DAIRY TECHNOLOGY

A TREATISE ON THE CITY MILK SUPPLY, MILK AS A FOOD, ICE CREAM MAKING, BY-PRODUCTS OF THE CREAMERY AND CHEESERY, FERMENTED MILKS, CONDENSED AND EVAPORATED MILKS, MILK POWDER, RENOVATED BUTTER, AND OLEOMARGARINE

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DAIRY TECHNOLOGY

PART I.

MILK AS A FOOD.

CHAPTER I.

MILK—ITS PROPERTIES AND COMPOSITION.

What is Milk? — According to the government standard, "Milk is the 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."

Milk is a fluid secreted by females of the mammalian group for the special purpose of providing their young with a proper food. It is a watery solution of milk sugar, albumen and mineral salts, containing casein and fat in suspension.

The only milk of great commercial importance to man is that of the cow. Unless otherwise specified, therefore, the word "milk" always refers to the product of the cow.

Properties of Milk. — Milk ranges in color from a bluish white to a golden yellow, depending upon the breed of the animal, the food consumed, and the season of the year. It appears completely opaque when in large quantities, but in thin layers is slightly transparent. When freshly drawn it possesses a characteristic odor. This animal odor is very volatile and soon escapes from the milk, if left exposed to the air. The flavor of milk is slightly sweetish. Fresh milk has an amphoteric reaction, turns red litmus paper blue and blue litmus paper red. This reaction, so far as known, is due to the presence of phosphates in the milk. Fresh milk, however, appears acid to phenolphthalein, and when titrated with tenth-normal alkali shows an apparent acidity of from 0.10 to 0.14 per cent. This acidity is undoubtedly due to the presence in the milk of phosphates, citrates, casein and carbon dioxide.

The viscosity of milk is greater than that of water. It is increased by age, low temperature, products of fermentation and a high solid and fat content. The viscosity of milk is decreased by high temperature, a low solid and fat content and certain fermentations.

Milk possesses a certain adhesive property. It sticks to wood, glass and metals to a greater degree than does water. A paper moistened with milk or cream makes a label that will stick to any dry object. A similar paper moistened with skimmed milk has less adhesive power. The adhesive property of milk is in part dependent upon the nitrogenous matter. This fact is made use of in painting and whitewashing. The addition of milk causes the paint to adhere better. When milk is allowed to stand at room temperature, it undergoes fermentation; lactic acid is formed and the milk becomes thick and curdled. The curdling of milk may be produced by the addition of any dilute acid. If the milk thus curdled is neutralized with an alkali, such as lime water, ammonia or potash, the curd is redissolved. Milk may also be curdled by rennet or pepsin, and the curd thus produced cannot so easily be redissolved by weak alkali solutions.

Milk is slightly heavier than water; its specific gravity varies from 1.029 to 1.034 at 60° F.

The specific heat of milk is less than that of water; that is, it requires less heat to warm a definite amount of milk one degree. It also takes less ice to cool a certain volume of milk one degree than it does to cool the same quantity of water one degree. The specific heat of milk is, according to Fjord, 0.94; the specific heat of cream is about 0.7, depending upon the percentage of fat it contains. Rich cream has a lower specific heat than poor cream.

The maximum density of milk is not, like water, at 4° C. (39.2° F.), but at about 32.9° F. The boiling point is a trifle higher, and the freezing point a trifle lower than that of water.

Composition of Milk. — Probably no other food found in nature, except meat, is subject to such great variation in composition as is milk. The average composition of American milk, according to Babcock,[1] is:

Water	87.17
Fat	3.69
Casein	3.02
Albumen	.53
Sugar	4.88
Ash	.71

The milk of individual animals varies from day to day, and varies as the period of lactation advances. However, the mixed milk from a large herd is not subject to very great variations, but the milk of one herd may differ greatly from that of another herd, due to the breed of the cattle. The constituents subject to the greatest variation are the fat and casein. The following table[2] shows this:

[1] Farrington and Woll — *Testing Milk and Its Products.*

[2] Van Slyke — *Science and Practice of Cheese Making.*

Breed.	Per cent fat.	Per cent casein.	Per cent total solids.
Holstein	3.26	2.20	11.80
Ayrshire	3.76	2.46	12.75
Shorthorn	4.28	2.79	14.30
Devon	4.89	3.10	14.50
Guernsey	5.38	2.91	14.90
Jersey	5.78	3.03	15.40

Milk from one dealer may contain 25 per cent to 40 per cent more nutrients than milk from another dealer, but in the same locality the consumer usually pays the same price for both.

CHAPTER II.

NORMAL MILK AND ITS PRODUCTS AS FOOD.

FOOD is any substance taken into and used in the body for the purpose of building new tissues and repairing the old, and for supplying the body with heat and energy. The best foods are those which produce the best physiological results with the least amount of waste. They must be hygienic, digestible, palatable, furnish the nutrients needed by the system in proper amounts and be reasonably cheap.

Milk, properly produced, is a food having all these requirements.

There are three chief classes of nutrients necessary to maintain the human body:

1. Fats, sugars, starches and cellulose. These are the chief food elements that produce energy, fat and heat in the body. Cellulose and starch are not found in milk. The sugar and fat are the most important ones. They are found in milk in sufficient and proper quantities to supply the body.

2. Proteids. These chiefly produce the muscles, tendons and hair. They are also to some extent producers of energy. Good examples of the proteid group are casein and albumen found in milk.

3. Mineral foods. The chief of these are phosphates, chlorides and other salts, calcium, potash and soda, with small quantities of iron and magnesia. They chiefly produce the bones of the body.

Milk contains iron and phosphorus in sufficient quantities to supply the needs of a growing individual. These minerals are specially needed during the period of cell and tissue building, the nucleus of the body cell being rich in iron and phosphorus.

The water in milk is also essential to the body. Milk contains enough water to supply the body, providing the body is at rest and no dry food other than milk is consumed.

The nutritive ratio of milk is about 1: 4. While this ratio is a little narrow, the proportion of the different components is nearer perfect than in any other single food.

Pure, sweet and wholesome milk as a food is preferred to any other natural food, that is, food not prepared by man. Originally the milk from cows was utilized solely for their young. Owing to man's skill in selecting and breeding, the qualities of dairy cows and their products have been regulated and developed to such an extent that the cow's milk serves in a large measure as a food for man. The specialized dairy types produce large quantities of milk, and the richness of the milk can be regulated by making the proper selection of cows.

Milk cannot be said to be a perfect food for adults, because, in the first place, milk contains too large a per cent of water. As a consequence, too much bulk (8 to 11 lbs. daily) would have to be consumed to obtain the necessary nutrients. Secondly, there is a trifle too large a percentage of protein in milk in proportion to the fat and carbohydrates (1 : 4). Thirdly, the milk nutrients, not including water, are too concentrated or condensed. A certain amount of bulky food is generally admitted to be necessary to the best digestion and health of a person or animal. Fourthly, a digestive system, receiving no other food than milk, is eventually likely to lack in development, because of being unaccustomed to handle other foods, digested with greater difficulty; just as the muscles of an idle person, or one who does little work, are likely to become soft and weak. Milk as a food for adults is most effective when used in conjunction with other foods.

The present extensive and increasing use of milk as a food is due chiefly to five things:

1. Fresh milk, properly produced and handled, is palatable and relished by most people.
2. All the chief classes of nutrients (proteids, carbohydrates and fats, and minerals) necessary for the development of the animal and human body are present in such proportions as to render milk most serviceable as a food.
3. The food constituents are present in milk in such form as to make them easily digestible.
4. Milk is a cheap food.
5. Milk is a food already prepared by nature.

Palatability of Cows' Milk. — The palatability of milk is due to the fact that the different components of milk are present in such a proportion as to produce a flavor suitable to the majority of people. It is a general principle, that the more volatile and soluble a substance is, the more easily it can be detected by the senses of taste and smell. Some of the natural flavoring substances in milk, though present in very small quantities, are volatile and soluble at a low temperature, so that when warmed in the mouth the flavor is quickly detected. Milk, in order to have its best flavor, should be produced from healthy cows, fed on food that will impart the best flavors, such as well-cured, good, sweet hay, grain, ensilage or roots in winter, and grass in summer. Milk is best for direct consumption as soon as possible after it is drawn and cooled. In case of specially fermented milks this does not apply. On standing, milk undergoes fermentation and decomposition. The extent to which these changes occur depends upon the temperature at which milk is kept and upon the number and kinds of germs in the milk. If milk and other dairy products are kept, they should be held at a low temperature. Unpalatable and other abnormal milk will be mentioned later.

Digestibility of Milk. – Milk, generally speaking, ranks high as a digestible food; but in this connection it should be stated that the digestibility of cows' milk varies. First, it varies according to the condition of the milk (whether fresh or old, whether adulterated or not), and according to the composition of the milk. Secondly, the digestibility of milk varies according to the power of digestion of different persons. Thirdly, its digestibility varies according to the amount consumed, and whether it is taken with other foods or not.

When milk is consumed, it passes first into the stomach, where the acid and pepsin in the gastric juice curdle and dissolve it. When milk is consumed in large quantities at a time, without the addition of any other food, the curd or casein may gather in lumps. In this condition the gastric juice digests it with difficulty. Abnormal fermentation may set in and cause sickness before the digestive juices have a chance to bring the normal digestive changes about. This condition is especially common with infants and with adults having a weak digestive system.

Human milk curdles differently from cows' milk. The former contains less casein than the latter, and the casein is probably combined with the mineral salts in a different manner. The casein of human milk is separated and more flocculent when curdled. In this condition the digestive juices attack it with greater ease.

Pasteurized cows' milk coagulates into a more flocculent or separated curd than does raw milk.

Raw vs. Heated Milk. — The effect of heat upon the digestibility of milk is a matter that the best authorities do not agree upon, though it has been the subject of considerable investigation. Heating milk to a temperature sufficiently high for efficient pasteurization partly renders the calcium salts insoluble and may partly coagulate the lactalbumin. But since investigators obtain different results in their work, it seems evident that the ease of digestibility of heated milk cannot differ greatly from that of raw milk. And, as will be shown later, the pasteurization of average city milk is beneficial.

Use of Milk with Other Foods. — In a series of digestion experiments conducted by Professor Harry Snyder at the Minnesota Experiment Station, various foods were used at different times, milk constituting in many cases a considerable part of the diet. One fact of great practical importance brought out by this work was that the various foods showed a higher digestibility when milk was included in the diet than when fed alone.

The food components may undergo many different changes in the digestive tract, depending upon the person and the conditions and demands of the person's system. The complex cleavage and synthetic changes of digestion and assimilation, especially during the end processes, are imperfectly understood.

When the digestibility of the components of milk is compared with that of other food substances, milk ranks among the most digestible of all foods.

According to experiments, cows' milk contains 3.6 per cent proteid, of which 3.48 per cent is digestible. It contains 4.9 per cent carbohydrates, of which 4.7 per cent is digestible. It contains 3.7 per cent fat, of which 3.7 per cent is digestible.

Relative Cost of Milk. — The place of milk in the diet, its use as a substitute for other foods and the relative value of the nutrients it contains, as compared with the cost of nutrients in other foods, are not generally realized. Some investigations were made at the University of Maine,[1] in which the effect of quantities of milk was tried at the university boarding house. From this investigation the following conclusions were drawn: 1. An abundant supply of milk in the dietary decreased the cost without decreasing the acceptability of it to the consumer. 2. The increased consumption of milk increased the proportion of protein in the diet. 3. The consumption of large quantities of milk was accompanied by a decreased consumption of other foods. 4. Milk is not a luxury but an economical food that might be more widely used as a means of improving the character of the diet and of reducing the cost of animal foods.

One quart of milk (2 lbs.), and three quarters of a pound of moderately fat beef, such as sirloin, contain about the same food value,[2]. but we pay different prices for them. Milk is the cheaper and comes the nearer to being a perfect food. One might live on beef alone, but it would be a one-sided diet, while milk is more nearly a balanced ration.

[1] U. S. Dept. of Agr., *Office of Exp. Sta. Bul.* 37.

[2] U. S. Dept. of Agr., *Farmers' Bul.* No. 23.

TABLE WHICH SHOWS AMOUNTS OF NUTRIENTS IN A POUND OF MILK AS COMPARED WITH A POUND OF MEAT, BREAD AND OTHER FOOD PRODUCTS.[1]

Food materials.	Refuse.	Edible portion.					Fuel value.
		Nutrients.					
		Water.	Protein.	Fat.	Carbo-hydrates.	Mineral matter.	
	Lbs.	Lb.	Lb.	Lb.	Lb.	Lb.	Cal.
Milk (1 pint or 1 pound):							
Whole milk	....	0.87	0.03	0.04	0.05	0.01	325
Skim milk (0.3 per cent fat)	....	0.90	0.04	....	0.05	0.01	170
Buttermilk	....	0.91	0.03	0.01	0.05	0.01	165
Other food materials (1 pound each):							
Cheese	....	0.34	0.26	0.34	0.02	0.04	1965
Butter	....	0.11	0.01	0.85	....	0.03	3605
Beef:							
Round	0.08	0.61	0.18	0.12	....	0.01	870
Shoulder clod	....	0.69	0.19	0.11	....	0.01	835
Sirloin	0.13	0.53	0.16	0.17	....	0.01	1040
Fore quarters	0.19	0.50	0.14	0.16	....	0.01	950
Hind quarters	0.16	0.51	0.15	0.17	....	0.01	1000
Mutton, side	0.19	0.43	0.13	0.24	....	0.01	1275
Pork:							
Loin	0.16	0.44	0.14	0.25	....	0.01	1340
Ham	0.14	0.35	0.13	0.34	....	0.04	1655
Salt, fat	....	0.07	0.02	0.87	....	0.04	3715
Chicken	0.35	0.48	0.15	0.01	....	0.01	325
Codfish:							
Fresh	0.30	0.58	0.11	....	....	0.01	205
Salt	0.25	0.40	0.16	....	....	0.19	315
Mackerel, salt	0.23	0.38	0.17	0.17	....	0.10	1050
Oysters, solids	....	0.88	0.06	0.02	0.03	0.01	235
Wheat flour	....	0.12	0.11	0.01	0.75	0.01	1645
Corn meal	....	0.13	0.09	0.02	0.75	0.01	1655
Oatmeal	....	0.07	0.16	0.07	0.68	0.02	1860
Wheat bread	....	0.35	0.10	0.01	0.53	0.01	1205
Crackers	....	0.08	0.11	0.10	0.69	0.02	1895
Dried beans	....	0.13	0.22	0.02	0.59	0.04	1590
Beets	0.20	0.70	0.01	....	0.08	0.01	170
Potatoes	0.15	0.67	0.02	....	0.15	0.01	325
Turnips	0.30	0.62	0.01	....	0.06	0.01	135
Apples	0.25	0.62	0.01	....	0.12	....	255

[1] U. S. Dept. of Agr., *Farmers' Bul.* No. 74.

TABLE WHICH SHOWS NUTRIENTS AND ENERGY IN ONE POUND OF THE WATER-FREE EDIBLE PORTION OF SEVERAL FOOD MATERIALS.[1]

Food materials.	Protein.	Fat.	Carbohydrates.	Mineral matter.	Fuel value.
	Lb.	Lb.	Lb.	Lb.	Cal.[1]
Whole milk	0.25	0.31	0.39	0.05	2475
Skim milk (0.3 per cent fat)	0.36	0.03	0.55	0.06	1835
Buttermilk	0.33	0.06	0.53	0.08	1845
Cheese	0.39	0.52	0.03	0.06	2990
Beef, round	0.57	0.40	....	0.03	2750
Smoked ham	0.26	0.66	....	0.08	3275
Wheat flour	0.13	0.01	0.85	0.01	1865
Wheat bread	0.15	0.02	0.82	0.01	1865
Potatoes	0.10	0.01	0.85	0.04	1790
Apples	0.03	0.03	0.92	0.02	1885

[1] One calorie is the amount of heat necessary to raise the temperature of one pound of water 4° F. or 1 kilogram of water 1° C.

The cheapest food is that which furnishes the largest amount of digestible and healthful nutrients at the least cost. The cost of one pound of round steak is about twelve cents; of one pound of sirloin about fifteen cents; and of one pound of milk about two and one half cents. In price five pounds of milk is equal to one pound of round steak, and six pounds is equal to one pound of sirloin steak.

[1] U. S. Dept. of Agr., *Farmers' Bul.* No. 74.

APPROXIMATE COST OF NUTRIENTS IN MILK AS COMPARED WITH OTHER FOOD MATERIALS.[1]

Food materials.	Whole milk.		Skim milk.	
	Amount.	Cost at 6 cents per qt.	Amount.	Cost at 3 cents per qt.
	Quarts.	Cents.	Quarts.	Cents.
One pound of beef:				
Round furnishes protein equivalent to	2.7	16	2.7	8
Round furnishes fuel value equivalent to	1.3	8	2.6	8
Shoulder clod furnishes protein equivalent to	2.9	17	2.9	9
Shoulder clod furnishes fuel value equivalent to	1.2	7	2.5	7
Sirloin furnishes protein equivalent to	2.4	14	2.4	7
Sirloin furnishes fuel value equivalent to	1.6	10	3.2	10
Mutton loin furnishes protein equivalent to	2.0	12	2.0	6
Mutton loin furnishes fuel value equal to	2.2	13	4.4	13
Pork:				
Fresh, furnishes protein equivalent to	2.1	13	2.1	6
Fresh, furnishes fuel value equal to	2.1	13	4.1	12
Salt, fat, furnishes protein equal to	2.3	2	0.3	1
Salt, fat, furnishes fuel value equal to	5.7	34	11.3	34
Smoked ham furnishes protein equal to	2.0	12	2.0	6
Smoked ham furnishes fuel value equal to	2.5	15	5.0	15
Chicken furnishes protein equal to	2.2	13	2.2	7
Chicken furnishes fuel value equal to	0.5	3	1.0	3
Salt cod furnishes protein equal to	2.4	14	2.4	7
Salt cod furnishes fuel value equal to	0.5	3	1.0	3
Oysters, "solid," furnish protein equal to	1.9	11	1.9	6
Oysters, "solid," furnish fuel value equal to	0.4	2	0.7	2
Wheat flour furnishes protein equal to	1.7	10	1.7	5
Wheat flour furnishes fuel value equal to	2.5	15	5.0	15
Wheat bread furnishes protein equal to	1.4	8	1.4	4
Wheat bread furnishes fuel value equal to	1.9	11	3.7	11
Beans, dried, furnish protein equal to	3.3	20	3.3	10
Beans, dried, furnish fuel value equal to	2.4	14	4.8	14
Potatoes furnish protein equal to	0.3	2	0.3	1
Potatoes furnish fuel value equal to	0.5	3	1.0	3
Turnips furnish protein equal to	0.2	1	0.2	1
Turnips furnish fuel value equal to	0.2	1	0.4	1

5 pounds of milk worth 12 cents have a total fuel value of 1625 calories.

1 pound of round steak worth 12 cents has a total fuel value of 855 calories.

1 pound of sirloin steak worth 12 cents has a total fuel value of 970 calories.

$4\frac{4}{5}$ pounds of wheat flour worth 12 cents have a total fuel value of 7896 calories.

[1] U. S. Dept. of Agr., *Farmers' Bul.* No. 74.

3 pounds of wheat bread worth 12 cents have a total fuel value of 3840 calories.

$9\frac{3}{5}$ pounds of potatoes worth 12 cents have a total fuel value of 3600 calories.

$2\frac{2}{5}$ pounds of beans worth 12 cents have a total fuel value of 3876 calories.

The prices of the different foods mentioned above vary. The prices prevailing in this section of the country have been used in making the above comparison.

From the above statement it will be seen that the food value of milk is much greater than that of beef when the price of each is taken into consideration. On the other hand, wheat bread and potatoes are foods having a high fuel value; but both are rather one-sided rations, as may be seen from the preceding table giving the nutritive ratio. Potatoes as an exclusive diet would be undesirable on account of the great quantity necessary in order to get the required number of calories. From the analysis of beans, it will be seen that they form a very narrow ration, but when eaten with some fatty food, they are cheap.

Fresh, normal milk is a healthful, palatable, cheap and easily digested food. It is owing to this that the demand for milk is constantly on the increase. With the increased production of milk for direct consumption in cities, great care has been exercised, and must be, in order to get the milk into the market in good condition.

"If the American people would eat half less meat and consume one half more milk, they would save about one hundred and fifty millions of dollars in money, and, in health, enough to make the doctors' bills look small." [1]

Skim milk. — The value of skim milk depends to a certain extent upon the method employed in separating the cream.

[1] Storrs — *Conn. Bul.* No. 51.

The method of separation affects the age of the skim milk and the per cent fat remaining in the skim milk.

The shallow pan gravity system of creaming leaves from 0.3 per cent to 0.5 per cent fat in the skim milk. This method requires about thirty-six hours for the cream to rise. During this time the temperature of the milk is about 60° F., and in some instances higher. These conditions, although favorable for a high per cent of fat, are not conducive to the best quality of skim milk, as the various ferments are more or less active at the above-mentioned temperature.

The "Cooley" or deep setting system of creaming produces skim milk which contains about 0.2 per cent to 0.4 per cent fat. The cream rises in about twenty-four hours, and during this time it is kept at from 40° to 50° F. This temperature is so low that the ferments have little or no deleterious effect on the quality of the skim milk.

The skim milk obtained by the water-dilution method of separation will not be considered in this connection.

Most of the dairy farmers in the central west now have hand separators, which do more efficient skimming than can be accomplished by any of the gravity systems. The skim milk obtained by the centrifugal method, under ideal conditions, does not contain more than 0.1 per cent butter fat. The machines, however, are seldom operated under ideal conditions, and the milk is not always skimmed under conditions most conducive to the complete removal of the fat. Tests and observations by the authors warrant the statement that skim milk from hand separators on the farm, on an average, contains about 0.2 per cent fat. This skim milk is fresh, and many of the impurities and germs have been removed in the process of separation. Fresh skim milk obtained in this manner is healthful and nutritious. The average composition of centrifugal skim milk is:[1]

	Per cent.
Water	90.25
Fat	0.20
Casein and albumen	3.60
Milk sugar	5.15
Ash	0.80

Skim milk may be used profitably as a food more extensively than it is, both in the kitchen, as an ingredient in cooked foods, and for direct use, as a drink. When the butter fat is removed, the percentage of the other milk components is slightly increased. The protein, sugar, minerals and some fat are still left. These constitute some of the most valuable nutrients of milk.

