30.0%) of milk fat.

3. Homogenized cream is cream that has been mechanically treated in such a manner as to alter its physical properties, with particular reference to the condition and appearance of the fat globules.

4. Evaporated cream, clotted cream, is cream from which a considerable portion of water has been evaporated.

Cheese. 1. Cheese is the sound product made from curd obtained from the whole, partly skimmed, or skimmed milk of cows, or from the milk of other animals, with or without added cream, by coagulating the casein with rennet, lactic acid, or other suitable enzyme or acid, and with or without further treatment of the separated curd by heat or pressure, or by means of ripening ferments, special molds, or seasoning.

By act of congress, approved June 6, 1896, cheese may also contain added coloring matter.

In the United States, the name "Cheese" unqualified, is understood to mean Cheddar Cheese, American Cheese, American Cheddar Cheese.

2. Whole milk cheese is cheese made from whole milk.

3. Partly skimmed milk cheese is cheese made from partly skimmed milk.

4. Skimmed milk cheese is cheese made from skimmed milk.

Whole Milk Cheeses. 5. Cheddar cheese, American cheese, American Cheddar cheese, is the cheese made by the Cheddar process, from heated and pressed curd obtained by the action of rennet on whole milk. It contains not more than thirty-nine per cent (39%) of water, and, in the water-free substance, not less than fifty per cent (50%) of milk fat.

6. Stirred curd cheese, sweet curd cheese, is the cheese made by a modified Cheddar process, from curd obtained by the action of rennet on whole milk. The special treatment of the curd, after the removal of the whey, yields a cheese of more open, granular texture than Cheddar cheese. It contains, in the water-free substance, not less than fifty per cent (50%) of milk fat.

7. Pineapple cheese is the cheese made by the pineapple Cheddar cheese process, from pressed curd obtained by the action of rennet on whole milk. The curd is formed into a shape resembling a pineapple, with characteristic surface corrugations, and during the ripening period the cheese is thoroughly coated and rubbed with a suitable drying oil, with or without shellac. It contains, in the water-free substance, not less than fifty per cent (50%) of milk fat.

8. Limburger cheese is the cheese made by the Limburger process, from unpressed curd obtained by the action of rennet on

whole milk. The curd is ripened in a damp atmosphere by special fermentation. It contains, in the water-free substance, not less than fifty per cent (50%) of milk fat.

9. Brick cheese is the quick-ripened cheese made by the brick cheese process, from pressed curd obtained by the action of rennet on whole milk. It contains, in the water-free substance, not less than fifty per cent (50%) of milk fat.

10. Stilton cheese is the cheese made by the Stilton process from unpressed curd obtained by the action of rennet on whole milk, with or without added cream. The cheese, ripened by a special blue-green mold, has a mottled or marbled appearance in section.

11. Gouda cheese is the cheese made by the Gouda process, from heated and pressed curd obtained by the action of rennet on whole milk. The rind is colored with saffron. It contains, in the water-free substance, not less than forty-five per cent (45%) of milk fat.

12. Neufchatel cheese is the cheese made by the Neufchatel process, from unheated curd obtained by the combined action of lactic fermentation and rennet on whole milk. The curd, drained by gravity and light pressure, is kneaded or worked into a butter-like consistence and pressed into forms for immediate consumption or for ripening. It contains, in the water-free substance, not less than fifty per cent (50%) of milk fat.

13. Cream cheese is the unripened cheese made by the Neufchatel process from whole milk enriched with cream. It contains, in the water-free substance, not less than sixty-five per cent (65%) of milk fat.

14. Roquefort cheese is the cheese made by the Roquefort process, from unheated, unpressed curd obtained by the action of rennet on the whole milk of sheep, with or without the addition of a small proportion of the milk of goats. The curd is inoculated with a special ripening mold (Penicillium Roqueforti) and ripens with the growth of the mold in the interior. The fully ripened cheese is friable and has a mottled or marbled appearance in section.

15. Gorgonzola cheese is the cheese made by the Gorgonzola process, from curd obtained by the action of rennet on whole milk.

The cheese, ripened in a cool, moist atmosphere by the development of a blue-green mold, has a mottled or marbled appearance in section.

Whole Milk or Partly Skimmed Milk Cheeses. 16. Edam cheese is the cheese made by the Edam process, from heated and pressed curd obtained by the action of rennet on whole milk, or on partly skimmed milk. It is commonly made in spherical form and coated with a suitable oil and a harmless red coloring matter.

17. Emmenthaler cheese, Swiss cheese, is the cheese made by the Emmenthaler process, from heated and pressed curd obtained by the action of rennet on whole milk or on partly skimmed milk, and is ripened by special gas-producing bacteria, causing characteristic "eyes" or holes. The cheese is also known in the United States as "Schweitzer." It contains, in the water-free substance, not less than forty-five per cent (45%) of milk fat.

18. Camembert cheese is the cheese made by the Camembert process, from unheated, unpressed curd obtained by the action of rennet on whole milk or on slightly skimmed milk, and is ripened by the growth of a special mold (Penicillium Camemberti) on the outer surface. It contains, in the water-free substance, not less than forty-five per cent (45%) of milk fat.

19. Brie cheese is the cheese made by the Brie process, from unheated, unpressed curd obtained by the action of rennet on whole milk, on milk with added cream, or on slightly skimmed milk, and is ripened by the growth of a special mold on the outer surface.

20. Parmesan cheese is the cheese made by the Parmesan process, from heated and hard-pressed curd obtained by the action of rennet on partly skimmed milk. The cheese, during the long ripening process, is coated with a suitable oil.

Skimmed Milk Cheeses. 21. Cottage cheese, Schmierkase, is the unripened cheese made from heated (or scalded) curd obtained by the action of lactic fermentation or lactic acid or rennet, or any combination of these agents, on skimmed milk, with or without the addition of butter-milk. The drained curd is sometimes mixed with cream, salted, and sometimes otherwise seasoned.

Whey Cheeses. 22. Whey cheese (so called) is produced by various processes from the constituents of whey. There are a

number of varieties each of which bears a distinctive name, according to the nature of the process by which it has been produced, as, for example, "Ricotta," "Zieger," "Primost," "Mysost."

Sugar and Sugar Products—Sugars. 1. Sugar is the product chemically known as sucrose (saccharose), chiefly obtained from sugar cane, sugar beets, sorghum, maple and palm.

2. Granulated, loaf, cut, milled, and powdered sugars, are different forms of sugar, and contain at least ninety-nine and five-tenths per cent (99.5%) of sucrose.

3. Maple sugar, maple concrete, is the solid product resulting from the evaporation of maple sap or maple syrup.

4. Massecuite, melada, mush sugar, and concrete, are products made by evaporating the purified juice of a sugar-producing plant, or a solution of sugar, to a solid or semi-solid consistence, and in which the sugar chiefly exists in a crystalline state.

Molasses and Refiners' Syrup. 1. Molasses is the product left after separating the sugar from massecuite, melada, mush sugar, or concrete, and contains not more than twenty-five per cent (25%) of water and not more than five per cent (5%) of ash.

2. Refiners' syrup, treacle, is the residual liquid product obtained in the process of refining raw sugars, and contains not more than twenty-five per cent (25%) of water and not more than eight per cent (8%) of ash.

Syrups. 1. Syrup is the sound product made by purifying and evaporating the juice of a sugar-producing plant without removing any of the sugar.

2. Sugar-cane syrup is syrup made by the evaporation of the juice of the sugar-cane or by the solution of sugar-cane concrete, and contains not more than thirty per cent (30%) of water and not more than two and five-tenths per cent (2.5%) of ash.

3. Sorghum syrup is syrup made by the evaporation of sorghum juice or by the solution of sorghum concrete, and contains not more than thirty per cent (30%) of water and not more than two and five-tenths per cent (2.5%) of ash.

4. Maple syrup is syrup made by the evaporation of maple sap or by the solution of maple concrete, and contains not more

than thirty-five per cent (35%) of water, and weighs not less than eleven (11) pounds to the gallon (231 cu. in.)

5. Sugar syrup is the product made by dissolving sugar to the consistence of a syrup, and contains not more than thirty-five per cent (35%) of water.

Glucose Products. 1. Starch sugar is the solid product made by hydrolyzing starch or a starch-containing substance until the greater part of the starch is converted into dextrose. Starch sugar appears in commerce in two forms, anhydrous starch sugar and hydrous starch sugar. The former, crystallized without water of crystallization, contains not less than ninety-five per cent (95%) of dextrose and not more than eight-tenths per cent (0.8%) of ash. The latter, crystallized with water of crystallization, is of two varieties: 70 sugar, also known as brewers' sugar, contains not less than seventy per cent (70%) of dextrose and not more than eight-tenths per cent (0.8%) of ash; 80 sugar, climax or acme sugar, contains not less than eighty per cent (80%) of dextrose and not more than one and one-half per cent (1.5%) of ash.

Honey. 1. Honey is the nectar and saccharine exudations of plants gathered, modified and stored in the comb of honey bees (Aphis mellifica and A. dorsata); is laevo-rotatory, contains not more than twenty-five per cent (25%) of water, not more than twenty-five hundredths per cent (.25%) of ash, and not more than eight per cent (8%) of sucrose.

2. Comb honey is honey contained in the cells of comb.

3. Extracted honey is honey which has been separated from the uncrushed comb by centrifugal force or gravity.

4. Strained honey is honey removed from the crushed comb by straining or other means.

Cacao Products. 1. Cacao beans, cocoa beans, are the seeds of the cacao tree, Theobroma cacao L.

2. Cacao nibs, cocoa nibs, cracked cocoa, is the roasted, broken cacao bean freed as far as is practicable from cacao shell or husk.

3. Chocolate, plain chocolate, bitter chocolate, chocolate liquor, chocolate paste, bitter chocolate coating, is the solid plastic mass obtained by grinding cacao nibs without the removal of fat or other constituents except the germ, and contains not less than fifty per cent (50%) cacao fat and, on the moisture and fat-free

basis, not more than eight and five-tenths per cent (8.5%) total ash, not more than four-tenths per cent (0.4%) ash insoluble in hydrochcloric acid, not more than five and six-tenths per cent (5.6%) ash insoluble in water, not more than seven per cent (7%) crude fiber, not more than four per cent (4%) cacao shell.

4. Sweet chocolate, sweet chocolate coating, is chocolate mixed with sugar (sucrose), with or without the addition of cocoa butter, spices, or other flavoring material, and contains on the moisture, sugar and fat-free basis, no higher percentage of total ash, ash insoluble in hyrochloric acid, ash insoluble in water, crude fiber, or cacao shell, respectively, than is found in the moisture and fat-free residue of chocolate.

5. Cocoa, powdered cocoa, is chocolate deprived of a portion of its fat and finely pulverized and contains not less than twenty per cent (20%) cacao fat and, on the moisture and fat-free basis, no higher percentage of total ash, ash insoluble in hydrochloric acid, ash insoluble in water, crude fiber, or cacao shell, respectively, than is found in the moisture and fat-free residue of chocolate.

6. Sweet cocoa, sweetened cocoa, is cocoa mixed with sugar (sucrose), and contains not more than sixty per cent (60%) sugar in the finished product, and, on the moisture, sugar and fat-free basis, no higher percentage of total ash, ash insoluble in hydrochloric acid, ash insoluble in water, crude fiber, or cacao shell respectively, than is found in the moisture and fat-free residue of chocolate.

7. Milk chocolate, milk cocoa, sweet milk chocolate, and sweet milk cocoa, are chocolate, cocoa, sweet chocolate, and sweet cocoa, respectively, to which milk has been added in the course of their preparation and which contain not less than twelve per cent (12%) of whole milk solids in the finished product.

Flavoring Extracts.—1. A flavoring extract is a solution in ethyl alcohol of proper strength of the sapid and odorous principles drived from an aromatic plant, or parts of the plant, with or without its coloring matter, and conforms in name to the plant used in its preparation.

2. Almond extract is the flavoring extract prepared from oil of bitter almonds, free from hydrocyanic acid, and contains not less than one per cent (1%) by volume of oil of bitter almonds.

2a. Oil of bitter almonds, commercial, is the volatile oil obtained from the seed of the bitter almond (Amygdalus communis L.), the apricot (Prunus armeniaca L.), or the peach (Amygdalus persica L.).

3. Anise extract is the flavoring extract prepared from oil of anise, and contains not less than three per cent (3%) of oil of anise.

3a. Oil of anise is the volatile oil obtained from the anise seed.

4. Celery seed extract is the flavoring extract prepared from celery seed or the oil of celery seed, or both, and contains not less than three-tenths per cent (0.3%) by volume of oil of celery seed.

4a. Oil of celery seed is the volatile oil obtained from celery seed.

5. Cassia extract is the flavoring extract prepared from oil of cassia, and contains not less than two per cent (2%) by volume of oil of cassia.

5a. Oil of cassia is the lead-free volatile oil obtained from the leaves or bark of Cinnamomum cassia Bl. and contains not less than seventy-five per cent (75%) by weight of cinnamic aldehyde.

6. Cinnamon extract is the flavoring extract prepared from oil of cinnamon, and contains not less than two per cent (2%) by volume of oil of cinnamon.

6a. Oil of cinnamon is the lead-free volatile oil obtained from the bark of the Ceylon cinnamon (Cinnamomum zeylanicum Breyne), and contains not less than sixty-five per cent (65%) by weight of cinnamic aldehyde and not more than ten per cent (10%) by weight of eugenal.

7. Clove extract is the flavoring extract prepared from oil of cloves, and contains not less than two per cent (2%) by volume of oil of cloves.

7a. Oil of cloves is the lead-free, volatile oil obtained from cloves.

8. Ginger extract is the flavoring extract prepared from ginger, and contains in each one hundred (100) cubic centimeters the alcohol-soluble matters from not less than twenty (20) grams of ginger.

9. Lemon extract is the flavoring extract prepared from oil of lemon or from lemon peel, or both, and contains not less than five per cent (5%) by volume of oil of lemon.

9a. Oil of lemon is the volatile oil obtained, by expression or alcoholic solution, from the fresh peel of the lemon (Citrus Limomum L.), has an optical rotation (25° C.) of not less than +60° in a 100-millimeter tube, and contains not less than four per cent (4%) by weight of citral.

10. Terpeneless extract of lemon is the flavoring extract prepared by shaking oil of lemon with dilute alcohol, or by dissolving terpeneless oil of lemon in dilute alcohol, and contains not less than two-tenths per cent (0.2%) by weight of citral derived from oil of lemon.

10a. Terpeneless oil of lemon is oil of lemon from which all or nearly all of the terpens have been removed.

11. Nutmeg extract is the flavoring extract prepared from oil of nutmeg, and contains not less than two per cent (2%) by volume of oil of nutmeg.

11a. Oil of nutmeg is the volatile oil obtained from nutmegs.

12. Orange extract is the flavoring extract prepared from oil of orange, or from orange peel, or both, and contains not less than five per cent (5%) by volume of oil of orange.

12a. Oil of orange is the volatile oil obtained, by expression or alcoholic solution, from the fresh peel of the orange (Citrus aurantium L.), and has an optical rotation (25°C.) of not less than +95° in a 100-millimeter tube.

13. Terpeneless extract of orange is the flavoring extract prepared by shaking oil of orange with dilute alcohol, or by dissolving terpeneless oil of orange in dilute alcohol, and corresponds in flavoring strength to orange extract.

13a. Terpeneless oil of orange is oil of orange from which all or nearly all of the terpenes have been removed.

14. Peppermint extract is the flavoring extract prepared from oil of peppermint, or from peppermint, or both, and contains not less than three per cent (3%) by volume of oil of peppermint.

14a. Peppermint is the leaves and flowering tops of Mentha piperita L.

14b. Oil of peppermint is the volatile oil obtained from pepperment, and contains not less than fifty per cent (50%) by weight of menthol.

15. Rose extract is the flavoring extract prepared from otto of roses, with or without red rose petals, and contains not less than four-tenths per cent (0.4%) by volume of otto of roses.

15a. Otto of roses is the volatile oil obtained from the petals of Rosa damascent Mill., R. centrifolia L., or R. moschata Herrm.

16. Savory extract is the flavoring extract prepared from oil of savory, or from savory, or both, and contains not less than thirty-five hundredths per cent (0.35%) by volume of oil of savory.

16a. Oil of savory is the volatile oil obtained from savory.

17. Spearmint extract is the flavoring extract prepared from oil of spearmint, or from spearmint, or both, and contains not less than three per cent (3%) by volume of oil of spearmint.

17a. Spearmint is the leaves and flowerings tops of Mentha spicata L.

17b. Oil of spearmint is the volatile oil obtained from spearmint.

18. Star anise extract is the flavoring extract prepared from oil of star anise, and contains not less than three per cent (3%) by volume of oil of star anise.

18a. Oil of star anise is the volatile oil distilled from the fruit of the star anise (Illicium verum Hook).

19. Sweet basil extract is the flavoring extract prepared from oil of sweet basil, or from sweet basil, or both, and contains not less than one-tenth per cent (0.1%) by volume of oil of sweet basil.

19a. Sweet basil is the leaves and tops of Ocymum basilicum L.

19b. Oil of sweet basil is the volatile oil obtained from basil.

20. Sweet marjoram extract, marjoram extract, is the flavoring extract prepared from the oil of marjoram, or from marjoram, or both, and contains not less than one per cent (1%) by volume of oil of marjoram.

20a. Oil of marjoram is the volatile oil obtained from marjoram.

21. Thyme extract is the flavoring extract prepared from oil of thyme, or from thyme, or both, and contains not less than two-tenths per cent (0.2%) by volume of oil of thyme.

21a. Oil of thyme is the volatile oil obtained from thyme.

22. Tonka extract is the flavoring extract prepared from tonka bean, with or without sugar or glycerin, and contains not less than one-tenth per cent (0.1%) by weight of coumarin extracted from the tonka bean, together with a corresponding proportion of the other soluble matters thereof.

22a. Tonka bean is the seed of Coumarouna adorata Abulet (Dipteryx odorata (Aubl.). Willd.)

23. Vanilla extract is the flavoring extract prepared from vanilla bean, with or without sugar or glycerin, and contains in one hundred (100) cubic centimeters the soluble matters from not less than ten (10) grams of the vanilla bean.

23a. Vanilla bean is the dried, cured fruit of Vanilla planifolia Andrews.

24. Wintergreen extract is the flavoring extract prepared from oil of wintergreen, and contains not less than three per cent (3%) by volume of oil of wintergreen.

24a. Oil of wintergreen is the volatile oil distilled from the leaves of the Gaultheria procumbens L.

The state and territorial standards prevailing, as far as could be ascertained at time of going to press, are given in Table 151. This table follows closely the legal standards for dairy products issued May 1st, 1916, by the U. S. Department of Agriculture, and which was subsequently revised by Taylor and Thomas.[2] Numerous further revisions have been made, based upon information contained in letters or circulars obtained at original sources. In a few instances it has been found impossible to obtain any confirmatory information.

STATE BACTERIA STANDARDS.

The only states that have adopted bacteria standards are the following:

California.—In milk as **Note** (1); cream as **Note** (2).

Connecticut.—In milk 100,000 per cc., in cream 5,000,000 per cc. After pasteurizing in milk 50,000 per cc., in cream 100,000 per cc.

Delaware.—In milk, 100,000 per cc., Cream as **Note** (7).

Georgia.—In milk 500,000 per cc.

Hawaii.—In milk, 1,000,000 per cc.
Idaho.—In milk 500,000 per cc., cream, 500,000 cc.
Montana.—In milk or ice cream, 500,000 per cc.
New Hampshire.—In milk, 500,000 per cc.
New York.—In milk and cream as **Note** (13).
Oklahoma.—In milk as **Note** (16).
Porto Rico.—In milk, 100,000 per cc.
Vermont.—In milk, 200,000 per cc.
Washington.—In milk, 400,000 per cc.

STANDARDIZATION OF PASTEURIZATION—TIME AND TEMPERATURES.

The States that have established control of pasteurization and the standards adopted are as follows:—

Arizona.—145° F. for 30 minutes.
California.—140-145° F. for 25 minutes. (5).
Connecticut.—142-148°F. for 30 minutes.
Delaware.—145° F. for 30 minutes.
Indiana.—145° F. for 30 minutes or 160° F. for 30 seconds. (9).
Iowa.—145° F. for 30 minutes.
Louisiana.—140° F. for 20 minutes.
Massachusetts.—140-145° F. for 30 minutes.
Michigan.—145° F. for 30 minutes or 185° flash.
Minnesota.—145° F. for 30 minutes or 180° flash.
Montana.—140-145° F. for 30 minutes.
Nebraska.—(5).
New Jersey.—142-145° F. for 30 minutes.
Nevada.—140° F. for 25 minutes or 170° F. flash method.
New York.—142-145° F. for 30 minutes.
Oklahoma.—145° F. for 25 minutes, or 150° F. for 20 minutes, or 170° F., flash method.
Oregon.—140° F. for 30 minutes (5).
Tennessee.—145° F. for 30 minutes or 165° F. for 30 seconds.
Vermont.—145° F. for 30 minutes.
Washington.—140° F. for 25 minutes.
Wyoming.—145° F. for 30 minutes or 165° for 30 seconds.

These standards were established in the manner indicated under the heading "Standards Established by" in the tables.

TABLE 151.
State and Territorial Standards.

STATE	Milk					Butter		Condensed Milk				Ice Cream				Cheese		Standards Established by
	Total Solids	Solids Not Fat	Fat	Skim-Milk Total Solids	Cream Fat	Fat	Moisture	Sweetened		Unsweetened		Plain		Fruit or Nut		Fat in Water Free Substance		
								Fat	Total Milk Solids	Fat	Total Solids	Fat	Gelatin	Fat	Gelatin	Whole Milk	Skim-milk	
	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	
Alabama	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	No state standards.
Alaska	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	No territorial standards.
Arizona (29)	.....	.....	3.25	9.25	18	80	16	.....	.....	.....	.....	10	.....	8	.....	50	(6)	Act of legislature.
Arkansas	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	No state standards.
California (22)	11.50	8.5	3	8.8	18	80	.....	(3)	(3)	(3)	(3)	10	.60	8	.60	50	(4)	Act of legislature.
Colorado	.....	.....	3	.....	16	80	16	7.7	28	7.7	24	10	.....	10	.....	50	(6)	Act of legislature.
Connecticut	11.75	8.5	3.25	.....	16	.....	.....	.....	.....	8.68	28 (23)	8	.....	6	.....	.....	.....	Act of legislature.
Delaware (24)	.....	.....	.....	.....	16	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	State Board of Health under legislative authority.
District of Columbia (3)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Act of Congress.
Florida (3)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Legislature provides for adoption of federal standards.
Georgia	11.75	8.5	3.25	9.25	18	82.5	.....	.....	.....	.....	.....	8 (8)	.....	8	.....	50	.....	State veterinarian under legislative authority.
Hawaii (3)	11.5	8.5	3	.....	18	(3)	.....	(3)	(3)	(3)	(3)	14	.....	12	.....	(3)	(3)	Act of legislature and Food Department under legislative authority.
Idaho (31)	11.0	8	3.2	9 3	18	82.5	.....	7.7	.....	7.8	34.3	14	.....	12	.....	30	15	Act of legislature and by Public Welfare Department under legislative authority.
Illinois	.....	8.5	3	9.25	18	82.5	.....	8.	8	7.8	25.5	8	.....	8	.....	50	.....	Act of legislature and Food Standard Commission under legislative authority.
Indiana	.....	8.5	3.25	9.25	18	82.5	16	(3)	(3)	7.8	25.5	8	.70(28)	8	.....	50	.....	Act of legislature and State Board of Health under legislative authority.
Iowa	11.5	.....	3	.....	16	80	.....	(3)	(3)	(3)	(3)	12	1.0	10	1.0	(3)	(3)	By act of legislature and Dairy and Food Commission under legislative authority.
Kansas (21)	.....	.....	3.25	9.25	18	80	16	8	28	7.8	25.5	10	.....	12	.....	50	.....	State Board of Health under legislative authority.