In some of the older countries of Europe, skim milk is used daily in the kitchen. Gruels, puddings, gravies and soups are made by using skim milk instead of water. White bread dough is made from skim milk. Skim milk is also used very extensively as a drink in connection with lunches. Machines have been made and set out on the corners of the streets and other public places where a person may obtain a glass of milk by dropping a coin in the slot. Such machines are not at all common. When used, great care is necessary to keep the milk in good condition and to keep the apparatus sanitary.

Skim milk, together with bread, furnishes a cheap, healthful and nutritious lunch. It is generally assumed that an average-sized man doing average manual work requires 0.28 pound of protein and enough of the other food constituents to make a total fuel value of 3500 calories per day.[2]

[1] Snyder — *Dairy Chemistry.*

[2] U. S. Dept. of Agr., *Farmers' Bul.* No. 74.

The following meal of bread and milk furnishes nearly one third the nutrients required by a man per day.[1]

	Protein.	Fat.	Carbo-hydrates.	Mineral matter.	Fuel value.	Esti-mated cost.
	Lb.	Lb.	Lb.	Lb.	Cals.	Cents.
($\frac{5}{8}$ Lb.) 10 oz. of wheat bread.	0.062	0.0062	0.33	0.0062	753	3
(1 Lb.) 1 pt. of skim milk...	0.040	0.0030	0.05	0.0070	175	1
Total.........	0.102	0.0092	0.38	0.0132	928	4

A woman and a boy between 14 and 16 years of age require about 0.8 the food of a man.

A girl 14 to 16 years old requires about 0.7 the food of a man.

A child 10 to 13 years old requires about 0.6 the food of a man.

A child 6 to 9 years old requires about 0.5 the food of a man.

A child 3 to 5 years old requires about 0.4 the food of a man.

A child under 2 years old requires about 0.3 the food of a man.

Buttermilk. — Buttermilk is an important dairy by-product. As most of the butter is made at creameries or at central points the bulk of the buttermilk is produced at central places, where the supply is greater than the demand. As a consequence, a large portion of it is not utilized at all.

Buttermilk has, practically speaking, the same food value as skim milk, if during the manufacturing processes the buttermilk has not been adulterated. It contains from 0.4 to 0.8 per cent lactic acid, according to age and degree of ripening of the cream. This acid is produced

[1] U. S. Dept. of Agr., *Farmers' Bul.* No. 74.

through fermentation. About one per cent of sugar is required to produce the amount of lactic acid mentioned above. In this change of milk sugar to lactic acid, other by-products are simultaneously produced. The completeness with which the milk sugar is transformed into lactic acid depends upon the species of germs present. Buttermilk then contains more acid and less sugar than skim milk.

It is also claimed that the casein in buttermilk is easier to digest, because it exists in a more soluble form, being partly combined with lactic acid in the form of casein lactate.

Buttermilk is used extensively as a beverage. When the cream has been properly ripened, the buttermilk is not only nutritious but it is healthful. Some physicians prescribe it for their patients. It is widely believed that it may be used successfully as a remedy for kidney trouble.

Buttermilk is used extensively as a food for hogs and chickens.

The average composition of buttermilk is:[1]

	Per cent.
Water	90.50
Fat	0.20
Casein and albumen	3 30
Milk sugar	5.30
Ash	0.70

Cream. — Cream is the portion of milk containing most of the fat. It may be separated either by gravity or by a centrifugal separator, and to be legal, cream may contain from 18 to 50 per cent fat, and even more. Market cream normally contains 18 to 25 per cent fat. The fuel value of a pint of cream is about 1425 calories, more than four quarts of milk. However, cream is lacking in pro-

[1] Snyder — *Dairy Chemistry.*

tein, and is chiefly valuable as a producer of heat and energy, and for this purpose it is not so economical as butter. On account of its delicious flavor and high food value, cream is extensively used, chiefly in connection with other foods. Sweet cream is perhaps relished by more people than is any other one food.

The following is a fair average composition of cream as found on the markets of this country:[1]

	Per cent.
Water	66.41
Fat	25.72
Casein and albumen	3.70
Milk sugar	3.54
Ash	0.63

Butter. — Butter is one of the most important sources of fat in our diet, one of the most palatable and easily digested. According to recent statistics, butter constitutes about two per cent of the total food, and furnishes 19.7 per cent of the total fat in the average American diet. Its flavor depends more upon the fermentation and chemical changes that have taken place in the cream before churning than upon the fat itself. However, butyrin, the characteristic fat of butter, imparts to good butter a peculiar and desirable flavor that cannot be imitated by any other substance. In old or highly salted butter, this delicate flavor is replaced by the stronger and undesirable flavors.

The price of butter is not necessarily dependent upon its food value, but upon supply and demand, and upon its flavor and appearance. The best grade of butter frequently sells for 50 per cent more than the lowest grade.

The coefficient of digestion of butter is about ninety-nine. This is higher than other animal fats, the latter

[1] Snyder — *Dairy Chemistry.*

being about 95 per cent digestible. Butter is made up of a relatively large percentage of fats having a low melting point. Butter has a melting point of about 33° C. (91.4° F.), while the fats of beef and mutton melt at 40° to 45° C. (109° F.), higher than the body temperature of man. Butter-fat globules are very minute in size, and hence are readily emulsified, digested and absorbed. Because of its low melting point and its physical condition, butter is more easily digested than other animal fats.

As much as a quarter of a pound of butter per day has been consumed by an individual and found to be readily absorbed. It is recommended by some physicians as a tonic instead of cod liver oil or similar preparations.

Composition of Butter:[1]

	Per cent.
Fat	82.97
Water	13.78
Proteids	0.84
Milk sugar	0.39
Ash	0.16
Salt	1.86

Cheddar Cheese. — Cheese is a concentrated form of certain constituents of milk, and hence has a high food value. It is a very concentrated food and gives best results when used in combination with other and more bulky foods. A large number of experiments carried on by the Office of Experiment Stations in coöperation with the Bureau of Animal Industry of the Department of Agriculture has shown that, when consumed even in relatively large amounts, cheese is very thoroughly digested and assimilated. The cheaper varieties of cheese usually contain as much food value as the higher priced kinds.

[1] Storch — Richmond's *Dairy Chemistry.*

Nutrients may, therefore, be supplied at a less cost by using cheeses, such as Cottage and Cheddar (American), than by buying the fancy and imported varieties.

From the standpoint of the protein content alone, two thirds of a pound of cheese has the same food value as one pound of beefsteak. The fuel value of cheese is nearly twice that of beef. As much as a half pound of cheese per day may be used in the diet without any physiological disturbances.

Composition of Cheddar Cheese: [1]

	Per cent.
Water	36.84
Protein	23.72
Fat	33.83
Ash, etc	5.61

Cottage Cheese. — This product of the dairy, known also by the names " Dutch Cheese " and " Schmier Kase," should have a more prominent place in our diet.

Professor Snyder of the University of Minnesota fed several farm laborers on the following daily ration: 1.1 pounds cottage cheese, 1.16 pounds bread, 4.12 pounds milk and 0.06 pound sugar. The cottage cheese supplied over 40 per cent of the total protein and about 28 per cent of the total fat of the ration. This was found to be a very satisfactory ration from the standpoint of digestibility and nutritive value. On an average, 95 per cent of the protein and fat and 97 per cent of the carbohydrates were digested, and 90 per cent of the energy was available to the body. These are approximately the same results as were secured when milk furnished the major portion of the nutrients.

" Pound for pound, cottage cheese prepared with cream compares favorably in composition and digestibility with

[1] Van Slyke — *Science and Practice of Cheese Making.*

beef and other meats. One hundred pounds of skim milk and 4 pounds of cream, containing 20 per cent fat, will make from 15 to 16 pounds or more of moist cottage cheese. At 2 cents per quart for skim milk and 35 cents per quart for cream, cottage cheese would cost about eleven cents per pound, and compares very favorably in nutritive value with meats at the same price per pound. Where skim milk can be procured at a low cost, cottage cheese is one of the most economical foods that can be used. The addition of cream to cottage cheese favorably influences both its nutritive value and its palatability without increasing the cost above that of average meats. Upon the farm, where milk is produced, cottage cheese is one of the cheapest foods that can be used."[1]

The composition of cottage cheese varies greatly, depending upon the method of manufacture, the fat content of the milk used, and the addition of milk or cream to the curd. The following is considered a fair average composition of cottage cheese as commonly made:[2]

	Per cent.
Water	37.35
Fat	24.61
Proteids	32.40
Ash	5.65

[1] *Minnesota Bul.* No. 92.
[2] König — Richmond's *Dairy Chemistry.*

CHAPTER III.

ABNORMAL MILK.

ALTHOUGH milk is normally such a desirable and excellent food, it is, like other foods, subject to various modifications and fermentations, depending upon the conditions under which it is produced and subsequently handled. This abnormality may be merely a slightly bad odor and flavor or it may be some very marked undesirable characteristic of color, consistency, odor or taste. Again, the milk may appear and taste perfectly normal but at the same time contain pathogenic organisms or toxic properties that may prove serious and even fatal to the consumer.

Milk may acquire abnormal flavors or odors in several ways: The cow may be slightly sick and produce milk with an unusual flavor. This is usually temporary. Highly flavored foods such as onions or turnips, when eaten by the cow, may impart their flavor to the milk. Milk absorbs any odor that it may be exposed to, such as zenoleum, creolin, or other strong-smelling disinfectants, when used in the barn too close to milking time. Flavor of milk may be altered after it has been drawn, by growth of bacteria in it. The commonest change is the souring and curdling of the milk, due to a fermentation of the milk sugar in which the latter is broken down into lactic acid. This is a normal fermentation and, though not desired in fresh milk, is not deleterious to health.

Poisonous Milk. — When cows eat leaves of the common poison ivy (Rhus toxicodendron) the toxic properties may be found in the milk. Ingestion of such milk by a human being may cause severe gastro-intestinal trouble. Leaves of the common artichoke are also said to produce certain toxic properties in the milk which cause abdominal pains and diarrhea in the consumer. In a few instances, milk sellers unlawfully add preservatives, such as formalin.

Colored Milk. — Milk may have a reddish color due to the presence of blood in the milk, or such color may be caused by bacterial growth. Eating certain plants may affect the color of the milk. Bacillus cyanogenes is known to have infected dairies and caused a bluish discoloration of the milk.

Bitter Milk.—Bitter milk occasionally may be observed during the late stages of lactation. It may be caused by the cow eating lupines, wormwood, etc., or it may be the result of bacterial growth.

Stringy or Ropy Milk. — Stringy or ropy milk is caused by a growth of bacteria that are surrounded by a gummy capsule. So far as known there is nothing harmful about this fermentation, but milk of this kind is very distasteful to most people in this country. Some foreign people consider ropy milk a desirable beverage. In some instances they produce this condition by introducing into the milk leaves of certain plants on which bacteria causing milk to be ropy are found. Edam cheese is nearly all made from milk that has undergone this or similar fermentation. In modern factories pure cultures of this particular ferment (Bacillus Hollandicus) are propagated.

Colostrum. — This substance, although the natural product of the mammary glands, is not milk according to our pure food laws. We may, however, from the standpoint of human food call it abnormal milk. Colostrum is a yellow, viscid fluid of abnormal milk odor, and somewhat bitter taste. It is especially secreted as the first food for the young, and is adapted only to that purpose. The ingestion of such milk, especially by children, is apt to produce diarrhea, colic or other digestive disturbances. Some foreign people, however, after the first two days, use it for cooking purposes.

General. — Until a few years ago little was known about the effects of bacteria and other germs. This very seriously interfered with the dairy industry. Major Alvord reports that in a period from 1815 to 1830, in an agricultural district in Mecklenburg, Germany, the disease of blueness in the milk lasted eight years, and that in earlier times, in the best agricultural districts of Schleswig-Holstein, butter would become cheesy and moldy for several months in the summer. Such defects in dairy products occur at the present time, but in intelligent dairy circles they last only a short time, as the causes of them are known and remedies can be applied.

We know now that the chief cause of these defects is the action of bacteria on the components of milk. Milk, when first drawn, contains gases and animal odors, which in a large measure may be eliminated by cooling and aërating it in a clean atmosphere immediately after it has been drawn. The aëration causes the gases to pass off, and the cooling keeps the milk in good condition and causes fermentation to be wholly or partly checked. Cooling milk to about 50° F. and below this temperature checks fermentation so that the natural sweet flavor of the milk can be preserved without other preservatives for 72 hours or longer, providing all utensils, receptacles and surroundings are perfectly clean. If not, the milk will go " off " in flavor. Milk, kept even at a low temperature, will in time lose its palatability, owing to the many forms of ferments existing in milk and to our incomplete control over the fermentations.

Generally speaking, milk properly produced and handled does not become abnormal. When, in special cases, abnormal milk is produced, it should be excluded from the consuming channel and measures be enforced to overcome the adverse conditions.

J. H. Mohler[1] describes the effect of diseased conditions of cows upon the hygienic qualities of the milk secreted. He states that any of the following-named diseases of the cow may seriously affect the milk, making milk from cows afflicted with such diseases unusable as human food: tuberculosis, foot and mouth disease, actinomycosis of the udder, anthrax, cow-pox, rabies, mammitis or garget, gastro-enteritis, or any condition causing a great increase in the leucocyte content of the milk.

[1]Hygienic Laboratory, *Bul.* No. 56.

PART II.

CITY MILK SUPPLY.

CHAPTER IV.

EXTENT AND IMPORTANCE OF THIS INDUSTRY.

THE distribution of fresh milk to the consumer is an industry of great economic and hygienic importance. Its vastness is indicated by the following statistics gathered by the United States Department of Agriculture: The American people consume annually over a billion gallons of milk in its natural state, the product of nearly one-third of the milch cows in this country. Milk is almost as necessary in cooking as flour. Few meals are served at which milk and cream do not form a part. The following table shows the daily per capita consumption of milk in 1900 in the fifteen largest cities of the United States.[1]

	Pints.
New York, N. Y.	.660
Chicago, Ill.	.758
Philadelphia, Pa.	.466
St. Louis, Mo.	.409
Boston, Mass.	1.172
Baltimore, Md.	.393
Cleveland, Ohio.	.482
Buffalo, N. Y.	.704
San Francisco, Cal.	.630
Cincinnati, Ohio.	.614
Pittsburgh, Pa.	.746
New Orleans, La.	.275
Detroit, Mich.	.700
Milwaukee, Wis.	.691
Washington, D. C.	.344

[1] U. S. Dept. of Agr., Div. of Statistics, *Bul.* 25.

Southern cities consume less milk per capita than do Northern cities. The following cities are reported to have a per capita consumption of about one pint of milk per day: Worcester, Mass.; Newton, Mass.; Providence, R. I.; Hoboken, N. J.; Minneapolis, Minn.; and Sioux City, Ia.

The increase in the production of milk is indicated by the increase in the number of dairy cows, which according to United States statistics, are as follows in the United States:

	No. of cows.
1870	10,096,000
1880	12,027,000
1890	15,953,000
1900	16,292,000
1910	21,801,000

The per capita consumption of milk is on the increase. As an illustration of this, let us consider the milk and cream supply of New York City for the past 25 years.

	Gallons.
1885	51,026,660
1890	64,801,190
1895	80,270,400
1900	98,116,920
1902	106,910,940
1908	109,500,000

The increase in milk consumption has been greater than the increase in population, indicating that the per capita consumption has increased.[1]

Milk, unlike most foodstuffs, is consumed largely in an uncooked state. Because of this fact, milk, when not produced and distributed under proper conditions, may become dangerous as a carrier of contagious diseases. This

[1] "Next to bread, milk is more extensively used as an article of diet than any other foodstuff." — (J. H. Mohler, A. M. V. M. D.)

fact, in turn, is particularly important because milk is an important article of diet of infants, children and many invalids, all of whose bodies have but slight power to resist the inroads of disease germs.

The city of New York in 1908 consumed 438,000,000 quarts of milk, which was produced in the States of New York, New Jersey, Pennsylvania, Connecticut, Vermont, Massachusetts, Ohio and Maryland. Some of it traveled 350 miles by rail to reach the city. Over 5000 wagons were employed in distributing it to the consumers.

The milk supply of Philadelphia is obtained from 5473 dairy farms located in four states.

Because of the consumption of great quantities of milk from such widely scattered sources, because of the use of milk in the uncooked state, because of its place in the diet of infants and invalids, because of the ease with which it may be contaminated with disease-producing germs, and because of the fact that milk forms a favorable medium for bacterial growth, the city milk supply is a subject of great importance to the entire public. The problem of how to insure a sanitary milk supply for a large city is one of the greatest with which food and health officers have to deal.

Condition of the City Milk Supply in Past Years. — The realization of the important rôle that this subject plays in the public welfare has come only in recent years. Investigations into the condition of the milk supply of cities were seldom, if ever, made until about two decades ago. These first investigations showed conditions to be bad in many places. Later and more thorough investigations have brought out some very startling facts.

Investigations in Illinois Cities. — An investigation of the milk supply of Chicago and other Illinois cities in 1905, by J. M. Truman,[1] revealed a very unsatisfactory state of affairs. Some whole districts were found supplied with very good milk, but other districts, especially those supplied chiefly by the small milk depots, received mainly poor milk. A very great majority of these small milk depots were dirty and unsanitary; many were in dark, unclean, ill-ventilated cellars, where the sunlight never entered. And in most of these places the milk was kept in cans, dipped into open dishes when sold, and often carried several blocks through dusty streets.

In the better portions of the city, the milk was delivered by large dealers from wagons, and was of good quality, except that in some cases an undue amount of sediment was found in the bottles.

The following table shows the results of an examination of several hundred samples of milk obtained in Illinois cities:

Number of samples.	Per cent of samples below fat standard.	Number of samples.	Per cent of samples showing sediment.
413	32	89	68
95	20	232	66
150	50	143	68
95	9	212	88
325	19	...	..
Total, 1078	Average, 27.4	Total, 676	Average, 73.5

Milk and Infant Mortality.—City health authorities in the past were more disposed to inspect milk for preservatives than for cleanliness, yet the latter is as important as the former. No doubt children are occasionally injured by the indiscreet use of preservatives,

[1] Ill. *Bulletin* 120.

but the number that die from the effects of milk which has been contaminated with undesirable ferments is greater.

The death rate of any city shows that more children die during July and August than at any other time of the year, and that a large percentage of these deaths are due to intestinal troubles. In general, 90 per cent of the infants that die are artificially fed.

Balestre and Gileta de St. Joseph, in France, showed that from 1892 to 1897 in every 1000 infant deaths under one year of age, 385 were due to gastro-intestinal diseases. This was the average for the whole country. The number of deaths from this cause in Troyes, in 1892, was 700 per 1000.

In 42 cities of Germany, in 1906, the average infantile death rate was 198 per 1000 births. Of these, 44 per cent were due to diarrhea.

The relation between infant mortality and city milk supply is becoming generally understood among medical men. The high infantile death rate, especially during the summer months, should not, of course, be charged wholly to a poor milk supply. Undoubtedly this is simply one factor which conspires with others to cause the high infantile death rate.

In New York City, it was early recognized by the health authorities that some system of regulation of the milk supply must be established. The first ruling established a standard for the composition of dairy products. In 1902 the New York City Department of Health made a comprehensive investigation of the conditions surrounding the production, transportation and distribution of the milk supply. The market milk was, as a rule, from a sanitary point of view, in a bad condition.

Epidemics Spread by Milk. — There are on record over 500 epidemics of typhoid fever, scarlet fever and diphtheria that were traced to the milk supply.

One of the worst milk epidemics on record is the typhoid epidemic at Stamford, Conn., in 1895. Stamford is a town of 15,000 population and had for some months been comparatively free from typhoid fever. During the nine days following April 14, 1895, 160 cases were reported, and 24 noted as suspicious. 147 of the 160 cases, and all of the suspected cases, used milk from one dairyman. Between April 15 and May 28, 386 cases living in 160 houses were reported. The dairy was closed April 21, and on May 6, just fifteen days after the sale of milk was stopped, the outbreak had practically subsided. Of the 386 cases, 352 (97.2 per cent) lived in houses taking milk from the same dairyman, 12 were known to have used this milk at a café supplied by him, 2 obtained it at a bakeshop selling the same milk, and 2 obtained it in other ways, making 368 cases so traced, or 95.3 per cent.

Sources of Milk Contamination. — Similar epidemics of scarlet fever and diphtheria are on record, the source of the milk contamination being probably one of the following:

1. Water supply.
2. Hands of milker.
3. Can, pail, cooler or other utensils.
4. Transportation.
5. Air and dust of stable.
6. Bottles.
7. Deliveryman.

J. W. Eyre has shown by experiment that B. typhosus and B. diphtheriæ are able to proliferate in milk. Since the causal organism of scarlet fever has not been isolated, it is not known whether it may or may not multiply in milk.

Bovine Tuberculosis. — Investigations have shown that tuberculosis of the bovine type is common in children. The infection may be caused by the ingestion of meat from tubercular animals; it may be caused by inhaling infected air; and in all probability it may be caused by drinking milk from tuberculous cows. Indeed, when we consider that meat is usually cooked before being eaten, while milk is used raw, and that children consume a relatively small amount of meat and a very large quantity of milk, we cannot but conclude that milk is the main food that disseminates this disease among children.

In milk examined for the presence of tubercle bacilli, an average of 5 per cent of all samples examined in various cities in this country contained tubercle organisms virulent for guinea pigs. In many places the percentage was much higher. In Philadelphia, 14.6 per cent of the samples of milk examined were tuberculous. Hess found 16 per cent of the milk supply of New York City to contain virulent tubercle bacilli.

Butter and cheese are of much less importance in this respect, but it has been shown by Mohler, Washburn, Rogers and Doane, that tubercle bacilli retain their virulence for six months in butter, and for eight months in cheese.