Kentucky (21)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10	.....	8	.....	.....	.....	State Board of Health under legislative authority.
Louisiana	12	8.5	3.5	8	18	.....	.....	8	28	7.8	25.5	10	.....	8	.....	.....	.....	Act of legislature and State Board of Health under legislative authority.
Maine	11.75	8.5	3.5	.....	18	.....	.....	.....	.....	.....	.....	14	.....	12	.....	.....	.....	Act of legislature.
Maryland (21)	.....	8.5	3.25	9.25	18	82.5	.....	8	28	7.8	25.5	8	.....	6(10)	.....	50	.....	Legislative act provides for adoption of standards and definitions under U. S. Food and Drugs Act.
Massachusetts (21)	12	.....	3.35	9.3	15	80	.....	.....	.....	.....	.....	7	.....	7	.....	.....	.....	Act of legislature and State Board of Health under legislative authority.
Michigan (21)	11.5	8.5	3.	.....	18	.....	.....	.....	.....	.....	.....	10	.....	8	.....	30	under 30	Act of legislature.
Minnesota (3)	.....	.....	.....	.....	20	80	16	8	28	7.8	25.5	12	.....	10	.....	50		Act of legislature and State Dairy and Food Commission under legislative authority.
Mississippi (21)	11.75	8.5	3.0	.....	18	82.5	.....	8	28	7.8	25.5	8	.5	8	.5	50	.....	Act of legislature.
Missouri (21)	11.75	8.50	3.25	9.25	18	82.5	16	8	28	7.8	25.5	8	.....	8	.....	50	.....	Act of legislature.
Montana (21)	11.75	8.5	3.25	9.90	20	82.5	16	8	28	7.8	25.5	10	.....	9	.....	50	.....	Act of legislature.
Nebraska	.....	.....	3	9.25	18	.....	.....	.....	.....	.....	.....	14	.....	12	.....	.....	.....	Act of legislature and Food, Drug, Dairy and Oil Commission under legislative authority.
Nevada (21)	.....	.....	.....	.....	22	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Legislative act provides for federal standards.
New Hampshire	.....	.....	3.35	8.50	18	.....	16	(3)	(3)	(3)	(3)	14	.....	14	.....	(3)	(3)	Act of legislature and State Board of Health under legislative authority.
New Jersey	11.5	8.5	3.	.....	16	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Act of legislature and Board of Health.
New Mexico	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	No state standards.
New York	11.5	.....	3	8.5	18	.....	.....	8	28	7.8	25.5	8	.....	6.5	.....	.....	(13) (14)	Act of legislature and Public Health Council under legislative authority.
North Carolina	11.75	8.5	3.25	9.25	18	82.5	16	7.7	28	7.7	28.0	8	.....	8	.....	50	.....	State Agricultural Department under legislative authority.
North Dakota	12.00	.....	3.00	15	15	.....	15	(3)	(3)	(3)	(3)	11	.....	10	.....	(3)	(3)	Food department under legislative authority.
Ohio	12.	9.	3	.....	18	.....	.....	.....	.....	25% of T. S.	.....	.....	.....	.....	.....	30	under 20	Act of legislature.
Oklahoma	12	9.5	3.5	.....	18	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	State Board of Agriculture under legislative authority.
Oregon	11.7	8.5	3.2	.....	18	80	.....	.....	.....	7.8	25.5	8	.....	6	.....	50	25	Act of legislature.
Pennsylvania	12	.....	(18) (3.25)	.....	18	80	16	.....	.....	.....	.....	8	.....	6	.....	32	(19)	Act of legislature.
Philippine Isl'ds	11.75	8.5	3.25	(3)	18	82.5	.....	8	28	7.8	25.5	14	.....	12	.....	50	(3)	By Health Department under legislative authority.

TABLE 151—Continued.

STATE	Milk			Skim-Milk Total Solids	Cream Fat	Butter		Condensed Milk				Ice Cream				Cheese		Standards Established by
	Total Solids	Solids Not Fat	Fat			Fat	Moisture	Sweetened		Unsweetened		Plain		Fruit or Nut		Fat in Water Free Substance		
								Fat	Total Milk Solids	Fat	Total Solids	Fat	Gelatin	Fat	Gelatin	Whole Milk	Skim-milk	
	Per Cent (3)	Per Cent (3)	Per Cent (3)	Per Cent	Per Cent (3)	Per Cent (3)	Per Cent (3)	Per Cent (3)	Per Cent (3)	Per Cent (3)	Per Cent (3)	Per Cent (3)	Per Cent	Per Cent (3)	Per Cent	Per Cent (3)	Per Cent (3)	
Porto Rico.....																		U. S. Food and Drugs Act and Board of Health under legislative authority.
Rhode Island (32)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Food and Dairy Department under legislative authority.
South Carolina...	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	No state standards.
South Dakota....	11.75	8.5	3.25	9.25	18	80	.....	7.7	28	7.7	28	14	.....	12	.....	50	.....	Act of legislature.
Tennessee.....	.....	8.5	3.25	9.25	18	.....	.....	.....	.....	.....	.....	(28)8	.....	8	.....	.....	.....	Act of legislature Food and Drug Dept. under legislative authority.
Texas.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Food and Drug Department under legislative authority.
Utah (21).....	12	8.8	3.2	9	18 24 30	80	16	.....	.....	.....	.....	.....	.....	.....	.....	30	.....	Act of legislature.
Vermont (21)....	11.75	8.5	3.25	9.25	18	.....	.....	.....	.....	.....	.....	8	.....	8	.....	.....	.....	Act of legislature and State Board of Health under legislative authority.
Virginia.....	11.75	8.5	3.25	9.25	18	82.5	16	7.7	28.0	7.8	26.5	8	.....	8	.....	50	.....	Food Department under legislative authority.
Washington.....	.....	8.5	3.25	8.8	18	80	.....	7.8	25.5	7.8	25.5	(28)8	.....	8	.....	50	(20)	Act of legislature.
West Virginia....	12	.....	3	.....	16	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Public Health Council under legislative authority. No State standards.
Wisconsin.....	.....	8.5	3	9	18	82.5	.....	8	28	7.8	25.5	12	.....	10	.....	43	.....	Act of legislature.
Wyoming.....	.....	.....	.....	.....	.....	80	.....	80	28	7.8	25.5	10	.....	10	.....	.....	.....	Dairy, Food and Oil Department under legislative authority.

NOTES

(1). Grade A.—raw—less than 100,000 bacteria per cc.
Grade A—pasteurized—less than 200,000 bacteria per cc. before pasteurization; less than 15,000 after pasteurization.
Grade B—less than 1 million bacteria per cc. before pasteurization; less than 50,000 after pasteurization.

(2). Not more than two times the bacteria in the corresponding grade of milk.

(3). U. S. Department of Agriculture Standards.

(4). Half skim, 25 per cent fat.

(5). Unless milk is from herds free from tuberculosis as evidenced by the tuberculin test.

(6). Less than 50 per cent of total solids.

(7). Raw cream—less than 500,000 bacteria per cc. Pasteurized cream—less than 250,000 bacteria per cc.

(8). Bacteria standard for milk and ice cream is 500,000 per cc.

(9). Compulsory pasteurization of milk products entering into the manufacture of ice cream.

(10). Fruit ice cream, 4 per cent fat; nut ice cream, 6 per cent fat.

(11). Skim-milk from creameries required to be pasteurized to 180° F.

(12). "By terms of law enacted in 1917, provision is made for the sale of milk, provided that such be 'pure natural milk' and that 'every can, bottle, or other container in which such milk is shipped, sold or delivered, at wholesale or retail, is plainly labeled so as to show its guaranteed composition.'"

(13). Grade A, Raw:
Milk—not more than 60,000 bacteria per cc.
Cream—not more than 300,000 bacteria per cc.
Grade A, pasteurized: (Milk or cream before pasteurization not more than 200,000 bacteria per cc.)
Milk—not more than 30,000 bacteria per cc.
Cream—not more than 150,000 bacteria per cc.
Grade B, raw:
Milk—not more than 200,000 bacteria per cc.
Cream—not more than 750,000 bacteria per cc.
Grade B, pasteurized: (Milk or cream before pasteurization, no more than 1,500,000 bacteria per cc.)
Milk—not more than 100,000 bacteria per cc.
Cream—not more than 500,000 bacteria per cc.

(14). Cheese made from skimmed or partially skimmed milk must be branded with the words, "Skim-milk Cheese;" if it contains 13 per cent milk fat or over, it may be branded, "Medium Skim-milk Cheese," or if it contains 18 per cent of milk fat or over, it may be branded "Special Skim-milk Cheese."

(15). Milk falling under the standard for whole milk shall be termed skim-milk.

(16). "Bottled raw milk must not contain more than 100,000 bacteria from May 1 until Oct. 1. All pasteurized bottled milk not more than 50,000 in the same period of time."

(17). "All milk and cream used in manufacture of creamery butter and ice cream for commercial purposes, and all milk bought to be resold, must be pasteurized."

(18). "If a person accused of violating section one of this act shall furnish satisfactory affidavit that nothing has been added to or taken from the milk in question, which is otherwise pure and wholesome, and is not below three (3) per centum of butterfat, . . . no prosecution shall be instituted against said person."

(19). Cheese—full cream, not less than 32 per cent butter fat. Three fourth cream not less than 24 per cent butterfat. One-half cream not less than 16 per cent butter fat. One-fourth cream not less than 8 per cent butter fat. Skimmed—less than 8 per cent butter fat.

(20). Cheese—half skim not less than 25 per cent butter fat, and quarter skim not less than 12 per cent butter fat, in the water-free substance.

(21). United States standards followed upon products not specified in State laws.

(22). Ice milk (frozen) 2.40 per cent fat and .60 per cent gelatin.

NOTES—(Continued)

(23). Composition is to be indicated upon the label, in the case of evaporated milk.
(24). No state standards. Nearly all incorporated municipalities control sale of dairy products by ordinance.
(25). Ice cream to contain not less than 20 per cent milk solids, and to weigh not less than 4.75 lbs. per gallon.
(26). Plain ice cream to contain not less than 18 per cent of milk solids. Fruit ice cream not less than 15 per cent of milk solids.
(27). Ice cream to contain 32.5 per cent total solids.
(28). Ice cream to contain not less than 18.00 per cent milk solids.
(29) Milk for making butter, cheese and condensed milk may contain 3.0 per cent fat.
(30). Ice cream to contain not less than 30 per cent of total solids.
(31). Data given not confirmed at original sources.
(32). No state standards upon dairy products, excepting oleomargarine.

STATISTICS ON MILK AND CREAM REGULATIONS IN CITIES AND TOWNS.

In 1916 a committee from the Official Dairy Instructors' Association[3] made a study of the milk and cream regulations in 694 cities and towns in the United States The cities were classified into four groups according to population and studies were made of the various regulations. Some of the information obtained is shown in detail in Table 152 to 172 as follows:

TABLE 152.
Grouping of Cities and Regulations Available for Study.

	POPULATION				TOTAL CITIES
	5,000 to 25,000	25,000 to 100,000	100,000 to 500,000	Over 500,000	
Number of cities and towns represented in this survey	511	133	42	8	694
Number of cities and towns reporting no regulations	218	5	0	0	223
Number of cities and towns from which partial regulations were available	59	3	0	0	62
Number of complete regulations of cities and towns represented	234	125	42	8	409

TABLE 153.
Regulations Relating to Water.

	POPULATION				TOTAL CITIES
	5,000 to 25,000	25,000 to 100,000	100,000 to 500,000	Over 500,000	
Number of regulations limiting percentage of water	79	53	21	7	160
Number of regulations not referring to percentage of water	155	72	21	1	249
Number of regulations limiting water content of milk to					
89.00 per cent	1	0	1	0	2
88.51 per cent	0	11	0	0	11
88.50 per cent	3	0	2	2	7
88.25 per cent	2	2	1	0	5
88.00 per cent	44	29	12	4	89
87.51 per cent	1	2	0	0	3
87.50 per cent	12	4	3	1	20
87.05 per cent	0	1	0	0	1
87.00 per cent	12	3	2	0	17
80.50 per cent	1	0	0	0	1
80.00 per cent	2	1	0	0	3
8.00 per cent	1	0	0	0	1

TABLE 154.
Regulations Relating to Total Solids.

Number of regulations requiring a minimum percentage of total solids	106	60	25	7	198
Number of regulations not referring to percentage of total solids	128	65	17	1	211

	POPULATION				TOTAL CITIES
	5,000 to 25,000	25,000 to 100,000	100,000 to 500,000	Over 500,000	
Number of regulations having or calling for					
13.00 per cent total solids	13	2	2	0	17
12.51 per cent total solids	2	2	1	0	5
12.50 per cent total solids	15	1	3	1	20
12.15 per cent total solids	6	2	0	0	8
12.00 per cent total solids	59	46	15	4	124
11.75 per cent total solids	2	2	1	0	5
11.50 per cent total solids	7	5	3	2	17
11.00 per cent total solids	1	0	0	0	1
10.50 per cent total solids	1	0	0	0	1

TABLE 155.

Regulations Relating to Solids Not Fat.

	POPULATION				TOTAL CITIES
	5,000 to 25,000	25,000 to 100,000	100,000 to 500,000	Over 500,000	
Number of regulations calling for minimum percentage of solids not fat	38	24	16	1	79
Number of regulations not referring to percentage of solids not fat	198	103	26	7	334
Number of regulations calling for					
10.50 per cent solids not fat	0	1	0	0	1
9.50 per cent solids not fat	1	1	0	0	2
9.25 per cent solids not fat	0	1	0	0	1
9.00 per cent solids not fat	6	2	1	0	9
8.75 per cent solids not fat	1	2	4	0	7
8.50 per cent solids not fat	28	14	11	1	54
8.25 per cent solids not fat	0	1	0	0	1
8.00 per cent solids not fat	2	2	0	0	4

TABLE 156.

Regulations Relating to Fat in Milk.

Number of regulations requiring a minimum percentage of fat	137	81	32	7	257
Number of regulations not referring to percentage of fat	97	44	10	1	152
Number of regulations calling for					
4.00 per cent fat	0	0	1	0	1
3.70 per cent fat	2	0	0	0	2
3.60 per cent fat	2	1	1	0	4
3 51 per cent fat	0	1	1	0	2
3.50 per cent fat	35	10	7	1	53
3.40 per cent fat	3	1	1	0	5
3.35 per cent fat	8	2	0	0	10
Number of regulations calling for					
3.30 per cent fat	0	1	0	0	1
3.25 per cent fat	20	19	6	1	46
3.20 per cent fat	0	2	2	0	4
3.00 per cent fat	67	43	12	5	127
2.50 per cent fat	0	1	1	0	2

TABLE 157. Regulations Relating to Bacteria in Milk

	POPULATION				TOTAL CITIES
	5,000 to 25,000	25,000 to 100,000	100,000 to 500,000	Over 500,000	
Number of regulations having a legal limit for bacteria in milk	95	66	24	4	189
Number of regulations not referring to bacterial limits	139	59	18	4	220
Number of regulations having a numerical limit for bacteria of					
50,000 per cubic centimeter	1	1	0	0	2
100,000 per cubic centimeter	21	11	3	0	35
150,000 per cubic centimeter	1	3	1	0	5
200,000 per cubic centimeter	6	7	4	0	17
250,000 per cubic centimeter	7	4	2	0	13
300,000 per cubic centimeter	7	10	2	0	19
350,000 per cubic centimeter	0	0	0	0	0

TABLE 158. Regulations Relating to Fat in Cream.

Number of regulations requiring a minimum percentage of fat	87	49	20	5	161
Number of regulations not referring to percentage of fat	147	76	22	3	248
Number of regulations calling for					
25.0 per cent fat	3	1	0	0	4
22.0 per cent fat	1	0	0	0	1
20.0 per cent fat	13	3	5	0	21
19.0 per cent fat	1	0	0	0	1
18.0 per cent fat	42	29	12	2	85
17.5 per cent fat	1	0	0	0	1
16.0 per cent fat	10	6	3	0	19
15.0 per cent fat	13	10	0	3	26
14.0 per cent fat	2	0	0	0	2
10.0 per cent fat	1	0	0	0	1

TABLE 159. Regulations Relating to Tuberculin Test.

	POPULATION				TOTAL CITIES
	5,000 to 25,000	25,000 to 100,000	100,000 to 500,000	Over 500,000	
Number of regulations specifying that cows					
Be tuberculin tested	53	21	21	3	98
Be tested once a year	20	16	14	0	50
Be tested once in two years	2	1	0	0	3
Be tested twice a year	0	1	0	0	1
Be tested at discretion of inspector	0	0	1	0	1

TABLE 160.

Regulations Relating to Bacteria in Cream.

	POPULATION				TOTAL CITIES
	5,000 to 25,000	25,000 to 100,000	100,000 to 500,000	Over 500,000	
Number of regulations having a numerical limit for bacteria of:					
400,000 per cubic centimeter	1	1	1	0	3
500,000 per cubic centimeter	49	27	11	2	89
1,000,000 per cubic centimeter	2	2	0	1	5
5,000,000 per cubic centimeter	0	0	0	1	1
Number of regulations having a legal limit for bacteria in cream	7	15	8	0	30
Number of regulations not referring to bacterial limits in cream	227	110	34	8	379
Number of regulations having a numerical limit for bacteria of					
50,000 per cubic centimeter	1	0	0	0	1
100,000 per cubic centimeter	0	1	0	0	1
150,000 per cubic centimeter	0	1	0	0	1
200,000 per cubic centimeter	1	1	0	0	2
250,000 per cubic centimeter	0	0	0	0	0
300,000 per cubic centimeter	0	1	2	0	3
350,000 per cubic centimeter	0	1	0	0	1
500,000 per cubic centimeter	1	4	5	0	10
800,000 per cubic centimeter	1	0	0	0	1
1,000,000 per cubic centimeter	3	6	1	0	10

TABLE 161.

Regulations Relating to Temperature.

	POPULATION				TOTAL CITIES
	5,000 to 25,000	25,000 to 100,000	100,000 to 500,000	Over 500,000	
Number of regulations calling for a temperature not higher than					
65° F.	6	1	2	0	9
63° F.	0	2	0	0	2
60° F.	27	19	11	1	58
58° F.	0	1	0	0	1
56° F.	1	0	0	0	1
55° F.	12	13	2	0	27
50° F.	46	36	15	5	102
45° F.	1	0	0	1	2

TABLE 162. Regulations Relating to Specific Gravity.

	POPULATION				TOTAL CITIES
	5,000 to 25,000	25,000 to 100,000	100,000 to 500,000	Over 500,000	
Number of regulations prescribing a minimum specific gravity	0	31	7	0	38
Number of regulations requiring a specific gravity of					
1030.0	0	2	0	0	2
1029.0	0	4	0	0	4
10.29	0	2	0	0	2
1.030	0	1	1	0	2
1.029–1.033	0	0	3	0	3
1.029	0	20	3	0	23
1.028	0	1	0	0	1
1.027	0	1	0	0	1

TABLE 163. Regulations Relating to Water Supply.

	POPULATION				TOTAL CITIES
	5,000 to 25,000	25,000 to 100,000	100,000 to 500,000	Over 500,000	
Number of regulations requiring that water supply be					
Clean	70	26	11	0	107
Fresh	23	3	4	0	30
Convenient	7	0	4	1	12
Abundant	29	14	9	1	53
Free from contamination	54	30	12	2	98
Pure	0	6	8	0	14
Well chosen	0	1	0	0	1
Suitable	.0	1	0	0	1

TABLE 164. Regulations Relating to Milkers.

	POPULATION				TOTAL CITIES
	5,000 to 25,000	25,000 to 100,000	100,000 to 500,000	Over 500,000	
Number of regulations requiring that					
Milker be free from disease	109	54	22	5	190
Milker be clean	78	40	13	0	131
Milker wear clean clothes	61	34	12	1	108
Milker wash hands before milking	52	41	16	2	111
Milker brush nails before milking	8	4	2	0	14
Milking be done with clean dry hands	46	22	10	1	79
Hands be not wet during milking	12	22	4	0	38

TABLE 165.

Conditions Which Render Milk Legally Unsalable.

	POPULATION				TOTAL CITIES
	5,000 to 25,000	25,000 to 100,000	100,000 to 500,000	Over 500,000	
Number of regulations which forbid the sale of milk under conditions stated below	234	115	39	8	396
Number of regulations which do not mention when milk is unsalable	0	10	3	0	13
Number of regulations which mention					
Diseased cows	160	85	34	8	287
Cows kept in filthy quarters	67	36	12	0	115
Milk containing visible dirt	46	29	6	1	82
Cows kept in crowded and unhealthy stable	79	43	20	2	144

	POPULATION				TOTAL CITIES
	5,000 to 25,000	25,000 to 100,000	100,000 to 500,000	Over 500,000	
Number of regulations which mention					
Sediment	1	0	1	0	2
Sour	1	0	0	0	1
Sophisticated	1	0	0	0	1
Mouldy	1	2	0	0	3
Decayed	3	0	0	0	3
Acid plus 2	1	6	1	0	8
Garget	1	0	0	0	1
Abnormal	3	0	0	0	3
Unnatural	0	1	2	0	3
Bitter	0	1	0	0	1
Decomposed	0	1	0	0	1
Glucose	0	3	0	0	3
Garlic	0	1	0	0	1
Unhealthy	0	9	4	0	13
Stringy	0	2	2	0	4
Cabbage	0	2	0	0	2
Slimy	0	0	2	1	3
Sugar waste	0	0	1	0	1

TABLE 165—Continued.

	POPULATION				TOTAL CITIES
	5,000 to 25,000	25,000 to 100,000	100,000 to 500,000	Over 500,000	
Number of regulations which mention					
Milk when adulterated	150	77	30	3	260
When cows are fed distillers' grains	59	42	17	7	125
When cows are fed swill	58	41	14	3	116
From cows a certain number of days before calving	139	86	27	6	258
From cows a certain number of days after calving	138	89	27	6	260
Foreign substance in milk	107	65	28	5	205
Putrefactive feeds	57	38	21	4	120
Feeds unwholesome	73	50	22	0	145
Feeds impure	47	38	10	0	95
Milk unclean	23	16	5	0	44
Cows fed on refuse	41	28	9	2	80
Cows fed garbage	34	34	13	3	84
Cows fed wet brewers' grains	32	22	12	2	68
Cows given contaminated water	19	10	18	3	50
Cows fed vinegar waste	6	6	6	0	18
Pus in milk	8	4	1	0	13
Cows fed beet pulp	5	1	0	0	6
Cows fed turnips	2	2	0	0	4
Cows fed starch waste	8	4	0	0	12
Diseased cows	1	2	0	0	3
Insanitary foods	1	0	0	0	1
Frozen foods	1	0	0	0	1
Ropy milk	8	6	0	0	14
Bloody milk	14	11	4	1	30
Milk above legal limits in bacteria	94	18	0	0	112
Milk above legal limits in temperature	139	44	2	0	185
Improper milk	2	4	3	0	9
Watered	1	0	0	0	1
Diluted	3	0	0	0	3
Silage	1	1	0	0	2
Unsound	1	0	0	0	1
Tainted	1	1	1	0	3
Musty	1	0	0	0	1
Insects	1	0	0	0	1
Hairs	1	0	0	0	1
Flies	1	0	0	0	1

TABLE 166.

Regulations in Regard to Parturition.

	POPULATION				TOTAL CITIES
	5,000 to 25,000	25,000 to 100,000	100,000 to 500,000	Over 500,000	
Number of regulations providing for a specific number of days before and after parturition that the milk cannot be used	139	89	27	6	261
Number of regulations which do not cover this point	95	36	15	2	148
Number of regulations prohibiting the sale of milk					
60 days before parturition	4	0	0	0	4
45 days before parturition	1	0	0	0	1
42 days before parturition	0	1	0	0	1
40 days before parturition	0	1	0	0	1
30 days before parturition	19	3	1	0	23
21 days before parturition	6	5	0	0	11
20 days before parturition	11	7	3	0	21
15 days before parturition	89	63	23	5	180
14 days before parturition	4	1	0	0	5
12 days before parturition	0	1	0	0	1
10 days before parturition	1	2	0	1	4
8 days before parturition	4	1	0	0	5
4 days before parturition	0	1	0	0	1
Number of regulations prohibiting the sale of milk					
21 days after parturition	1	0	0	0	1
15 days after parturition	5	3	1	0	9
12 days after parturition	7	7	3	0	17
10 days after parturition	28	12	5	1	46
9 days after parturition	3	2	0	0	5
8 days after parturition	4	0	1	0	5
7 days after parturition	10	8	2	1	21
6 days after parturition	4	3	2	1	10
5 days after parturition	72	52	13	3	140
4 days after parturition	3	2	0	0	5
3 days after parturition	1	0	0	0	1

TABLE 167.

Regulations Relating to Milk House.

	POPULATION				TOTAL CITIES
	5,000 to 25,000	25,000 to 100,000	100,000 to 500,000	Over 500,000	
Number of regulations requiring that milk houses be					
Clean	132	75	22	3	232
Used for no other purpose	82	46	19	3	150
Have tight sound floor	46	27	13	1	87
Be well ventilated	62	27	11	1	101
Be well lighted	51	24	11	1	87
Be well drained	36	20	14	1	71
Number of regulations requiring sterilizing equipment in the milk house	13	16	2	0	31
Number of regulations requiring that milk house be					
Well screened	63	44	16	2	125
Provided with suitable racks	5	4	6	0	15
Provided with cooling tanks	8	12	5	1	26
Located a certain distance from the stable	45	15	11	0	71
Number of regulations requiring milk house to be located					
100 feet from stable	3	2	0	0	5
50 feet from stable	4	0	1	0	5
40 feet from stable	1	0	0	0	1
25 feet from stable	1	0	1	0	2
20 feet from stable	1	0	0	0	1
15 feet from stable	1	0	0	0	1
12 feet from stable	0	0	1	0	1
Number of regulations requiring milk house to be located					
10 feet from stable	1	0	1	0	2
Away from stable	28	10	2	0	40
At a distance from stable	2	0	0	0	2
With an air space between milk house and stable	1	0	0	0	1
Apart	1	3	0	0	4
Distance not given	1	1	5	0	7
Number of regulations requring that					
Milk house be free from odors	52	22	6	0	80
No swine be within a stated distance	27	7	0	1	35
No swine be within 100 feet	1	0	0	0	1
No swine be within 50 feet	26	0	0	0	26
Swine be "not near"	0	0	1	0	1

TABLE 167—Continued.

	POPULATION				TOTAL CITIES
	5,000 to 25,000	25,000 to 100,000	100,000 to 500,000	Over 500,000	
Number of regulations requiring that milk house					
Be a separate room	74	48	26	3	151
Be a distance from privy	56	40	13	1	110
300 feet from privy	0	1	0	0	1
200 feet from privy	1	0	0	0	1
100 feet from privy	2	3	1	0	6
75 feet from privy	0	0	1	0	1
50 feet from privy	4	1	1	1	7
40 feet from privy	2	0	0	0	2
25 feet from privy	2	3	0	0	5
15 feet from privy	2	3	0	0	5
10 feet from privy	0	0	1	0	1
Away from privy	16	18	0	0	34
Not near privy	6	1	0	0	7
Distant	21	0	0	0	21
Not mentioned	0	10	9	0	19

TABLE 168. Regulations Relating to Milk Utensils.

	POPULATION				TOTAL CITIES
	5,000 to 25,000	25,000 to 100,000	100,000 to 500,000	Over 500,000	
Number of regulations requiring that only round cornered utensils be used	6	5	0	0	11
Number of regulations requiring that only utensils with smooth joints be used	5	4	7	3	19
Number of regulations requiring that utensils be made of non-absorbent material	36	15	7	0	58
Number of regulations requiring that utensils be well constructed	30	17	14	1	62
Number of regulations requiring that utensils be clean	112	71	22	1	206
Washed	94	52	17	2	165
Scalded	48	28	14	3	93
Sterilized	121	73	25	7	226
Used for no other purpose	56	33	17	3	109
Protected from contamination	52	51	16	1	120
Number of regulations represented in the above items	184	114	37	7	342
Number of regulations containing nothing regarding the cleaning of utenlils		11	5	1	67

TABLE 169. Regulations Relating to City Milk Plants.

	POPULATION				TOTAL CITIES
	5,000 to 25,000	25,000 to 100,000	100,000 to 500,000	Over 500,000	
Number of regulations requiring that milk plant shall					
Be well lighted	9	8	7	2	26
Be well ventilated	6	7	6	2	21
Be well screened	10	18	6	1	35
Be well drained	7	8	6	2	23
Be properly constructed	2	7	5	2	16
Be properly equipped	8	6	8	0	22
Be clean	19	27	19	5	70
Be free from flies	5	1	2	2	10
Be free from odors	4	1	2	1	8
Be free from contamination	2	3	1	2	8
Have sewer connections	2	3	2	0	7
Have facilities for cleaning utensils in plant	2	5	5	3	15
Have facilities for storing milk in plant	3	2	0	2	7
Have running hot and cold water	2	5	1	1	9
Have separate room for handling milk	4	2	5	1	12
Have tight walls and ceilings	2	5	6	1	14
Have tight floors	9	7	7	2	25
Score a certain number of points	5	5	3	0	13
Shall score not less than					
40 points	0	1	0	0	1
50 points	1	1	0	0	2
60 points	0	1	1	0	2
70 points	2	2	1	0	5
75 points	0	0	1	0	1
not mentioned	2	0	0	0	2

TABLE 170. Regulations Relating to Delivery Wagons.

	POPULATION				TOTAL CITIES
	5,000 to 25,000	25,000 to 100,000	100,000 to 500,000	Over 500,000	
Number of regulations requiring					
Drivers to be free from disease	110	53	14	0	177
Wagons to be covered	42	30	12	1	85
Wagons to be clean	88	52	15	3	158
Wagons not to haul refuse or be used for any other purpose	61	41	14	0	116
Name of dealer to appear on wagon	112	78	23	4	217
Number of license to appear on wagon	123	74	29	6	232

TABLE 171. Regulations Relating to the Milk.

	POPULATION				TOTAL CITIES
	5,000 to 25,000	25,000 to 100,000	100,000 to 500,000	Over 500,000	
Number of regulations requiring that					
Milk be removed immediately from barn...	89	45	17	3	154
Milk be cooled immediately.....	89	61	18	3	171
Milk be aerated.....	23	11	6	0	40
Fore milk be discarded.....	4	6	6	1	17
Milk must not be strained in barn.....	4	4	2	1	11
Milk must be stored only in milk house....	9	33	6	0	48
Milk be milked into covered pails.....	20	14	8	2	44
Milk be graded.....	0	5	4	0	9

TABLE 172. Regulations Relating to the Scoring of Dairy Farms.

	POPULATION				TOTAL CITIES
	5,000 to 25,000	25,000 to 100,000	100,000 to 500,000	Over 500,000	
Minimum score of dairy farms					
80.....	2	1	0	0	3
75.....	1	0	0	0	1
65.....	2	0	1	1	4
60.....	8	12	3	0	23
55.....	0	2	1	1	4
50.....	3	1	0	0	4
46.....	0	0	1	0	1
45.....	3	2	0	0	5
40.....	6	4	0	0	10
Not given.....	1	0	0	0	1

GRADING MILK AND CREAM.

The old system of purchasing milk and cream by weight or measure with little attention being given to quality has been largely displaced in recent years by the adoption of methods which insure a higher price to the producer for rich milk or cream and for milk or cream of high sanitary quality. In order to apply this principle to the purchase of milk for the New York City supply the Board of Health of that city established different grades for both milk and cream and formulated regulations governing distribution.

These regulations are given in detail as follows:

"Regulations of the Department of Health of the City of New York Relative to the Grading of Milk and Cream.—Sec. 156. Milk and cream; grades and designations.—All milk or cream held, kept, offered for sale, sold, or delivered in the City of New York shall be so held, kept, offered for sale, sold or delivered in accordance with the Regulations of the Board of Health and under any of the following grades or designations and not otherwise:

"Grade A: For Infants and Children."

1. Milk or cream (raw).
2. Milk or cream (pasteurized).

"Grade B: For Adults."

1. Milk or cream (pasteurized).

"Grade C.: For Cooking and Manufacturing Purposes Only."

1. Milk or cream not conforming to the requirements of any of the subdivisions of Grade A or Grade B, and which has been pasteurized according to the Regulations of the Board of Health or boiled for at least two (2) minutes.
2. Condensed skimmed milk.

The provisions of this section shall apply to milk or cream used for the purpose of producing or used in preparation of sour milk, buttermilk, homogenized milk, milk curds, sour cream, Smeteny, Kumyss, Matzoon, Zoolak, and other similar products or preparations, provided that any such product or preparation be held, kept, offered for sale, sold, or delivered in the City of New York.

"Regulations Governing the Sale of Grade 'A' Milk or Cream (Raw).—Definition.—Grade 'A' milk or cream (raw) is milk or cream produced and handled in accordance with the Regulations as herein set forth.

"Regulation 113. Tuberculin test and physical condition.—Only such animals shall be admitted to the herd as are in good physical condition, as shown by a thorough physical examination accompanied by a test with the diagnostic injection of tuberculin, within a period of one month previous to such admission. The test

is to be carried out as prescribed in the Regulations of the Department of Health governing the tuberculin testing of cattle. A chart recording the result of the official test must be in the possession of the Department of Health before the admission of any animal to the herd.

"Regulation 114. Bacterial contents.—Grade 'A' milk (raw) shall not contain more than 60,000 bacteria per c. c. and cream more than 300,000 bacteria per c. c. when delivered to the consumer or at any time prior to such delivery.

"Regulation 115. Scoring of dairies.—All dairies producing milk of this designation shall score at least 25 points on equipment and 50 points on methods, or a total score of 75 points on an official dairy score card approved by the Department of Health.

"Regulation 116. Time of delivery.—Milk of this designation shall be delivered to the consumer within 36 hours after production.

Regulation 117. Bottling.—Milk or cream of this designation shall be delivered to the consumer only in bottles, unless otherwise specified in the permit.

"Regulation 118. Labeling.—The caps of all bottles containing Grade 'A' milk or cream (raw) shall be white, with the grade and designation 'Grade A (raw)' the name and address of the dealer, and the word 'certified' when authorized by the state law, clearly, legibly, and conspicuously displayed on the outer side thereof. No other word, statement, design, mark, or device shall appear on that part of the outer cap containing the grade and the designation unless authorized and permitted by the Department of Health. A proof print or sketch of such cap, showing the size and arrangement of the lettering thereon, shall be submitted to and approved by the said Department before being attached to any bottle containing milk or cream of the said grade and designation.

"**Additional Regulations Governing the Sale of Grade 'A' Milk or Cream (Pasteurized).** Definition.—Grade 'A' milk or cream (pasteurized) is milk or cream handled and sold by dealers holding permits therefor from the Board of Health, and produced and handled in accordance with the Regulations as herein set forth.

"Regulation 119. Physical examination of cows.—All cows producing milk or cream of this designation must be healthy, as determined by a physical examination made annually by a duly licensed veterinarian.

"Regulation 120. Bacterial content.—Milk of this designation shall not contain more than 30,000 bacteria per c. c. and cream more than 150,000 bacteria per c. c. when delivered to the consumer or at any time after pasteurization and prior to such delivery. No milk supply averaging more than 200,000 bacteria per c. c. shall be pasteurized to be sold under this designation.

"Regulation 121. Scoring of dairies.—All dairies producing milk or cream of this designation shall score at least 25 points on equipment and 43 points on methods, or a total score of 68 points on an official score card approved by the Department of Health.

"Regulation 122. Times of delivery.—Milk or cream of this designation shall be delivered within 36 hours after pasteurization.

"Regulation 123. Bottling.—Milk or cream of this designation shall be delivered to the consumer only in bottles unless otherwise specified.

Regulation 124. Bottles only.—The caps of all bottles containing Grade 'A' milk or cream (pasteurized) shall be white with the grade and designation 'Grade A (pasteurized),' the name and address of the dealer, the date and hours between which pasteurization was completed, and the place where pasteurization was performed, clearly, legibly, and conspicuously displayed on the outer side thereof. No other word, statement, design, mark, or device shall appear on that part of the outer cap containing the grade and designation, unless authorized and permitted by the Department of Health. A proof print or sketch of such cap, showing the size and arrangement of the lettering thereon, shall be submitted to and approved by the said Department before being attachd to the bottles containing milk of the said grade and designation. No other words, statement, design or device shall appear upon the outer cap unless approved by the Department of Health. The size and arrangement of lettering on such cap must be approved by the Department of Health.

"Regulation 125. Pasteurization.—Only such milk or cream shall be regarded as pasteurized as has been subjected to a tem-

perature of from 142 to 145 degrees F. for not less than thirty minutes.

"**Additional Regulations Governing the Sale of Grade 'B' Milk or Cream (Pasteurized).** Definition.—Grade 'B' milk or cream (pasteurized) is milk or cream produced and handled in accordance with the minimum requirements of the Regulations herein set forth and which has been pasteurized in accordance with the Regulations of the Department of Health for pasteurization.

"Regulation 128. Physical examination of cows.—All cows producing milk or cream of this designation must be healthy as determined by a physical examination made and approved by a duly licensed veterinarian.

"Regulation 129. Bacterial contents.—No milk under this designation shall contain more than 100,000 bacteria per c. c. and no cream shall contain more than 500,000 bacteria per c. c. when delivered to the consumer, or at any time after pasteurization and prior to such delivery. No milk supply averaging more than 1,500,000 bacteria per c. c. shall be pasteurized in this city under this designation. No milk supply averaging more than 300,000 bacteria per c. c. shall be pasteurized outside the City of New York to be sold in said city under this designation.

"Regulation 130. Scoring of dairies.—Dairies producing milk or cream of this designation shall score at least 20 points on equipment and 35 points on methods, or a total score of 55 points on an official score card approved by the Department of Health.

"Regulation 131. Time of delivery.—Milk of this designation shall be delivered within 36 hours. Cream shall be delivered within seventy-two (72) hours after pasteurization. Cream intended for manufacturing purposes may be stored in cold storage and held thereat in bulk at a temperature not higher than 32 degrees F. for a period conforming with the laws of the state of New York. Such cream shall be delivered in containers, other than bottles, within twenty-four (24) hours after removal from cold storage and shall be used only in the manufacture of products in which cooking is required.

"Regulation 132. Bottling.—Milk of this designation may be delivered in cans or bottles.

"Regulation 133—Labeling.—The caps of all bottles containing Grade 'B' milk (pasteurized) and the tags attached to all cans containing Grade 'B' milk or cream (pasteurized) shall be white with the grade and designation 'Grade B(pasteurized),' the name and address of the dealer, and the date when and place where pasteurization was performed, clearly, legibly, and conspicuously displayed on the outer side thereof. The caps of all bottles containing Grade 'B' cream (pasteurized) shall be white with the grade and designation 'Grade B Cream (pasteurized),' the name and address of the dealer, and the date when and the place where bottled, clearly, legibly, and conspicuously displayed on the outer side thereof. No other word, statement, design, mark, or device shall appear on that part of the outer cap or tag containing the grade and designation unless authorized and permitted by the Department of Health. A proof print or sketch of such cap or tag, showing the size and arrangement of the lettering thereon shall be submitted to and approved by the said Department before being attached to any receptacle containing milk or cream of the said grade and designation.

"Regulation 134. Pasteurization.—Only such milk or cream shall be regarded as pasteurized as has been subjected to a temperature of from 142 to 145 degrees F. for not less than thirty minutes.

"Additional Regulations Governing the Sale of Grade 'C' Milk or Cream (Pasteurized) (for Cooking and Manufacturing Purposes Only). Definition.—Grade 'C' milk or cream is milk or cream not conforming to the requirements of any of the subdivisions of Grade 'A' or Grade 'B' and which has been pasteurized according to the Regulations of the Board of Health or boiled for at least two minutes.

"Regulation 136. Physical examination of cows.—All cows producing milk or cream of this designation must be healthy as determined by a physical examination made by a duly licensed veterinarian.

"Regulation 137. Bacterial content.—No milk of this designation shall contain more than 300,000 bacteria per c. c. and no cream of this grade shall contain more than 1,500,000 bacteria per c. c. after pasteurization.

"Regulation 138. Scoring of dairies.—Dairies producing milk or cream of this designation must score at least 40 points on an official score card approved by the Department of Health.

"Regulation 139. Time of delivery.—Milk or cream of this designation shall be delivered within 48 hours after pasteurization.

"Regulation 140. Bottling.—Milk or cream of this designation shall be delivered in cans only.

"Regulation 141. Labeling.—The tags attached to all cans containing Grade 'C' milk (for cooking) shall be white with the grade and designation 'Grade C Milk (for cooking),' the name and address of the dealer, and the date when and place where pasteurization was performed, clearly, legibly, and conspicuously displayed thereon. No other word, statement, design, mark, or device shall appear on that part of the tag containing the grade and designation, unless authorized and permitted by the Department of Health. A proof print or sketch of such tag, showing the size and arrangement of the lettering thereon shall be submitted to and approved by the said Department before being attached to the cans containing milk of the said grade and designation. The cans shall have properly sealed metal covers painted red.

"Regulation 142. Pasteurization.—Only such milk or cream shall be regarded as pasteurized as has been subjected to a temperature of 145 degrees, for not less than thirty minutes.

"**Additional Regulations Governing the Sale of Condensed Skim-Milk.** Definition.—Condensed skimmed milk is condensed milk in which the butter-fat is less than twenty-five (25) per cent of the total milk solids.

"Regulation 145. Cans to be painted blue.—The cans containing condensed skimmed milk shall be colored a bright blue and shall bear the words "Condensed Skimmed Milk" in block letters at least two inches high and two inches wide, with a space of at least one-half inch between any two letters. The milk shall be delivered to the person to whom sold, in can or cans, as required in this regulation, excepting when sold in hermetically sealed cans.

"Additional Regulations Governing the Labeling of Milk or Cream Brought Into, Delivered, Offered for Sale, and Sold in New York City. Regulation 146. Labeling of milk or cream.—Each container or receptacle used for bringing milk or cream into or delivering it in the City of New York shall bear a tag or label stating, if shipped from a creamery or dairy, the location of the said creamery or dairy, the date of shipment, the name of the dealer, and the grade of the product contained therein, except as elsewhere provided for delivery of cream in bottles.

"Regulation 147. Labeling of milk or cream to be pasteurized.—All milk or cream brought into the City of New York to be pasteurized shall have a tag affixed to each and every can or other receptacle indicating the place of shipment, date of shipment, and the words 'to be pasteurized at (stating location of pasteurizing plants).'

"Regulation 148. Mislabeling of milk or cream.—Milk or cream of one grade or designation shall not be held, kept, offered for sale, sold, or labeled as milk or cream of a higher grade or designation.

"Regulation 149. Word, statement, design, mark or device on label.—No word, statement, design, mark, or device regarding the milk or cream shall appear on any cap or tag attached to any bottle, can, or other receptacles containing milk or cream which words, statement, design, mark, or device is false or misleading in any particular.

"Regulation 150. Tags to be saved.—As soon as the contents of such container or receptacle are sold, or before the said container is returned or otherwise disposed of, or leaves the possession of the dealer, the tag thereon shall be removed and kept on file in the store, where such milk or cream has been sold, for a period of two months thereafter, for inspection by the Department of Health.

"Regulation 151. Record of milk or cream delivered.—Every wholesale dealer in the city of New York shall keep a record in his main office in the said city, which shall show from which place or places milk or cream, delivered by him daily to retail stores in the city of New York, has been received and to whom delivered,

and the said record shall be kept for a period of two months, for inspection by the Department of Health, and shall be readily accessible to the inspectors of the said Department at all times.''

REFERENCES.

[1]Circular 136, U. S. Department of Agriculture.

[2]Taylor, Geo. B. and Thomas, Harry N. Mimeographed circular, Legal Standards for Dairy Products.

[3]Report of the committee of Statistics of the milk and cream. Regulations of the Official Dairy Instructions Ass'n. Jour. Dairy Science Vol. 1 No. 1, 1917.

CHAPTER XXII

MISCELLANEOUS INFORMATION REGARDING DAIRY PRODUCTS

Flow Sheets of Various Dairy Products.—Figs. 176 to 191 indicate the various steps commonly taken in the handling of all the common dairy products, under the American methods of manufacture now in general use. They represent the line or the lines of flow of the several products while going through the plant, and make it possible readily to visualize the various operations involved.

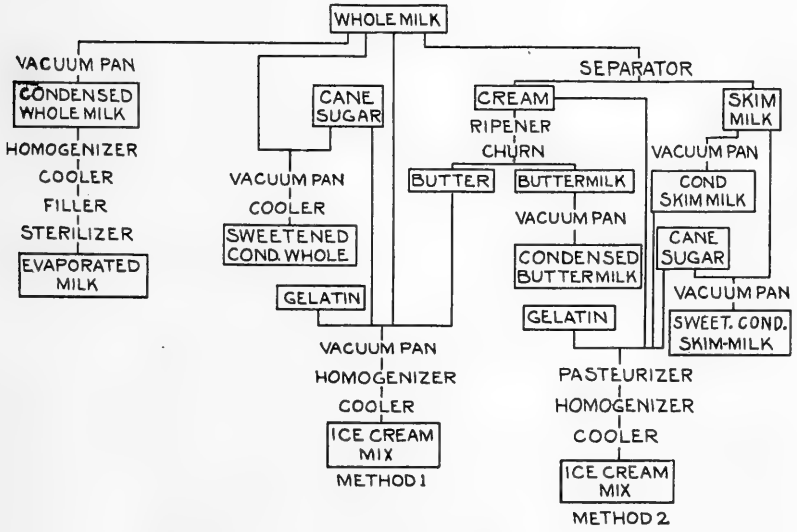

Fig. 176. General Flow Sheet of Milk.

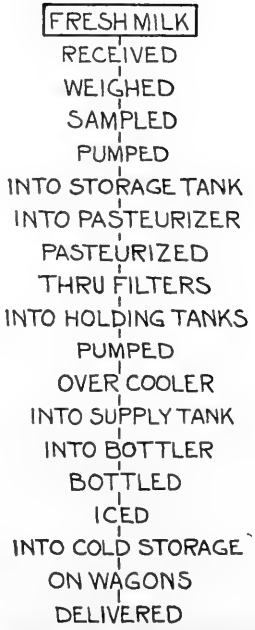

Fig. 177. Flow Sheet of Pasteurized Whole Milk.

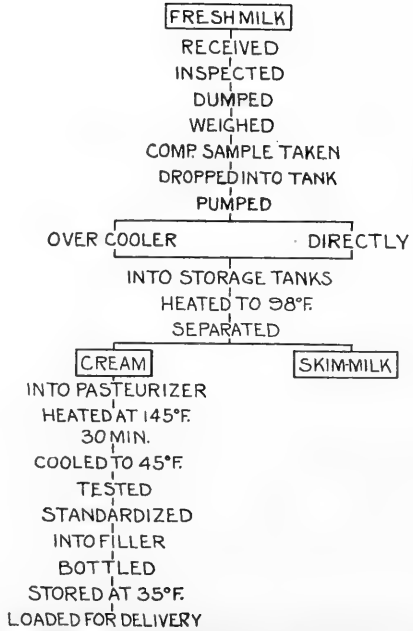

Fig. 178. Flow Sheet of Pasteurized Cream.

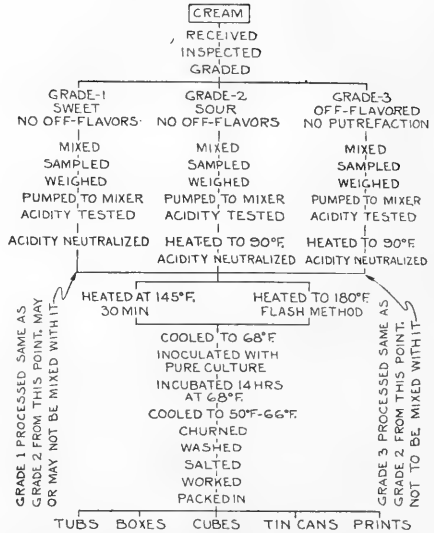

Fig. 179. Flow Sheet of Butter Manufacture at Centralized Creamery.

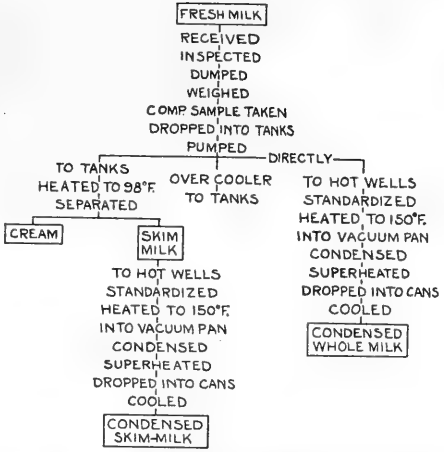

Fig. 180. Flow Sheet of Bulk Condensed Milk Manufacture.

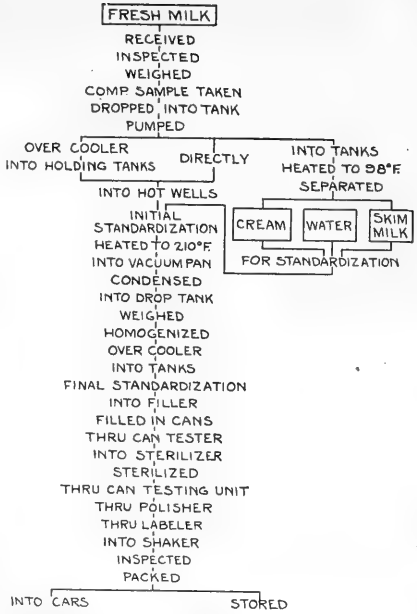

Fig. 181. Flow Sheet of Evaporated Milk Manufacture.

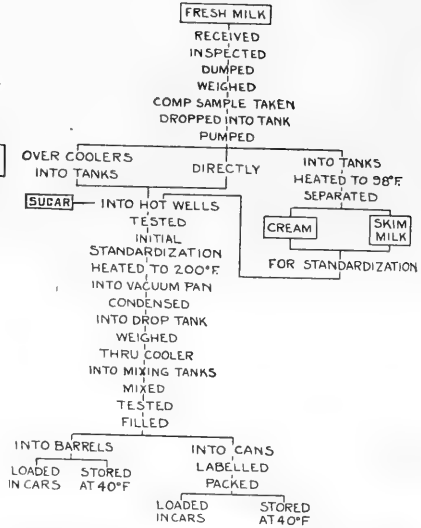

Fig. 182. Flow Sheet of Sweetened Condensed Milk Manufacture.

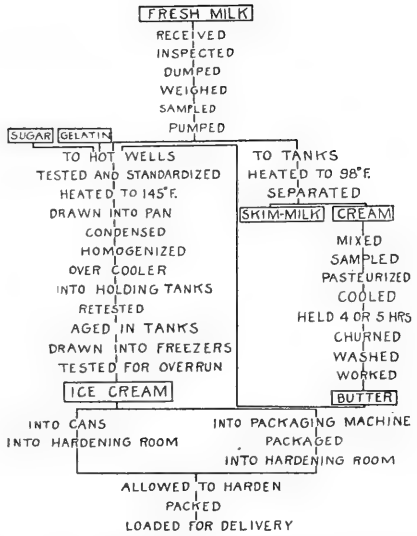

Fig. 183. Flow Sheet of Ice Cream Manufacture. Method I.