Parke of New York City has found bovine tubercle bacilli in 26 per cent of the cases of tuberculosis in children under 5 years of age.

Of the fatal cases of tuberculosis among children investigated by the German and British tuberculosis commissions, about one-third was found to be due to the bovine type of bacillus.

The lowest estimate made by the best authorities is that from 2400 to 3200 deaths are caused annually in this country, principally among children, by bovine tubercle bacilli. Most authorities to-day believe this estimate to be too low. Von Behring believes that tubercular cows' milk fed to infants is the chief cause of tuberculosis in man.

CHAPTER V.

IMPROVEMENT OF THE MILK SUPPLY.

When health authorities and the public in general came to realize the close relationship between the milk supply and public health, many plans were suggested for improving the sanitary conditions of the product.

The inspection and regulation of other food products were provided for many years before any attention was given to milk.

Inspection of Dairy Farms and of Milk. — Probably the first legislation that pertained to the sale of milk was that enacted in the city of Washington in 1863. As early as 1873, the food inspectors of that city recognized the importance of the inspection of milk not only in the market but at the place of production. This latter point was not emphasized by sanitarians until about twenty years later. The Washington milk law of 1895 was one of the first to provide for a proper inspection and regulation of the milk supply. This law proposed to begin the milk inspection at the cow and to follow the product as it passed through the hands of the transportation company, the wholesaler and the retailer, to the ultimate consumer.

This law made it the duty of the health officer of the District of Columbia to enforce regulations to secure proper water supply, drainage, ventilation, air space, floor space, cleaning of all dairies and dairy farms within the District, and the isolation of diseased cattle. No milk could be sold in the District except that coming from inspected farms, and, although the District authorities could not legally go beyond their territorial limits to inspect cows or farms, they could refuse to admit milk from farms not inspected. Dairy farmers wishing to market their product in the District asked to have the agents of the health authorities inspect their dairies for them.

Cost of Inspection. Many cities now have laws providing for the inspection of dairy farms and of milk from the time it leaves the cow until it reaches the consumer. The city of Washington spends for this purpose $20,000 annually. The Milk Commissioner of Philadelphia estimated that it would cost nearly $100,000 to inspect all dairy farms that contributed the 146,000,000 quarts of milk consumed during the year 1910. The cost of this inspection amounts to about 0.07 of a cent per quart.

Geo. M. Whitaker,[1] in calculating the extra cost of producing clean milk, finds that, in order to increase the score of a dairy farm about forty-two points to seventy points, in a 15-cow dairy, an added expense is incurred of 5 cents per cow per day for labor. When new or additional equipments are needed, the cost is still greater. Assuming that the cows produce from 4000 to 12,000 pounds of milk per year each, the added expense for labor would be about one-half cent to one cent per quart. For the extreme cases requiring new equipment, the expense would be still greater.

Fear that the price of milk would be advanced has kept many a city council from passing an ordinance requiring adequate milk inspection, and it has also prevented health commissioners from enforcing such ordinances. But such an attitude is manifestly wrong. Even though it may cost a little more to produce clean milk than impure milk, the

[1] U. S. Dept. of Agr., Bu. An. Ind. *An. Rept.*, 1909.

increased cost is very slight, and, as sanitary milk is one of the cheapest and best foods we have, there should be no objection to a slight increase in price, if it be accompanied by an improvement in the quality. The cause of impure and unhygienic milk is not so much a lack of expensive equipment, as it is a lack of clean methods, and the presence of unhealthy cows.

The Score Card.—The inspection of dairy farms and dairies necessitated the adoption of a score card to insure uniformity of reports from various inspectors. The Official Dairy Instructors' Association has introduced such a score card, that has been adopted by the Dairy Division of the United States Department of Agriculture, and is being used at the present time, sometimes in a modified form, in more than 60 of the larger cities of the country and in many smaller ones. The latest form of this score card is as follows:

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
DAIRY DIVISION.

SANITARY INSPECTION OF DAIRIES.

DAIRY SCORE CARD.

Adopted by the Official Dairy Instructors' Association. (Subject to revision at future meetings.)

Owner or lessee of farm..

P. O. address.....................State.........................

Total number of cows.........Number milking.....................

Gallons of milk produced daily..................................

Product is retailed by producer in..............................

Sold at wholesale to..

For milk supply of..

Permit No................Date of inspection.................191

REMARKS...

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(*Signed*)............................

Inspector.

DETAILED SCORE.

Equipment.	Score. Perfect.	Score. Allowed.	Methods.	Score. Perfect.	Score. Allowed.
Cows.			*Cows.*		
Health.................... Apparently in good health...............1 If tested with tuberculin once a year and no tuberculosis is found, or if tested once in six months and all reacting animals removed.......5 (If tested only once a year and reacting animals found and removed, 2.)	6	......	Cleanliness of cows.......	8	....
Comfort................... Bedding...............1 Temperature of stable. 1	2	....	*Stables.*		
Food (clean and wholesome)...........	2	....	Cleanliness of stables... Floor................2 Walls................1 Ceilings and ledges . 1 Mangers and partitions 1 Windows............ 1	6	....
Water....................	2	....	Stable air at milking time................	6	....
Clean and fresh........1 Convenient and abundant................1			Barnyard clean and well drained...........	2	....
			Removal of manure daily to field or proper pit.......... .. (To 50 feet from stable, 1.)	2	....
Stables.			*Milk Room.*		
Location of stable......... Well drained..........1 Free from contaminating surroundings.....1	2	....	Cleanliness of milk room .	3	....
Construction of stable..... Tight, sound floor and proper gutter........2 Smooth, tight walls and ceiling..........1 Proper stall, tie, and manger.............1	4	....	*Utensils and Milking.*		
Light: Four sq. ft. of glass per cow.......... (Three sq. ft., 3; 2 sq. ft., 2; 1 sq. ft., 1; Deduct for uneven distribution.)	4	....	Care and cleanliness of utensils.............. Thoroughly washed and sterilized in live steam for 30 minutes................5 (Thoroughly washed and placed over steam jet, 4; thoroughly washed and scalded with boiling water, 3; thoroughly washed, not scalded, 2.) Inverted in pure air...3	8	....
Ventilation: Automatic system............... (Adjustable windows, 1.)	3	....	Cleanliness of milking.... Clean, dry hands......3 Udders washed and dried..............6 (Udders cleaned with moist cloth, 4; cleaned with dry cloth at least 15 minutes before milking, 1.)	9	....
Cubic feet of space for cow: 500 to 1000 feet.... (Less than 500 feet, 2; less than 400 feet, 1; less than 300 feet, 0; over 1000 feet, 0.)	3	....			

DETAILED SCORE. *(Continued)*

Equipment.	Score. Perfect.	Score. Allowed.	Methods.	Score. Perfect.	Score. Allowed.
Utensils.			*Handling the Milk.*		
Construction and condition of utensils	1	....	Cleanliness of attendants	1	....
Water for cleaning (Clean, convenient, and abundant.)	1	....	Milk removed immediately from stable	2	....
Small-top milking pail	3	....	Prompt cooling. (Cooled immediately after milking each cow)	2	....
Facilities for hot water or steam (Should be in milk house, not in kitchen)	1	....	Efficient cooling; below 50° F. (51° to 55°, 4; 56° to 60°, 2.)	5	....
Milk cooler	1	....	Storage; below 50° F. (51° to 55°, 2; 56° to 60°, 1.)	3	....
Clean milking suits	1	....			
Milk Room.					
Location of milk room: Free from contaminating surroundings ... 1; Convenient ... 1	2	....	Transportation; iced in summer (For jacket or wet blanket allow 2; dry blanket or covered wagon, 1.)	3	....
Construction of milk room: Floor, walls, and ceiling ... 1; Light, ventilation, screens ... 1	2	....			
Total	40	.. ..	Total	60	....

Score for equipment —— plus Score for methods —— equals —— FINAL SCORE.

NOTE 1. — If any filthy condition is found, particularly dirty utensils, the total score shall be limited to 49.

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.

Advantages of Score Card Inspection.—The score card system of inspection is found to have the following good points:

1. It gives the health officer a concise, exact report, in a convenient form, of all dairies marketing milk in a given district.

2. The score may be used as a basis for issuing licenses. Dairies scoring below 50 or 60 points are in some cities barred from selling milk until the necessary improvements are made to bring their score up to standard.

3. The health commissioner or person in charge may use the score card as a check on the inspectors, as these cards indicate exactly where each inspector has been each day and how much he has accomplished.

4. One of the greatest advantages of this method, if properly used, is the possibility of bringing about improvements in the dairies by means of the publication of all scores. When the attention of the public is called to the relative scores of the various dairymen, the man with the low score suffers a loss of trade, while there is a big demand for the product of the high-scoring man. Publicity incites competition and is a great stimulus to the improvement of conditions.

5. The card tells the inspector exactly what to look for, so that it is practically impossible for him to overlook any important point.

6. This system is generally well received by the dairymen, because it is thorough, easily understood, and absolutely fair.

7. It enables inexperienced inspectors to do efficient work, because of the detailed explanations on the card.

8. It educates the producer, points out his failings, and instructs him how to improve his conditions.

9. It develops better business methods on the farm, and usually leads to greater profits.

10. The milk dealer is enabled to discriminate between producers, to locate the better dairies, and thus to secure a higher grade of milk.

Results of Score-card Inspections. A report of the Richmond, Va., board of health, October, 1907, shows the improvement in dairies during six months following the adoption of the score-card system.

	First score.	Last score.	Points gained.	Percentage gained.
Average........	33.4	56.8	23.4	76.8

The following extract from the Thirteenth Report of the Board of Health of Montclair, N. J., shows a marked improvement in dairy conditions due to the use of the score card:

Scores.	1906.		1907.	
	Number of dairies.	Percentage of total.	Number of dairies.	Percentage of total.
Below 50.............	6	13.05	0	0
Between 70 and 100....	35	76.09	45	90

Many large dealers either require in their contracts with the producer that his score be up to a certain standard, or they pay a reduced price for milk from low-scoring dairies and a premium for milk from high-scoring dairies.

This is true in Geneva, N. Y., where the city authorities have carried on a publicity campaign, and have used their influence to induce the milk dealers to buy from the producer on the basis of the score placed upon the dairy by the city inspector. At the beginning of this campaign, conditions were about the same as are found in many small cities, and the improvement from time to time may be noted in the following table:

	Percentage of dairies.			
	Excellent.	Good.	Medium.	Poor.
Beginning	0	5.0	57.5	37.5
End of first year	2.9	58.9	38.2	0
End of second year	8.6	82.8	8.6	0
End of third year	12.8	74.4	12.8	0
1st quarter of fourth year	12.8	87.2	0	0

Inspection of City Milk Plants.—In the larger cities there is, in most instances, a middle man between the producer and the consumer. At the place of business of this middle man, the milk may simply be cooled and loaded into wagons for distribution, or it may be clarified, pasteurized and standardized; it may be a small place with but little equipment or it may be a huge building containing much expensive apparatus. In either case, there is necessity for supervision by the board of health, and the following score card has been devised for this purpose by the Dairy Division of the United States Department of Agriculture:

SANITARY INSPECTION OF CITY MILK PLANTS.

Equipment.	Score. Perfect.	Score. Allowed.
Plant:		
Location	18	
Convenience 6		
Surroundings 12		
Arrangements	7	
Proper rooms 3		
Convenience 4		
Constructions	9	
Floor 5		
Walls 3		
Ceiling 1		
Light	1	
Ventilation	1	
Screens	1	
Machinery and utensils	20	
Kind and quality, 7 (Steam or hot water bottle and can washer, bottling machine, drying racks, crates, sinks, pasteurizer, cold storage.)		
Condition 7		
Arrangement 6		
Water for cleaning	28	
Wagons:		
Construction, condition	4	
Salesroom	11	
Location 4		
Construction 4		
Equipment 3		
	100	
Additional Deductions.		
For exceptionally bad conditions:		
Total deductions		
Net total		

Methods.	Score. Perfect.	Score. Allowed.
Plant:		
Cleanliness	15	
Floor 6		
Walls 4		
Ceilings 1		
Doors 1		
Windows 1		
Good order 1		
Free from odors 1		
Machinery and utensils:		
Cleanliness	25	
Milk:		
Handling (Clarifying, pasteurizing, cooling, bottling).	25	
Storage	20	
45° F. or below 20		
45° F. to 50° F. 15		
50° to 55° F. 10		
Wagons	6	
Cleanliness 3		
Protection of product 3		
Salesroom:		
Cleanliness	9	
	100	
Additional Deductions.		
For exceptionally bad conditions:		
Total deductions		
Net total		

Score for methods.....———; multiplied by 2.........———

Score for equipment...———; multiplied by 1.........———

Total, to be divided by 3.........................———

Final Score......................................———

Milk and Cream Contests.—Another method of arousing competition and inciting dealers to deliver the best quality, is the holding of milk and cream contests. These contests are usually given great publicity. Hence they form excellent advertisements for the dairymen participating, and particularly profitable advertisements for those who make a good showing in the contest.

The first milk and cream contest in this country was held at the National Dairy Show in 1906, under the supervision of the Dairy Division of the United States Department of Agriculture. The object of the contest was, first, educational; second, to determine the possibilities of long-distance shipments and long holdings of milk produced under sanitary conditions and kept cold; third, to test the efficiency and practicability of a score card for this class of dairy products. Milk was sent to this contest from thirteen different states, and it was here demonstrated that clean milk, held at a low temperature, can be shipped a thousand miles and be kept sweet for a period of over five weeks.

Since that time, states and cities have employed the milk and cream contest with very gratifying results.

The score card used is as follows:

SCORE CARD FOR MARKET MILK.

Exhibitor.......................................

Address..................... ....

NUMERAL SCORE.

Flavor, 40.	Composition, 25.	Bacteria, 20.	Acidity, 5.	Appearance of package and contents, 10.	Perfect score, 100.
					Judge's score.

DESCRIPTIVE SCORE.

Flavor.	Composition.	Bacteria.	Acidity.	Package and contents.
Excellent.............	Perfect.	Perfect.	Perfect.	Perfect.
Good..........	Fat, — per cent.	Total, ...	— per cent.	Foreign matter.
Fair...........				
Bad.......				
Flat..	....	Liquefiers.	....	Metal parts.
Bitter	Solids, not fat, — per cent.	....	....	Unattractive.
Weedy............ ..				
Garlic.........				
Silage..............				
Manure.............				
Smothered				
Other taints				
....				
....				

Remarks............. ....

.. . ., *Judge.*

Date...............................

Directions for Scoring

Flavor.

If rich, sweet, clean, and pleasant flavor and odor, score perfect (40). Deduct for objectionable flavors and odors according to conditions found.

If 3.25 per cent fat or above and 8.5 per cent solids not fat or above, score perfect (25). Deduct 1 point for each one-fourth per cent fat below 3.25 and 1 point for each one-fourth per cent solids not fat below 8.5.

Bacteria.

Less than 10,000 per cubic centimeter.......(perfect)......	20
Over 10,000 and less than 25,000 per cubic centimeter.......	19
Over 25,000 and less than 50,000 per cubic centimeter.	18
Over 50,000 and less than 75,000 per cubic centimeter.......	17
Over 75,000 and less than 100,000 per cubic centimeter......	16

Deduct 1 point for each 25,000 above 100,000

When an unusually large number of liquefying bacteria are present, further deduction should be made according to conditions found.

Acidity.

If 0.2 per cent or below, score perfect (5). Deduct 1 point for each 0.01 per cent above 0.2 per cent. (If Mann's test is used, discontinue adding indicator on first appearance of a pink color.)

Appearance of Package and Contents.

If a package is clean, free from metal parts, and no foreign matter can be detected in the contents, score perfect (10). Make deductions according to conditions found.

Such contests greatly improve the milk supply if the consumer is interested in the project and is willing to pay a slightly higher price for milk of good quality than for that of poor quality.

Number of Inspections Made in New York City. — During the year 1908, there were inspected and rated on a score card, 41,937 dairy farms that sell milk in New York City. Inspectors within the city examined 101,049 specimens of milk, and took 6268 samples for chemical analysis, and about the same number for bacteriological examination. 26,500 quarts of milk were destroyed for being above 50° F., and the total milk destroyed by inspectors for all reasons was 43,140 quarts.

Limitations of General Inspection. — Whenever a system of inspection is properly carried out, many improvements may be noted in the sanitary condition of farms, dairies, and depots. However, in spite of the continuous and thorough inspection in New York City, 16 per cent of the samples analyzed were found to be below standard, and 25 per cent of the samples examined bacteriologically contained over 1,000,000 bacteria per cubic centimeter. The dairy farms inspected and scored in New York City in 1908 showed the following condition:

2,179 dairies scored between 76 and 100.
24,130 dairies scored between 51 and 75.
15,628 dairies scored below 50.
Average score — 57.

A similar inspection and scoring, in New York City, of creameries, or places where milk is handled, revealed a somewhat better condition.

613 creameries scored between 76 and 100.
671 creameries scored between 51 and 75.
162 creameries scored below 50.
Average score — 71.

It is evident from these figures that there is still room for improvement. However, although the object of city milk inspection is to improve the general sanitary condition of the milk supply, this general inspection does not aim, nor is it in itself sufficiently thorough, to insure a product absolutely pure and sanitary and safe for invalid or infant feeding. The good will and coöperation between health officers and dairymen for the mutual good of all is essential.

Classes of Milk. — The general milk supply of many cities is divided into classes according to certain standards, such as the degree of sanitation observed in the production and handling of the milk, the treatment of milk before delivering (pasteurization), or the amount of supervision by health authorities.

All milk in New York City must be sold under the following grades or designations in accordance with the regulations adopted by the Board of Health:

Milk. — This term shall be applied to cows' milk which conforms to the requirements of the Sanitary Code and which does not meet the requirements of milk sold under other grades or designations herein provided for.

Selected Milk. — The minimum requirements are as follows:

1. Only such cows shall be admitted to the herd as are free from all diseases of the udder, and from clinically manifest tuberculosis.

2. That all the cows be examined clinically each year by a veterinarian of the Department of Health; all cows with any disease of the udder, or with clinically manifest tuberculosis, to be excluded from the herd and farm. It shall be unlawful to sell or use the milk from such cows for food purposes.

3. That the milk shall never contain more than 60,000

germs per cubic centimeter in winter, nor more than 100,000 germs per cubic centimeter in summer.

4. That such milk be delivered to the consumer only in sealed bottles, which shall have been filled at the dairy or creamery, and shall be labeled with the date of the earliest milking whose milk forms part of the contents of the bottle.

5. That such milk be delivered to the consumer within thirty-six hours after milking.

Inspected Milk. — Which milk produced under the supervision of a Milk Commission appointed by the Medical Society of the County of New York or by the Medical Society of the County of Kings, or under certificates for "Inspected Milk," issued by said Commission. No milk, however, shall be held, kept, offered for sale or sold and delivered as inspected milk in the City of New York which is produced under requirements less than those of the said Board of Selected Milk.

Guaranteed Milk. — The minimum requirements are as follows:

1. That only such cows be admitted to the herd as have not re-acted to a diagnostic injection of tuberculin.

2. That all such cows be tested annually with tuberculin, and all re-acting animals be excluded from the herd.

3. That the milk shall not contain more than 30,000 germs per cubic centimeter when delivered to the consumer.

4. That the milk be delivered to the consumer only in sealed bottles which shall have been filled at the dairy, and shall bear a label giving the name of the dairy, and the date of the earliest milking at which the milk forming part of the contents was drawn.

5. That such milk be delivered to the consumer within thirty-six hours.

Certified Milk. — Which is milk certified by the Milk Commission appointed by the Medical Society of the County of New York or the Medical Society of the County of Kings as being produced under the supervision and in conformity with the requirements of that Commission as laid down for Certified Milk. No milk, however, shall be held, kept, offered for sale or sold and delivered as Certified Milk in the City of New York which is produced under requirements less than those of the said Board for Guaranteed Milk.

Pasteurized Milk: —

1. Pasteurization of milk must be carried out under a permit therefor issued by the Board of Health, in addition to the usual permit for milk required by Section 56 of the Sanitary Code.

2. The milk after pasteurization must be at once cooled and placed in sterilized containers, and the containers sealed.

3. All containers in which pasteurized milk is delivered to the consumer shall be plainly labeled "pasteurized." The labels must also bear the date and hour when the pasteurization was completed, the degree of the heat, and the length of time exposed to the heat, and the name of the dealer.

4. Pasteurized milk must be delivered to the consumer within twenty-four hours of the pasteurization.

5. No milk shall be pasteurized a second time.

6. No milk which contains an excessive number of bacteria shall be pasteurized.

The classification of market milk into the following three grades is suggested by the Bureau of Animal Industry, United States Department of Agriculture. A fourth grade is added by the authors.

1. Certified Milk.
2. Inspected Milk.
3. Pasteurized Milk.
4. Modified Milk.

The use of these terms is recommended to be limited to the following:

Certified milk is the product of dairies that are subject to periodic inspection by a medical milk commission, the products of such dairies being subject to frequent chemical and bacteriological examination. The cows, barns, milk house, utensils and milkers must come up to a very high standard of sanitation. The manner of handling the milk, its chemical composition and bacterial content are carefully prescribed. It is certified, by an authorized officer, to be absolutely pure and sanitary.

Inspected milk is produced and handled under conditions similar to those under which certified milk is produced and handled, but to not quite so high a degree of perfection, and the product is not certified to by a milk commission, or an authorized health officer.

Pasteurized milk, though clean and fresh, is of less known origin, and is subjected to heating to a temperature of 150° F. for 20 minutes, or 160° F. for 10 minutes, and immediately cooled to a temperature not exceeding 50° F.

Modified milk is sanitary milk, the composition of which is modified to conform with the food requirements of persons unable to use milk in its natural state. Such modification should be done under supervision of, or by prescription of, a physician or milk expert.

Results of the Improvement of Milk Supply. — The chief purpose of our present-day extensive milk inspection and the establishment of various grades of milk is to supply a sanitary cheap food and to save lives. The success of such inspections must then be measured by their efficiency in accomplishing these ends.

The milk-inspection service has lessened the danger of severe epidemics of contagious diseases due to milk infection. The most important and extensive service expected of milk inspection is to diminish the mortality from diarrheal diseases of children under two years of age. In Washington, D. C., the death rate from diarrhea and enteritis among infants during the fiscal year following the enactment of the milk-inspection law in 1895, was 168 per 100,000 of population. The next year it fell to 151; the third year to 136; and the fourth year to 110. In 1903 it was 91; in 1905, 104; in 1906, 97.

Infants' Milk Depots in New York. — The improvement of milk supply by pasteurization is demonstrated by the reports of the Nathan Straus depots and the orphan asylum on Randall's Island, New York City.

In 1893, Nathan Straus established a depot for the dispensing of pasteurized milk for infant feeding. In this year 34,400 bottles of milk were dispensed; in 1906, 17 Straus stations dispensed 3,142,253 bottles and 1,078,405 glasses of pasteurized milk.

Just prior to the beginning of this work by Straus, the death rate of children under 5 years of age in New York City was 96.2 out of every 1000. In 1906 the death rate had fallen to 55 per 1000, due, in a large measure, to the improvement of the milk supply by pasteurization.

At the rate of mortality of 1892, there would have been 27,169 deaths of children under 5 years of age in 1906, instead of the 15,534 that actually occurred. A general milk inspection was in operation at this time, and no doubt had some part in reducing the death rate. There were other agencies at work which contributed toward accomplishing the same results, such as the campaign of fresh air for children, use of diphtheria antitoxin, improved tenement houses, etc.

The efficiency of pasteurization under commercial conditions is indicated in the following data collected in Chicago in 1909. A bacterial examination of 829 samples of milk during seven weeks ending September, 1909, showed that the unpasteurized milk contained 5,547,502 bacteria per cubic centimeter and the pasteurized 944,465. It is probable that practically all bacteria in the vegetative condition (this includes all pathogenic organisms) were destroyed.

At the present time the Bureau of Municipal Research has charge of the pure-milk crusade, and the lowering of the infant death rate in New York City. During some of the hot weeks of the summer of 1911 the Bureau had about 5000 babies under its direct care.

Seventy-five milk depots form the centers from which this extensive work is carried on. At the depots are 250 trained nurses who distribute sanitary milk, prescribe for babies and advise and teach mothers how to feed and care for their children. Physicians are in attendance at the depots at certain hours during the day to attend to the more serious cases. 146 visiting nurses go to the houses where there are young children, and teach the mothers home sanitation, and influence them to procure from the depot whatever milk may be necessary for the children.

It is here demonstrated that the distribution of clean milk combined with the education of mothers is one of the most economical and efficient methods of reducing infant mortality.

Milk Depots in Other Cities. — The first definite improvements in any milk supply were made by a few institutions that prepared and dispensed a sanitary product for infant feeding. Probably the first of these institutions in this country was the Eastern Dispensary of New York City, which, in 1889, dispensed sanitary milk for infant feeding.

Since that time, about three hundred infants' milk depots, as they have come to be known, have been opened in some thirty cities in this country. Many of these are supported by private philanthropy, others by a city board of health or board of charities. In all cases they are under the supervision of persons qualified to attend to the bacterial, chemical and sanitary condition of the milk. The milk of various depots is certified, pasteurized or modified, and in several cases two of these classes of milk are supplied from the same depot. The milk is commonly put up in bottles containing but one feeding, which bottles are so designed that they cannot stand on end and, therefore, cannot be left standing open. Milk of widely different formulas is put up at these depots; the following is taken as an example:

Milk	ounces,	64
Limewater	"	4
Milk sugar	"	6
Filtered water	"	60

The infants, in the care of New York City authorities were fed on milk from carefully selected herds. The death rate among these infants, for the years 1895 to 1897 inclusive, was 41.8 per cent. Early in 1898, a pasteurizing plant was installed. No other change in hygiene or diet was made, but the death rate dropped to 19.8 in 1898 and averaged 21.75 for the succeeding six years.

Investigations of the cause of the high death rate among infants and young children have revealed, in numerous instances, that the number of deaths among children bears a direct relation to the quality of the milk consumed. Money spent to improve the milk supply buys and saves the lives of many infants. It is cheaper for even the poorest people to pay a higher price for a high-grade milk than to buy an unsanitary product for a cent or two less per quart.

CHAPTER VI.

CERTIFIED MILK.

INVESTIGATIONS show that market milk is improved by general inspection, and that, by grading or classifying, some milk of very high quality can be brought upon the market. For a general supply of milk to be used by healthy adults or in cooking, the problem is not so great, because probably no great harm will come from the use of

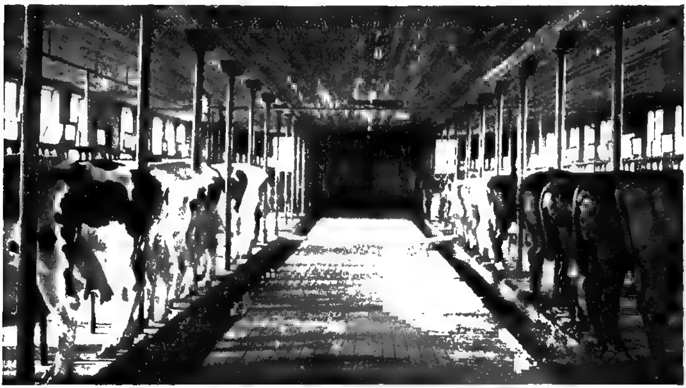

FIG. 1. — Interior view of South Dakota State College dairy barn, showing clean cows in a clean, well-ventilated and comfortable place.

ordinary market milk produced in compliance with our present laws and regulations. But for invalid or infant feeding, a much better quality is necessary.

Origin of the Term "Certified Milk." — This term, so far as known, was coined by Dr. Henry L. Coit of Newark, N. J., who was perhaps the foremost man in the originating and establishing of the first milk commission. The term was registered in the United States Patent Office to protect it from being degraded by dairymen not producing milk under supervision of a medical commission. Some states have passed laws limiting the use of this term to milk of sufficiently high quality to come up to Dr. Coit's standard for certified milk.

Certified milk is sanitary milk produced under the strict supervision and according to rules of some health authorities. The herd producing the milk is examined as to its healthfulness at intervals. The sanitary condition of barn and all surroundings, bacterial content and age of milk are carefully watched. If these conditions come up to the standard the owner of the place receives a certificate showing that he is authorized to sell his milk as certified milk.

Certified milk has all the qualifications of a perfectly sanitary and hygienic food but the price is so high as to be almost prohibitory for the mass of common people. The only alternative seems to be pasteurized milk. This can be supplied at a reasonable cost and, if properly pasteurized, will be practically as sanitary and hygienic as certified milk. However, it is very necessary that the pasteurization be properly done, and to insure this all pasteurizing plants should be carefully and frequently inspected by competent authorities.

The quantity of certified milk produced in this country is less than one per cent of the total amount of market milk annually consumed. Nevertheless, this product is of very great value in feeding infants and invalids; it has aided in reducing the death rate among children and has had an indirect beneficial influence upon the general milk supply.

The First Medical Milk Commission. — In the year 1890 the Medical Society of New Jersey started a movement to effect an improvement in the milk supply, which resulted in the formation of "The Medical Milk Commission of Essex County, New Jersey." Since that time many others have been formed in various cities upon a similar plan.

Milk Commissions. — A milk commission usually consists of from 5 to 12 men, as a rule physicians, but sometimes including business men who are interested in the welfare of the city. This board serves without pay; but the chemist, bacteriologist and veterinarian, who do the inspecting, commonly receive a fee. The first commission and several of the later ones formed contracts with the producers, wherein were exact specifications for all the details of the dairy and its management. However, most of the present-day commissions simply fix the required standard and leave the details of the work to the dairymen's judgment. The conditions surrounding the production and handling of the milk are necessarily about as good as the commission could demand, or it would not be possible to keep the milk up to the high standard required.

Requirements of the Milk Commission of New York City. — In New York City no contract is made with the dairymen, but a circular is sent them giving information concerning the production, standards and general requirements of certified milk. This circular reads as follows:

The commission has fixed upon a maximum of 30,000 germs of all kinds per cubic centimeter of milk, which must not be exceeded to obtain the endorsement of the commission. This standard must be attained solely by measures directed toward scrupulous cleanliness, proper cooling, and prompt delivery.

The milk certified by the commission must contain not less than 4 per cent of butter fat on the average, and have all other characteristics of pure, wholesome milk.

Milk must not be sold as certified more than twenty-four hours after its arrival in New York City.

Dealers. In order that dealers, who incur the expense and take the precautions necessary to furnish a truly clean and wholesome milk, may have some suitable means of bringing these facts before the public, the commission offers them the right to use caps on their milk jars stamped with the words: "Certified by the Milk Commission of the Medical Society of the County of New York." The dealers are given the right to use these certificates when their milk is obtained under the conditions required by the commission and conforms to its standards.

In accordance with a law passed at the last legislature, the word, "Certified," may be used on the cap only when accompanied by the name of the society which certifies it.

The tinned sealed cap, authorized by the commission, must be used on all the certified milk passing through the hands of dealers selling milk other than the certified. These caps are sent by the makers, only to the farm where the milk is bottled.

The name of the farm from which the milk comes must appear on either the paper cap or the tin cap.

Each bottle of milk must be dated on the date of bottling.

The milk commission looks to the dealers for its fee.

The dealer is expected to send a bottle of milk each week to the research laboratory of the department of health, taken at random from the day's supply for examination, by experts for the commission.

The dealers are to furnish deep, covered boxes for the certified milk.

The required conditions at the farm are as follows:

1. *The Barnyard.*—The barnyard should be free from manure and well drained, so that it may not harbor stagnant water. The manure which collects each day should not be piled close to the barn, but should be taken several

hundred feet away. If these rules are observed not only will the barnyard be free from objectionable smell, which is an injury to the milk, but the number of flies in the summer will be considerably diminished. These flies are an element of danger, for they are fond of both filth and milk and are liable to get into the milk after having soiled their bodies and legs in recently visited filth, thus carrying it into the milk.

2. *The Stable.*—In the stable the principles of cleanliness must be strictly observed. The room in which the cows are milked should have no storage loft above it; where this is not feasible the floor of the loft should be tight, to prevent the sifting of dust into the stable beneath.

The stables should be well ventilated, lighted, and drained, and should have tight floors, preferably of cement, never of dirt.

They should be whitewashed inside at least twice a year, unless the walls are painted or of smooth cement finish which can be washed frequently.

The air should always be fresh and without bad odor. A sufficient number of lanterns should be provided to enable the necessary work to be properly done during the dark hours. The manure should be removed twice daily, except when the cows are outside in the fields the entire time between the morning and afternoon milkings. The manure gutter must be kept in a sanitary condition. All sweeping must be finished before the grooming of the cows begins, so that the air may be free from dust at the time of milking.

There should be an adequate supply of warm and cold water and the necessary wash basins, soap, and towels.

3. *Water Supply.*—The whole premises used for dairy purposes, as well as the barn, must have a supply of water absolutely free from any danger of pollution with animal matter and sufficiently abundant for all purposes and easy of access.

4. *The Cows.*—No cows will be allowed in the herd furnishing certified milk except those which have successfully passed a tuberculin test. All must be tested at least once a year, by a veterinarian approved by the milk com-

mission. Any animal suspected of being in bad health must be promptly removed from the herd and her milk rejected. Do not allow the cows to be excited by hard driving, abuse, loud talking, or any unnecessary disturbance.

Feed.—Do not allow any strongly flavored food, like garlic, to be eaten by the cows. When ensilage is fed, it must be given in only one feeding daily, and that after the morning milking, and the full ration shall consist of not more than 20 pounds daily for the average-sized cow. When fed in the fall, small amounts must be given and the increase to the full ration must be gradual.

Corn stalks must not be fed until after the corn has blossomed, and the first feedings must be in small amounts and the increase must be gradual.

If fed otherwise, ensilage and corn stalks are liable to cause the milk to affect children seriously.

Cleaning.—Groom the entire body of the cow daily. Before each milking wash the udder with a cloth used only for the udders, and wipe it with a clean, dry towel. Never leave the udder wet, and be sure that the water and towel are clean. The tail should be kept clean by frequent washing. If the hair on the flanks, tail, and udder is clipped close and the brush on the tail is cut short, it will be much easier to keep the cow clean.

The cows must be kept standing after the cleaning until the milking is finished. This may be done by a chain or a rope under the neck.

5. *The Milkers.*—The milker must be personally clean. He should neither have nor come in contact with any contagious disease while employed in handling the milk. In case of any illness in the person or family of any employee in the dairy, such employee must absent himself from the dairy until a physician certifies that it is safe for him to return.

In order that the milk commission may be informed as to the health of the employees at the certified farms, the commission has had postal cards printed to be supplied to the farms, and to be filled out and returned each week by the owner, manager, or physician of the farm, certifying that none are handling the milk who are in contact with any contagious disease.

Before milking, the hands should be washed in warm water with soap and nail brush and well dried with a clean towel. On no account should the hands be wet during milking.

The milkers should have light-colored, washable suits, including caps, and not less than two clean suits weekly. The garments should be kept in a clean place, protected from dust, when not in use.

Iron milking stools are recommended, and they should be kept clean.

Milkers should do their work quietly and at the same hour morning and evening. Jerking the teat increases materially the bacterial contamination of the milk and should be forbidden.

6. *Helpers Other than Milkers.* — All persons engaged in the stable and dairy should be reliable and intelligent. Children under 12 should not be allowed in the stable or dairy during milking, since in their ignorance they may do harm, and from their liability to contagious diseases they are more apt than older persons to transmit them through the milk.

7. *Small Animals.* — Cats and dogs must be excluded from the stables during the time of milking.

8. *The Milk.* — All milk from cows 60 days before and 10 days after calving must be rejected.

The first few streams from each teat should be discarded in order to free the milk ducts from the milk that has remained in them for some time and in which the bacteria are sure to have multiplied greatly. If any part of the milk is bloody or stringy or unnatural in appearance, the whole quantity yielded by that animal must be rejected. If any accident occurs in which a pail becomes dirty, or the milk in a pail becomes dirty, do not try to remove the dirt by straining, but put aside the pail, and do not use the milk for bottling, and use a clean pail.

Remove the milk from each cow from the stable immediately after it is obtained to a clean room and strain through a sterilized strainer of cheese cloth and absorbent cotton.

The rapid cooling is a matter of great importance. The milk should be cooled to 45° F. within an hour and not allowed to rise above that as long as it is in the hands of producer or dealer. In order to assist in the rapid cooling, the bottles should be cold before the milk is put into them.

Aëration of milk beyond that obtained in milking is unnecessary.

9. *Utensils.*—All utensils should be as simple in construction as possible, and so made that they may be thoroughly sterilized before each using.

Coolers, if used, should be sterilized in a closed sterilizer, unless a very high temperature can be obtained by the steam sent through them.

Bottling machines should be made entirely of metal with no rubber about them, and should be sterilized in the closed sterilizer before each milking, or bottling.

If cans are used, all should have smoothly soldered joints, with no places to collect the dirt.

Pails should have openings not exceeding 8 inches in diameter, and may be either straight pails, or the usual shape with the top protected by a hood.

Bottles should be of the kind known as "common sense" and capped with a sterilized paraffined paper disk, and the caps authorized by the commission.

All dairy utensils, including the bottles, must be thoroughly cleansed and sterilized. This can be done by first thoroughly rinsing in warm water, then washing with a brush and soap, or other alkaline cleansing material, and hot water, and thoroughly rinsing. After this cleansing they should be sterilized by boiling, or in a closed sterilizer with steam, and then kept inverted in a place free from dust.

10. *The Dairy.*—The room or rooms where the utensils are washed and sterilized and the milk bottled should be at a distance from the house, so as to lessen the danger of transmitting through the milk any disease which may occur in the house.

The bottling room, where the milk is exposed, should be so situated that the doors may be entirely closed during the bottling and not opened to admit the milk nor to take out the filled bottles.

The empty cases should not be allowed to enter the bottling room nor should the washing of any utensils be allowed in the room.

The workers in the dairy should wear white washable suits, including cap, when handling the milk.

Bottles must be capped, as soon as possible after filling, with the sterilized disks.

11. *Examination of the Milk, and Dairy Inspection.*— In order that the dealer and the commission may be kept informed of the character of the milk, specimens taken at random will be examined weekly by experts for the commission of the department of health, the use of the laboratories having been given for that purpose.

The commission reserves to itself the right to make inspections of certified farms at any time, and to take specimens of the milk for examination, and to impose fines for repeated or deliberate violations of the requirements of the commission.

The commission also reserves the right to change its standards in any reasonable manner upon due notice being given to the dealers.

The expense of making the regular milk reports and the inspections are borne by the dealers. The treasurer of the Medical Society of the County of New York will send bills the first of each month for the certification for the previous month.

The monthly charges, which are intended to cover all expenses, are as follows:

For daily output of less than 100 quarts	$ 8
For daily output of from 100 to 200 quarts	10
For daily output of from 200 to 500 quarts	12
For daily output of over 500 quarts	15

Where the output of a farm is sent to several dealers, each dealer pays:

For daily output of less than 100 quarts	$ 6
For daily output of from 100 to 200 quarts	8
For daily output of from 200 to 500 quarts	10
For daily output of over 500 quarts	12

The names of the dealers, with their addresses, are printed on cards, and enclosed with the monthly bulletin of the medical society, which is sent to about 1700 physicians. For this one dollar is charged each month.

Details of the Workings of Various Commissions. — The maximum number of bacteria per cubic centimeter allowed in certified milk is, in the majority of cases, 10,000; however, this factor varies with different commissions from 5000 to 25,000 in winter and from 10,000 to 50,000 in summer.

The per cent of fat in the certified milk may vary from 3.25 to 5.5. Some commissions require the approximate per cent of fat to be stated on the bottle. Only about one-half the commissions have a standard for solids not fat, and in these cases it varies from 8 per cent to 9.3 per cent.

All the commissions report little or no difficulty in keeping the milk up to the standard.

The number of quarts of milk handled daily under certification of one commission varies from 120 to 9373. The price for which this product is sold is from one to twelve cents per quart higher than the price paid for general market milk.

New commissions are constantly being organized, and there is a steadily increasing demand for certified milk, but there is some scarcity of dairymen competent and willing to undertake the task of producing milk of such high grade. The price received for the product hardly pays for the great expense and care necessary to keep up to standard.

Use of Certified Milk. — Certified milk will probably never displace the common market milk because it is of higher grade than is necessary for general consumption.

But the value of this milk, for the feeding of infants and others whose digestive systems are not strong, is generally recognized.

The greatest and probably the only objection to the use of certified milk is its greater cost, but this disadvantage is offset by the following advantages:

1. Certified milk is free from pathogenic organisms.
2. It is low in total bacteria and especially so in undesirable species.
3. The physical and chemical properties of the milk are uniform from day to day.
4. Cleanliness and cold are the only preservatives used.
5. It is a safe food for any one.

Production of Certified Milk. — A model dairy farm for the production of certified milk is equipped with a well lighted, well ventilated, tight barn, having few beams and braces to catch dust, a cement floor, mangers, and plastered walls, so that the whole place may be cleaned easily and quickly each day.

All cows are annually tested for tuberculosis, and any cow showing any indications of disease or abnormality of any kind is isolated and her milk rejected. The cows are daily curried or brushed, or cleaned with a vacuum cleaner; the hair on flank and udder is clipped short; and the greatest care taken to have the animal perfectly clean. Before milking, all cows are made to stand on their feet, and a chain is run under their necks along the stanchions to prevent them from lying down again before being milked; then the udder and flank are washed with clean warm water.

No cleaning, brushing or disturbing of bedding and hay is permitted within an hour before milking time, so that the air may be free from dust when the milk is drawn.

At milking time the milker, dressed in a clean white suit, approaches the cleaned cow with a steam-sterilized, covered milk pail, sits well back from the cow to avoid brushing her with his arms or head, and holds the pail at an angle to prevent dirt from dropping into the milk. The milker's hands are clean and he touches no part of the cow but her teats; the fore milk is drawn into a separate receptacle and discarded.

Having completed the milking of one cow, the milker carries his pail to the milk room, hands it to the person in charge, who weighs the milk, wipes the top of the pail with a damp cloth and pours the milk over an enclosed cooler. During this time, the milker washes his hands and wipes them on a clean towel, then returns to milk another cow.

In the milk room the milk is run over a cooler into sterile cans, then removed to the bottling room and put into sterile bottles, capped and packed in ice ready for delivery.

This milk reaches the consumer within less than 24 hours from the time it is drawn and at a temperature of 50° F. or less.

Inspected Milk.

Milk of this grade is general market milk produced on average farms, but subject to supervision of inspectors. This grade of milk is usually of sufficiently high quality for general use in the household.

CHAPTER VII.

PASTEURIZED MILK.

PASTEURIZATION of milk in the city milk plant is becoming very general, so that frequently the inspected and ordinary market milk are subjected to this process. In some instances this grade of milk wholly displaces the inspected milk. The advisability of adopting pasteurization instead of, and in addition to, close inspection as a means of improving our milk supply is a much-mooted question.

The problem of quickly perfecting the milk supply of a city is a very difficult one. If stringent laws were enacted and immediately put into force (for example, a law prohibiting the sale of milk from dairies scoring under 80 per cent by the score card) there would be a milk famine in many cities. Hence it is evident that improvement at the place of production cannot be made in a day or a week; but when it does come, it will be a gradual evolution stimulated by education and public sentiment, and by paying the producer a higher price for his product. Therefore, quantities of milk produced under conditions of an unknown degree of sanitation must be admitted to the market. In order to improve the milk of doubtful character, it is recommended that all such milk be properly pasteurized. It is an undisputed fact that certified milk is better than pasteurized milk, but under existing conditions it is sometimes necessary to choose between pasteurized milk and no milk.

Alleged Disadvantages of Pasteurization.