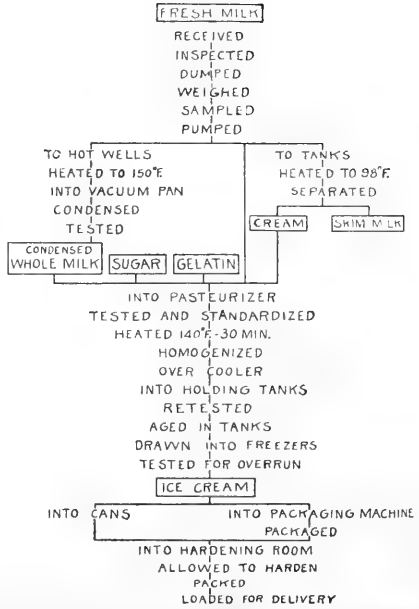

Fig. 184. Flow Sheet of Ice Cream Manufacture. Method II.

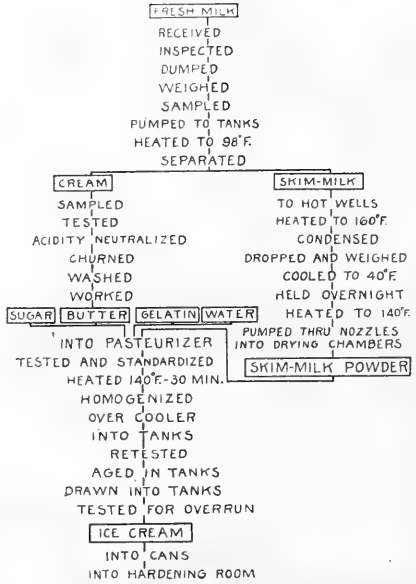

Fig. 185. Flow Sheet of Ice Cream Manufacture. Method III.

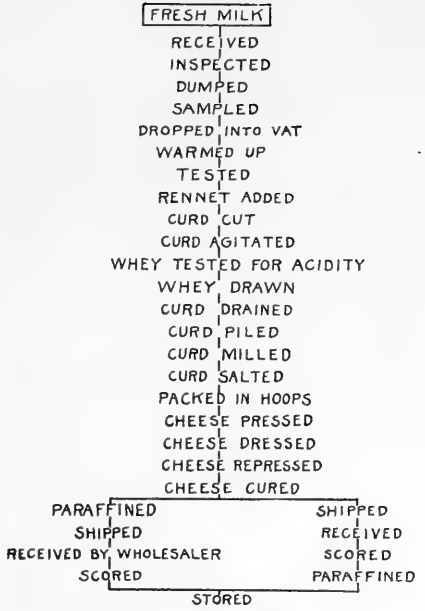

Fig. 186. Flow Sheet of Cheddar Cheese Manufacture.

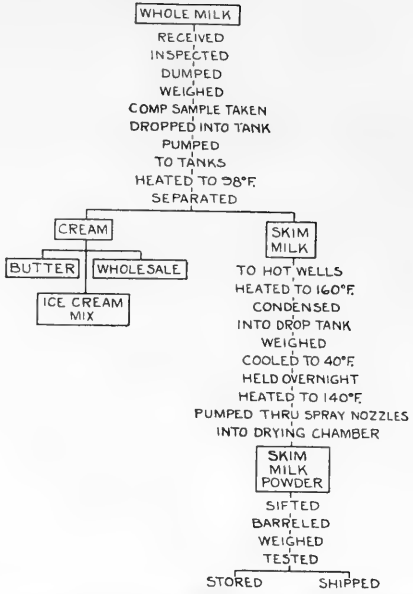

Fig. 187. Flow Sheet of Cream and Skim-milk Powder Manufacture.

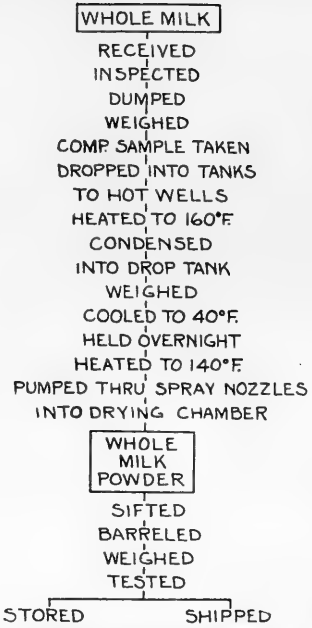

Fig. 188. Flow Sheet of Whole Milk Powder Manufacture.

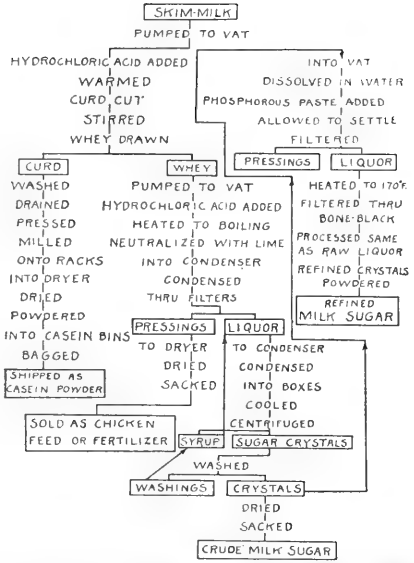

Fig. 189. Flow Sheet of Casein and Milk Sugar Manufacture.

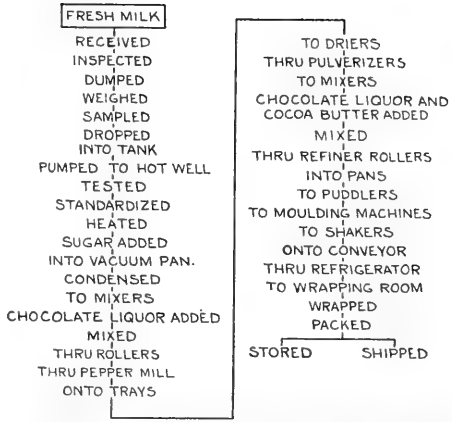

Fig. 190. Flow Sheet of Milk Chocolate Manufacture.

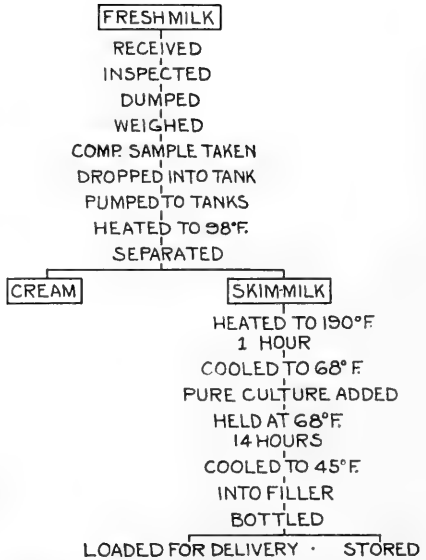

Fig. 191. Flow Sheet of Culture Buttermilk Manufacture.

TEMPERATURES FOR HOLDING, MANUFACTURING AND STORING DAIRY PRODUCTS.

In the handling of dairy products, there is probably no one single factor that influences the quality and the commercial value of the product, so much as temperature. Table 173 lists the temperatures that in good practice give the best results under the various conditions named.

TABLE 173.

Temperatures for Holding, Manufacturing and Storing Dairy Products.

Name of Product.	Temp. ° F. recommended
Fluid milk and skim-milk to be held under 12 hours after milking, not pasteurized	50 or below
Fluid milk and skim-milk to be held under 24 hours after milking, not pasteurized	40
Fluid milk and skim-milk to be held under 48 hours after milking, not pasteurized	34
Fluid milk or skim-milk, pasteurized, to be held 24 hours or less	40
Fluid milk or skim-milk, pasteurized, to be held up to 6 days	34
Fluid milk heated to pasteurizing temperatures and held without cooling up to 6 hours	142 to 145
Cream not pasteurized, to be held 24 hours or less	40
Fluid milk and cream pasteurizing temperatures	140 to 145
Cream pasteurized, to be held up to 10 days	34
Cream pasteurized, to be frozen and held up to 3 months	25
Whey not pasteurized, to be held 6 hours or less	50
Cultured buttermilk, pasteurizing temperature before inoculating	170 to 190
Cultured buttermilk, lactic type, inoculating temperature	68
Cultured buttermilk lactic type, incubating temperature	68
Cultured buttermilk, Bulgaricus type, inoculating temperature	98
Cultured buttermilk, Bulgaricus type, incubating temperature	98
Cultured buttermilk, either type, holding temperature	45 to 50
Buttermilk cultures, either lactic or Bulgaricus type. Holding temperature	In water 35
Ice cream mix to be held for 24 to 96 hours	32 to 40
Ice cream hardening and holding	0 to 5
Evaporated milk hot well temperatures	160 to 212
Evaporated milk, temperature in vacuum pan	125 to 140
Evaporated milk before processing. When canned immediately after condensing	60
Evaporated milk before processing. When canned 24 hours after condensing	42
Evaporated milk before processing. When canned 48 hours after condensing	40

TABLE 173 (Continued).

Evaporated milk after processing. When held before packing to develop leakers	68
Evaporated milk after processing. If consumed within two months after manufacture	Ordinary temperature
Evaporated milk after processing. When held in storage for one year or less	35 to 40
Sweetened condensed milk, hot well temperatures	160 to 212
Sweetened condensed milk, pan temperatures	125 to 140
Sweetened condensed milk. Temperature at which to barrel or can	About 74
Sweetened condensed milk. When held for early consumption	Ordinary temperature
Sweetened condensed milk. When held in storage for one year or less	35 to 40
Bulk unsweetened condensed milk. For consumption inside of one week	40
Butter churning temperatures, Summer	48 to 53
Average about 56° F. Winter	52 to 60
Where cotton seed meal is fed and under certain feed and breed conditions higher churning temperatures may be used.	
Butter in cold storage	—10
Cheese, best temperature for action of rennet in making cheddar cheese	86 to 88
Cheese, high curing temperature, cheddar cheese	60 to 68
Cheese, low curing temperature, cheddar cheese	45 to 50
Cheese in storage	35
Temperature at which milk powder can be heated during manufacture without impairing flavor	140
Milk powder in storage	35 to 40

THE ACTION OF MILK UPON METALS AND CERTAIN PROPERTIES OF METALS AND ALLOYS.

The action of milk upon various metals as well as upon other products used in its handling is of importance in several respects. The principal factors of interest are the influence of the metals upon the flavor of the milk or products derived from it; life and cost of the equipment made from various metals; properties that affect the appearance of the equipment; the ease or the difficulty with which the various metals are kept in a clean, and sanitary condition, and heat transmitting qualities of the various metals.

Relatively little published data is available upon the above subjects. Erf[1] made a considerable study of the influence of various metals upon the flavor of milk. "A solution of dilute lactic acid mixed with citric acid charged slightly with carbon dioxide was first used, as it was very difficult to obtain any re-

action from the small quantities of metal actually dissolved. Then we continued to dilute this with milk, and noted the effect upon the flavor."

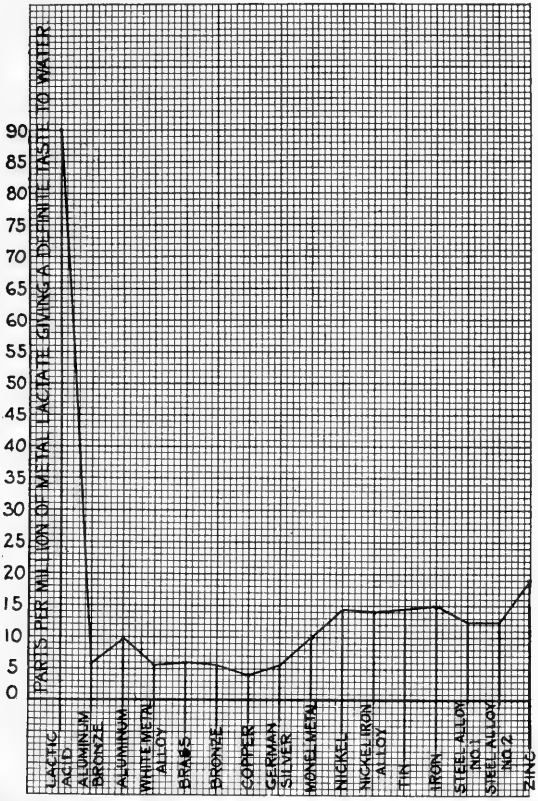

Fig. 192. Parts Per Million of Metallic Lactates required to Impart a Definite Taste to Water. Based Upon Donauer's Results.

The order of solubilities of the various metals was as follows: wrought iron, cast iron, steel, brass, lead, copper and tin. "As nearly as we could calculate about one millionth part of copper would give a decided flavor to the milk. The amount of flavor given by the tin was very small." Careful tests were made in the Research Laboratories of Mojonnier Bros. Co.[2] and the results obtained will be given in this chapter.

The best work reported upon the subject is by Donauer of the Research Laboratories of the Elyria Enamelled Products Co.[3]

Fig. 192 shows the amount in parts per million in water of the various metallic lactates which according to Donauer are required to impart a definite taste to water. No exact data is yet available to indicate the amount of metallic lactates that are required to impart a metallic flavor to milk, or to products derived from milk. It is well known that many or probably all of the metallic salts combine readily with the casein in milk, forming insoluble compounds whose properties and reactions are not well understood. It is not established if there is any chemical reaction between metallic salts and butter fat or other constituents of the milk besides the casein. The evidence at the present time is that a different result should be obtained when the metallic lactates are added to milk, as against when added in equal amounts to water. On account of the compounds formed by metallic salts in milk, probably a larger quantity would be required to impart a metallic flavor to milk than to water.

The solubility of metals in milk is influenced by the temperatures used; by the time of contact of the metal with the milk, and by the acid content of the milk. The results reported by Donauer in the case of whole milk are given under Table 174 for temperatures at 64 and 149° F.

TABLE 174.

Influence of Temperature Upon the Solubility of Metals in Milk Based Upon Donauer's Results. Whole Milk Testing .26 Per Cent Lactic Acid.

Temperature of Experiment		Loss in weight in mg. per sq. cm. per 24 hours							
		Aluminum Bronze	Aluminum	White Metal Alloy	Brass	Bronze	Copper	German Silver	Monel Metal
°F.	°C.								
64	18	.015	.0195	.01	.095	.09	.07	.05	.045
149	65	.250	.57	.08	.06	.055	.04	.08	.07

Temperature of Experiment		Loss in weight in mg. per sq. cm. per 24 hours						
		Nickel	Nickel Iron Alloy	Tin	Iron	Steel Alloy No. 1	Steel Alloy No. 2	Zinc
°F.	°C.							
64	18	.095	.011	.0125	.041	.015	.014	.0575
149	65	.09	.15	.15	1.71	.34	.25	2.18

The results in Table 174 show that in the case of whole milk testing .26 per cent lactic acid more of the metals pass into solution at pasteurizing temperatures than at room temperature. Liedel obtained similar results in the case of copper in fresh whole milk testing .18 per cent acid as follows:—

At 65°F. for 24 hours, .024 mg. dissolved per sq. cm.

At 140° F. for 7 hours, .071 mg. dissolved per sq. cm.

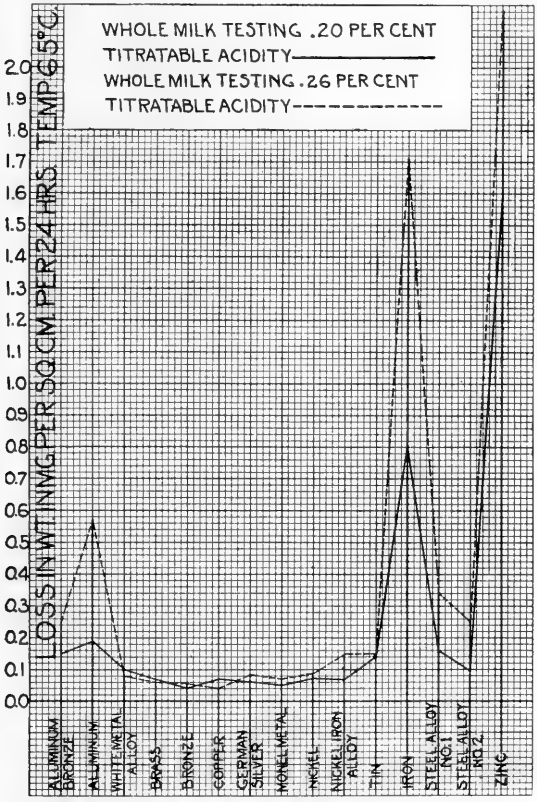

Fig. 193. The Influence of the Acid Content of Milk Upon the Solubility of Metals. Based Upon Donauer's Results.

At 140° F., Liedel[2] obtained a solubility of .020 mg. per sq. cm., at the end of one hour, and .071 mg. per sq. cm., at the end of seven hours in the case of whole milk. The rate of solution

is probably much larger during the first hour of contact than during succeeding periods. This may be due to the formation of a film or coating of milk solids over the metals, or to the presence of a more readily soluble coating of an oxide of the metal upon its surface before placing the metal in the milk.

The influence of the acidity of the milk upon the solubility of the metals is shown in Fig. 193 which is based upon Donauer's results.

The results obtained show a slight difference in the action, being in the majority of cases slightly higher in the case of sour milk.

Relation of Metallic Taste to Quantity of Metal Dissolved.— A careful comparison is presented herewith of the relation between the amounts of metallic lactates reported by Donauer as being required to impart a metallic taste to water, and the quantity of metals that were found to pass into solution in fresh whole milk. It is assumed that the rate of solution during the first hour is equal to 25 per cent of the total amount that passed into solution in 24 hours. The method of calculation used by Donauer[4] throughout the comparisons, is given as follows: "Calculations concerning the pasteurizer were based on an average standard 500 gallon vat with rotating coil, the heating surface being approximately 20 sq. in. per gallon."

In the methods in general use the world over for handling milk and its products it is seldom that the heat treatment exceeds one hour at 140° F. The values given in Table 175 are therefore conservative, and in practice the quantities of metal dissolved, are probably less than those given, under the conditions named. Copper, tin, brass and German silver were found to dissolve in smaller quantities than are necessary to impart a metallic flavor. Iron and aluminum dissolved in excess of the amount required to impart a metallic flavor.

The above named results are confirmed by practical experience covering many years and in various branches of the dairy industry. Equipment, used in the manufacture of dairy products, made either of pure copper or of tinned copper is known to have given many years of daily service without showing appreciable wear, other than the mechanical wear caused by daily cleaning.

TABLE 175.

Comparison of Metallic Lactates Required to Impart Taste, and of Metal Actually Dissolved. Based Upon 1 Hour Contact of Whole Fresh Milk with Metals, at 140° F.

Name of Metal	Parts Per Million of Metallic Lactates Required to Impart Metallic Flavor to Water	Loss in Mg. Per Sq. Cm. at End One Hour at 140° F. Calculated as Pure Metal	Loss in Mg. Per Sq. Cm. at End One Hour at 140° F. Calculated as Metallic Lactates	Name and Formula of Lactate Upon Which Calculation is Based	Parts Per Million of Metallic Lactates Dissolved in Milk at 140° F. in One Hour	Quantities of Lactates Actually Dissolved in Parts Per Million of Milk, More (+) or Less (−) than the Quantities Actually Required to Impart a Metallic Flavor With Water	Percentage of Total Amount Required to Impart Flavor Actually Dissolved by the Milk Per Cents	Authority for Analytical Results
Copper	4	.020	.076	Cupric Lactate $Cu(C_3H_5O_3)_2$	2.5	− 1.5	62.5	Liedel
Copper	4	.019	.072	Cupric Lactate $Cu(C_3H_5O_3)_2$	2.4	− 1.6	60.0	Donauer
Tin	50	.038	.152	Stannic Lactate $Sn(C_3H_5O_3)_4$	5.1	−44.6	10.2	Liedel
Tin	50	.035	.40	Stannic Lactate $Sn(C_3H_5O_3)_4$	4.7	−45.3	9.4	Donauer
Brass	7	.017	.064	Loss all Calculated as Cupric Lactate	2.1	− 4.9	30.0	Liedel
Brass	7	.018	.068	Loss all Calculated as Cupric Lactate	2.3	− 4.7	32.9	Donauer
Iron	15	.164	.556	Ferric Lactate $Fe_3(C_3H_5O_3)_3$	18.6	+ 3.6	124.0	Liedel
Iron	15	.200	.678	Ferric Lactate $Fe_3(C_3H_5O_3)_3$	22.7	+ 7.7	151.3	Donauer
Aluminum	9	.053	.314	Aluminum Lactate $Al_2(C_3H_5O_3)_3$	10.5	+ 1.5	116.6	Liedel
Aluminum	9	.048	.288	Aluminum Lactate $Al_2(C_3H_5O_3)_3$	9.6	+ .6	106.7	Donauer
German Silver	6	.020	.081	Nickel Lactate $Ni(C_3H_5O_2)_2$	2.7	− 3.3	47.5	Liedel
German Silver	6	.015	.061	Nickel Lactate $Ni(C_3H_5O_2)_2$	2.0	− 4.0	33.3	Donauer

Hess[5] reports one experiment in which milk was pasteurized for 30 minutes at 145° F. in a copper vessel, and upon feeding this milk to guinea pigs the animals developed scurvy. A portion of the same lot of milk pasteurized in a glass vessel and fed to guinea pigs did not produce scurvy. Contrary to this result may he cited the case of condensed buttermilk which has assumed comparatively large commercial proportions. This product is manufactured entirely in copper vacuum pans, and its content of lactic acid would produce maximum action upon the copper of any of the common dairy product, yet it is recognized as being able to stimulate growth in poultry and hogs to a remarkable degree. No experiments are known to have been made regarding its content of antiscorbutic vitamine.

The life and the relative cost of the various metals, other considerations being equal, is a deciding factor in the selection of the proper metals. Products made of copper have the advantage of retaining a considerable part of their original cost in junk form. Equipment products in certain sizes or shapes can be produced most economically if made in pure copper or in tinned copper. Again, in other cases, nearly every advantage is in favor of glass enamelled equipment, which has numerous characteristic advantages. Aluminum has so far found but scant use in the dairy industry, but it has certain properties that may entitle it to definite use. It is already being used in France for making milk cans and milk bottles. For making containers for milk products that are to be handled cold, it may come into further use. For handling hot milk products, it meets with the objection of its comparative solubility at high temperatures. No exact data is available regarding the influence of vacuum upon the solubility of metals in milk. Likewise the influences of agitation, composition and concentration of the milk products.

The Action of Condensed and Evaporated Milk Upon Tin and Iron.—The action of various foods including condensed and evaporated milks upon the solubility of tin and iron in tin cans was made the subject of a very comprehensive study under the general direction of the research committee of the National Canners Association.[7]

In the case of condensed milk they found "that the amount of tin and iron increased slightly during storage, but the increase

had little significance, as the total amounts were very small. The tin varied from five to 22 milligrams, and the iron from two to 10 milligrams per kilograms of product."

In the case of evaporated milk, "the average tin content varied from 60 to 106 milligrams per kilogram of milk, which was considerably higher than with condensed milk. There was a slight but definite increase in tin and iron with storage. Differences in coating had no effect upon the solution of tin and iron."

THE HEAT TRANSMISSION OF METALS AND ALLOYS.

The ease with which heat can be transmitted through various metals is a factor of great practical and commercial importance, in aiming at the proper choice. This is the factor that influences most of all the time element in the handling of dairy products. Table 176 gives the conductivity of the more common metals and alloys.

TABLE 176.

Conductivity for Heat of Certain Metals, Alloys and Glass.

Substance	Temp. °		Conductivity for Heat Coefficient K	Substance	Temp. °		Conductivity for Heat Coefficient K
	C	F			C	F	
Alumiunm	18	64	.480	Nickel	18	64	.142
Aluminum	100	212	.492	Nickel	100	212	.138
Brass	17	63	.260	Platinum	18	64	.166
Brass, yellow	0	32	.204	Platinum	100	212	.173
Brass, red	0	32	.246	Silver	18	64	1.006
Copper	18	64	.918	Silver	100	212	.992
Copper	100	212	.908	Tin	0	32	.155
German Silver	0	32	.070	Tin	100	212	.145
Gold	17	63	.705	Zinc	18	64	.265
Iron, pure	18	64	.161	Zinc	100	212	.262
Iron, pure	100	212	.151	Glass	0	32	.0028
Iron, steel	18	64	.108				
Iron, steel	100	212	.107				
Lead	18	64	.083				
Lead	100	212	.081				

The coefficient K is the quantity of heat in small calories which is transmitted per second through a plate one centimeter thick per square centimeter of its surface, when the difference of temperature between the two faces of the plate is one degree centigrade.[8]

The figures in Table 176 show that next to silver, copper is the best conductor of heat known, and it is one of the best reasons for the strong position of copper in the dairy industry.

The knowledge of the relation of milk and its products to various metals is incomplete in many particulars, and exact data is relatively scarce. Much remains to be learned upon these subjects.

REFERENCES.

[1] Erf, Oscar; Prof. of Dairying Ohio State University, personal letter May 4, 1922.

[2] Analytical results all obtained by H. J. Liedel. Research Laboratory Mojonnier Bros. Co., Chicago, Ill.

[3] Donauer, Max. The action of metals upon Milk. The Ice Cream Review, Milwaukee, Wis., p 78, 1922.
1921, p 115.

[4] Donauer, Max; Letter April 14, 1922.

[5] Hess, Alfred F. The antiscorbutic vitamine. Journal Ind. and Eng. Chem.

[6] Smithsonian Physical Tables 1921, p 213.

[7] Relative value of different weights of tin coating on canned food containers. National Canners Ass'n. 1917.

[8] Smithsonian Physical Tables, 1921, p 213.

APPENDIX

TABLE 177.

Degrees Twaddell with Corresponding Specific Gravity.

$$\text{Temp.}\frac{60^\circ\text{ F.}}{60^\circ\text{ F.}} \qquad (3)$$

Formula: Degrees Twaddell = (200 × Sp. Gr.) — 200

Formula: $\text{Specific Gravity} = \frac{\text{Degrees Twaddell} + 200}{200}$

Degrees Twaddle 60° F.	Specific Gravity 60°/60° F.	Degrees Twaddle 60° F	Specific Gravity 60°/60° F	Degrees Twaddle 60° F	Specific Gravity 60°/60° F	Degrees Twaddle 60° F	Specific Gravity 60°/60° F	Degrees Twaddle 60° F	Specific Gravity 60°/60° F
0	1.000	40	1.200	80	1.400	120	1.600	160	1.800
1	1.005	41	1.205	81	1.405	121	1.605	161	1.805
2	1.010	42	1.210	82	1.410	122	1.610	162	1.810
3	1.015	43	1.215	83	1.415	123	1.615	163	1.815
4	1.020	44	1.220	84	1.420	124	1.620	164	1.820
5	1.025	45	1.225	85	1.425	125	1.625	165	1.825
6	1.030	46	1.230	86	1.430	126	1.630	166	1.830
7	1.035	47	1.235	87	1.435	127	1.635	167	1.835
8	1.040	48	1.240	88	1.440	128	1.640	168	1.840
9	1.045	49	1.245	89	1.445	129	1.645	169	1.845
10	1.050	50	1.250	90	1.450	130	1.650	170	1.850
11	1.055	51	1.255	91	1.455	131	1.655	171	1.855
12	1.060	52	1.260	92	1.460	132	1.660	172	1.860
13	1.065	53	1.265	93	1.465	133	1.665	173	1.865
14	1.070	54	1.270	94	1.470	134	1.670	174	1.870
15	1.075	55	1.275	95	1.475	135	1.675	175	1.875
16	1.080	56	1.280	96	1.480	136	1.680	176	1.880
17	1.085	57	1.285	97	1.485	137	1.685	177	1.885
18	1.090	58	1.290	98	1.490	138	1.690	178	1.890
19	1.095	59	1.295	99	1.495	139	1.695	179	1.895
20	1.100	60	1.300	100	1.500	140	1.700	180	1.900
21	1.105	61	1.305	101	1.505	141	1.705		
22	1.110	62	1.310	102	1.510	142	1.710		
23	1.115	63	1.315	103	1.515	143	1.715		
24	1.120	64	1.320	104	1.520	144	1.720		
25	1.125	65	1.325	105	1.525	145	1.725		
26	1.130	66	1.330	106	1.530	146	1.730		
27	1.135	67	1.335	107	1.535	147	1.735		
28	1.140	68	1.340	108	1.540	148	1.740		
29	1.145	69	1.345	109	1.545	149	1.745		
30	1.150	70	1.350	110	1.550	150	1.750		
31	1.155	71	1.355	111	1.555	151	1.755		
32	1.160	72	1.360	112	1.560	152	1.760		
33	1.165	73	1.365	113	1.565	153	1.765		
34	1.170	74	1.370	114	1.570	154	1.770		
35	1.175	75	1.375	115	1.575	155	1.775		
36	1.180	76	1.380	116	1.580	156	1.780		
37	1.185	77	1.385	117	1.585	157	1.785		
38	1.190	78	1.390	118	1.590	158	1.790		
39	1.195	79	1.395	119	1.595	159	1.795		

TABLE 178.
Constants of the elements.[1]

No	Name	Symbol	Atomic Wt.	Molecular Wt.	Valency	Specific Gravity		Atomic Volume At. Wt. / Sp. Gr.	Specific Heat at —223°C	Atomic Heat Sp. Gr. × At.Wt. —223°C	Electrical Conductivity At 0°C	Thermal Conductivity K—°C	Linear Coefficient of Expansion		Melting Point °C	Boiling Point °C
						Water=1 Air=1(A)	Tem.°C						C×10⁴	Temp.°C		
1	Aluminum	Al	27.0	.....	3	2.70	20°	10 0	.0413	1.12	324,000	.480¹⁸°	.2313	40°	658.7	1800.
2	Antimony	Sb	120.2	.....	3, 5	6.618	20°	18 2	.0240	2.89	27,100	.0442⁰°	.1152	40°	630.0	1440.
3	Argon, Gas	A	39.9	39.9	0	1.379(A)	.....	.....	.1233⁰°	4.92	.....	.....	.....	.....	—188.	—186.1
4	Liquid	A	39.9	.....	0	1.3345	—183°	28.5	.....	.....	.....	.....	.....	.....	.....	.....
5	Arsenic, Amorph	As	74.96	299.84	3, 5	5.73	14°	15.9	.0258	1.04	28,600	.....	.0559	40°	850.	>360.
6	Cryst	As	74.96	299.84	3, 5	3.70	.....	13.2	.0830–65°	6.23	.....	.....	.....	.....	Sublimes	.....
7	Barium	Ba	137.37	.....	2.	3.78	.....	36.6	.0350	4.80	.....	.....	.....	.....	850.	Vol. 950.
8	Bismuth	Bi	209.0	.....	3, 5	9.747	.....	21.3	.0218	4.54	9,260	.0194¹⁸°	.1346	40°	271.	1430.
9	Boron, Amorph	B	10.9	.....	3.	2.45	.....	4.5	.0212	.24	.....	.....	.....	.....	2200.—	Sublimes
10	Cryst	B	10.9	.....	3	2.535	.....	4.2	.....	.....	.....	.....	.....	.....	2500.	At 3500.
11	Bromine, Gas	Br_2	79.92	159.84	1	5.869(A)	60°	.....	.0555–83°	4.44	.....	.....	.....	.....	.....	.....
12	Liquid	Br_2	79.92	159.84	1	3.12	.....	24.9	.0453	3.62	.....	.....	.....	.....	—7.3	61.1
13	Cadmium	Cd	112.40	112.40	2	8.648	20°	13.0	.0308	3.46	146,000	.222¹⁸°	.3069	40°	320.9	778.
14	Caesium	Cs	132.81	.....	1	1.873	.....	71.0	.0513	6.82	25,400	.....	.3940	27—100°	26.	670.
15	Calcium	Ca	40.07	.....	2	1.54	.....	25.9	.0714	2.86	95,000	.....	.....	.....	810.	.....
16	Carbon, Amorph	C	12.005	.....	4	1.75—2.25	.....	6.0	.241⁰°	2.89	.....	.....	.0540	40°	Sublimes	3600.
17	Graphite	C	12.005	.....	4	2.25	.....	5.1	.0137	.16	.....	.....	.0786	40°	Sublimes	3600.
18	Diamond	C	12.005	.....	4	3.52	.....	3.4	.0028	.03	.....	.....	.0118	40°	Sublimes	3600.
19	Cerium	Ce	140.25	.....	3, 4	7.02	.....	20.3	.0330	4.64	.....	.....	.....	.....	640.	.....
20	Chlorine, Gas	Cl	35.46	70.92	1	2.491(A)	0°	.....	.1241	4.40	.....	.....	.....	.....	—101.5	—33.6
21	Liquid	Cl	35.46	.....	1	1.507	—33.6°	24.6	.0967	3.43	.....	.....	.1978	0—10°	.....	.....
22	Chromium	Cr	52.00	.....	2, 3, 6	6.92	20°	7.6	.0142	.70	.....	.....	.....	.....	1615.	2200.
23	Cobalt	Co	58.97	.....	2, 3	8.71	21°	6.8	.0207	1.22	.....	.....	.1236	40°	1480.	.....
24	Columbium	Cb	93.10	.....	5	8.4	15°	13.3	.....	.....	83,200	.....	.....	.....	1950.	.....
25	Copper	Cu	63.57	.....	1, 2	8.9326	20°	7.1	.0245	1.56	640,600	.918¹⁸°	.1678	40°	1083±3	2310.
26	Dysprosium	Dy	162.5	.....	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
27	Erbium	Er	167.7	.....	3	4.77	.....	34.8	.....	.....	.....	.....	.....	.....	.....	.....

28	Europium	Eu	152.0	.....	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
29	Fluorine, Gas	F	19.0	38.0	1	1.31	15°	.....	.....	.....	.....	.....	.....	.....	—223.	.....
30	Liquid	F	19.0	38.0	1	1.14	—200°	16.7	.....	.....	.....	.....	.....	.....	.....	—187.
31	Gadolinium	Gd	157.3	.....	3	1.31	.....	119.1	.....	.....	.....	.....	.....	.....	.....	.....
32	Gallium	Ga	70.1	.....	3	5.93	23°	11.8	.079°°	5.53	.....	.....	.....	.....	30.1	.....
33	Germanium	Ge	72.5	.....	4	5.46	20°	13.3	.0737°°	5.34	.....	.....	.....	.....	958.	Vol. 1350.
34	Glucinum	Gl	9.1	.....	2	1.85	.....	4.9	.0137	.125	.....	.....	.....	.....	>960.	.....
35	Gold	Au	197.2	.....	I, 3	19.27	20°	10.2	.0160	3.16	468,000	.705[17]°	.1443	40°	1063.0	.....
36	Helium	He	4.00	4.00	0	.15	—263°	.....	.....	.....	.....	.3386°°	.....	.....	Adjusted <—271.	—267.
37	Holmium	Ho	163.5	.....	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
38	Hydrogen, Gas	H	1.008	2.016	1	.069(A)	.....	.....	3.410—0°	3.44	.....	.3270°°	.....	.....	—259.	—252.6
39	Liquid	H	1.008	2.016	1	.070	—252°	1.4	6.0°	6.05	.....	.....	.....	.....	.....	.....
40	Indium	In	114.8	.....	3	.728	.....	16.1	.05695°°	6.56	119,500	.....	.4170	40°	155.	Red Heat
41	Iodine, Gas	I	126.92	.....	1	8.72(A)	.....	.....	.0336°°	4.27	.....	.....	.....	.....	.....	.....
42	Solid	I	126.92	253.84	1	4.94	20°	25.7	.0361	4.59	.....	.....	.837	—190—17	113.5	>200.
43	Iridium, Spongy	Ir	193.1	.....	4	15.86	.....	12.2	.....	.....	.....	.141[17]°	.0888	18°	.....	.....
44	Crystalline	Ir	193.1	.....	4	22.42	17°	8.6	.0099	1.92	.....	.....	.0700	40°	2350.	.....
45	Iron, Pure	Fe	55.84	.....	2, 3	7.85—7.88	.....	7.1	.0175	.98	131,000	.161[18]°	.1210	40°	1530.	2450.
46	Wrought	Fe	55.84	.....	2, 3	7.80—7.90	.....	7.1	.1130°°	6.32	.....	.144[18]°	.1140	—18° to 100°	1600.	.....
47	Steel	Fe	55.84	.....	2, 3	7.60—7.80	.....	7.3	.1066°°	5.96	63,000	.108[18]°	.1322	40°	1375.	.....
48	Gray Pig	Fe	55.84	.....	2, 3	7.03—7.13	.....	7.9	.....	.....	.....	.....	.....	.....	.....	.....
49	White Pig	Fe	55.84	.....	2, 3	7.58—7.73	.....	7.3	.1050°°	5.87	{10,200–	.....	.110	0°—100°	1275.	.....
											{11,300	.....	.1061	40°	1075.	.....
50	Krypton, Gas	Kr	82.92	82.92	0	2.818(A)	.....	.....	.....	.....	.....	.1490°°	.....	.....	—169.	—151.7
51	Liquid	Kr	82.92	.....	0	2.16	—146°	.....	37.9	.....	.....	.....	.....	.....	.....	.....
52	Lanthanum	La	139.0	.....	3	6.15	.....	22.6	.0322	4.60	.....	.....	.....	.....	810.	.....
53	Lead	Pb	207.2	.....	2, 4	11.342	20°	18.3	.0240	4.96	50,400	.083[13]°	.2924	40°	327.	1525.
54	Lithium	Li	6.94	.....	1	.534	20°	13.0	.1924	1.35	119,000	.....	.....	.....	186.	1400.
55	Lutecium	Lu	175.0	.....	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
56	Magnesium	Mg	24.32	.....	2	1.741	.....	14.1	.0713	1.74	230,000	376°–100°	.2694	40°	651.	1120.
57	Manganese	Mn	54.93	.....	2, 3, 7	7.42	.....	7.4	.0229	1.26	.....	.0519[13]°	.....	.....	1230.	1900.
58	Mercury	Hg	200.6	200.6	1, 2	13.546	20°	14.8	.0232	4.65	10,630	.0148°°	.182	0°—100°	—38.87	357.
59	Molybdenum	Mo	96.0	.....	4, 6	9.01	.....	9.3	.0141	1.36	.....	.346[17]°	.....	.....	2535.	3620.
60	Neodymium	Nd	144.3	.....	3	6.96	.....	20.6	.....	.....	.....	.....	.....	.....	840.	.....
61	Neon	Ne	20.2	.....	0	.674(A)	.....	.....	.....	.....	.....	.....	.....	.....	—253.	—239.

†Where the temperature is not given, ordinary atmospheric temperature is understood.

TABLE 178—Continued.

No.	Name	Symbol	Atomic Wt.	Molecular Wt.	Valency	Specific Gravity		Atomic Volume At. Wt. / Sp. Gr.	Specific Heat at —223°C	Atomic Heat Sp. Gr. ×At.Wt. —223°C	Electrical Conductivity At 0°C	Thermal Conductivity K—°C	Linear Coefficient of Expansion		Melting Point °C	Boiling Point °C
						Water=1 Air=1(A)	Tem.°C†						C×10⁴	Temp.°C		
62	Nickel	Ni	58.68	.....	2, 3	8.60—8.90	.....	6.7	.0208	1.22	144,200	.1420¹⁸°	.1279	40°	1452.	.....
63	Niton	Nt	222.4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
64	Nitrogen, Gas	N	14.008	28.016	3, 5	.967(A)	.....	.....	.2438⁰°	3.42	.....	.524⁰°	.....	.....	—211.	—195.
65	Liquid	N	14.008	.....	3, 5	.810	—195°	17.5	.....	.....	.....	.....	.....	.....	.....	.....
66	Osmium	Os	190.9	.....	6, 8	22.5	.....	8.5	.0078	1.49	105,300	.....	.0657	40°	About 2700.	.....
67	Oxygen, Gas	O	16.0	32.0	2	1.105(A)	.....	.....	.2175⁰°	3.48	.....	.563⁰°	.....	.....	—218.	—182.7
68	Liquid	O	16.0	32.0	2	1.14	—184°	14.3	.....	.....	.....	.....	.....	.....	.....	.....
69	Ozone	O_3	.....	48.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	—119.0
70	Palladium	Pd	106.7	.....	2, 4	12.16	.....	9.2	.0190	2.03	97,900	.1683¹⁸°	.1176	40°	1549±5	.....
71	Phosphorus, Yellow	P	31.04	124.16	3, 5	1.832	20°	17.0	.0774	2.40	.....	.....	1.2530	0°—40°	44.2	.....
72	Red	P	31.04	124.16	3, 5	2.20	.....	13.5	.0431	1.34	.....	.....	.....	.....	.....	288.
73	Liquid	P	31.04	.....	3, 5	1.764	44°	.....	.....	.....	.....	.....	.....	.....	.....	.....
74	Platinum	Pt	195.2	.....	2, 4	21.37	20°	9.2	.0135	2.63	91,200	.1664¹⁸°	.0899	40°	1755±5	3910.
75	Potassium	K	39.10	.....	1	.870	20°	44.7	.1280	5.01	150,500	.232⁵°	.8300	0°—50°	62.3	712.
76	Praseodymium	Pr	140.9	.....	3	6.475	.....	21.6	.....	.....	.....	.....	.....	.....	940.	.....
77	Radium	Ra	226.0	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	700.	.....
78	Rhodium	Rh	102.9	.....	3	12.44	.....	8.5	.0134	1.38	.....	.210¹⁷°	.0850	40°	1950.	.....
79	Rubidium	Rb	85.45	.....	1	1.532	20°	55.8	.0711	6.05	.....	.....	.....	.....	38.	696.
80	Ruthenium	Ru	101.7	.....	6, 8	8.6	.....	9.0	.0109	1.11	.....	.....	.....	.....	2450.	.....
81	Melted	Ru	101.7	.....	6, 8	11.4	.....	8.9	.....	.....	.....	.....	.....	.....	2000.	.....
82	Crys	Ru	101.7	.....	6, 8	12.06	0°	8.3	.0611⁰°	6.21	.....	.....	.0963	40°	2000.	.....
83	Samarium	Sa	150.4	.....	3	7.7—7.8	.....	19.4	.....	.....	.....	.....	.....	.....	1300—1400	.....
84	Scandium	Sc	45.1	.....	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	?	.....
85	Selenium, Amorph	Se	79.2	633.6	2, 4, 6	4.26—4.28	25°	18.5	.0361	2.86	.....	.....	.....	.....	50.	690.
86	Monoclinic	Se	79.2	633.6	2, 4, 6	4.47	25°	17.7	.0840¹⁰°	.....	.....	.....	.3680	40°	170—180	690.

87	Hexagonal	Se	79.2	633.6	2, 4, 6	4.8	25°	16.5							217.	690.
88	Silicon, Amorph	Si	28.1		4	2.35	15°	14.2	.0303	.86						3500.
89	Cryst	Si	28.1		4	2.42	20°	11.4	.0303	.77	200—15,600		.0763	40°	1420. Adjusted	3500.
90	Silver	Ag.	107.88		1	10.492	20°	10.2	.0242	2.62	681,200	$1.006^{18°}$	.1921	40°	1960.5 Adjusted	1955.
91	Sodium	Na	23.00		1	.9712	20°	23.6	.1519	3.50	211,000	$.321^{5.7°}$	2.26	0°—90°	97.5	750.
92	Strontium	Sr	87.63		2	2.50—2.58		34.5	.0550	4.82	40,300				?	
93	Sulphur	S	32.06	256.48	2, 4, 6	2.0—2.1		16.0	.0546	1.75					Si —112.8 Sii —119.2 Siii—106.8	444.7
94	Amorphous, Soft	S	32.06	256.48	2, 4, 6	1.9556	0°	16.4								444.7
95	Amorphous, Yellow	S	32.06	256.48	2, 4, 6	2.046		15.6								444.7
96	Rhombic	S	32.06	256.48	2, 4, 6	2.05—2.07	0°	15.6	$.163^{0°}$	5.23			.6413	40°		444.7
97	Monoclinic	S	32.06	256.48	2, 4, 6	1.958		16.4								444.7
98	Plastic	S	32.06	256.48	2, 4, 6	1.92		16.7								444.7
99	Tantalum	Ta	181.5		5	16.6		143.0			60,600	$.130^{17°}$	.08		2900.	
100	Tellurium, Amorph	Te	127.5	255.0	2, 4, 6	6.02	20°	21.2	.0288	3.68			.1675	40°	446.	1390.
101	Cryst	Te	127.5	255.0	2, 4, 6	6.25		20.4	$.0475^{0°}$	6.07	46,600		.3440	0°—20°	452.	1390.
102	Terbium	Tb	159.2		3											
103	Thallium	Tl	204.0		1, 3	11.86		17.2	.0235	4.82	56,800		.3021	40°	302.	1280.
104	Thorium, Amorph	Th	232.15		4	11.00	17°	21.1	.0197	4.58					>1700.	
105	Cryst	Th	232.15		4	12.16	17°	20.7							>Mo	
106	Thulium	Tm	169.9		3											
107	Tin, Gray	Sn	118.7		2, 4	5.8		20.3	.0286	3.41		$.155^{0°}$			Stable <20.	
108	Rhombic	Sn	118.7		2, 4	6.53—6.56		18.2	$.0559^{0°}$	6.65			.2234	40°	Stable >170.	
109	Tetragonal	Sn	118.7		2, 4	7.29	15°	16.3	$.0559^{0°}$	6.65	76,600				231.9±2	2270.
110	Titanium	Ti	48.1		4	4.5	18°	10.7	.0205	.99					1795.	
111	Tungsten	W	184.0		6	18.6—19.1		9.8	.0095	1.75		$.476^{17°}$			3400.	5830.
112	Uranium	U	238.2		4, 6	18.7	13°	12.8	.0138	3.30					<1850	
113	Vanadium	V	51.0		3, 5	5.69		8.7	$.1153^{0°}$	5.90					1720.	
114	Xenon, Gas	Xe	130.2		0	4.422(A)									—140.	—109.1
115	Liquid	Xe	130.2		0	3.52	109°	49.1								
116	Ytterbium	Yb	173.5		3											
117	Yttrium	Yt	89.33		3	3.80	15°	23.4							1490.	
118	Zinc	Zn	65.37		2	6.92	20°	9.2	.0384	2.52	186,000	$.2653^{18°}$	.2918	40°	419.4	930.
119	Zirconium, Amorph	Zr	90.6		4	4.15		21.8	.0262	2.38					1500.	
120	Cryst	Zr	90.6		4	6.44		17.1	$.0660^{0°}$	5.98					1700.	

†Where the temperature is not given, ordinary atmospheric temperature is understood.

TABLE 179.

Specific gravity at $\frac{60^\circ \text{ F.}}{60^\circ \text{ F.}}$ corresponding to Degrees Baume for liquids lighter than water.

$$\text{Sp. Gr. at } 60^\circ \text{ F.} = \frac{140}{130 + \text{Baume}^\circ} \quad \text{and} \quad \text{Baume}^\circ = \left(\frac{140}{\text{Sp. Gr.} \frac{60^\circ \text{ F.}}{60^\circ \text{ F.}}} \right) - 130$$

Degrees Baume	TENTHS OF DEGREES									
	0	1	2	3	4	5	6	7	8	9
10	1.0000	.9993	.9986	.9979	.9971	.9964	.9957	.9950	.9943	.9936
11	.9929	.9922	.9915	.9908	.9901	.9894	.9887	.9880	.9873	.9866
12	.9859	.9852	.9845	.9838	.9831	.9824	.9818	.9811	.9804	.9797
13	.9790	.9783	.9776	.9770	.9763	.9756	.9749	.9742	.9736	.9729
14	.9722	.9715	.9709	.9702	.9695	.9688	.9682	.9675	.9668	.9662
15	.9655	.9649	.9642	.9635	.9629	.9622	.9615	.9609	.9602	.9596
16	.9589	.9582	.9576	.9569	.9563	.9556	.9550	.9543	.9537	.9530
17	.9524	.9517	.9511	.9504	.9497	.9491	.9485	.9479	.9472	.9465
18	.9459	.9453	.9447	.9440	.9434	.9428	.9421	.9415	.9408	.9402
19	.9396	.9390	.9383	.9377	.9371	.9365	.9358	.9352	.9346	.9340
20	.9333	.9327	.9321	.9315	.9309	.9302	.9296	.9290	.9284	.9278
21	.9272	.9265	.9259	.9253	.9247	.9241	.9235	.9229	.9223	.9216
22	.9210	92.04	.9198	.9192	.9186	.9180	.9174	.9168	.9162	.9156
23	.9150	.9144	.9138	.9132	.9126	.9120	.9114	.9109	.9103	.9097
24	.9091	.9085	.9079	.9073	.9067	.9061	.9056	.9050	.9044	.9038
25	.9032	.9026	.9021	.9015	.9009	.9003	.8997	.8992	.8986	.8980
26	.8374	.8968	.8963	.8957	.8951	.8946	.8940	.8934	.8929	.8923
27	.8917	.8911	.8906	.8900	.8895	.8889	.8883	.8878	.8872	.8866
28	.8861	.8855	.8850	.8845	.8839	.8833	.8827	.8822	.8816	.8810
29	.8805	.8799	.8794	.8788	.8782	.8777	.8772	.8766	.8761	.8756
30	.8750	.8744	.8739	.8734	.8728	.8722	.8717	.8712	.8706	.8701
31	.8696	.8690	.8685	.8679	.8674	.8669	.8663	.8658	.8653	.8647
32	.8642	.8637	.8631	.8626	.8621	.8615	.8610	.8605	.8600	.8594
33	.8589	.8584	.8578	.8573	.8568	.8562	.8557	.8552	.8547	.8542
34	.8537	.8531	.8526	.8521	.8516	.8511	.8505	.8501	.8496	.8491
35	.8485	.8480	.8474	.8469	.8464	.8459	.8454	.8449	.8444	.8439
36	.8434	.8429	.8423	.8418	.8413	.8408	.8403	.8398	.8393	.8388
37	.8383	.8378	.8373	.8368	.8363	.8358	.8353	.8348	.8343	.8339
38	.8333	.8329	.8323	.8318	.8313	.8309	.8304	.8299	.8294	.8289
39	.8284	.8279	.8274	.8269	.8264	.8259	.8254	.8250	.8245	.8240
40	.8235	.8230	.8225	.8220	.8215	.8211	.8206	.8201	.8197	.8192
41	.8187	.8182	.8177	.8173	.8168	.8163	.8158	.8154	.8149	.8144
42	.8139	.8134	.8130	.8125	.8121	.8116	.8111	.8107	.8102	.8097
43	.8092	.8088	.8083	.8078	.8074	.8069	.8064	.8060	.8055	.8051
44	.8046	.8041	.8037	.8032	.8027	.8022	.8018	.8014	.8008	.8004
45	.8000	.7995	.7991	.7986	.7981	.7978	.7973	.7968	.7964	.7959
46	.7955	.7950	.7945	.7940	.7936	.7932	.7928	.7923	.7919	.7914
47	.7910	.7905	.7901	.7897	.7892	.7887	.7883	.7878	.7874	.7870
48	.7866	.7861	.7856	.7852	.7848	.7844	.7839	.7835	.7830	.7826
49	.7821	.7817	.7812	.7808	.7804	.7799	.7795	.7791	.7786	.7782
50	.7778	.7773	.7769	.7765	.7760	.7756	.7752	.7747	.7743	.7739

TABLE 179—Continued.