Those opposed to the use of pasteurized milk for city milk supply, find the following objections to this product:

1. It promotes carelessness and discourages efforts to produce clean milk.
2. It produces chemical changes in the milk which render it less easily digested.
3. Desirable lactic-acid bacteria are killed, while some undesirable types (spore formers) are not.
4. Germs are killed, but their toxic by-products remain.
5. Pasteurization covers defects in milk.
6. It affects flavor and creaming property.
7. The cost of pasteurization is considerable.

1. *Promotes Carelessness.*—It is claimed that pasteurization will encourage the producer and handler of milk to be careless and use unclean methods, believing great care unnecessary because the milk is going to be "cooked" anyway. The dealer may be careless in regard to the temperature at which the pasteurized milk is held and permit the spores to vegetate and multiply to such an extent that the milk would be a very dangerous food. If pasteurized milk be placed in unclean bottles and the organisms be permitted to multiply, by keeping it too long a time, such milk probably would be more unhygienic than the raw product.

In reply to this it may be said that pasteurization is a corrective measure and this is never as satisfactory as a preventive measure. In many cities milk is inspected by the health authorities before pasteurization, and if found to be very unsanitary is condemned. It is to the interest of the dealer to have milk in good condition before pasteurization, because it insures a product having better flavor and keeping qualities than that from unsanitary milk. Milk of doubtful sanitary qualities is an existing evil, and pasteurization is a present and efficient remedy.

2. *Produces Chemical Changes in Milk.* — The chemical changes wrought in milk by the heating process are said to render milk less digestible and to cause rickets and scurvy in children.

The pasteurization of milk for adults, however, can be no more objectionable than the cooking of meat. It is sterilization and high temperature pasteurization which cause changes in milk, while on the other hand, a temperature of 145° F. for twenty minutes (as is commonly used in commercial pasteurization) does not appreciably affect its physical and chemical properties.

Nature did not intend that milk should be cooked, neither did nature intend that milk should be exposed to bacterial contamination and unfavorable surroundings, and be allowed to undergo fermentative changes for a day or two before being consumed.

An excessively high temperature, especially if prolonged, will, it is true, decompose some of the proteins, diminish the organic phosphorous, increase the inorganic phosphorous, precipitate the calcium and magnesium salts and phosphates, expel most of the carbon dioxide, partially caramelize the lactose, cause a coalescence of some of the fat globules, and coagulate some of the serum albumin. Heat also destroys the enzymes which, according to some authors, aid in digestion and metabolism.

3. *Desirable Lactic-acid Bacteria are Killed, while Some Undesirable Types are not.* — Since lactic-acid organisms are not spore producers they have as low a thermal death point as the pathogenic organisms, and are killed by pasteurization. In raw milk the lactic-acid

bacteria inhibit the growth of the putrefactive organisms, but in pasteurized milk the spore-producing putrefactive bacteria have a clearer field for growth, and may develop poisonous substances without changing the appearance or physical condition of the milk.

Ayers and Johnson[1] have found that milk pasteurized under commercial conditions sours because of the development of lactic-acid bacteria which, on account of their high thermal death point, survive pasteurization; and perhaps, in some cases, because of subsequent infection with acid-forming bacteria, during cooling and bottling. The nature of the souring of efficiently pasteurized milk (140° F. for 30 minutes or 160° F. for a few seconds) is similar to that of clean raw milk. In both classes of milk, according to the same authorities, the alkali or inert bacteria constitute the largest group, the lactic acid next, and the peptonizers the smallest group. As these milks are held, the lactic-acid group gains ascendency over the other two classes, while the peptonizers remain the smallest group.

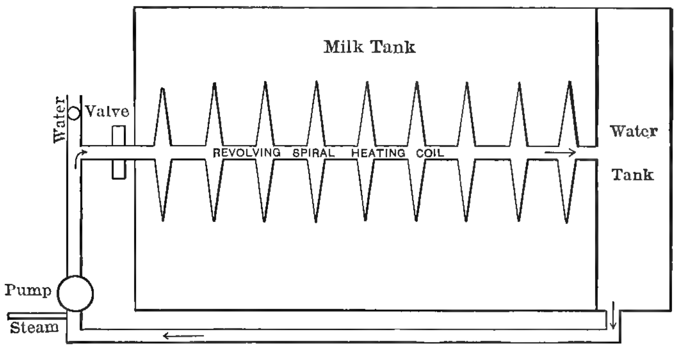

FIG. 2. — Combination heating, holding, and cooling tank. (Circular 184, Dairy Division, U. S. Dept. of Agr.)

[1] U. S. Dept. of Agr., Bu. An. Ind., *Bul.* 126.

The cleaner the raw milk, the smaller is the percentage of lactic-acid bacteria. Also, the more efficient the pasteurization, the smaller is the percentage of lactic-acid organisms. The number of peptonizers, in a good grade of commercially

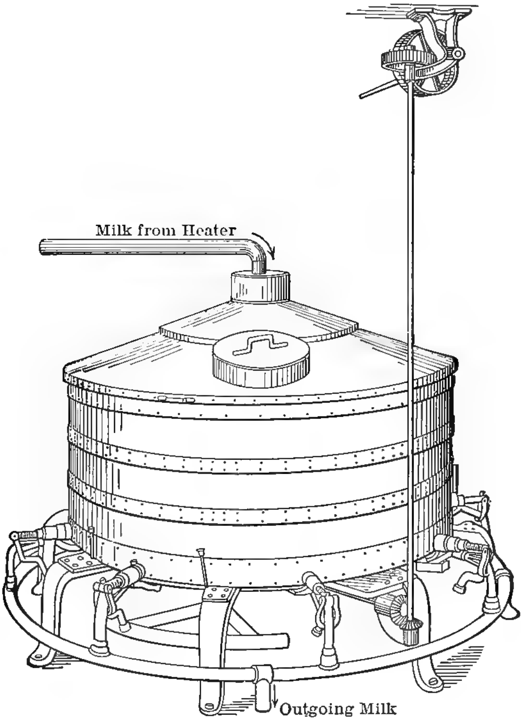

FIG. 3. — Holding tank with automatic emptying device. (Circular 184, Dairy Division, U. S. Dept. of Agr.)

pasteurized milk, on the initial count and on succeeding days, is approximately the same as in a clean raw milk held at the same temperature. In milk heated for 30 minutes at 140° F., it was found that about five per cent of the acid producers resisted the heating.

4. *Toxic Properties Remain in Milk.* — Many bacterial toxines are destroyed by heat, but others are not; hence it is argued that pasteurized milk may still be an unwholesome product.

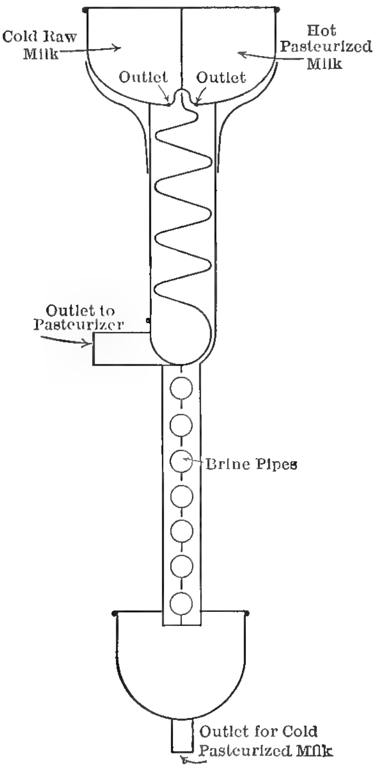

FIG. 4. — Sectional view of a regenerative cooler. (Circular 184, Dairy Division, U. S. Dept. of Agr.)

The existence of toxines in market milk has been largely inferred, not demonstrated. If heat-resisting toxines exist in milk, the raw product will be just as toxic as the heated, and probably more so, because heating would stop the development of the toxines.

5. *Pasteurization Covers Defects in Milk.* — Pasteurization may be used to hide the age of milk, so that the surplus from one day may be disposed of on the following day. By re-pasteurization, milk might be held for a long time without showing its aged condition.

The re-pasteurization of milk, however, is prohibited by law in some cities. Such a practice is not conducive to securing a high-grade product and, so far as known, does not obtain under commercial conditions.

6. *Affects Flavor and Creaming Property.* — When milk has been subjected to a high temperature the cream rises

more slowly and less completely than it does in the case of unheated milk. The viscosity of the milk is lessened and the milk appears to have a lower fat content. Heated milk has a characteristic, so-called, cooked flavor, which is objectionable to many people.

Although pasteurization inhibits cream from rising, the amount of cream in the milk is not decreased. When customers learn to know this fact, pasteurization is not so much objected to. As the process of pasteurization

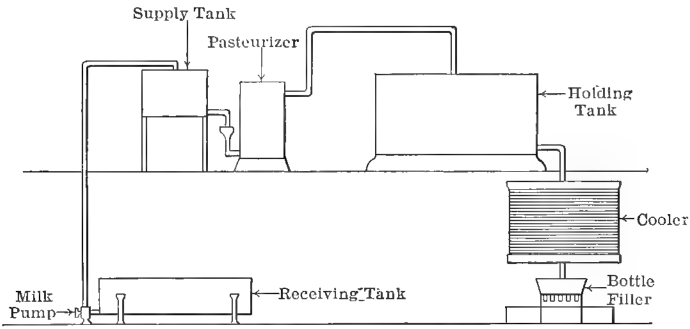

FIG. 5. — General arrangement of machinery for pasteurizing milk. (Circular 184, Dairy Division, U. S. Dept. of Agr.)

is carried on under commercial conditions at the present time, the creaming property of the milk is affected but little, if at all, and no cooked flavor can be detected after the milk has been cooled and held a few hours. Some people prefer the flavor of heated milk to that of unheated.

7. *Cost of Pasteurization.* — The cost of pasteurizing milk for city supply is difficult to state. This would vary with the amount to be pasteurized, the kind of help, the method of pasteurization, the efficiency of boiler and other machinery, and the handiness of the plant.

Generally speaking, 1 pound of steam heats 1000 pounds or 500 quarts of milk 1° F. It is necessary to heat the milk about 100° F. 100 pounds of steam are then required to heat 1000 pounds of milk 100° F. As 1 pound of coal produces about six pounds of steam, about seventeen pounds of coal are necessary to pasteurize the 1000 pounds of milk. The cost of this coal at $6.00 per ton, is about 5.1 cents. It costs an equal amount, 5.1 cents, to bring the temperature of the boiler up to the point of

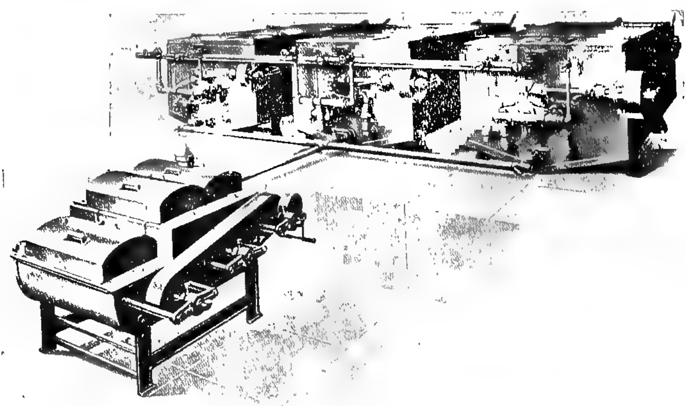

Fig. 6. — View of C. P. pasteurizing machine.

steam pressure. The cost of cooling this amount of milk may be estimated at 50 cents. If the pasteurizing machinery costs $2000 the depreciation of same may be estimated at $1 per day; thus the machinery should last 10 years. The interest at 7 per cent amounts to about forty cents per day. In addition it costs $1.50 for one-half day's labor. The total cost of pasteurizing 500 quarts of milk 100° F. is then about $3.50 per day, or 0.7 cent per quart.

Advantages of Pasteurization.

The following arguments are presented in favor of the use of pasteurized milk:

1. Protection from pathogenic bacteria occasionally found in milk.
2. A decrease in the total number of bacteria.
3. Aids in the preservation of milk.

1. *Protection from Pathogenic Bacteria.* — Epidemics, such as typhoid fever, diphtheria and scarlet fever, are on record as having been transmitted through milk, as has already been mentioned in Chapter IV. Several investigations of market milk have revealed the presence of the tubercle bacillus in approximately 10 per cent of the dairies. There is strong evidence showing that these diseases, under certain conditions, may be transmitted to the consumer. This danger may be obviated and the public protected by efficient pasteurization of the entire city milk supply. All of these pathogenic germs are destroyed by pasteurization, as they are not spore forming.

2. *Decreases the Total Number of Bacteria.* — Milk as a food is of greatest importance to the welfare of children, and the decrease of infant mortality is one of the virtues claimed for pasteurized milk.

We have already seen in a previous chapter how the Nathan Straus milk depots alleviated infantile gastro-mesenteric illness, and how the installation of a pasteurizing plant at the Children's Home on Randall Island, New York City, decreased the annual death rate. Many similar instances of the benefits of milk pasteurization may be mentioned.

Variot distributed for 12 years in the poorest quarters of Paris about 400,000 bottles of pasteurized milk to more than 3000 infants, and reports that there was never a single case of scurvy or rachitis among the consumers of the milk, and that the infants maintained their health and normal development on this diet.

Park & Holth of New York City found (1902–1903) that infants fed on pasteurized milk thrived much better than those fed on raw milk. They experimented on 50 babies from the tenement houses, and divided them into two equal lots. They were all fed on milk modified at the Straus milk depot. They were treated the same, excepting one lot, who were fed milk pasteurized 30 minutes at 165° F., and the other half were fed the same kind of milk unheated. The pasteurized milk in the morning contained 1000 germs per cubic centimeter, while the raw milk contained 1,200,000 per cubic centimeter, and the pasteurized milk contained in the afternoon of the same day 50,000 germs per cubic centimeter while the raw milk contained 20,000,000 per cubic centimeter.

The investigators made the following remarks:

"Within 1 week, 20 of the 27 infants put on the raw milk, suffered from moderate or severe diarrhea, while during the same time, only 5 cases of moderate and none of severe diarrhea, occurred in those taking pasteurized milk. Within a month, 8 of the 27 had to be changed from raw, back to heated milk, because of their continued illness. 7, or 25 percent, did well all summer on raw milk. On the other hand, of those receiving the pasteurized milk, 75 percent remained well or nearly so all summer, while 25 percent had one or more attacks of severe diarrhea. There were no deaths in either group of cases."

Berlioz, in Grenoble, France, distributed from 1894 to 1897 sterilized milk (heated under pressure) for infant feeding, and found an average death rate of 27.9 per 1000 for those using the sterile product, as compared with a death rate of 69.3 per 1000 for infants fed on raw milk.

3. *Pasteurized Milk Keeps Longer.* — Milk is commonly bought in quantities sufficiently large to supply the consumer for 24 hours. During hot weather, even a good quality of inspected milk may become unfit for use in 24 hours, unless a very low temperature is maintained. Among the poorer classes and even among the middle classes, ice is too expensive to use for cooling purposes. But because of the improved keeping qualities of pasteurized milk, the consumer is able to keep this grade of milk in a hygienic condition for a longer time than the regular, inspected raw milk can be kept.

Because of the prolonged keeping quality, the dealer has fewer complaints from his customers, and he has less loss through the souring of milk before it can be delivered. Hence pasteurization is of economic importance.

Pasteurization of Milk Increasing. — That pasteurization is being adopted by more and more cities and dealers, speaks strongly in favor of this grade of milk. In the year 1900, only 5 per cent of New York City's milk supply was pasteurized; in 1909, 25 per cent was pasteurized, and probably 33 per cent now undergoes heating. The city board of health has ruled that after January 1, 1912, all milk, except that produced under certain conditions, shall be pasteurized. In Boston 33 per cent of the milk is pasteurized; in Chicago 50 per cent, and in Milwaukee about seventy-five per cent.

Official Supervision of Pasteurization. — H. C. Campbell[1] has shown that, in cities where milk pasteurization is not under official supervision, commercial pasteurization cannot be relied upon as a means of destroying pathogenic bacteria in milk.

[1] U. S. Dept. of Agr., Bu. An. Ind., *An. Rept.*, 1909.

Russell and Hastings,[1] Schroeder[2] and others have shown that a temperature of 140° F., for 20 minutes, is sufficient to kill tubercle bacilli in milk. Schroeder tells us that:

"The simplest, the least expensive, and the most efficient available expedient through which the public can be protected against bovine tubercle bacilli and other viruses that may be disseminated with milk is pasteurization."

He also states that, until commercial pasteurization has been placed under official supervision, home pasteurization should be employed as the best solution to the milk problem.

Inefficiency of pasteurization under commercial conditions is usually due to ignorance or carelessness. The degree of heat and the time of exposure that are necessary to improve the keeping quality of milk also kill all pathogenic organisms. The finding of contagious disease producing germs in milk is an indication that the dealer has not even accomplished his special object of improving the keeping properties of his milk. The dealers, as well as the patrons, suffer because of this lack of efficient pasteurization.

The movement for the adoption of compulsory official supervision of all milk for city supply is gathering momentum and producing most satisfactory results. In cities where such supervision is properly enforced, the pasteurized milk can be relied upon.

Laws and Ordinances Pertaining to Pasteurization. — There has been, during the past few years, considerable legislation pertaining to pasteurization. New York City has recently added the following rules to its sanitary code:

1. Pasteurization must be carried out under a permit therefor issued by the board of health, in addition to the usual permit for milk.

[1] *Outlines of Dairy Bacteriology.*

[2] U. S. Dept. of Agr., Bu. An. Ind., *An. Rept.*, 1909.

2. Only such milk or cream shall be regarded as pasteurized as has been subjected to a process in which the temperature and exposure conform to one of the following:

No less than 158 degrees F. for at least 3 minutes.
No less than 155 degrees F. for at least 5 minutes.
No less than 152 degrees F. for at least 10 minutes.
No less than 148 degrees F. for at least 15 minutes.
No less than 145 degrees F. for at least 18 minutes.
No less than 140 degrees F. for at least 20 minutes.

3. The milk after pasteurization must be at once cooled and placed in sterile containers and the containers sealed.

4. All pasteurized milk must be delivered to the consumer in sealed containers which are plainly labeled, "Pasteurized." The label must also bear the date and hour when the pasteurization of the milk was completed, the degree of the heat employed, the length of time exposed to the heat and the number of the pasteurization permit issued by the board of health.

5. Pasteurized milk must be delivered to the consumer within 24 hours of the pasteurization.

6. No milk shall be pasteurized a second time.

Home Pasteurization. — Milk may be efficiently pasteurized in the home, if the person doing the work has a thorough knowledge of the process. It is not safe, howeve, to leave it to irresponsible servants.

The bottle of milk as it is received from the deliveryman may be immersed in water (not hot enough to break the bottle) to its neck in a cooking vessel. The milk should first be well shaken to insure uniform heating. If thick cream be left on top of the milk, it will not circulate well and will not be so quickly nor efficiently heated. A dairy thermometer may be stuck through the pulp cap, the vessel set upon the stove and the milk heated to the necessary temperature. The milk may be cooled slowly in this vessel by occasionally adding a small quantity of cold water until the milk is cooled to the temperature of the water.

CHAPTER VIII.

MODIFIED MILK.

Use of Modified Milk. — The normal healthy adult does not need this class of milk. But the ability of the infant, the invalid, and persons suffering from indigestion, is at times such that normal milk may not be properly digested and assimilated. Hence, it becomes necessary to modify this natural product to meet the requirements of these individuals.

Although the quantity of this grade of milk consumed, like certified milk, is very small compared with the great bulk of regular market milk, it is of great importance, because of its extensive use for infants.

Digestibility of Modified Milk. — The modification of milk for infant feeding owes its origin and present use to the fact that normal cow's milk frequently cannot be properly digested by an infant. This is due, first, to cows' milk having a different composition from that of human milk; and, secondly, to the fact that some infants have weak digestive systems and therefore require milk of special composition. Therefore, it becomes necessary so to alter the composition and the physical and chemical properties of the milk that it may be properly digested and assimilated.

It is possible that the casein in cows' milk is too often held to be responsible for digestive troubles in infants.

Huebner,[1] Keller and Czerny in Europe, and Brenne-

[1] Hygienic Laboratory, *Bul.* 56.

mann[1] and Walls in this country have shown that, in itself, cows' milk proteid is almost as easily digested by infants as is that of human milk. Czerny and Keller have shown that it is the fat, not the proteid, that is the main cause of digestive disturbances.

Since there are so many infants that, for various reasons, are artificially fed, the proper modification of milk to meet their needs is a very delicate and important matter. The milk provided by nature for the infant is usually the best food; hence, in artificial feeding, the aim is to imitate this product as closely as possible. It is therefore necessary to have an exact knowledge of the composition and characteristics of human milk.

Human Milk. — The first few days after parturition, colostrum is secreted as in the case of lower animals. This is characterized by a higher proteid and mineral content, and a lower fat and sugar content than the normal milk, and in addition contains numerous colostrum corpuscles, which are four to five times as large as the normal fat globules.

The composition of human colostrum milk, according to Pfeiffer, is

Proteid	5.71
Fat	2.04
Sugar	3.74
Salts or minerals	0.25
Water	88.23

Normal Human Milk Compared with Cows' Milk. — The composition of human milk has not been very thoroughly investigated, but an average of the most recent analyses by some of our best authorities is shown in the

[1] Hygienic Laboratory, *Bul.* 56.

following table, together with the average composition of cows' milk.

	Human.	Cow.
Fat	4.00	3.50
Proteid	1.50	4.00
Sugar	7.00	4.50
Salts (ash)	0.20	0.75
Water	87.30	87.25
	100.00	100.00
Calories per kilogram (or 2.2 lbs.)	710.50	726.00

It may be noted in the table that the main difference in the composition of the two milks is that human milk is lower in proteids and ash and higher in sugar than is cows' milk.

According to Koenig, the proportion of lactalbumin to casein is as 5 to 4 in human milk. This is a marked variation from the proportion of these constituents in cows' milk, which latter is about one to three.

When dilute acids are added to normal human milk a light flocculent precipitate is formed instead of the solid curd formed in cows' milk. Rennet extract, although it quickly coagulates cows' milk (when under proper conditions) does not materially affect human milk.

Food Requirements of Infants. — The diet of adult man has been a subject of study for many years, but the nutritive requirements of infants have received detailed and thorough attention only during the past few years. O. Heubner[1] of Berlin was, so far as known, the first investigator along this line, but he now has many followers.[2]

[1] Heubner — Die Energiebilanz des Sauglings. Zeitschrift f. diate u. physik. Theraouem, 1901. Vol. V. — Reviewed in Hygienic Lab. *Bul.* 56.

[2] Bren and Walls — *Am. Journal Med. Ass'n.*, 1907, Vol. XLVIII.

He calculated the bodily needs of the infant on the calorie basis, and finds the following daily requirements per kilogram (about 2.2 pounds) of body weight: First week in life, 60 calories (1 calorie being the amount of heat required to raise 1 kilogram of water 1° C.); first 3 months, 100 calories; second 3 months, 100 to 90 calories; third and fourth 3 months, 80 calories per kilogram of body weight per day. The maximum and minimum requirements being 100 to 70 calories respectively, when these limits were overstepped unfavorable results ensued.

In addition to the required heat units, the infants' food must contain the proper proportion of the various classes of nutrients — proteid, carbohydrates and fat, and mineral matter. The proper ratio of the different constituents will vary, depending upon the following conditions: individuality, age, activity of the infant, amount of fresh air received and other general conditions of living.

Manner of Modifying Milk. — The milk prescribed shall be of such quality and quantity (above-named conditions considered) as to furnish the energy quotients required, and no more, and, at the same time, contain the proper proportionate amount of each of the different food nutrients.

To calculate the number of calories in the modified milk the following figures may be used:

1 gram of butter fat produces 9.3 calories.
1 gram of proteid produces 4.1 calories.
1 gram of carbohydrate produces 4.1 calories.

To insure the proper proportionate amounts of the different nutrients and make the modified milk resemble in composition human milk, it is necessary to reduce the amount of casein in cows' milk, increase the amount of sugar, and still maintain the other constituents at normal. This may be done by mixing, in the proper proportion, liquids of known composition, for example, cream, whey (containing added milk sugar) and distilled water as follows:

To make 100 pounds modified milk:

	Fat.	Casein.	Albumin.	Sugar.	Ash.
	Lbs.	Lb.	Lb.	Lbs.	Lb.
20 lbs. cream (18 per cent fat)	3.60	0.50	0.15	1.00	0.14
70 lbs. whey (8.5 per cent milk sugar)	0.14	0.03	0.49	5.95	0.49
10 lbs. distilled water	0.00	0.00	0.00	0.00	0.00
100 lbs. containing	3.74	0.53	0.64	6.95	0.63

The composition of this modified milk approaches, very closely, that of human milk.

In large cities there are special laboratories in which modified milk is prepared. Calculated tables are consulted, so that any quantity of fresh modified milk can quickly be made. The physician prescribes milk of a certain composition. This prescription can then be taken to the laboratory, and the modified milk is put up in accordance with the prescription. This milk is put into small bottles containing only one feed. The Walker Gordon laboratories are in operation in many of the large cities in the United States, and do a large volume of business along this line.

Homogenized Milk.[1] — This class of milk is found on the markets of this country only in very rare instances, though it is used to some extent in European countries.

Homogenized milk seems to be objected to in this coun-

[1] The homogenizing machine and the use of homogenized cream for ice-cream making are described in Chapter XIX.

try. In the first place, there is a wide practice of using the cream from the top of the bottle for coffee or other special purposes. This cannot be done when homogenized milk is used, because there is no apparent cream on homogenized milk.

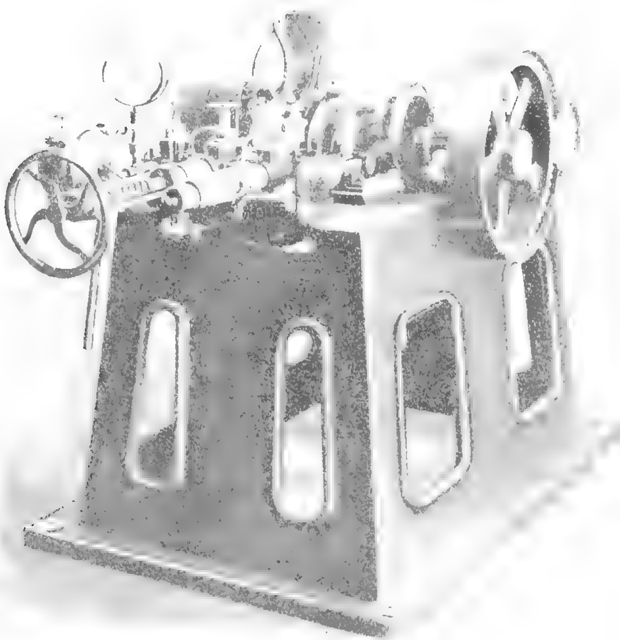

FIG. 7. — The Gaulin homogenizer.

The consumer commonly judges the richness of milk by the amount of cream that can be seen at the top of the bottle. By this standard homogenized milk does not show up well.

However, in all cases where it is desirable to use whole milk the homogenized milk is preferable to natural milk, because the former is always ready to use without mixing, and the cream never forms in hard lumps as is sometimes the case when natural milk stands for a long period. The fat globules of homogenized milk are very minute, which condition makes them more easily digested. It is also claimed that the homogenization process destroys many bacteria, and therefore homogenized milk has better keeping properties. This latter, however, has not been thoroughly investigated.

CHAPTER IX.

THE VILLAGE MILK PLANT.

The milk supply of a farm community is not so vital a problem for consideration by the general public, because the consumer, as a rule, is his own producer. The consumer uses the quality of milk that he produces, and if he does not have a pure and sanitary milk for use, no one but himself is to blame.

In the small city or village, conditions are but one step more complex than this. The consumer is supplied with milk by his neighbor, who generally resides just outside of the village limits. The city milk dealer and the producer are, as a rule, one and the same person. The milk produced in the morning, together with that of the previous night, is delivered to the consumer the same morning by the dairyman who produced it. This milk usually is exposed to less contamination, and is kept for a shorter time before delivery than the ordinary market milk of a large city. But from a sanitary point of view there is wide latitude in the operation of small city milk plants.

Objectionable Practices. — The small city milk plant, operating on but a small scale, cannot afford an elaborate and expensive equipment. In many places hot water and steam for cleaning purposes are available only in limited supply, which results in less thorough cleaning of bottles and utensils.

A number of practices that some small milk dealers follow should be condemned. Among these are, first, the selling of "loose milk," that is, dipping out from a supply can the amount desired by the purchaser, and placing it in a pan or other receptable; second, omitting to wash and sterilize returned bottles merely because

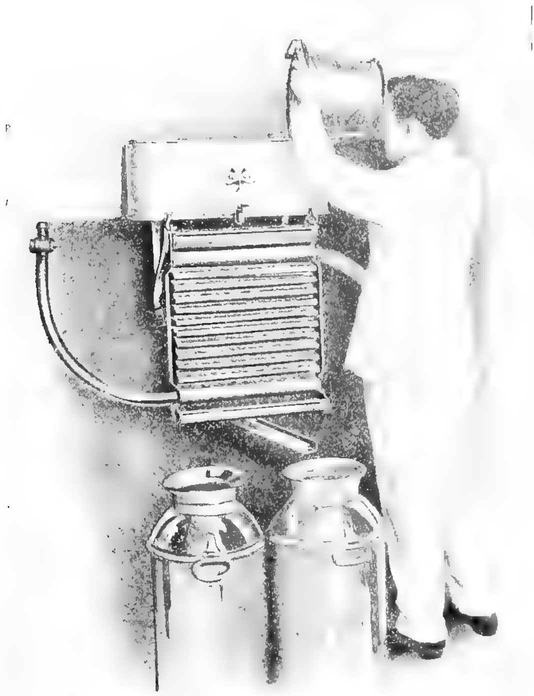

FIG. 8. — The Bestov milk-cooler.

they appear to be clean or allowing careless cleaning in the milk plant, the milk bottles when refilled without being washed may be the means of spreading disease; third, filling the bottles on the street.

A dairy of forty or more cows should afford a well-equipped milk house; and, since cleanliness is the most important consideration, the factors of prime importance in the milk house are sanitary construction and a small upright boiler to furnish an abundant supply of hot water or steam for cleansing and sterilizing.

Equipment of the Plant.

The equipment of a small dairy may vary between wide limits, depending upon size, prosperity, grade of milk produced, and the individuality of the owner.

Cooling the Milk. — The milk may be cooled by setting the cans in a tank of water, or an expensive cooling apparatus may be used. Between these extremes are numerous coolers adaptable to all conditions. Whatever method of cooling is employed, it is extremely important that the milk be cooled at once after it has been drawn from the cow.

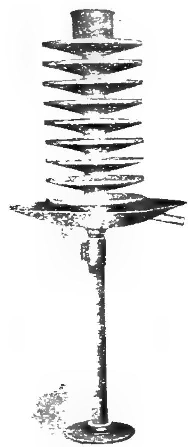

Fig. 9. — Circular disk milk cooler.

Bottling. — Bottles may be filled by pouring from a pitcher or spouted can, or a modern bottle-filling machine may be used. Many small dairymen use a large can similar to a small weigh can, but having one or two small faucets, under which bottles are placed for filling. Superior to this, but more costly, is the filler with the automatic cut-off valve, that insures having the bottles filled to the right point and prevents overflowing. When bottles are filled in this way there is no milk spilled on the outside of the bottle. The bottle is filled to such a point that the cap may be placed upon it without dipping it into the milk.

Capping bottles that are over full causes the excess of milk to squirt out on to the dairyman's hands and to drip from

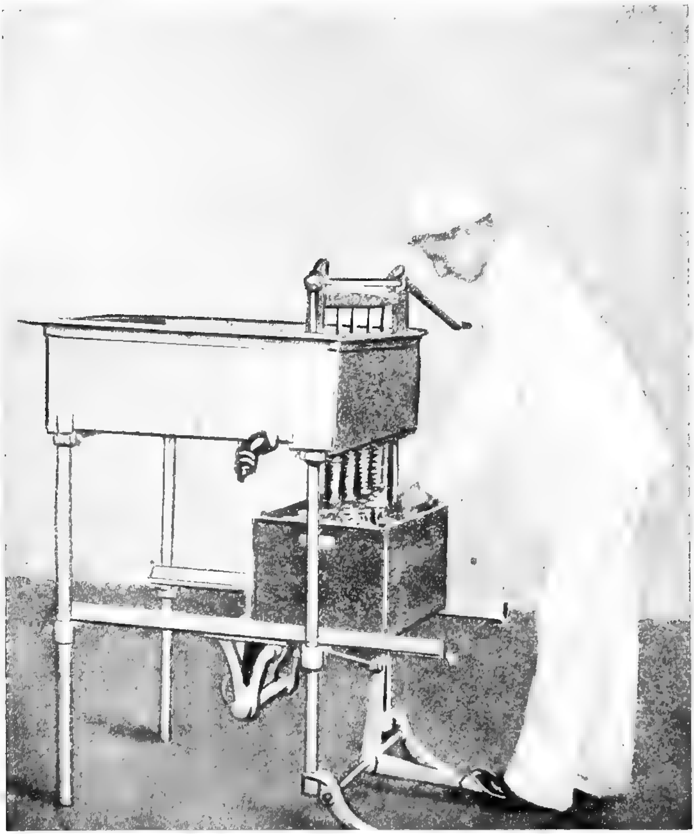

FIG. 10. - Quaker City milk-filler.

there to other caps and into other bottles. This is not sanitary.

In a report of the "Association for Improvement of the Milk Supply of New York City" is given the bacterial content of milk bottled and capped by hand and that of milk bottled and capped by machine. The average of three samples of each class of milk is as follows: Bottled by hand, 19,800 bacteria per cubic centimeter; bottled by machine, 6266 bacteria per cubic centimeter.

FIG. 11. — Davis hand bottle filler.

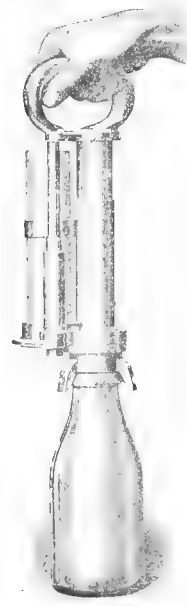

FIG. 12. — Davis hand bottle capper.

Capping the bottles by hand, although a very common practice, is not so sanitary as using a machine, neither is it so rapid. Caps for machine use may be bought. These are packed in paper tubes direct from the machine which makes the caps. These tubes are sealed so that the caps are not exposed to dirt and dust. Where bulk caps are used, they may be loaded into the metal tubes that are furnished with capping machines and sterilized. The simplest machine of this character is the single bottle capper, though, in a moderately large dairy, the combined filler and capper is found more economical in point of time.

Bottle Washing. – Many small dairymen object to the expenditure necessary to secure a bottle-washing outfit,

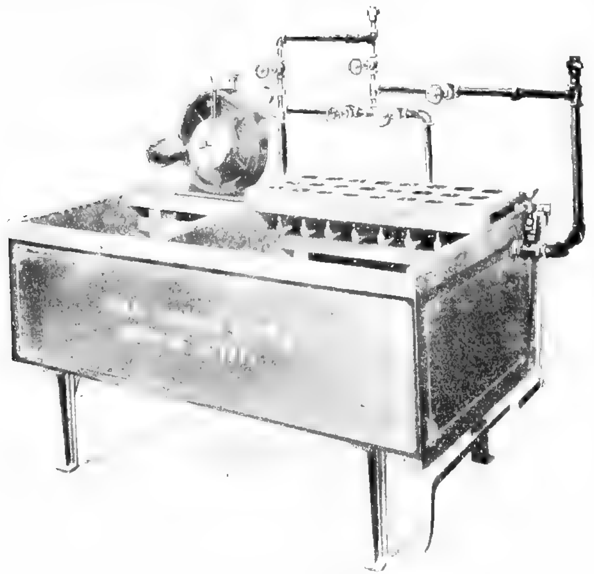

Fig. 13. — Turbine bottle washer.

but the time saved and the better results secured by a washer will soon pay for one. The machine best adapted to the small dairy is a brush revolved by a steam turbine or by a water motor, combined with suitable sinks and rinsing apparatus.

The small dairy that is equipped with a steam boiler to supply plenty of hot water for washing should have no difficulty in getting the bottles and cans almost sterile.

A sterile oven is a great addition to a dairy room, though a rather costly one. It is recommended for dairies producing a high grade of sanitary milk.

CHAPTER X.

THE CITY MILK PLANT.

THE large milk plant of a great city requires extensive equipment and a large building, and hence calls for considerable capital as well as knowledge of the dairy business.

The milk is practically all received by rail, so that it is subjected to more possibilities of contamination than that of the village milk dealer. Generally the milk passes through the hands of at least three different persons or companies — the farmer or producer, the transportation company and the city milk company.

Transportation. — Milk may be transported from the place of production to the market by steam or electric roads, boats or wagons.

In practically all small cities, the wagon carries most of the milk from the farm to the consumer. And even in some very large cities this mode of transportation is employed to a great extent. We find that in Washington, D. C.; Detroit, Mich.; San Francisco, Cal., and St. Louis, Mo., about half of the milk supply of the city comes in on wagons; while in Milwaukee, Wis.; Cincinnati, Ohio, and New Orleans, La., wagons bring about three-fourths of the milk. But in the larger cities, such as New York, Chicago and Philadelphia, about nine-tenths of the milk is brought in by steam and electric cars.

Most of the milk that is shipped less than 100 miles is carried in baggage or express cars attached to local passenger trains. But for greater distances special refrigerator cars are commonly used. This depends upon the time of year and the weather conditions. For milk cars, some roads employ a modified baggage car equipped with racks along the side for holding ice. A better milk car is used by one of the roads carrying milk to New York City. It is a refrigerator car with a capacity of 325 eight-gallon cans, having an ice compartment at each end, so that milk may be kept at a temperature of 50° F. Every day the cars are scrubbed and thoroughly cleaned.

Another road has refrigerator milk cars with asbestos-lined walls, sheet-steel floors and regular refrigerator doors and an ice capacity of 500 pounds at each end of the car.

The careful dairyman delivers his well-cooled milk at the station a short time before the arrival of the car or boat, but right here is a possibility of spoiling milk. Milk stations are often merely open platforms with no roof or other protection for the cans from the sun and heat in summer. Milk will quickly warm to the danger point if left on such a platform. And as delayed trains are not an unusual thing, the souring of milk while in the hands of the transportation company is not an infrequent occurrence. In the older dairy districts we find milk stations with proper protection for the milk while it awaits the arrival of the train.

Until very recent years, milk was brought from a distance by steam cars or by boat, but the electric railway is now a keen competitor for the hauling of milk and has some advantages over the other methods of transportation. The electric lines penetrate the rural communities to a greater extent than do the steam roads, so that the farmer has the milk station closer to his door. The electric lines can carry their loads of milk to the center of the city, or to the milk plant itself, instead of dumping it all at one great depot, located, perhaps, more than a mile from the milk plant, as is done, necessarily, by the steam road. Los Angeles has satisfactorily developed the milk traffic in this way.

Under present conditions, in most cities, milk is hauled by dray from the railway station to the city milk plant. This extra handling and labor cannot wholly be done away with.

The Intake. — On arrival at the city milk plant each can must be inspected by an experienced man with a keen

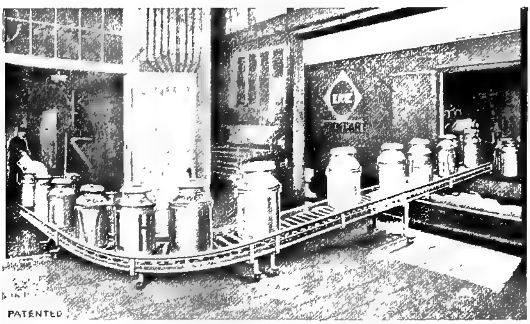

FIG. 14. — A-F gravity conveyers installed in Howell Condensed Milk and Cream Co. plant.

sense of smell. Milk containing any sour or other undesirable odor is not, and should not be, accepted. The inspection of milk on a large scale is done almost entirely by the sense of smell, because the sense of taste cannot be relied upon after several hundred cans of milk have been tasted in quick succession.

However, there are other tests for the sanitary condition of milk which are very useful under certain conditions, but are not being extensively used in this country at the present time. (See Chapter XII.)

The cans, when empty, may be turned up on a drip-saver, which, as the name indicates, saves whatever milk may drip out from the cans. Just beyond the drip-saver is the can washer. The cans are taken from the drip-saver, washed, steamed, and taken out by another door to the dray, which hauls them back to the railway station to be returned to the shipper.

Sanitary Piping. — Having passed the inspector, the milk is emptied into a receiving vat, from which it is pumped into a storage tank that feeds the pasteurizer. This necessitates passing the milk through considerable piping as well as a pump. Needless to say, the pumps should be of the sanitary type, so that they may be taken apart and thoroughly cleaned after each using. The piping must be the so-called sanitary piping, being tinned throughout, having a perfectly smooth interior, and in short lengths joined by couplings easily taken apart with a spanner wrench. These pipes should be washed daily by rinsing with cold water, then pumping hot washing powder solution through them and finally rinsing with plenty of boiling hot water.

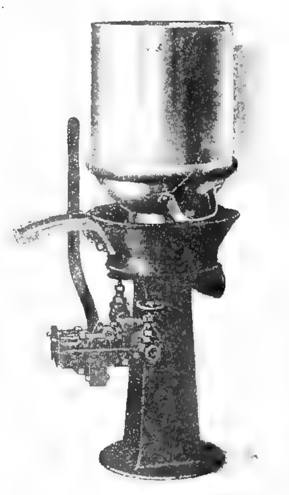

FIG. 15. — The Victor can washer.

However, they should be taken apart and thoroughly cleaned with a brush and sterilized at least once each week.

Clarifying. — The presence of dirt or sediment of any kind in milk is strenuously objected to by the consumer.

For this reason, some filter and clarify the milk. Milk filters have not given much satisfaction and are not used to any considerable extent. But the clarifying of milk by centrifugal force is being adopted to a large extent by city milk plants. Some of them use an ordinary cream separator and run the cream and skim milk together. At times the milk is standardized to the desired percentage of fat.

The milk clarifier is a modification of the cream separator, providing a greater capacity for the deposit of sediment and delivering the whole milk from the machine instead of separating it. Removing dirt from milk removes some bacteria, leucocytes, etc., so that the clarified milk is a purer and cleaner food.

Pasteurization and Cooling. — The large city milk plant commonly pasteurizes the milk, and for this purpose an intermittent pasteurizer or a continuous machine with a retarder is used, usually the latter. The milk is heated to from 140° to 160° F. and held at that temperature for from 15 to 30 minutes, when it is discharged and conducted to the cooler. This latter is very commonly a vertical coil of pipes over which the milk flows in very thin sheets, while at the same time cold water or brine is flowing through the interior of the pipes, entering at the bottom and flowing out at the top.

The pasteurization of milk, to be successful from a commercial standpoint, must be so carried on that the keeping qualities of the milk will be improved without heating to such an extent as to impart a cooked flavor or materially to injure the creaming qualities of the milk. It is a well-known fact among dairymen, that excessive heating and stirring of milk breaks the clusters of fat globules and scatters them throughout the serum. This

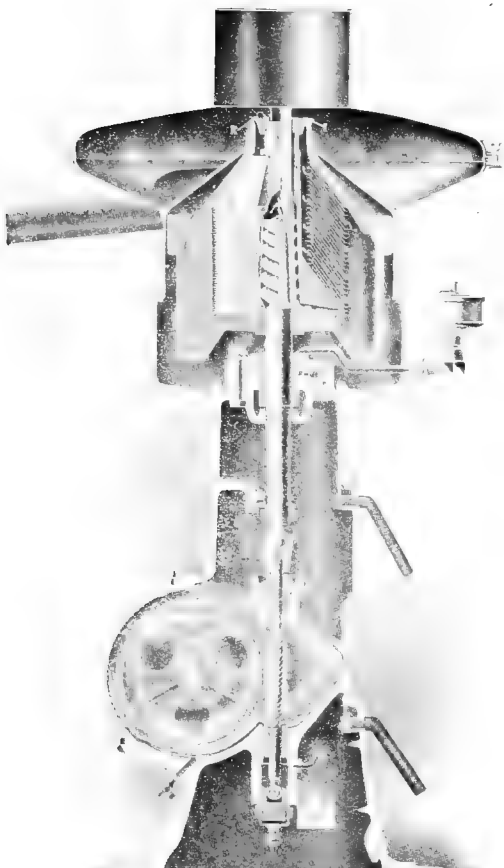

FIG. 16. — The De Laval centrifugal clarifier.

makes creaming very difficult, because the small globules are unable to overcome the viscosity of the milk serum. In unheated milk the fat globules are well clustered, and present a relatively small surface as compared with their volume. The creaming of milk is but slightly affected by temperatures up to 150° F., but subjecting it to a temperature of 160° F. for 20 minutes retards it very markedly.