Specific Gravity 60° F.

Degrees Baume	TENTHS OF DEGREES									
	0	1	2	3	4	5	6	7	8	9
51	.7735	.7730	.7726	.7722	.7718	.7714	.7709	.7705	.7701	.7696
52	.7692	.7688	.7684	.7680	.7675	.7671	.7667	.7663	.7658	.7654
53	.7650	.7646	.7642	.7637	.7633	.7629	.7625	.7621	.7617	.7613
54	.7609	.7605	.7601	.7597	.7593	.7588	.7584	.7580	.7576	.7572
55	.7568	.7563	.7559	.7555	.7551	.7547	.7543	.7539	.7535	.7531
56	.7527	.7523	.7519	.7515	.7511	.7507	.7503	.7499	.7495	.7492
57	.7487	.7483	.7479	.7475	.7471	.7467	.7463	.7459	.7455	.7451
58	.7447	.7443	.7439	.7435	.7431	.7427	.7423	.7419	.7415	.7411
59	.7407	.7403	.7399	.7396	.7392	.7388	.7384	.7380	.7376	.7372
60	.7368	.7364	.7361	.7357	.7353	.7349	.7345	.7341	.7338	.7334
61	.7330	.7326	.7322	.7318	.7314	.7311	.7307	.7303	.7299	.7295
62	.7291	.7288	.7284	.7280	.7276	.7273	.7269	.7265	.7261	.7258
63	.7254	.7250	.7246	.7243	.7239	.7235	.7231	.7228	.7224	.7220
64	.7216	.7213	.7209	.7205	.7202	.7198	.7194	.7190	.7186	.7182
65	.7179	.7176	.7172	.7169	.7165	.7161	.7158	.7154	.7150	.7147
66	.7143	.7139	.7136	.7132	.7128	.7125	.7121	.7117	.7114	.7110
67	.7106	.7103	.7099	.7095	.7092	.7088	.7084	.7081	.7077	.7074
68	.7071	.7067	.7064	.7060	.7057	.7053	.7049	.7045	.7042	.7039
69	.7035	.7032	.7028	.7025	.7021	.7017	.7014	.7010	.7007	.7003
70	.7000	.6996	.6993	.6989	.6986	.6982	.6979	.6975	.6972	.6969
71	.6965	.6962	.6958	.6955	.6951	.6948	.6944	.6941	.6937	.6934
72	.6931	.6927	.6924	.6920	.6917	.6913	.6910	.6906	.6903	.6900
73	.6896	.6893	.6889	.6886	.6882	.6879	.6876	.6872	.6869	.6866
74	.6863	.6859	.6856	.6853	.6850	.6846	.6843	.6839	.6836	.6833
75	.6829	.6826	.6823	.6819	.6816	.6813	.6809	.6806	.6803	.6799
76	.6796	.6792	.6789	.6786	.6782	.6779	.6776	.6772	.6769	.6766
77	.6763	.6760	.6757	.6753	.6750	.6746	.6743	.6740	.6737	.6734
78	.6731	.6727	.6724	.6721	.6717	.6714	.6711	.6708	.6705	.6702
79	.6698	.6695	.6692	.6689	.6686	.6683	.6679	.6676	.6673	.6670
80	.6667	.6663	.6660	.6657	.6654	.6651	.6648	.6645	.6641	.6638
81	.6635	.6632	.6629	.6626	.6623	.6619	.6616	.6613	.6610	.6607
82	.6604	.6601	.6598	.6595	.6591	.6588	.6585	.6582	.6579	.6576
83	.6573	.6570	.6567	.6563	.6560	.6557	.6554	.6551	.6548	.6545
84	.6542	.6538	.6536	.6533	.6530	6527	.6524	.6521	.6518	.6515
85	.6512	.6509	.6506	.6503	.6500	.6496	.6493	.6490	.6487	.8484
86	.8481	.6478	.6475	.6472	.6469	.6466	.6463	.6460	.6457	.6454
87	.6452	.6449	.6446	.6443	.6440	.6437	.6434	.6431	.6428	.6425
88	.6422	.6419	.6416	.6413	.6410	.6407	.6404	.6401	.6398	.6396
89	6393	.6390	.6387	.6384	.6381	6378	.6373	.6372	.6369	.6367
90	.6364	.6361	.6358	6355	.6352	.6349	6346	.6343	6340	.6338

TABLE 180.

Specific Gravity at $\frac{60^\circ \text{ F.}}{60^\circ \text{ F.}}$ corresponding to degrees Baumé for liquids heavier than water.

$$\text{Sp. Gr. } 60^\circ \text{ F.} = \frac{145}{145 - \text{Deg. Baumé}} \qquad \text{Baumé degrees} = 145 - \left(\frac{145}{\frac{\text{Sp. Gr. } 60^\circ \text{F.}}{60^\circ = \text{F.}}} \right)$$

SPECIFIC GRAVITY (0

Degrees Baumé	TENTHS OF DEGREES									
	0	1	2	3	4	5	6	7	8	9
0	1.0000	1.0007	1.0014	1.0021	1.0028	1.0035	1.0042	1.0049	1.0055	1.0062
1	1.0069	1.0076	1.0083	1.0090	1.0097	1.0105	1.0112	1.0119	1.0126	1.0133
2	1.0140	1.0147	1.0154	1.0161	1.0168	1.0175	1.0183	1.0190	1.0197	1.0204
3	1.0211	1.0218	1.0226	1.0233	1.0240	1.0247	1.0255	1.0262	1.0269	1.0276
4	1.0284	1.0291	1.0298	1.0306	1.0313	1.0320	1.0328	1.0335	1.0342	1.0350
5	1.0357	1.0365	1.0372	1.0379	1.0387	1.0394	1.0402	1.0409	1.0417	1.0424
6	1.0432	1.0439	1.0447	1.0454	1.0462	1.0469	1.0477	1.0484	1.0492	1.0500
7	1.0507	1.0515	1.0522	1.0530	1.0538	1.0545	1.0553	1.0561	1.0569	1.0576
8	1.0584	1.0592	1.0599	1.0607	1.0615	1.0623	1.0630	1.0638	1.0646	1.0654
9	1.0662	1.0670	1.0677	1.0685	1.0693	1.0701	1.0709	1.0717	1.0725	1.0733
10	1.0741	1.0749	1.0757	1.0765	1.0773	1.0781	1.0789	1.0797	1.0805	1.0813
11	1.0821	1.0829	1.0837	1.0845	1.0853	1.0861	1.0870	1.0878	1.0886	1.0894
12	1.0902	1.0910	1.0919	1.0927	1.0935	1.0943	1.0952	1.0960	1.0968	1.0977
13	1.0985	1.0993	1.1002	1.1010	1.1018	1.1027	1.1035	1.1043	1.1052	1.1060
14	1.1069	1.1077	1.1086	1.1094	1.1103	1.1111	1.1120	1.1128	1.1137	1.1145
15	1.1154	1.1162	1.1171	1.1180	1.1188	1.1197	1.1206	1.1214	1.1223	1.1232
16	1.1240	1.1249	1.1258	1.1267	1.1275	1.1284	1.1293	1.1302	1.1310	1.1319
17	1.1328	1.1337	1.1346	1.1355	1.1364	1.1373	1.1381	1.1390	1.1399	1.1408
18	1.1417	1.1426	1.1435	1.1444	1.1453	1.1462	1.1472	1.1481	1.1490	1.1499
19	1.1508	1.1517	1.1526	1.1535	1.1545	1.1554	1.1563	1.1572	1.1581	1.1591
20	1.1600	1.1609	1.1619	1.1628	1.1637	1.1647	1.1656	1.1665	1.1675	1.1684
21	1.1694	1.1703	1.1712	1.1722	1.1731	1.1741	1.1750	1.1760	1.1769	1.1779
22	1.1789	1.1798	1.1808	1.1817	1.1827	1.1837	1.1846	1.1856	1.1866	1.1876
23	1.1885	1.1895	1.1905	1.1915	1.1924	1.1934	1.1944	1.1954	1.1964	1.1974
24	1.1983	1.1993	1.2003	1.2013	1.2023	1.2033	1.2043	1.2053	1.2063	1.2073
25	1.2083	1.2093	1.2104	1.2114	1.2124	1.2134	1.2144	1.2154	1.2164	1.2175
26	1.2185	1.2195	1.2205	1.2216	1.2226	1.2236	1.2247	1.2257	1.2267	1.2278
27	1.2288	1.2299	1.2309	1.2319	1.2330	1.2340	1.2351	1.2361	1.2372	1.2383
28	1.2393	1.2404	1.2414	1.2425	1.2436	1.2446	1.2457	1.2468	1.2478	1.2489
29	1.2500	1.2511	1.2522	1.2532	1.2543	1.2554	1.2565	1.2576	1.2587	1.2598
30	1.2609	1.2619	1.2630	1.2641	1.2652	1.2663	1.2674	1.2685	1.2697	1.2708
31	1.2719	1.2730	1.2741	1.2752	1.2763	1.2775	1.2786	1.2797	1.2808	1.2820
32	1.2831	1.2842	1.2854	1.2866	1.2877	1.2888	1.2900	1.2912	1.2923	1.2934
33	1.2946	1.2957	1.2968	1.2979	1.2991	1.3004	1.3016	1.3028	1.3040	1.3052
34	1.3063	1.3075	1.3087	1.3098	1.3110	1.3122	1.3134	1.3146	1.3158	1.3170
35	1.3182	1.3194	1.3206	1.3218	1.3230	1.3242	1.3254	1.3266	1.3278	1.3290
36	1.3302	1.3314	1.3326	1.3339	1.3352	1.3364	1.3376	1.3389	1.3401	1.3414

TABLE 180—Continued.

SPECIFIC GRAVITY 60° F.

Degrees Baume	TENTHS OF DEGREES									
	0	1	2	3	4	5	6	7	8	9
37	1.3426	1.3438	1.3451	1.3464	1.3476	1.3488	1.3500	1.3512	1.3525	1.3528
38	1.3551	1.3564	1.3577	1.3589	1.3602	1.3615	1.3627	1.3640	1.3653	1.3666
39	1.3679	1.3692	1.3705	1.3718	1.3731	1.3744	1.3757	1.3770	1.3783	1.3796
40	1.3809	1.3822	1.3836	1.3849	1.3862	1.3875	1.3888	1.3902	1.3915	1.3928
41	1.3942	1.3955	1.3969	1.3982	1.3996	1.4009	1.4023	1.4036	1.4050	1.4064
42	1.4078	1.4091	1.4105	1.4118	1.4132	1.4146	1.4160	1.4174	1.4188	1.4202
43	1.4216	1.4230	1.4244	1.4258	1.4272	1.4286	1.4300	1.4314	1.4328	1.4342
44	1.4356	1.4370	1.4385	1.4399	1.4413	1.4428	1.4442	1.4456	1.4471	1.4485
45	1.4500	1.4514	1.4529	1.4543	1.4558	1.4573	1.4588	1.4602	1.4617	1.4632
46	1.4646	1.4661	1.4676	1.4691	1.4706	1.4721	1.4736	1.4751	1.4766	1.4781
47	1.4796	1.4811	1.4826	1.4841	1.4856	1.4871	1.4887	1.4902	1.4917	1.4933
48	1.4948	1.4963	1.4979	1.4994	1.5010	1.5026	1.5041	1.5057	1.5073	1.5088
49	1.5104	1.5120	1.5136	1.5142	1.5167	1.5182	1.5199	1.5215	1.5231	1.5247
50	1.5263	1.5279	1.5295	1.5311	1.5327	1.5343	1.5360	1.5376	1.5392	1.5409
51	1.5425	1.5442	1.5458	1.5474	1.5491	1.5508	1.5525	1.5541	1.5558	1.5574
52	1.5591	1.5608	1.5625	1.5642	1.5659	1.5676	1.5693	1.5710	1.5727	1.5744
53	1.5761	1.5778	1.5795	1.5812	1.5829	1.5847	1.5864	1.5882	1.5899	1.5916
54	1.5934	1.5951	1.5969	1.5986	1.6004	1.6022	1.6040	1.6057	1.6075	1.6093
55	1.6111	1.6129	1.6147	1.6165	1.6183	1.6201	1.6219	1.6237	1.6255	1.6274
56	1.6292	1.6310	1.6328	1.6347	1.6365	1.6384	1.6402	1.6421	1.6439	1.6458
57	1.6477	1.6496	1.6515	1.6534	1.6552	1.6571	1.6590	1.6609	1.6628	1.6647
58	1.6666	1.6686	1.6705	1.6724	1.6743	1.6763	1.6782	1.6802	1.6821	1.6840
59	1.6860	1.6879	1.6899	1.6919	1.6939	1.6959	1.6979	1.6999	1.7019	1.7039
60	1.7059	1.7079	1.7099	1.7119	1.7139	1.7159	1.7180	1.7200	1.7221	1.7241
61	1.7262	1.7282	1.7303	1.7324	1.7344	1.7365	1.7386	1.7407	1.7428	1.7449
62	1.7470	1.7491	1.7512	1.7533	1.7554	1.7576	1.7597	1.7619	1.7630	1.7661
63	1.7683	1.7704	1.7726	1.7748	1.7769	1.7791	1.7813	1.7835	1.7857	1.7879
64	1.7901	1.7923	1.7945	1.7967	1.7990	1.8012	1.8034	1.8057	1.8080	1.8102
65	1.8125	1.8148	1.8170	1.8193	1.8216	1.8239	1.8262	1.8285	1.8308	1.8331
66	1.8354	1.8377	1.8401	1.8424	1.8447	1.8471	1.8494	1.8518	1.8542	1.8566
67	1.8590	1.8614	1.8638	1.8662	1.8686	1.8710	1.8734	1.8758	1.8782	1.8806
68	1.8831	1.8855	1.8880	1.8905	1.8929	1.8954	1.8979	1.9904	1.9029	1.9054
69	1.9079	1.9104	1.9129	1.9154	1.9180	1.9205	1.9231	1.9256	1.9281	1.9307
70	1.9333	1.9359	1.9385	1.9411	1.9437	1.9463	1.9489	1.9515	1.9542	1.9568

TABLE 181.

Properties of Saturated Steam.[4]

Pressure in pounds per sq. in. above vacuum	Temperature in degrees Fahrenheit	Heat in liquid from 32° in units	Heat of vaporization, or latent heat in heat units	Total Heat in heat units from water at 32°	Density or weight of cubic ft. in pounds	Volume of 1 pound in cubic feet	Total pressure above vacuum
1	101.99	70.0	1043.0	1113.1	0.00299	334.5	1
2	126.27	94.4	1026.1	1120.5	0.00576	173.6	2
3	141.62	109.8	1015.3	1125.1	0.00844	118.5	3
4	153.09	121.4	1007.2	1128.6	0.01107	90.31	4
5	162.34	130.7	1000.8	1131.5	0.01366	73.21	5
6	170.14	138.6	995.2	1133.8	0.01622	61.67	6
7	176.90	145.4	990.5	1135.9	0.01874	53.37	7
8	182.92	151.5	986.2	1137.7	0.02125	47.06	8
9	188.33	156.9	982.5	1139.4	0.02374	42.12	9
10	193.25	161.9	979.0	1140.9	0.02621	38.15	10
14.7	212.00	180.9	965.7	1146.6	0.03794	26.36	14.7
15	213.03	181.8	965.1	1146.9	0.03826	26.14	15
20	227.95	196.9	954.6	1151.5	0.05023	19.91	20
25	240.04	209.1	946.0	1155.1	0.06199	16.13	25
30	250.27	219.4	938.9	1158.3	0.07360	13.59	30
35	259.19	228.4	932.6	1161.0	0.08508	11.75	35
40	267.13	236.4	927.0	1163.4	0.09644	10.37	40
45	274.29	243.6	922.0	1165.6	0.1077	9.287	45
50	280.85	250.2	917.4	1167.6	0.1188	8.414	50
55	286.89	256.3	913.4	1169.4	0.1299	7.696	55
60	292.51	261.9	909.3	1171.2	0.1409	7.097	60
65	297.77	267.2	905.5	1172.7	0.1519	6.583	65
70	302.71	272.2	902.1	1174.3	0.1628	6.143	70
75	307.38	276.9	898.8	1175.7	0.1736	5.762	75
80	311.80	281.4	895.6	1177.0	0.1843	5.426	80
85	316.02	285.8	892.5	1178.3	0.1951	5.126	85
90	320.04	290.0	889.6	1179.6	0.2058	4.859	90
95	323.89	294.0	886.7	1180.7	0.2165	4.619	95
100	327.58	297.9	884.0	1181.9	0.2271	4.403	100
105	331.13	301.6	881.3	1182.9	0.2378	4.205	105
110	334.56	305.2	878.8	1184.0	0.2484	4.026	110
115	337.86	308.7	876.3	1185.0	0.2589	3.862	115
120	341.05	312.0	874.0	1186.0	0.2695	3.711	120
125	344.13	315.2	871.7	1186.9	0.2800	3.571	125
130	347.12	318.4	869.4	1187.8	0.2904	3.444	130
140	352.85	324.4	865.1	1189.5	0.3113	3.212	140
150	358.26	330.0	861.2	1191.2	0.3321	3.011	150
160	363.40	335.4	857.4	1192.8	0.3530	2.833	160
170	368.29	340.5	853.8	1194.3	0.3737	2.676	170
180	372.97	345.4	850.3	1195.7	0.3945	2.535	180
190	377.44	350.1	847.0	1197.1	0.4153	2.408	190
200	381.73	354.6	843.8	1198.4	0.4359	2.294	200
225	391.79	365.1	836.3	1201.4	0.4876	2.051	225
250	400.99	374.7	829.5	1204.2	0.5393	1.854	250
275	409.50	383.6	823.2	1206.8	0.5913	1.691	275
300	417.42	391.9	817.4	1209.3	0.644	1.553	300
325	424.82	399.6	811.9	1211.5	0.696	1.437	325
350	431.90	406.9	806.8	1213.7	0.748	1.337	350
375	438.40	414.2	801.5	1215.7	0.800	1.250	375
400	445.15	421.4	796.3	1217.7	0.853	1.172	400
500	466.57	444.3	779.9	1224.2	1.065	.939	500

TABLE 181—Continued.

Temperature in degrees Fahrenheit	Total pressure above vacuum	Heat in liquid from 32° in units	Heat of vaporization, or latent heat in heat units	Total heat in heat units from water at 32°	Density or weight of cubic ft. in pounds	Volume of one pound in cubic feet	Temperature in degrees Fahrenheit
32	0.089	0.	1091.7	1091.7	0.0003	3387.	32
60	0.254	28.12	1072.1	1100.2	0.0008	1244.	60
90	0.692	58.04	1051.4	1109.4	0.0021	474.6	90
120	1.683	88.10	1034.4	1118.5	0.0049	204.4	120
140	2.877	108.2	1016.4	1124.6	0.0081	123.2	140
150	3.706	118.3	1009.4	1127.7	0.0103	97.03	150
160	4.729	128.4	1002.3	1130.7	0.0130	77.14	160
170	5.98	138.5	995.3	1133.8	0.0162	61.85	170
180	7.50	148.5	988.3	1136.8	0.0200	50.01	180
190	9.33	158.6	981.3	1139.9	0.0245	40.73	190
200	11.52	168.7	974.2	1142.9	0.0299	33.40	200
210	14.12	178.8	967.2	1146.0	0.0363	27.57	210
220	17.19	188.9	960.1	1149.0	0.0435	22.98	220
225	18.91	193.9	956.7	1150.6	0.0476	20.99	225
230	20.78	198.9	953.2	1152.1	0.0521	19.20	230
235	22.80	204.0	949.6	1153.6	0.0569	17.59	235
240	24.98	209.0	946.1	1155.1	0.0619	16.14	240
245	27.33	214.1	942.6	1156.7	0.0674	14.83	245
250	29.86	219.1	939.1	1158.2	0.0733	13.65	250
255	32.57	224.1	935.6	1159.7	0.0795	12.57	255
260	35.48	229.2	932.0	1161.2	0.0862	11.60	260
265	38.60	234.2	928.6	1162.8	0.0933	10.72	265
270	41.94	239.3	925.0	1164.3	0.1008	9.918	270
275	45.51	244.3	921.5	1165.8	0.1088	9.187	275
280	49.33	249.3	918.0	1167.3	0.1173	8.521	280
285	53.39	254.4	914.5	1168.9	0.1264	7.913	285
290	57.72	259.4	911.0	1170.4	0.1359	7.356	290
295	62.33	264.4	907.4	1171.9	0.1461	6.847	295
300	67.22	269.5	903.9	1173.4	0.1567	6.380	300
305	72.42	274.5	900.5	1175.0	0.1680	5.952	305
310	77.83	279.6	896.9	1176.5	0.1799	5.558	310
315	83.77	284.8	893.2	1178.0	0.1925	5.195	315
320	89.95	290.0	889.5	1179.5	0.2058	4.861	320
325	96.48	295.2	885.9	1181.1	0.2197	4.552	325
330	103.38	300.5	882.1	1128.6	0.2343	4.267	330
335	110.66	305.7	878.4	1184.1	0.2498	4.004	335
340	118.34	310.9	874.7	1185.6	0.2660	3.760	340
345	126.43	316.1	871.1	1187.2	0.2830	3.534	345
350	134.95	321.4	867.3	1188.7	0.3008	3.324	350
355	142.91	326.6	863.6	1190.2	0.3195	3.130	355
360	153.33	331.8	859.9	1191.7	0.3391	2.949	360
365	163.22	337.1	856.2	1193.3	0.3597	2.780	365
370	173.60	342.3	852.5	1194.8	0.3812	2.623	370
375	184.49	347.5	848.8	1196.3	0.4038	2.476	375
380	195.91	352.8	845.0	1197.8	0.4276	2.338	380
385	207.87	358.0	841.4	1199.4	0.4521	2.212	385
390	220.39	363.2	837.7	1200.9	0.4780	2.092	390
395	233.50	368.4	834.0	1202.4	0.5051	1.980	395
400	247.21	373.7	830.2	1203.9	0.5336	1.874	400
405	261.55	378.9	826.6	1205.5	0.5633	1.775	405
410	276.54	384.1	822.9	1207.0	0.5945	1.682	410
415	292.21	389.4	819.1	1208.5	0.6270	1.595	415
420	308.57	394.6	815.4	1210.0	0.6610	1.512	420
425	325.65	399.8	811.8	1211.6	0.6970	1.434	425

TABLE 182.

Tables for converting U. S. Weights and Measures Customary to Metric.[5]

LINEAR.

	Inches to millimeters.	Feet to meters.	Yards to meters.	Miles to kilometers.
1	25.4001	0.304801	0.914402	1.60935
2	50.8001	0.609601	1.828804	3.21869
3	76.2002	0.914402	2.743205	4.82804
4	101.6002	1.219202	3.657607	6.43739
5	127.0003	1.524003	4.572009	8.04674
6	152.4003	1.828804	5.486411	9.65608
7	177.8004	2.133604	6.400813	11.26543
8	203.2004	2.438405	7.315215	12.87478
9	228.6005	2.743205	8.229616	14.48412

CAPACITY.

	Fluid drams to milliliters or cubic centimeters.	Fluid ounces to milliliters.	Liquid quarts to liters.	Gallons to liters.
1	3.70	29.57	0.94633	3.78533
2	7.39	59.15	1.89267	7.57066
3	11.09	88.72	2.83900	11.35600
4	14.79	118.29	3.78533	15.14133
5	18.48	147.87	4.73167	18.92666
6	22.18	177.44	5.67800	22.71199
7	25.88	207.01	6.62433	26.49733
8	29.57	236.58	7.57066	30.28266
9	33.27	266.16	8.51700	34.06799

SQUARE.

	Square inches to square centimeters.	Square feet to square decimeters.	Square yards to square meters.	Acres to hectares.
1	6.452	9.290	0.836	0.4047
2	12.903	18.581	1.672	0.8094
3	19.355	27.871	2.508	1.2141
4	25.807	37.161	3.345	1.6187
5	32.258	46.452	4.181	2.0234
6	38.710	55.742	5.017	2.4281
7	45.161	65.032	5.853	2.8328
8	51.613	74.323	6.689	3.2375
9	58.065	83.613	7.525	3.6422

WEIGHT.

	Grains to milligrams.	Avoirdupois ounces to grams.	Avoirdupois pounds to kilograms.	Troy ounces to grams.
1	64.7989	28.3495	0.45359	31.10348
2	129.5978	56.6991	0.90718	62.20696
3	194.3968	85.0486	1.36078	93.31044
4	259.1957	113.3981	1.81437	124.41392
5	323.9946	141.7476	2.26796	155.51740
6	388.7935	170.0972	2.72155	186.62088
7	453.5924	198.4467	3.17515	217.72437
8	518.3913	226.7962	3.62874	248.82785
9	583.1903	255.1457	4.08233	279.93133

CUBIC.

	Cubic inches to cubic centimeters.	Cubic feet to cubic meters.	Cubic yards to cubic meters.	Bushels to hectoliters.
1	16.387	0.02832	0.765	0.35239
2	32.774	0.05663	1.529	0.70479
3	49.161	0.08495	2.294	1.05718
4	65.549	0.11327	3.058	1.40957
5	81.936	0.14159	3.823	1.76196
6	98.323	0.16990	4.587	2.11436
7	114.710	0.19822	5.352	2.46675
8	131.097	0.22654	6.116	2.81914
9	147.484	0.25485	6.881	3.17154

1 Gunter's chain	=	20.1168	meters.
1 sq. statute mile	=	259.000	hectares.
1 fathom	=	1.829	meters.
1 nautical mile	=	1853.25	meters.
1 foot	=	0.304801	meter.
1 avoir. pound	=	453.5924277	grams.
15432.35639 grains	=	1.000	kilogram.

TABLE 183.

Tables for converting U. S. weights and measures. Metric to customary.[c]

LINEAR.

	Meters to inches.	Meters to feet.	Meters to yards.	Kilometers to miles.
1	39.3700	3.28083	1.093611	0.62137
2	78.7400	6.56167	2.187222	1.24274
3	118.1100	9.84250	3.280833	1.86411
4	157.4800	13.12333	4.374444	2.48548
5	196.8500	16.40417	5.468056	3.10685
6	236.2200	19.68500	6.561667	3.72822
7	275.5900	22.96583	7.655278	4.34959
8	314.9600	26.24667	8.748889	4.97096
9	354.3300	29.52750	9.842500	5.59233

CAPACITY.

	Milliliters or cubic centimeters to fluid drams.	Centiliters to fluid ounces.	Liters to quarts.	Decaliters to gallons.	Hectoliters to bushels.
1	0.27	0.338	1.0567	2.6418	2.8378
2	0.54	0.676	2.1134	5.2836	5.6756
3	0.81	1.014	3.1701	7.9253	8.5135
4	1.08	1.353	4.2268	10.5671	11.3513
5	1.35	1.691	5.2836	13.2089	14.1891
6	1.62	2.029	6.3403	15.8507	17.0269
7	1.89	2.367	7.3970	18.4924	19.8647
8	2.16	2.705	8.4537	21.1342	22.7026
9	2.43	3.043	9.5104	23.7760	25.5404

SQUARE.

	Square centimeters to square inches.	Square meters to square feet.	Square meters to square yards.	Hectares to acres.
1	0.1550	10.764	1.196	2.471
2	0.3100	21.528	2.392	4.942
3	0.4650	32.292	3.588	7.413
4	0.6200	43.055	4.784	9.884
5	0.7750	53.819	5.980	12.355
6	0.9300	64.583	7.176	14.826
7	1.0850	75.347	8.372	17.297
8	1.2400	86.111	9.568	19.768
9	1.3950	96.875	10.764	22.239

WEIGHT.

	Milligrams to grains.	Kilograms to grains.	Hectograms to ounces avoirdupois.	Kilograms to pounds avoirdupois.
1	0.01543	15432.36	3.5274	2.20462
2	0.03086	30864.71	7.0548	4.40924
3	0.04630	46297.07	10.5822	6.61387
4	0.06173	61729.43	14.1096	8.81849
5	0.07716	77161.78	17.6370	11.02311
6	0.09259	92594.14	21.1644	13.22773
7	0.10803	108026.49	24.6918	15.43236
8	0.12346	123458.85	28.2192	17.63698
9	0.13889	138891.21	31.7466	19.84160

CUBIC.

	Cubic centimeters to cubic inches.	Cubic decimeters to cubic inches.	Cubic meters to cubic feet.	Cubic meters to cubic yards.
1	0.0610	61.023	35.314	1.308
2	0.1220	122.047	70.269	2.616
3	0.1831	183.070	105.943	3.924
4	0.2441	244.094	141.258	5.232
5	0.3051	305.117	176.572	6.540
6	0.3661	366.140	211.887	7.848
7	0.4272	427.164	247.201	9.156
8	0.4882	488.187	282.516	10.464
9	0.5492	549.210	317.830	11.771

WEIGHT.

	Quintals to pounds av.	Milliers or tonnes to pounds av.	Kilograms to ounces Troy.
1	220.46	2204.6	32.1507
2	440.92	4409.2	64.3015
3	661.39	6613.9	96.4522
4	881.85	8818.5	128.6030
5	1102.31	11023.1	160.7537
6	1322.77	13227.7	192.9045
7	1543.24	15432.4	225.0552
8	1763.70	17637.0	257.2059
9	1984.16	19841.6	289.3567

TABLE 184.

Equivalent of Metric and British Imperial Weights and Measures. Metric to Imperial.[8]

LINEAR MEASURE.

1 millimeter (mm.) (.001 m.)	=	0.03937 in.
1 centimeter (.01 m.)	=	0.39370 "
1 decimeter (.1 m)	=	3.93701 "
1 METER (m.)	=	39.370113 " 3.280843 ft. 1.09361425 yds.
1 dekameter (10 m.)	=	10.93614 "
1 hectometer (100 m.)	=	109.361425 "
1 kilometer (1,000 m.)	=	0.62137 mile.
1 myriameter (10,000 m.)	=	6.21372 miles.
1 micron	=	0.001 mm.

SQUARE MEASURE.

1 sq. centimeter	=	0.1550 sq. in.
1 sq. decimeter (100 sq. centm.)	=	15.500 sq. in.
1 sq. meter or centiare (100 sq. dcm.)	=	10.7639 sq. ft. 1.1960 sq. yds.
1 ARE (100 sq. m.)	=	119.60 sq. yds.
1 hectare (100 ares or 10,000 sq. m.)	=	2.4711 acres.

CUBIC MEASURE.

1 cub. centimeter (c.c.) (1,000 cubic millimeters)	=	0.0610 cub. in.
1 cub. decimeter (c.d.) (1,000 cubic centimeters)	=	61.024 " "
1 CUB. METER or stere (1,000 c.d.)	=	35.3148 cub. ft. 1.307954 cub. yds.

MEASURE OF CAPACITY.

1 milliliter (ml.) (.001 liter)	=	0.0610 cub. in.
1 centiliter (.01 liter)	=	0.61024 " " 0.070 gill.
1 deciliter (.1 liter)	=	0.176 pint.
1 LITER (1,000 cub. centimeters or 1 cub. decimeter)	=	1.75980 pints.
1 dekaliter (10 liters)	=	2.200 gallons.
1 hectoliter (100 ")	=	2.75 bushels.
1 kiloliter (1,000 ")	=	3.437 quarters.

APOTHECARIES' MEASURE.

1 cubic centimeter (1 gram w't)	=	0.03520 fluid ounce. 0.28157 fluid drachm. 15.43236 grains weight.
1 cub. millimeter	=	0.01693 minim.

AVOIRDUPOIS WEIGHT.

1 milligram (mgr.)	=	0.01543 grain.
1 centigram (.01 gram.)	=	0.15432 "
1 decigram (.1 ")	=	1.54324 grains.
1 GRAM	=	15.43236 "
1 dekagram (10 gram.)	=	5.64383 drams.
1 hectogram (100 ")	=	3.52739 oz.
1 KILOGRAM (1,000 ")	=	2.2046223 lb 15432.3564 grains.
1 myriagram (10 kilog.)	=	22.04622 lbs.
1 quintal (100 ")	=	1.96841 cwt.
1 millier or tonne (1,000 kilog.)	=	0.9842 ton.

TROY WEIGHT.

1 GRAM	=	0.03215 oz. Troy. 0.64301 pennyweight. 15.43236 grains.

APOTHECARIES' WEIGHT.

1 GRAM	=	0.25721 drachm. 0.77162 scruple. 15.43236 grains.

TABLE 185.

Equivalents of Metric and British Imperial weights and Measures. Metric to imperial.[9]

LINEAR MEASURE.

	Millimeters to inches.	Meters to feet.	Meters to yards.	Kilometers to miles.
1	0.03937011	3.28084	1.09361	0.62137
2	0.07874023	6.56169	2.18723	1.24274
3	0.11811034	9.84253	3.28084	1.86412
4	0.15748045	13.12337	4.37446	2.48549
5	0.19685056	16.40421	5.46807	3.10686
6	0.23622968	19.68506	6.56169	3.72823
7	0.27559079	22.96590	7.65530	4.34960
8	0 31496090	26.24674	8.74891	4.97097
9	0.35433102	29.52758	9.84253	5.59235

MEASURE OF CAPACITY.

	Liters to pints.	Dekaliters to gallons	Hectoliters to bushels.	Kiloliters to quarters.
1	1.75980	2.19975	2.74969	3.43712
2	3.51961	4.39951	5.49938	6.87423
3	5.27941	6.59926	8.24908	10.31135
4	7.03921	8.79902	10.99877	13.74846
5	8.79902	10.99877	13.74846	17.18558
6	10.55882	13.19852	16.49815	20.62269
7	12.31862	15.39828	19.24785	24.05981
8	14.07842	17.59803	21.99754	27.49692
9	15.83823	19.79778	24.74723	30.93404

SQUARE MEASURE.

	Square centimeters to square inches.	Square meters to square feet.	Square meters to square yards.	Hectares to acres.
1	0.15500	10.76393	1.19599	2.4711
2	0.31000	21.52786	2.39198	4 9421
3	0.46500	32.29179	3.58798	7.4132
4	0.62000	43.05572	4.78397	9.8842
5	0.77500	53.81965	5.97996	12.3553
6	0.93000	64.58357	7.17595	14.8263
7	1.08500	75.34750	8.37194	17.2974
8	1.24000	86.11143	9.56794	19.7685
9	1.39501	96.87536	10.76393	22.2395

WEIGHT (AVOIRDUPOIS).

	Milligrams to grains.	Kilograms to grains.	Kilograms to pounds.	Quintals to hundredweights.
1	0.01543	15432.356	2.20462	1.96841
2	0.03086	30864.713	4.40924	3.93683
3	0.04630	46297.069	6.61387	5.90524
4	0.06173	61729.426	8.81849	7.87365
5	0.07716	77161.782	11.02311	9.84206
6	0.09259	92594.138	13.22773	11.81048
7	0.10803	108026.495	15.43236	13.77889
8	0.12346	123458.851	17.63698	15.74730
9	0.13889	138891.208	19.84160	17.71572

CUBIC MEASURE.

	Cubic decimeters to cubic inches.	Cubic meters to cubic feet.	Cubic meters to cubic yards.	Cub. centimeters to fluid drachms.
1	61.02390	35.31476	1.30795	0.28157
2	122.04781	70.62952	2.61591	0.56314
3	183.07171	105.94428	3.92386	0.84471
4	244.09561	141.25904	5.23182	1.12627
5	305.11952	176.57379	6.53977	1.40784
6	366.14342	211.88855	7.84772	1.68941
7	427.16732	247.20331	9.15568	1.97098
8	488.19123	282.51807	10.46363	2.25255
9	549.21513	317.83283	11.77159	2.53412

APOTHECARIES' MEASURE.

AVOIRDUPOIS (*cont.*) — TROY WEIGHT. — APOTHECARIES' WEIGHT.

	Milliers or tonnes to tons.	Grams to ounces Troy.	Grams to pennyweights.	Grams to scruples.
1	0.98421	0.03215	0.64301	0.77162
2	1.96841	0.06430	1.28603	1.54324
3	2.95262	0.09645	1.92904	2.31485
4	3.93683	0.12860	2.57206	3.08647
5	4.92103	0.16075	3.21507	3.85809
6	5.90524	0.19290	3.85809	4.62971
7	6.88944	0.22506	4.50110	5.40132
8	7.87365	0.25721	5.14412	6.17294
9	8.85786	0.28936	5.78713	6.94456

TABLE 186.

Equivalent of British Imperial and Metric weights and measures. Imperial to metric.[10]

LINEAR MEASURE.

1 inch	= 25.400 millimeters.
1 foot (12 in.)	= 0.30480 meter.
1 YARD (3 ft.)	= 0.914399 "
1 pole (5½ yd.)	= 5.0292 meters.
1 chain (22 yd. or 100 links)	= 20.1168 "
1 furlong (220 yd.)	= 201.168 "
1 mile (1,760 yd.)	= 1.6093 kilometers.

SQUARE MEASURE.

1 square inch	= 6.4516 sq. centimeters.
1 sq. ft. (144 sq. in.)	= 9.2903 sq. decimeters.
1 SQ. YARD (9 sq. ft.)	= 0.836126 sq. meters.
1 perch (30¼ sq. yd.)	= 25.293 sq. meters.
1 rood (40 perches)	= 10.117 ares.
1 ACRE (4840 sq. yd.)	= 0.40468 hectare.
1 sq. mile (640 acres)	= 259.00 hectares.

CUBIC MEASURE.

1 cub. inch	= 16.387 cub. centimeters.
1 cub. foot (1728 cub. in.)	= 0.028317 cub. meter, or 28.317 cub. decimeters.
1 CUB. YARD (27 cub. ft.)	= 0.76455 cub. meter.

APOTHECARIES' MEASURE.

1 gallon (8 pints or 160 fluid ounces)	= 4.5459631 liters.
1 fluid ounce, f ʒ (8 drachms)	= 28.4123 cubic centimeters.
1 fluid drachm, f ʒ (60 minims)	= 3.5515 cubic centimeters.
1 minim, ♏ (0.91146 grain weight)	= 0.05919 cubic centimeters.

NOTE. — The Apothecaries' gallon is of the same capacity as the Imperial gallon.

MEASURE OF CAPACITY.

1 gill	= 1.42 deciliters.
1 pint (4 gills)	= 0.568 liter.
1 quart (2 pints)	= 1.136 liters.
1 GALLON (4 quarts)	= 4.5459631 "
1 peck (2 galls.)	= 9.092 "
1 bushel (8 galls.)	= 3.637 dekaliters.
1 quarter (8 bushels)	= 2.909 hectoliters.

AVOIRDUPOIS WEIGHT.

1 grain	= 64.8 milligrams.
1 dram	= 1.772 grams.
1 ounce (16 dr.)	= 28.350 "
1 POUND (16 oz. or 7,000 grains)	= 0.45359243 kilogr.
1 stone (14 lb.)	= 6.350 "
1 quarter (28 lb.)	= 12.70 "
1 hundredweight (112 lb.)	= 50.80 " = 0.5080 quintal.
1 ton (20 cwt.)	= 1.0160 tonnes or 1016 kilograms.

TROY WEIGHT.

1 Troy OUNCE (480 grains avoir.)	= 31.1035 grams.
1 pennyweight (24 grains)	= 1.5552 "

NOTE. — The Troy grain is of the same weight as the Avoirdupois grain.

APOTHECARIES' WEIGHT.

1 ounce (8 drachms)	= 31.1035 grams.
1 drachm, ʒ i (3 scruples)	= 3.888 "
1 scruple, ℈ i (20 grains)	= 1.296 "

NOTE. — The Apothecaries' ounce is of the same weight as the Troy ounce. The Apothecaries' grain is also of the same weight as the Avoirdupois grain.

TABLE 186—Continued.

Equivalent of British Imperial and metric weights and measures. Imperial to Metric.[11]

LINEAR MEASURE.

	Inches to centimeters.	Feet to meters.	Yards to meters.	Miles to kilometers.
1	2.539998	0.30480	0.91440	1.60934
2	5.079996	0.60960	1.82880	3.21869
3	7.619993	0.91440	2.74320	4.82803
4	10.159991	1.21920	3.65760	6.43737
5	12.699989	1.52400	4.57200	8.04671
6	15.239987	1.82880	5.48640	9.65606
7	17.779984	2.13360	6.40080	11.26540
8	20.319982	2.43840	7.31519	12.87474
9	22.859980	2.74320	8.22959	14.48408

MEASURE OF CAPACITY.

	Quarts to liters.	Gallons to liters.	Bushels to dekaliters.	Quarters to hectoliters.
1	1.13649	4.54596	3.63677	2.90942
2	2.27298	9.09193	7.27354	5.81883
3	3.40947	13.63789	10.91031	8.72825
4	4.54596	18.18385	14.54708	11.63767
5	5.68245	22.72982	18.18385	14.54708
6	6.81894	27.27578	21.82062	17.45650
7	7.95544	31.82174	25.45739	20.36591
8	9.09193	36.36770	29.09416	23.27533
9	10.22842	40.91367	32.73093	26.18475

SQUARE MEASURE.

	Square inches to square centimeters.	Square feet to square decimeters.	Square yards to square meters.	Acres to hectares.
1	6.45159	9.29029	0.83613	0.40468
2	12.90318	18.58058	1.67225	0.80937
3	19.35477	27.87086	2.50838	1.21405
4	25.80636	37.16115	3.34450	1.61874
5	32.25794	46.45144	4.18063	2.02342
6	38.70953	55.74173	5.01676	2.42811
7	45.16112	65.03201	5.85288	2.83279
8	51.61271	74.32230	6.68901	3.23748
9	58.06430	83.61259	7.52513	3.64216

WEIGHT (AVOIRDUPOIS).

	Grains to milligrams.	Ounces to grams.	Pounds to kilograms.	Hundredweights to quintals.
1	64.79892	28.34953	0.45359	0.50802
2	129.59784	56.69905	0.90718	1.01605
3	194.39675	85.04858	1.36078	1.52407
4	259.19567	113.39811	1.81437	2.03209
5	323.99459	141.74763	2.26796	2.54012
6	388.79351	170.09716	2.72155	3.04814
7	453.59243	198.44669	3.17515	3.55616
8	518.39135	226.79621	3.62874	4.06419
9	583.19026	255.14574	4.08233	4.57221

CUBIC MEASURE.

	Cubic inches to cubic centimeters.	Cubic feet to cubic meters.	Cubic yards to cubic meters.
1	16.38702	0.02832	0.76455
2	32.77404	0.05663	1.52911
3	49.16106	0.08495	2.29366
4	65.54808	0.11327	3.05821
5	81.93511	0.14158	3.82276
6	98.32213	0.16990	4.58732
7	114.70915	0.19822	5.35187
8	131.09617	0.22653	6.11642
9	147.48319	0.25485	6.88098

APOTHECARIES' MEASURE.

	Fluid drachms to cubic centimeters.
1	3.55153
2	7.10307
3	10.65460
4	14.20613
5	17.75767
6	21.30920
7	24.86074
8	28.41227
9	31.96380

AVOIRDUPOIS (*cont.*).

	Tons to milliers or tonnes.
1	1.01605
2	2.03209
3	3.04814
4	4.06419
5	5.08024
6	6.09628
7	7.11233
8	8.12838
9	9.14442

TROY WEIGHT

	Ounces to grams.	Pennyweights to grams.
1	31.10348	1.55517
2	62.20696	3.11035
3	93.31044	4.66552
4	124.41392	6.22070
5	155.51740	7.77587
6	186.62088	9.33104
7	217.72437	10.88622
8	248.82785	12.44139
9	279.93133	13.99657

APOTHECARIES' WEIGHT

	Scruples to grams.
1	1.29598
2	2.59196
3	3.88794
4	5.18391
5	6.47989
6	7.77587
7	9.07185
8	10.36783
9	11.66381

TABLE 187.

Miscellaneous equivalents of Metric weights and measures.[7]

LINEAR MEASURES.

1 mil (.001 in.) = 25.4001 μ
1 in. = .000015783 mile
1 hand (4 in.) = 10.16002 cm
1 link (.66 ft.) = 20.11684 cm
1 span (9 in.) = 22.86005 cm
1 fathom (6 ft.) = 1.828804 m
1 rod (25 links) = 5.029210 m
1 chain (4 rods) = 20.11684 m
1 light year (9.5×10^{12} km) = 5.9×10^{12} miles
1 par sec (31×10^{12} km) = 19×10^{12} miles
$\frac{1}{64}$ in. = .397 mm $\frac{1}{32}$ in. = .794 mm
$\frac{1}{16}$ in. = 1.588 mm $\frac{1}{8}$ in. = 3.175 mm
$\frac{1}{4}$ in. = 6.350 mm $\frac{1}{2}$ in. = 12.700 mm
1 Ångström unit = .000000001 m
1 micron (μ) = .00001 m = .00003937 in.
1 millimicron (mμ) = .000000001 m
1 m = 4.970960 links = 1.093611 yds.
= .198838 rod = .0497096 chain

SQUARE MEASURES.

1 sq. link (62.7264 sq. in.) = 404.6873 cm^2
1 sq. rod (625 sq. links) = 25.29295 m^2
1 sq. chain (16 sq. rods) = 404.6873 m^2
1 acre (10 sq. chains) = 4046.873 m^2
1 sq. mile (640 acres) = 2.589998 km^2
1 km^2 = .3861006 sq. mile
1 m^2 = 24.7104 sq. links = 10.76387 sq. ft.
= .039537 sq. rod. = .00247104 sq. chain

CUBIC MEASURES.

1 board foot (144 cu. in) = 2359.8 cm^3
1 cord (128 cu. ft.) = 3.625 m^3

CAPACITY MEASURES.

1 minim (♏) = .0616102 ml
1 fl. dram (60♏) = 3.69661 ml
1 fl. oz. (8 fl. dr.) = 1.80469 cu. in.
= 29.5729 ml
1 gill (4 fl. oz.) = 7.21875 cu. in. = 118.292 ml
1 liq. pt. (28.875 cu. in.) = .473167 l
1 liq. qt. (57.75 cu. in.) = .946333 l
1 gallon (4 qt., 231 cu. in.) = 3.785332 l
1 dry pt. (33.6003125 cu. in.) = .550599 l
1 dry qt. (67.200625 cu. in.) = 1.101198 l
1 pk. (8 dry qt., 537.605 cu. in.) = 8.80958 l
1 bu. (4 pk., 2150.42 cu. in.) = 35.2383 l
1 firkin (9 gallons) = 34.06799 l
1 liter = .264178 gal. = 1.05671 liq. qt.
= 33.8147 fl. oz. = 270.518 fl. dr.
1 ml = 16.2311 minims.
1 dkl = 18.620 dry pt. = 9.08102 dry qt.
= 1.13513 pk. = .28378 bu.

MASS MEASURES.

Avoirdupois weights.

1 grain = .064798918 g
1 dram av. (27.34375 gr.) = 1.771845 g
1 oz. av. (16 dr. av.) = 28.349527 g
1 pd. av. (16 oz. av. or 7000 gr.)
= 14.583333 oz. ap. (℥) or oz. t.
= 1.2152778 or 7000/5760 pd. ap or t.
= 453.5924277 g
1 kg = 2.204622341 pd. av.
1 g = 15.432356 gr. = .5643833 av. dr.
= .03527396 av. oz.
1 short hundred weight (100 pds.)
= 45.359243 kg
1 long hundred weight (112 pds.)
= 50.802352 kg
1 short ton (2000 pds.)
= 907.18486 kg
1 long ton (2240 pd.)
= 1016.04704 kg
1 metric ton = 0.98420640 long ton
= 1.1023112 short tons

Troy weights.

1 pennyweight (dwt., 24 gr.) = 1.555174 g; gr., oz., pd. are same as apothecary

Apothecaries' weights.

1 gr. = 64.798918 mg
1 scruple (℈, 20 gr.) = 1.2959784 g
1 dram (℥, 3 ℈) = 3.8879351 g
1 oz. (℥, 8 ℥) = 31.103481 g
1 pd (12℥, 5760 gr.) = 373.24177 g
1 g = 15.432356 gr. = 0.771618 ℈
= 0.2572059 ℥ = .03215074 ℥
1 kg = 32.150742 ℥ = 2.6792285 pd.

1 metric carat = 200 mg = 3.0864712 gr.

U. S. $\frac{1}{2}$ dollar should weigh 12.5 g and the smaller silver coins in proportion.

TABLE 188.

Conversion of Degrees Centigrade into Degrees Fahrenheit, or vice versa.