Pasteurizers. — The pasteurization of milk may be accomplished by heating at a low temperature for a long time or at a high temperature for a short time. One class of machines, known as the intermittent or batch pasteurizer, is so operated that the milk may be heated at any temperature for any desired length of time. These machines are commonly vats or other receptacles in which the milk is heated and agitated mechanically. Cooling is accomplished by passing cold water through the agitator or jacket as the case may be. These machines are very efficient, but it can readily be seen that their capacity is limited, and hence they are hardly practicable except in a small business.

The other class of pasteurizers is known as the continuous or flask machine, because there is a continuous flow of milk through the machine and it is heated instantaneously. The milk is heated to a high temperature and immediately passed on to the cooler. However, it has been shown by experiment, that all the milk is not heated to the same temperature, and hence some of it will not be thoroughly pasteurized and some of it will be over-pasteurized.

A test[1] of one of the commonly used machines revealed the fact that some of the milk passed through in 15 seconds, most of it was held 30 seconds and some of it 60 seconds.

[1] Russel and Hastings — *Outlines of Dairy Bacteriology.*

It is evident that a temperature sufficiently high to kill the bacteria in the milk that passed through in 15 seconds would cause undesirable effects on the milk that was exposed for 60 seconds. And if the temperature was regulated on the basis of an exposure of from 30 to 60 seconds, it is evident that the milk passing through in 15 seconds would be inefficiently pasteurized.

The necessity of a continuous pasteurizer and the faults of the first machines led to the adoption of "holding" devices or "retarders." In such machines the milk is passed through a continuous pasteurizer into a holding tank in which it is kept at the desired temperature for the desired length of time, then passed on to the cooler. Thus the good qualities of the two classes of pasteurizers are combined in one. These machines may be equipped with a thermo-regulator which automatically regulates the flow of steam to the pasteurizer and insures a uniform heating of the milk. In connection with this a recording device is commonly used, so that the slight variations in temperature are recorded.

Pasteurization applied to fresh, clean milk, and to old, impure milk may destroy 99 per cent of the bacteria in both cases. Now it is quite evident that the clean milk before and after pasteurization would contain by far the smaller number of bacteria, and hence would have the better keeping qualities and be more healthful.

Immediate cooling to about 40° F. subsequent to heating is necessary for successful pasteurization; also all contamination after pasteurization must be guarded against.

Pasteurization in the Bottle. — Another method of pasteurizing milk that has been introduced recently is pasteurization in the bottles. This method necessitates the use of a perfectly tight cap, one that will withstand the action of hot water and steam. Breweries have used such a method of pasteurizing their bottled beer for a number of years, while the dairy industry has but recently adapted it to bottled milk.

One of the objections to the commercially pasteurized milk of to-day is that, although the pasteurization may have been efficient, contamination during the cooling,

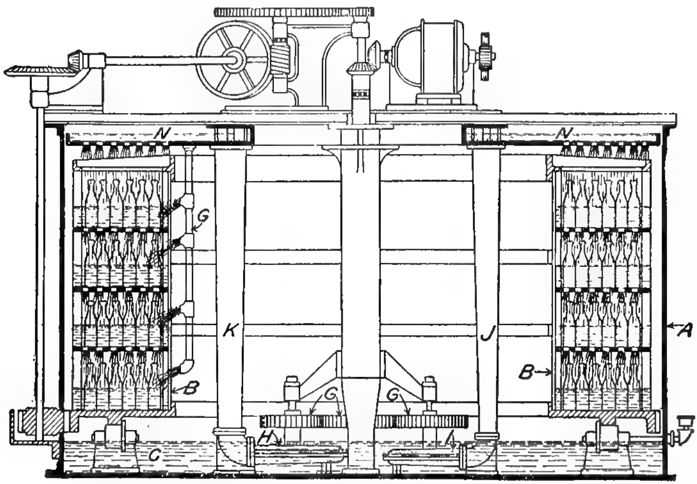

FIG. 17. — A type of beer-pasteurizing machine adaptable to the pasteurization of milk in bottles. (Circular 184, U. S. Dairy Division.)

bottling and capping processes is inevitable, and this contamination may be of a very serious nature. Pasteurization in the bottle prevents such contamination and insures a safer product.

Pasteurization of bottled milk is carried on to a limited extent in steam sterilizers, but a more efficient process is by the use of water. In the brewery there are two general classes of these pasteurizers. In one type the bottles are placed in baskets, which are carried on an endless chain into tanks of water having different temperatures. In this way the bottles are passed through lukewarm water, then through warmer and warmer water, until they reach the pasteurizing temperature. They remain at this temperature for 20 minutes or any desired time; then they pass through a series of cooling tanks, each successive tank containing cooler water than the previous one.

In the other type of machine, the bottles are placed in trays on a large wheel revolving horizontally, where they receive a heavy shower bath of water. As the wheel revolves the bottles pass through water of different temperatures just as in the above-described system, so that pasteurization and cooling are accomplished by a continuous process.

Mr. Bixby[1] of Boston compared pasteurization in a machine with pasteurization in bottles and secured the following results:

NUMBER OF BACTERIA IN ONE CUBIC CENTIMETER OF MILK.

Raw.	Pasteurized in machine.	Pasteurized in bottles.
2,000,000	99,000	30,000
2,000,000	102,000	34,000
6,300,000	42,000	6,600
1,960,000	70,000	1,200
6,200,000	65,000	4,000
2,100,000	65,000	8,100

In both these methods of pasteurization, the same degree of heat and same time of exposure were employed.

[1] *Medical Record.* — July 15, 1911.

It is very evident from these figures that heating in the bottles gives by far the better results.

In a similar experiment carried on by Dr. Charles E. North, New York, pasteurization in bottles reduced the bacterial content of the milk from about 500,000 to 500

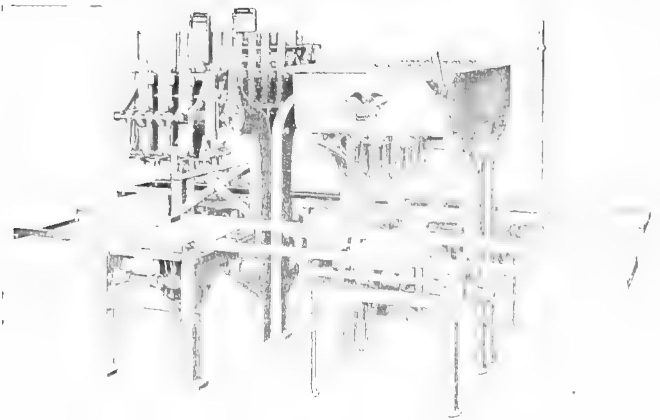

FIG. 18. — The Davis bottle filler and capper.

per cubic centimeter. This was accomplished without affecting the flavor or creaming of the milk.

Bottling. – After pasteurization and cooling, the milk may be conducted to a storage tank of glass-enameled iron located in a cold room. It is now ready to be bottled. For filling and capping bottles, on a large scale, an automatic, power-driven machine is commonly used. It may be run by an electric motor so that a movement of a lever causes a case of bottles to be filled and capped. The labor required to operate such a machine consists of one man to feed in the cases of empty bottles, and one man to take the filled bottles from the machine. If gravity conveyers are used, the man who takes the cases of filled bottles from the filler may place them on a conveyer which conducts them to a cold room for storage until called for by the delivery wagon.

Delivering. — Cases of filled bottles are usually hauled to the loading platform on hand trucks, and frequently have to be taken to the floor above on an elevator. A system more economical, in the use of time and labor, is

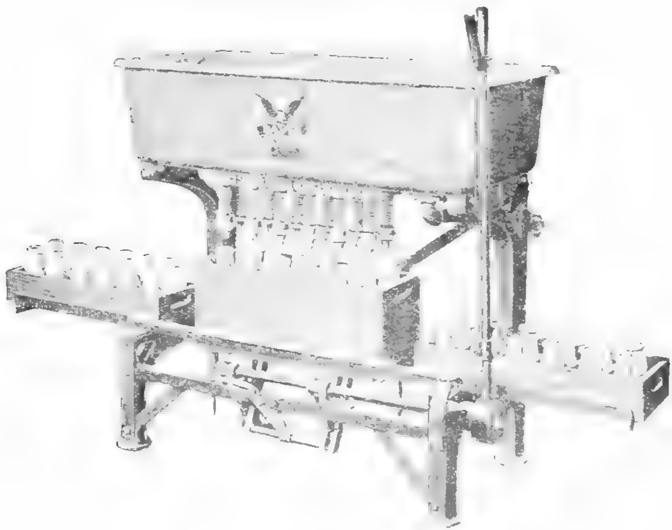

FIG. 10. — Davis Standard 12 bottle filler.

that of the gravity conveyer and automatic elevator, by means of which filled cases may be taken to the platform as fast as they can be loaded into the wagons.

Cases of empty bottles are readily conveyed to the washing room by the same method.

Bottle Washing. — The simplest method of washing bottles is by means of a revolving brush as described under "The Village Milk Plant." But this is not economical when a great number of bottles must be washed and sterilized each day. The modern bottle-washer handles the glassware in cases, taking them in at one end, just as they come from the wagons, and delivering them at the other end perfectly clean and sterilized.

In general there are two kinds of bottle washers: that in which brushes are used, and that in which jets of water are relied upon to do all the cleaning.

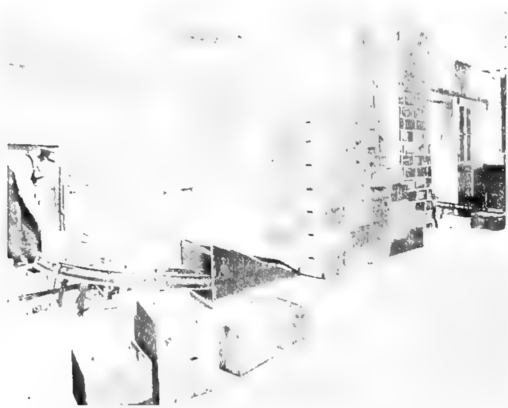

FIG. 20. — A-F gravity conveyers in Gridley Dairy Co. plant, carrying bottles from wagons to basement.

The automatic brush bottle washer soaks, washes with water under pressure and with brushes, and rinses and sterilizes the bottles. Sanitary cases may be used and the bottles kept in these cases during washing, filling, capping, and even on the wagon, so that separate handling of bottles is unnecessary. This not only saves a great deal of time, but also reduces the breakage to a minimum. In the operation of the machine, the cases of bottles are passed through the washer by means of a carrier, which operates automatically, stopping a sufficient length of time for

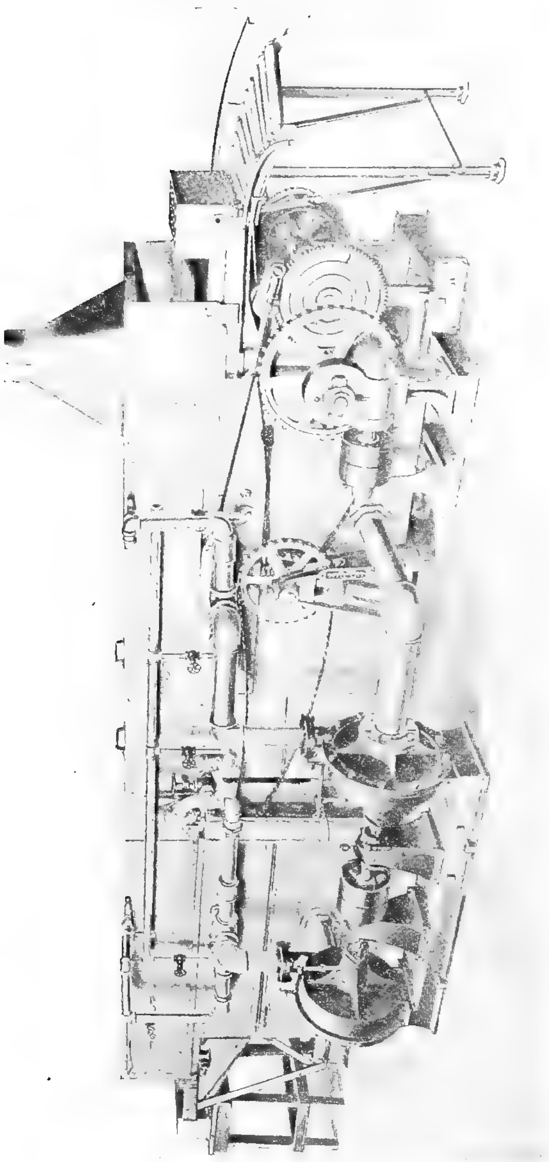

Fig. 21. — Davis automatic high-pressure brush bottle washer.

the various operations and discharging the bottles clean, practically sterile and hot. They dry quickly and assume

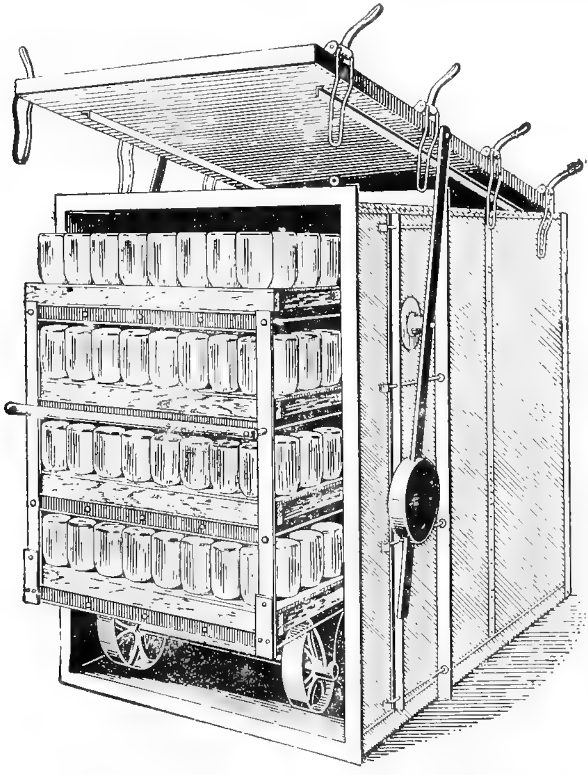

FIG. 22. —Steam chamber, showing method of steaming bottles. (Circular 184, Dairy Division, U. S. Dept. of Agr.)

a good clear luster. The washing process requires about five minutes.

The high-pressure bottle washer operates similarly to the brush washer, except that in the former no brushes are used. The work of the brush is accomplished by jets of water under high pressure. Large quantities of water are pumped over and over again with great force against the bottles, both inside and outside. The water in the tanks is renewed automatically and continuously, a small stream of water coming in and a small stream of impure water running out.

The Milk Bottle. — The only style of milk bottle used to any extent at the present time is that made of glass. The advantages of a glass bottle are as follows:

1. It is easily cleaned and sterilized.
2. The consumer can easily detect the presence of dirt of any kind in the bottle or the milk.
3. It cannot itself impart any flavor to the milk, and forms a perfectly tight package to keep out all dirt, flavors, etc.
4. It cannot corrode nor become unsanitary in any way, however old it may become.

The disadvantages of a glass bottle are:

1. It is fragile.
2. It is costly.
3. It is heavy.
4. Unless sterilized before being filled it may become a carrier of disease.

Because of these disadvantages, numerous attempts have been made to introduce a single-service container made of paraffined paper. This seems to be the only alternative to glass, all metals being out of the question. But the consumer cannot see the thickness of the layer of cream on the top, he cannot tell whether the milk in the paper container is clean or not, and the package is not so pleasing to the eye. These are the chief reasons for the failure of the single-service container to be generally adopted.

The Bottle Cap. Bottles of ordinary market milk are commonly capped with a pulp cap that fits into the countersink mouth of the bottle. This leaves the lip of the bottle exposed to the accumulation of dirt and

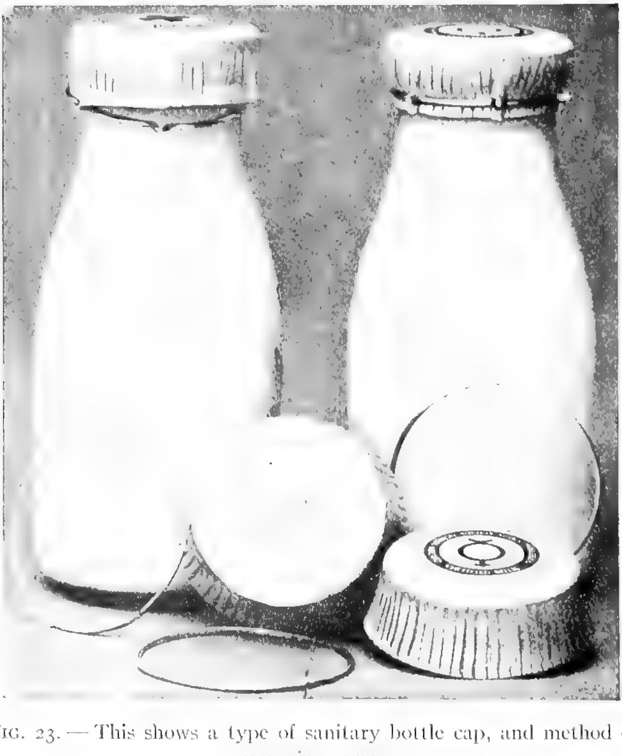

FIG. 23. — This shows a type of sanitary bottle cap, and method of removing same.

bacteria. When milk is poured from such a bottle it flows over and carries with it whatever contamination may be there.

Producers of certified milk have adopted various devices to protect the lip of the bottle. Many of them use the ordinary cap with a large hoodlike paper cap covering the entire top of the bottle. Others use a cap that fits tightly over the opening of the bottle, insuring a tight seal and protecting the lip at the same time.

Another style of cap being introduced is that similar to the cap used on pop and beer bottles, a metal cap lined with a fiber disk. These caps can be used only on bottles made for this purpose. They are placed upon the bottle by a machine that forces the corrugated skirt of the metal crown under the locking ring of the bottle, thus forming a hermetically tight seal, removable only by means of a bottle opener. This crown effectually protects the mouth of the bottle. Machines are on the market for automatically filling and capping bottles of this kind. With this system, milk can be pasteurized in the bottles and thus avoid possible contamination during cooling and filling of bottles.

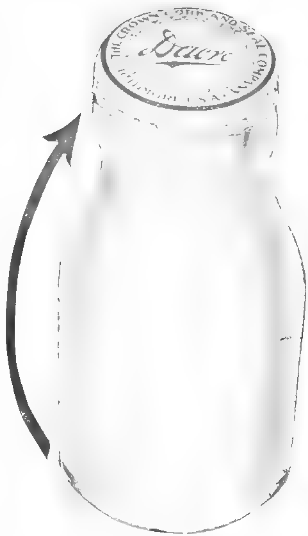

Fig. 24. — Another type of a sanitary bottle cap.

Business Principles. - The business of handling a large quantity of a perishable product demands close watchfulness on the part of the managers to avoid losses. The daily income and output of milk must be the same, as near as is possible to have it. Because of the perishable quality of the product, and because of the large quantity that must be handled in a short time each day, experienced help and efficient machinery are necessary.

FIG. 25. The foot milk bottle crowning machine.

The best of both, though high priced to start with, are cheaper in the long run. The retail milk business is one in which the sales are all for small amounts, hence the profit on each sale is very small. Success, therefore, depends upon a close attention to minute details.

One of the problems of greatest importance is how to keep a close check on the deliverymen. The manager usually does not come in direct contact with the customers; minor employees out through the city, away from the supervision of the employer, have to be trusted entirely with the dealings with customers, the handling of the entire finished product, the cash and the return of empty bottles.

The following system of checking the drivers is being used successfully in several large plants: When the driver goes out in the morning he is charged with the number of bottles of milk, the number of tickets or sheets of tickets and the cash he has in his possession. When he returns from the trip, he is again checked up and must have a used ticket or cash to account for every bottle of milk disposed of. He should also have an empty bottle for each full one sold. This latter is rather difficult, unless there is some

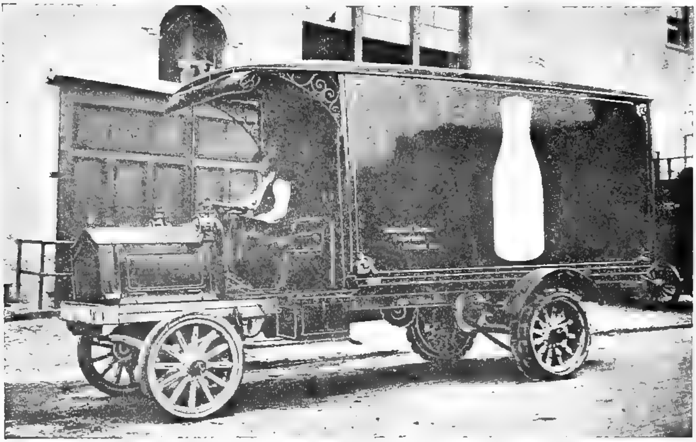

FIG. 26. — A motor truck specially equipped for handling dairy products. In the service of the Sheffield farms, N. Y.

incentive for the driver to return the empties. Probably the best way to prevent the loss of empty bottles is to scale the wage on a basis of the number of empty bottles returned. For instance, some companies pay their drivers one dollar per day and one cent for each empty bottle returned. Under this system the driver is pretty sure to induce his customers to have an empty bottle ready for him each day.