Formula: $F.=C.\times\frac{9}{5}+32$

Formula: $C.=F.-32\times\frac{5}{9}$

Degrees Centrigrade	Degrees Fahrenheit	Degrees Centrigrade	Degrees Fahrenheit
−17·78	0	24	75·2
−15	5·00	25	77·0
−10	14·00	30	86·0
− 5	23·00	35	95
0	32·00	37·78	100·0
1	33·8	40·0	104·0
2	35·6	45	113·0
3	37·4	50	122·0
4	39·2	55	131·0
5	41·0	60	140·0
6	42·8	65	149·0
7	44·6	70	158·0
8	46·4	75	167·0
9	48·2	80	176·0
10	50·0	85	185·0
11	51·8	90	194·0
12	53·6	95	203·0
13	55·4	100	212·0
14	57·2	105	221·0
15	59·0	110	230·0
15·56	60·0	115	239·0
16	60·8	120	248·0
17	62·6	125	257·0
18	64·4	130	266·0
19	66·2	135	275·0
20	68·0	140	284·0
21	69·8	145	293·0
22	71·6	150	302·0
23	73·4		

DIFFERENCE TABLE

Degrees	F into C	C into F
1	·56	1·8
2	1·11	3·6
3	1·67	5·4
4	2·22	7·2
5	2·78	9·0
6	3·33	10·8
7	3·89	12·6
8	4·44	14·4
9	5·00	16·2
10	5·56	18·0

TABLE 189.

Alcohol table for calculating the percentages of alcohol in mixtures of ethyl alcohol and water from their specific gravities. (Calculated by U. S. Bureau of Standards from its experimental results).[12]

Specific Gravity 20° C. / 4°	Alcohol			Specific Gravity 20° C. / 4°	Alcohol		
	Per Cent by Vol. at 20° C.	Per Cent by Weight	Grams Per 100 cc.		Per Cent by Vol. at 20° C.	Per Cent by Weight	Grams Per 100 cc.
0.99823	0.00	0.00	0.00	0.97704	16.75	13.53	13.22
0.99785	0.25	0.20	0.20	0.97678	17.00	13.74	13.42
0.99748	0.50	0.40	0.40	0.97650	17.25	13.94	13.62
0.99711	0.75	0.59	0.59	0.97624	17.50	14.15	13.81
0.99675	1.00	0.79	0.79	0.97596	17.75	14.35	14.01
0.99638	1.25	0.99	0.99	0.97570	18.00	14.56	14.21
0.99601	1.50	1.19	1.19	0.97542	18.25	14.77	14.41
0.99564	1.75	1.39	1.38	0.97517	18.50	14.97	14.60
0.99528	2.00	1.59	1.58	0.97490	18.75	15.18	14.80
0.99492	2.25	1.79	1.78	0.97464	19.00	15.39	15.00
0.99456	2.50	1.98	1.97	0.97438	19.25	15.59	15.20
0.99420	2.75	2.18	2.17	0.97412	19.50	15.80	15.39
0.99384	3.00	2.38	2.37	0.97386	19.75	16.01	15.59
0.99348	3.25	2.58	2.57	0.97359	20.00	16.21	15.79
0.99313	3.50	2.78	2.76	0.97333	20.25	16.42	15.99
0.99278	3.75	2.98	2.96	0.97306	20.50	16.63	16.18
0.99243	4.00	3.18	3.16	0.97278	20.75	16.84	16.38
0.99208	4.25	3.38	3.36	0.97252	21.00	17.04	16.58
0.99174	4.50	3.58	3.55	0.97227	21.25	17.25	16.77
0.99140	4.75	3.78	3.75	0.97199	21.50	17.46	16.97
0.99106	5.00	3.98	3.95	0.97172	21.75	17.67	17.17
0.99073	5.25	4.18	4.14	0.97145	22.00	17.88	17.37
0.99040	5.50	4.38	4.34	0.97118	22.25	18.08	17.56
0.99006	5.75	4.58	4.54	0.97091	22.50	18.29	17.76
0.98973	6.00	4.78	4.74	0.97063	22.75	18.50	17.96
0.98941	6.25	4.99	4.93	0.97036	23.00	18.71	18.16
0.98908	6.50	5.19	5.13	0.97007	23.25	18.92	18.35
0.98876	6.75	5.39	5.33	0.97982	23.50	19.13	18.55
0.98845	7.00	5.59	5.53	0.96952	23.75	19.33	18.75
0.98813	7.25	5.79	5.72	0.96925	24.00	19.55	18.94
0.98781	7.50	5.99	5.92	0.96896	24.25	19.75	19.14
0.98750	7.75	6.19	6.12	0.96869	24.50	19.96	19.34
0.98718	8.00	6.40	6.32	0.96840	24.75	20.17	19.54
0.98688	8.25	6.60	6.51	0.96812	25.00	20.38	19.73
0.98658	8.50	6.80	6.71	0.96783	25.25	20.59	19.93
0.98627	8.75	7.00	6.91	0.96755	25.50	20.80	20.13
0.98596	9.00	7.20	7.10	0.96727	25.75	21.01	20.33
0.98566	9.25	7.41	7.30	0.96699	26.00	21.22	20.52
0.98537	9.50	7.61	7.50	0.96669	26.25	21.43	20.72
0.98506	9.75	7.81	7.70	0.96641	26.50	21.64	20.92
0.98476	10.00	8.02	7.89	0.96612	26.75	21.85	21.12
0.98446	10.25	8.22	8.09	0.96583	27.00	22.07	21.31
0.98416	10.50	8.42	8.29	0.96553	27.25	22.28	21.51
0.98385	10.75	8.62	8.49	0.96525	27.50	22.49	21.71
0.98356	11.00	8.83	8.68	0.96495	27.75	22.70	21.91
0.98326	11.25	9.03	8.88	0.96465	28.00	22.91	22.10
0.98296	11.50	9.23	9.08	0.96436	28.25	23.12	22.30
0.98267	11.75	9.44	9.28	0.96406	28.50	23.33	22.50
0.98238	12.00	9.64	9.47	0.96375	28.75	23.55	22.69
0.98208	12.25	9.84	9.67	0.96346	29.00	23.76	22.89
0.98180	12.50	10.05	9.87	0.96316	29.25	23.97	23.09
0.98150	12.75	10.25	10.07	0.96285	29.50	24.18	23.29
0.98122	13.00	10.46	10.26	0.96255	29.75	24.39	23.48
0.98094	13.25	10.66	10.46	0.96224	30.00	24.61	23.68
0.98066	13.50	10.86	10.66	0.96193	30.25	24.82	23.88
0.98037	13.75	11.07	10.85	0.96163	30.50	25.04	24.08
0.98009	14.00	11.28	11.05	0.96132	30.75	25.25	24.27
0.97980	14.25	11.48	11.25	0.96100	31.00	25.46	24.47
0.97953	14.50	11.68	11.44	0.96069	31.25	25.67	24.67
0.97924	14.75	11.89	11.64	0.96036	31.50	25.89	24.86
0.97897	15.00	12.09	11.84	0.96005	31.75	26.10	25.06
0.97868	15.25	12.30	12.04	0.95972	32.00	26.32	25.26
0.97841	15.50	12.50	12.23	0.95939	32.25	26.53	25.46
0.97813	15.75	12.71	12.43	0.95906	32.50	26.75	25.64
0.97786	16.00	12.92	12.63	0.95873	32.75	26.96	25.84
0.97758	16.25	13.12	12.83	0.95839	33.00	27.18	26.05
0.97732	16.50	13.33	13.02	0.95806	33.25	27.39	26.25

TABLE 189—Continued.

Specific Gravity 20° C. / 4°	Alcohol			Specific Gravity 20° C. / 4°	Alcohol		
	Per Cent by Vol. at 20° C.	Per Cent by Weight	Grams Per 100 cc.		Per Cent by Vol. at 20° C.	Per Cent by Weight	Grams Per 100 cc.
0.95771	33.50	27.61	26.44	0.92967	50.25	42.66	39.67
0.95738	33.75	27.82	26.64	0.92918	50.50	42.90	39.86
0.95703	34.00	28.04	26.84	0.92869	50.75	43.13	40.06
0.95669	34.25	28.26	27.03	0.92818	51.00	43.37	40.26
0.95634	34.50	28.48	27.23	0.92768	51.25	43.60	40.46
0.95598	34.75	28.69	27.43	0.92719	51.50	43.84	40.65
0.95563	35.00	28.91	27.63	0.92668	51.75	44.08	40.85
0.95528	35.25	29.12	27.82	0.92617	52.00	44.31	41.05
0.95492	35.50	29.34	28.02	0.92567	52.25	44.55	41.24
0.95456	35.75	29.56	28.22	0.92516	52.50	44.79	41.44
0.95419	36.00	29.78	28.42	0.92466	52.75	45.03	41.64
0.95382	36.25	29.99	28.61	0.92414	53.00	45.27	41.83
0.95346	36.50	30.22	28.81	0.92363	53.25	45.51	42.03
0.95308	36.75	30.43	29.01	0.92312	53.50	45.75	42.23
0.95272	37.00	30.66	29.21	0.92261	53.75	45.98	42.43
0.95234	37.25	30.87	29.40	0.92209	54.00	46.23	42.62
0.95196	37.50	31.09	29.60	0.92157	54.25	46.46	42.82
0.95158	37.75	31.31	29.80	0.92105	54.50	46.71	43.02
0.95120	38.00	31.53	29.99	0.92053	54.75	46.94	43.22
0.95081	38.25	31.75	30.19	0.92000	55.00	47.19	43.42
0.95043	38.50	31.97	30.39	0.91948	55.25	47.43	43.61
0.95003	38.75	32.19	30.59	0.91895	55.50	47.67	43.81
0.94964	39.00	32.42	30.79	0.91842	55.75	47.91	44.01
0.94926	39.25	32.63	30.99	0.91789	56.00	48.16	44.20
0.94885	39.50	32.86	31.18	0.91736	56.25	48.40	44.40
0.94845	39.75	33.08	31.38	0.91683	56.50	48.64	44.60
0.94805	40.00	33.30	31.57	0.91629	56.75	48.89	44.80
0.94765	40.25	33.52	31.77	0.91575	57.00	49.13	44.99
0.94725	40.50	33.75	31.97	0.91521	57.25	49.38	45.19
0.94684	40.75	33.97	32.17	0.91467	57.50	49.62	45.39
0.94643	41.00	34.19	32.36	0.91414	57.75	49.87	45.59
0.94602	41.25	34.41	32.56	0.91359	58.00	50.11	45.78
0.94560	41.50	34.64	32.76	0.91304	58.25	50.36	45.98
0.94519	41.75	34.86	32.96	0.91250	58.50	50.60	46.17
0.94477	42.00	35.09	33.15	0.91194	58.75	50.85	46.37
0.94435	42.25	35.31	33.35	0.91138	59.00	51.10	46.57
0.94393	42.50	35.54	33.55	0.91082	59.25	51.35	46.77
0.94351	42.75	35.76	33.75	0.91027	59.50	51.60	46.97
0.94308	43.00	35.99	33.94	0.90971	59.75	51.84	47.16
0.94265	43.25	36.21	34.14	0.90915	60.00	52.09	47.36
0.94222	43.50	36.44	34.34	0.90859	60.25	52.34	47.56
0.94179	43.75	36.66	34.53	0.90803	60.50	52.59	47.76
0.94135	44.00	36.89	34.73	0.90747	60.75	52.84	47.95
0.94091	44.25	37.12	34.93	0.90690	61.00	53.09	48.15
0.94046	44.50	37.35	35.13	0.90633	61.25	53.34	48.35
0.94002	44.75	37.57	35.32	0.90577	61.50	53.60	48.55
0.93957	45.00	37.80	35.52	0.90520	61.75	53.85	48.74
0.93912	45.25	38.03	35.72	0.90463	62.00	54.10	48.94
0.93867	45.50	38.26	35.92	0.90406	62.25	54.35	49.14
0.93822	45.75	38.49	36.11	0.90349	62.50	54.60	49.33
0.93776	46.00	38.72	36.31	0.90290	62.75	54.86	49.53
0.93730	46.25	38.95	36.51	0.90233	63.00	55.11	49.73
0.93684	46.50	39.18	36.70	0.90175	63.25	55.37	49.93
0.93638	46.75	39.41	36.90	0.90117	63.50	55.62	50.12
0.93591	47.00	39.64	37.12	0.90059	63.75	55.88	50.32
0.93545	47.25	39.87	37.30	0.90001	64.00	56.13	50.52
0.93498	47.50	40.10	37.49	0.89942	64.25	56.39	50.72
0.93451	47.75	40.33	37.69	0.89884	64.50	56.64	50.91
0.93404	48.00	40.56	37.89	0.89825	64.75	56.90	51.11
0.93356	48.25	40.79	38.09	0.89767	65.00	57.16	51.31
0.93308	48.50	41.03	38.29	0.89708	65.25	57.41	51.51
0.93260	48.75	41.26	38.48	0.89649	65.50	57.67	51.71
0.93213	49.00	41.49	38.68	0.89590	65.75	57.93	51.90
0.93164	49.25	41.72	38.87	0.89531	66.00	58.19	52.10
0.93116	49.50	41.96	39.07	0.89471	66.25	58.45	52.30
0.93066	49.75	42.19	39.27	0.89411	66.50	58.71	52.49
0.93017	50.00	42.43	39.47	0.89351	66.75	58.97	52.69

TABLE 189—Continued.

Specific Gravity 20° C. / 4°	Alcohol		
	Per Cent by Vol. at 20° C.	Per Cent by Weight	Grams Per 100 cc.
0.89291	67.00	59.23	52.89
0.89231	67.25	59.49	53.08
0.89171	67.50	59.75	53.28
0.89110	67.75	60.02	53.48
0.89050	68.00	60.28	53.68
0.88989	68.25	60.54	53.87
0.88928	68.50	60.80	54.07
0.88867	68.75	61.07	54.27
0.88805	69.00	61.33	54.47
0.88744	69.25	61.60	54.66
0.88682	69.50	61.86	54.86
0.88621	69.75	62.13	55.06
0.88558	70.00	62.39	55.25
0.88496	70.25	62.66	55.45
0.88434	70.50	62.92	55.65
0.88372	70.75	63.20	55.85
0.88309	71.00	63.46	56.04
0.88246	71.25	63.74	56.24
0.88183	71.50	64.00	56.44
0.88120	71.75	64.27	56.64
0.88056	72.00	64.54	56.83
0.87993	72.25	64.82	57.03
0.87929	72.50	65.08	57.23
0.87865	72.75	65.36	57.42
0.87800	73.00	65.63	57.62
0.87737	73.25	65.91	57.82
0.87672	73.50	66.18	58.02
0.87607	73.75	66.45	58.21
0.87542	74.00	66.72	58.41
0.87478	74.25	67.00	58.61
0.87413	74.50	67.27	58.81
0.87347	74.75	67.55	59.01
0.87282	75.00	67.83	59.20
0.87217	75.25	68.11	59.40
0.87151	75.50	68.38	59.60
0.87084	75.75	68.66	59.79
0.87019	76.00	68.94	59.99
0.86952	76.25	69.22	60.19
0.86885	76.50	69.50	60.39
0.86818	76.75	69.78	60.58
0.86751	77.00	70.06	60.78
0.86684	77.25	70.35	60.98
0.86617	77.50	70.63	61.18
0.86548	77.75	70.91	61.37
0.86480	78.00	71.19	61.57
0.86412	78.25	71.48	61.77
0.86344	78.50	71.76	61.96
0.86275	78.75	72.05	62.16
0.86206	79.00	72.34	62.36
0.86137	79.25	72.63	62.56
0.86069	79.50	72.91	62.75
0.85999	79.75	73.20	62.95
0.85928	80.00	73.49	63.15
0.85859	80.25	73.78	63.34
0.85789	80.50	74.06	63.54
0.85719	80.75	74.36	63.74
0.85648	81.00	74.65	63.94
0.85578	81.25	74.94	64.13
0.85507	81.50	75.24	64.33
0.85436	81.75	75.53	64.53
0.85364	82.00	75.82	64.73
0.85293	82.25	76.12	64.92
0.85222	82.50	76.41	65.12
0.85151	82.75	76.71	65.32
0.85077	83.00	77.01	65.51
0.85006	83.25	77.30	65.71
0.84933	83.50	77.60	65.91
0.84859	83.75	77.90	66.11
0.84756	84.00	78.20	66.30
0.84713	84.25	78.50	66.50
0.84639	84.50	78.80	66.70
0.84564	84.75	79.11	66.90
0.84489	85.00	79.41	67.09
0.84413	85.25	79.75	67.29
0.84339	85.50	80.02	67.49
0.84263	85.75	80.33	67.69
0.84188	86.00	80.63	67.83
0.84110	86.25	80.94	68.08
0.84034	86.50	81.25	68.28
0.83957	86.75	81.56	68.48
0.83881	87.00	81.87	68.68
0.83802	87.25	82.18	68.88
0.83725	87.50	82.49	69.07
0.83647	87.75	82.80	69.27
0.83569	88.00	83.12	69.46
0.83489	88.25	83.43	69.66
0.83410	88.50	83.75	69.86
0.83331	88.75	84.06	70.05
0.83251	89.00	84.39	70.25
0.83170	89.25	84.70	70.45
0.83089	89.50	85.03	70.65
0.83008	89.75	85.34	70.84
0.82925	90.00	85.67	71.04
0.82843	90.25	85.99	71.24
0.82759	90.50	86.32	71.44
0.82674	90.75	86.64	71.63
0.82590	91.00	86.97	71.83
0.82505	91.25	87.30	72.03
0.82419	91.50	87.63	72.23
0.82332	91.75	87.96	72.42
0.82246	92.00	88.29	72.62
0.82159	92.25	88.63	72.82
0.82071	92.50	88.96	73.02
0.81982	92.75	89.30	73.21
0.81893	93.00	89.64	73.41
0.81803	93.25	89.98	73.61
0.81711	93.50	90.32	73.80
0.81620	93.75	90.67	74.00
0.81526	94.00	91.01	74.20
0.81432	94.25	91.36	74.40
0.81337	94.50	91.71	74.59
0.81241	94.75	92.06	74.79
0.81144	95.00	92.41	74.99
0.81047	95.25	92.77	75.19
0.80949	95.50	93.12	75.38
0.80849	95.75	93.48	75.58
0.80749	96.00	93.84	75.78
0.80648	96.25	94.21	75.98
0.80545	96.50	94.57	76.17
0.80442	96.75	94.94	76.37
0.80337	97.00	95.31	76.57
0.80230	97.25	95.68	76.76
0.80122	97.50	96.05	76.96
0.80012	97.75	96.44	77.16
0.79900	98.00	96.82	77.36
0.79786	98.25	97.20	77.55
0.79672	98.50	97.59	77.75
0.79553	98.75	97.98	77.95
0.79432	99.00	98.38	78.14
0.79311	99.25	98.78	78.34
0.79188	99.50	99.18	78.54
0.79062	99.75	99.59	78.74
0.78934	100.00	100.00	78.93

TABLE 190.
Capacities of cylindrical tanks.[13]

Outside Diameter (see Note)	Inside Diameter	CAPACITY IN GALLONS PER WIDTH OF RING (To compute capacity of tank add capacity of head to these figures.)								Per 1 Foot in Width	(Add) Capacity Each Regular Head
		30″	36″	42″	48″	54″	60″	66″	72″		
2′ 5″	24″	58.75	70.50	82.25	94.00	105.75	117.50	129.25	141.00	23.50	3. gals.
2′11″	30″	91.80	110.16	128.52	146.88	165.24	183.60	201.96	220.32	36.72	6. gals.
3′ 5″	36″	132.20	158.64	185.08	211.52	237.96	264.40	290.84	317.28	52.88	10.70 gals.
4′ 0″	42″	179.92	215.91	251.89	287.88	323.86	359.85	395.83	431.82	71.97	14.52 gals.
4′ 6″	48″	235.00	282.00	329.00	376.00	423.00	470.00	517.00	564.00	94.00	23.54 gals.
5′ 0″	54″	297.42	356.91	416.39	475.88	535.36	594.85	654.33	713.82	118.97	28.60 gals.
5′ 6″	60″	367.20	440.64	514.08	587.52	660.96	734.40	807.84	881.28	146.88	44.58 gals.
6′ 0″	66″	444.30	533.16	622.02	710.88	799.74	888.60	977.46	1066.32	177.72	53.99 gals.
6′ 6″	72″	528.77	634.53	740.28	846.04	951.79	1057.55	1163.30	1269.06	211.51	68.75 gals.
7′ 0″	78″	620.57	744.69	868.80	992.92	1117.03	1241.15	1365.26	1489.38	248.23	91.19 gals.
7′ 6″	84″	719.70	863.64	1007.58	1151.52	1295.46	1439.40	1583.34	1727.28	287.88	105.78 gals.
8′ 0″	90″	826.20	991.44	1156.68	1321.92	1487.16	1652.40	1817.64	1982.88	330.48	133.16 gals.
8′ 6″	96″	940.05	1128.03	1316.04	1504.04	1692.04	1880.05	2068.05	2256.06	376.01	154.08 gals.
9′ 0″	102″	1061.20	1273.44	1485.68	1697.92	1910.16	2122.40	2334.64	2546.88	424.48	170.57 gals.
9′ 6″	108″	1189.72	1427.67	1665.61	1903.56	2141.50	2379.45	2617.39	2855.34	475.89	232.05 gals.
10′ 0″	114″	1325.60	1590.72	1855.84	2120.96	2386.08	2651.20	2916.32	3181.44	530.24	257.53 gals.
10′ 6″	120″	1468.80	1762.56	2056.32	2350.08	2643.84	2937.60	3231.36	3525.12	587.52	287.96 gals.

Note:—Outside diameters as given apply only to actual (flanged) tanks. To compute capacities in pounds of whole milk multiply by 8.6.

TABLE 191.

Composition of Milk from Different Mammals.

Kind of Milk	No. of Samples	Water	Total Solids	Fat	Sugar	Nitrogenous Constituents		Ash
						Casein	Albumin	
Cow	.....	87.65	12.35	3.70	4.50	2.60	.60	.70
Human	200	87.43	12.57	3.78	6.21	1.02	1.26	.30
Goat	200	85.71	14.29	4.78	4.46	3.20	1.09	.76
Sheep	32	80.82	19.18	6.86	4.91	4.97	1.55	.89
Mare	31	90.06	9.94	1.09	6.65	1.89	1.89	.31
Mule	3	89.23	10.77	1.92	5.69	2.63	2.63	.53
Donkey	25	90.12	9.88	1.37	6.19	.79	1.06	.47
Egyptian Buffalo	60	82.84	17.76	7.96	4.86	4.16	4.16	.78
Camel	4	87.13	12.87	2.87	5.39	3.87	3.87	.74
Llama	1	86.55	13.45	3.15	5.60	3.90	3.90	.80
Swine	9	84.04	15.96	4.55	3.13	7.23	7.23	1.05
Zebra	1	86.13	13.87	4.80	5.34	3.03	3.03	.70
Reindeer	.....	62.00	38.00	23.64	2.50	10.44	10.44	1.42
Deer	2	65.88	34.12	19.73	2.61	10.35	10.35	1.43
Elephant	2	68.14	31.86	20.58	7.18	3.45	3.45	.65
Hippopotamus	.....	90.43	9.57	4.51	.....	Not reported		.....
Bitch	46	77.00	23.00	9.26	3.11	4.15	5.57	.91
Cat	.....	82.10	17.90	3.33	4.91	3.12	5.96	.58
Rabbit	.....	69.50	30.50	10.45	1.95	15.54	15.54	2.56
Dolphin or Porpoise	.....	48.67	51.33	43.76	.....	Not reported		.46
Whale	.....	70.18	29.82	19.40	none	9.43	9.43	.99

REFERENCES.

[1] Atomic Weight.

Report of International Committee on Atomic Weights, Journal American Chemical Society 1921, page 1751.

Valency Smithsonian Physical Tables 1921, p. 110-111.

Specific Gravity—Smithsonian Physical Tables 1921, p. 110-111.

Atomic Heat—Smithsonian Physical Tables 1921, p. 226.

Specific Heat—Smithsonian Physical Tables 1921, p. 226.

Atomic Heat—Smithsonian Physical Tables 1921, p. 226.

Thermal Conductivity—Smithsonian Physical Tables 1921, p. 226.

Linear Coefficient of Expansion—Smithsonian Physical Tables 1921, p. 218 and 219.

Melting Point—Smithsonian Physical Tables 1921, p. 198.

Boiling Point—Smithsonian Physical Tables 1921, p. 199.

Van Nostrand's Chemical Annual 1907.

[2] Richmond H. Droop. Dairy Chemistry 1899, p. 353.

[3] Courtesy Taylor Instrument Co. Catal. Par. 1500-1600, p. 20.

[4] Leland, Walter S. The Steam Engine, Technical World Magazine, Chicago, 1908, pp. 88 and 89.

[5] Smithsonian Physical Tables 1921, p. 6.

[6] Smithsonian Physical Tables 1921, p. 6.

[7] Smithsonian Physical Tables 1921, p. 7.

[8] Smithsonian Physical Tables 1921, p. 8.

[9] Smithsonian Physical Tables 1921, p. 9.

[10] Smithsonian Physical Tables 1921, p. 10.

[11] Smithsonian Physical Tables 1921, p. 11.

[12] Official and Tenatinve Methods of analysis of the Ass'n of Official Agr. Chemist.

[13] Courtesy the Pfaudler Co., Rochester, New York.

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