CHAPTER XI.

STANDARDIZATION OF MILK AND CREAM.

To standardize milk is to bring the butter-fat content to a given per cent regardless of the quality of the milk produced by the cow. Standardizing milk usually is done by the producer, because he cannot afford to produce, say, 5-per-cent milk, and sell it at the same price that 4-per-cent milk sells for. Neither can the consumer afford to pay for 5-per-cent milk when only 4-per-cent milk is delivered, so that some milk companies now guarantee their milk to contain a certain per cent of fat in return for a stated price to be paid by the consumer.

Standardization of milk may be accomplished in the following cases:

I. Where the per cent of fat is to be reduced by the addition of skim milk.

(*a*) Quantity of standardized milk not specified.
(*b*) Quantity of standardized milk specified.

II. Where the per cent of fat is to be increased by the extraction of skim milk.

(*a*) Quantity of standardized milk not specified.
(*b*) Quantity of standardized milk specified.

III. Where the per cent of fat is to be reduced by the addition of milk having a lower fat content.

(*a*) Quantity of standardized milk not specified.
(*b*) Quantity of standardized milk specified.

IV. Where the per cent of fat is to be increased by the addition of milk having a higher fat content.

(*a*) Quantity of standardized milk not specified.

(*b*) Quantity of standardized milk specified.

Formulas and Examples:

I. (*a*) To obtain milk containing 3.2 per cent of fat, from milk containing 4 per cent of fat and skim milk.

Draw a square. At the two left-hand corners write the numbers which represent the per cent of fat in the two liquids which are to be mixed. In the center of the square

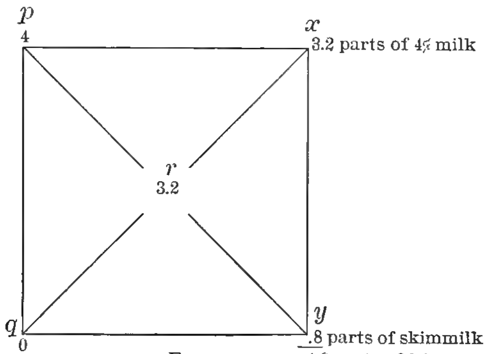

FIG. 27.

write the number representing the percentage of fat required. Then subtract the two numbers standing in line across the diagonals of the square and place the difference at the remaining two corners in such a way as to have the difference stand in line with the minuend and subtrahend. These last two numbers will indicate the proportions to be taken of the fluids whose percentages stand in the same horizontal line.

Since 3.2 : 0.8 : : 4 : 1 then we require 4 parts of 4 per cent milk and 1 part of skim milk to produce 5 parts of milk containing 3.2 per cent of fat.

The following formula may be used when the percentage is a convenient number to work with: Divide the per cent of fat in the milk that is desired by the per cent of fat in the milk on hand. The result will be the per cent of the milk on hand to be taken. The remaining per cent of milk will be the skim milk to be used.

The correctness of the graphical illustration, Fig. 27, may be proven as follows:

Let p be the per cent of fat in the cream of the richer of the two milks.

Let q be the per cent of fat in the milk of the poorer of the two milks.

Let r be the per cent of fat required,

x be the quantity of richer milk required,

y be the quantity of thinner milk required.

Then px is the fat in the richer milk for new mixture,

qy is the fat in the poorer milk of new mixture,

$(x + y)$ is quantity of new mixture,

$r(x + y)$ is the fat in new mixture,

$px + qy$ is the fat in new mixture.

Therefore, $px + qy = r(x + y)$.

Solving,

$$px + qy = rx + ry.$$

$$px - rx = ry - qy.$$

$$x(p - r) = y(r - q).$$

Then dividing both sides of the equation by $y(p - r)$ we have

$$\frac{x}{y} = \frac{r - q}{p - r}.$$

Substituting with figures from the above example we have

$$\frac{3.2}{8} = \frac{3.2}{8}.$$

In the above example we would have $3.2 \div 4 = 0.80$. Hence 80 per cent of 4-per-cent milk and $(100 - 80 = 20)$ 20 per cent of skim milk will produce milk containing 3.2 per cent of fat.

I. (*b*) To obtain 100 pounds of milk containing 3.2 per cent of fat from milk containing 4 per cent of fat, and skim milk.

Determine the number of pounds of fat required. Divide this number by the per cent of fat in the known milk. This will give the pounds of known milk required.

100×3.2 per cent $= 3.2$ which is the pounds of fat in 100 pounds of 3.2 per cent milk.

$3.2 \div 4 = 0.80$ or 80 per cent, which is the proportion of 4-per-cent milk required to make 3.2-per-cent milk.

80 per cent of 100 pounds = 80 pounds, the required pounds of 4-per-cent milk.

$100 - 80 = 20$, the required pounds of skim milk.

II. (*a*) To obtain milk containing 4 per cent of fat from milk containing 3.2 per cent of fat by the extraction of skim milk.

$$\frac{x(s-r)}{s} = \text{pounds of skim milk to be removed.}$$

When r = the per cent of fat in the known milk,
s = the per cent of fat in the standardized milk,
x = the pounds of known milk.

By substituting in the formula

$$\frac{x(4-3.2)}{4} = 0.2\,x = \text{pounds of skim milk to be removed.}$$

By removing from a given quantity of 3.2 per cent milk, skim milk equal to 0.2 of the weight of that milk, 4-per-cent milk will be obtained.

II. (*b*) To obtain 100 pounds of milk containing 4 per cent of fat from milk containing 3.2 per cent of fat by the extraction of skim milk.

Find pounds of fat required. Then divide the desired pounds of fat by the per cent of fat in the known milk and multiply the quotient by 100. The difference between this product and the pounds of standardized milk is the pounds of skim milk to be extracted.

$(4 \div 3.2) \times 100 = 125$, which is the pounds of 3.2-per-cent milk required to make 100 pounds of 4-per-cent milk.

$125 - 100 = 25$ which is the pounds of skim milk to be extracted.

III. (*a*) To obtain milk containing 3.5 per cent of fat

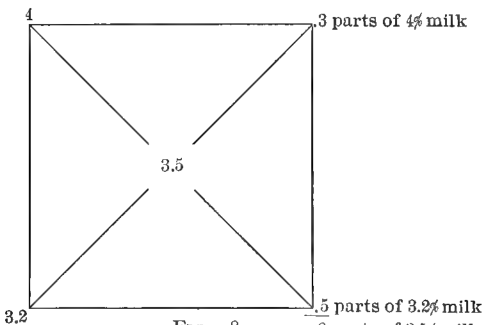

FIG. 28.

from milk containing 4 per cent of fat, by the addition of milk containing 3.2 per cent of fat.

Same method as is used in solving I. (*a*).

III. (*b*) To obtain 160 pounds of milk containing 3.5 per cent of fat from milk containing 4 per cent of fat, by the addition of milk containing 3.2 per cent of fat.

Same formula as is used in solving I. (*a*).

0.8 : 160 : : 0.3 : 60. Hence 60 pounds of 4-per-cent milk are required.

0.8 : 160 : : 0.5 : 100. Hence 100 pounds of 3.2-per-cent milk are required.

IV (*a*) To obtain milk containing 3.5 per cent fat from milk containing 3.2 per cent of fat by the addition of milk containing 4-per-cent milk.

Same formula as used in solving I. (*a*).

IV. (*b*) To obtain 160 pounds of milk containing 3.5 per cent of fat from milk containing 3.2 per cent of fat by the addition of milk containing 4 per cent of fat.

Same problem as in III. (*b*).

Standardization of Cream. — The standardization of cream is of still greater importance than the standardization of milk, because the variation of the percentage of fat in cream is relatively greater than that of the milk. The fat content of cream under normal conditions varies between 10 per cent and 50 per cent, while that of milk seldom varies over 2 per cent or 3 per cent.

When a certain volume of cream is being sold, a comparatively larger amount of butter fat is disposed of than when the same volume of milk is sold. As it is the butter fat which is the most valuable part of cream and milk, it is a good plan to regulate the price of cream according to (1) the percentage of fat in the cream, (2) the current price of the butter or butter fat.

Even when the same separator is being used daily, the percentage of fat in the cream is likely to vary as much as 5 per cent. This variation, if cream is not standardized, may cause a considerable loss to either consumer or producer. For instance, suppose 25 gallons of cream should contain 20 per cent of fat, and it was unknowingly increased to 25 per cent, there would than be 5 per cent more than the standard required. If this cream were sold at 80 cents a gallon, the price per pound of fat in the first case would be 50 cents. If the cream tests 25 per cent instead of 20 per cent, 0.4 of a pound of fat too much is given in each gallon of cream. In 25 gallons of cream 10 pounds too much would be given. This, at 50 cents per pound, would make a loss of $5.00 to the producer from the sale of 25 gallons alone. Such a loss would affect the profit directly.

The principal difference between milk and cream is that cream contains a larger per cent of fat than does milk. For this reason, the same methods which apply to the standardization of milk will also apply to the standardization of cream.

When the cost of butter fat is to be taken into consideration, then a separate process must be applied. If it is desired to find the price of butter fat when so much is obtained per gallon, then first multiply the pounds of cream per gallon by the per cent of butter fat in the cream. The product will equal the pounds of fat per gallon of cream. Then divide the price per gallon of cream by the number of pounds of butter fat. The quotient will be the price per pound of butter fat.

Example. What is the price per pound of butter fat when cream containing 20 per cent of fat sells for 50 cents per gallon?

A gallon of cream weighs about 8 pounds.

8 pounds $\times$ 0.20 = 1.60 pounds of fat in a gallon of cream.

.50 divided by 1.6 equals $0.31, the price of a pound of butter fat.

If it is desired to calculate the price of a gallon of cream when butter fat is worth a certain price, then multiply the pounds of cream per gallon by the per cent of fat in the cream. The product will represent the number of pounds of butter fat in one gallon of cream. Multiply this product by the price per pound of butter fat desired. The product will represent the price per gallon of cream.

Example. At 30 cents per pound of fat what would be the price of a gallon of cream containing 25 per cent of butter fat?

$8 \times 0.25 = 2$ pounds of butter fat.

2×30 cents $= 60$ cents, the price per gallon of cream testing 25 per cent of fat.

In case it is desired to make use of butter prices, it is essential to increase the fat by the average overrun.

If it is desired to find the equivalent price per gallon of cream containing different per cents of butter fat, the following method is the quickest.

Example. If cream containing 20 per cent of fat is worth 60 cents per gallon, what is cream worth containing 25 per cent of fat?

$$0.20 : 0.25 :: 0.60 : x.$$

$$60 \times 0.25 = 15.$$

15 divided by 20 equals 0.75, the equivalent price of 25-per-cent cream.

In some instances, cream is sold for so much per quart for each per cent of fat it contains. The usual price when sold in this way is one cent per quart for each per cent of fat it contains. For instance, if the cream contains 25 per cent of fat, then the price of it would be 25 cents per quart. If it contained 35 per cent of fat, it would be worth 35 cents per quart, etc. In case the quality of cream varies, this is a fairly good basis upon which to fix the price of cream.

In all instances, when milk or cream is being standardized, care should be taken not to mix old cream with fresh milk, or vice versa. Old cream and fresh milk, in the first place, do not mix as well as when both are fresh. Lumps of cream are likely to remain, even though it may seem as if the two had been mixed well. Thus an unattractive appearance is caused. Secondly, the older cream or milk, as a rule, contains a large number of bacteria, and in some instances undesirable ones. These when mixed with the good milk will cause the keeping property of the whole to be lessened, and in some instances cause the whole mixture to assume abnormal qualities.

CHAPTER XII.

SANITARY EXAMINATION OF MILK.

SEVERAL cities have adopted bacterial standards for milk. Rochester, N. Y., requires that the bacterial content of their city milk be kept below 100,000 per cubic centimeter. Boston permits 500,000 per cubic centimeter, and other cities have different requirements for different grades of milk.

The number of bacteria in milk cannot be determined until 24 to 48 hours after the sample was taken, by which time the milk has been consumed. A milk dealer demands a quicker test for the quality of the milk. Since the age of milk is indicated somewhat by the degree of acidity, the acid test is used to some extent to determine the quality of the milk.

Acidity Test. — The simplest method of determining roughly the acidity of milk is by the use of Farrington's Alkaline Tablets, using a solution made of one tablet to one ounce of hot water. Using the same unit for the measurement of both, the milk and the alkaline solution, one volume of alkaline solution added to one volume of milk will neutralize acid equivalent to one-tenth of one per cent. If the addition of two volumes of alkaline solution to one of cream does not neutralize all the acid (turn the milk pink), then that milk contains more than two-tenths of one per cent acid, and is not a first-grade product.

Sediment Test. – The cleanliness of milk is indicated somewhat by the amount of dirt or sediment it contains. There is no way of extracting all the dirt that may have fallen into the milk during or subsequent to milking, because nearly one-half of ordinary barn dirt is soluble; hence the presence of a small quantity of visible dirt is usually an indication that a greater quantity is present

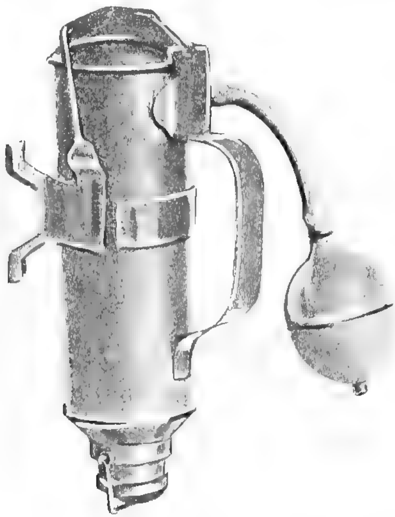

FIG. 29. — The Wisconsin milk sediment tester.

in the milk. The cleanliness of milk may be roughly ascertained by centrifuging a sample, or by filtering a certain volume through absorbent cotton and noting the amount of discoloration and filth deposit on the filter. Tests for this latter purpose are manufactured and offered for sale.

Babcock and Farrington describe a milk-sediment test devised by them in which one pint of milk is placed in a steam-heated jacketed container, and filtered through a disk of absorbent cotton, said cotton to be free from sizing or starch, which prevents satisfactory filtering of the milk. Milk may be graded according to the degree of discoloration of the cotton.

Leucocytes in Milk. — In the milk of normal, healthy cows may be found a number of leucocytes or white-blood corpuscles. The mixed milk from a healthy herd seldom contains more than 500,000 cells per cubic centimeter, although this number is often exceeded in the milk of individual cows. An inflamed or diseased condition of the udder causes a great increase in the leucocyte content of the milk, hence, at the present time, milk containing over 500,000 of these bodies per cubic centimeter is looked upon as coming from a bruised or inflamed udder and is considered unfit for food. However, this number cannot be adopted as a set standard, but it is well to class all milk as suspicious when it does exceed this limit. A physical examination of the cows producing the milk should be made and action taken according to the findings at this examination.

Fibrin has been found to accompany leucocytes; especially in acute cases. Professor Doane found that when a cow's udder is badly inflamed these fine threads, or fibrin, are found in the milk. The leucocytes in such milk also tend to hang together in clusters. In some experiments with milk from an inflamed udder, Doane found as many as 20,000,000 leucocytes per cubic centimeter of milk. Fibrin was also found in this milk. As the cow's udder became well, the number of leucocytes dropped to 500,000 per cubic centimeter. At this period, the fibrin disappeared. A number of counts were made from milk of different cows, and it was found that fibrin accompanied a large number of leucocytes.

Reduction-Fermentation Test. — This test was originated by Barthel of the Swedish Experiment Station and is used as follows: To 20 cubic centimeters of milk add 0.5 cubic centimeter methylene blue and 2.5 per cent saturated alcoholic solution in water. Keeping the samples at about one hundred degrees F., the rapidity of the reduction of the color, the change from blue to white, varies directly as the number of bacteria in the milk. This reduction test is combined with the fermentation test by keeping the samples until curdling takes place and noting the time required to curdle and the presence of gas or bad flavors in the curd.

According to Barthel, if the milk contains several hundred thousand bacteria per cubic centimeter, reduction will take place within fifteen minutes. If the blue color disappears within an hour, the milk is not first class. One to three hours are required for the reduction in high-grade market milk, but even a greater length of time is required for very fresh, clean milk.

Of course, this test is merely an indication of the number of bacteria present, but it may be found very useful to the dealer trying to buy a high-grade milk, or to the butter or cheese maker, who wishes to guard against the evils of over-ripe milk.

CHAPTER XIII.

WHIPPING OF CREAM.

Conditions Affecting Viscosity of Cream. – When cream is pasteurized, heated, or even warmed, the clusters of fat globules are broken up. This lessens the viscosity of the cream to such an extent that it does not whip so readily. It has the consistency of raw cream of a lower per cent of fat. This frequently misleads the consumer to think the cream is not up to standard in fat. The viscosity may be restored by holding the cream at a low temperature for a day, or at least 12 hours, but this is not practicable in city milk supply. Another way to restore the viscosity to cream as investigated by the Wisconsin Experiment Station is to add sucrate of lime, known commercially as "Viscogen." Cream containing viscogen must be so labeled because our pure food laws forbid the addition of any substance to milk or cream. The name "visco-cream" has been used to designate this product.

Preparing Viscogen. — Viscogen may be made as follows: Dissolve $2\frac{1}{2}$ parts granulated sugar in 5 parts water; slake 1 part good rock-lime in 3 parts water. Pour the slaked lime through a wire strainer to remove coarse, undissolved particles and add to the sugar solution. Agitate the mixture occasionally for two to three hours, then allow it to settle for about twelve hours or until the liquid becomes clear, when it can be siphoned off and is ready for use.

Viscogen should be kept in air-tight containers, because, when exposed, it absorbs carbon dioxide from the air and is weakened. Exposure to the air for a long time also darkens the solution, but this does not impair its usefulness.

The function of sugar in viscogen is to hold lime in solution. A sugar solution of equal parts of sugar and water will hold about one hundred times as much lime as is found in plain lime water.

Use of Viscogen in Cream. — One part of viscogen to from one hundred to one hundred and fifty parts of cream will produce the desired results. An excess of this substance imparts a soapy flavor to the cream, hence the following method of adding viscogen is recommended.

Titrate a small quantity of cream with the viscogen that is to be used, and calculate the quantity of viscogen required to neutralize (to phenolphthalein) all of the acid in the cream; then add from one-half to two-thirds this quantity.

For example: We have 800 pounds of 25 per cent cream, pasteurized. We wish to restore its viscosity by the addition of viscogen. Put some of the viscogen into a burette graduated in cubic centimeters, such as is used for Manns' acid test. Place a sample of cream, 35 cubic centimeters, or any convenient amount, in a white cup, add two or three drops of phenolphthalein, and then run in viscogen from the burette until a permanent faint pink color is secured. If the quantity of viscogen used to neutralize the acid in 35 cubic centimeters of cream was 0.6 cubic centimeter, then to neutralize the acid in 800 pounds of cream would require:

$$35 : 0.6 :: 800 : x \quad \text{or} \quad 13.7 \text{ pounds.}$$

But we wish to neutralize only one-half of the acid in the cream, so we require but one-half of 13.7 or 6.8 pounds of viscogen.

Pasteurized cream should be cooled to 60° F. or less before the viscogen is added; this is to avoid the production of an undesirable alkaline flavor.

The retailer of cream and the consumer should both be well posted on the influence of various conditions on the whipping quality of cream.

The greater the per cent of fat in cream, the better the cream will whip; but an excess of fat is not necessary or even desirable, and, if proper conditions are secured, cream containing 25 to 30 per cent of fat can be whipped until it stands alone.

Other conditions being observed the colder the cream (freezing point being the limit) the better it will whip. This is a very important point for the cook to observe, because cream that will produce an excellent whip at 50° F. can be only fair when whipped at 60° F. Failure to secure a good whip is too often due to the warming of the cream during the whipping; cream at 50° F. brought into a warm kitchen, placed in a warm dish, and having warm air beaten into it, will possibly acquire a temperature of 65° to 70°. Under such conditions it is doubtful if the whipping will produce good results; but if the same cream be whipped in a cold vessel, in a cool room, much better results will be secured.

Cream 24 hours old will whip better than fresh cream. This is due to the blending together of the various milk components, and to the gathering of the fat globules into clusters which increase the viscosity of the cream. The same result may be secured to a certain extent by the addition of viscogen.

C. W. Melick [1] notes the following points affecting the whipping of cream:

"1. There was no difference in the whipping qualities of gravity and separator cream. When any difference is experienced it is due to other factors and not to the method of getting the cream from milk.

2. Cream for whipping purposes should contain at least 20 per cent butterfat. The results were obtained with cream containing from 25 per cent to 40 per cent butterfat.

3. For best results cream should be held at as low a temperature as possible (35° to 45° F.) for at least two hours before whipping, and should be whipped in a cool room.

4. For good results cream should be from 12 to 24 hours old. This gives an opportunity for the development of a small amount of acid in the cream. The acid effected a gelatinous consistency in the casein and albumin and thus facilitated the incorporation of air in whipping. When it is desired to whip fresh cream, $\frac{3}{10}$ per cent commercial lactic acid may be added to take the place of the acid which would develop by setting the cream from 12 to 24 hours.

5. Pasteurized cream may be whipped as easily as unpasteurized cream if it is thoroughly cooled and held at 35° to 45° F. for at least two hours before whipping.

6. For good results cream should whip in from 30 to 60 seconds. When a longer time is required there is danger of some of the butterfat separating or churning.

7. The addition of one-tenth per cent of commercial lactic acid to cream facilitated its whipping and made it possible to whip cream which was fresher, which contained less butterfat and which was warmer than is advisable for the best results.

8. The use of viscogen facilitated the whipping of cream to a greater extent than any other ingredient with the exception of lactic acid. It proved less effective than the

[1] *Maryland Bul.* 136.

latter and also less effective than a low temperature. The addition of viscogen caused cream to remain sweet from 12 to 24 hours longer than it otherwise would.

9. The use of powdered sugar, powdered milk, salt, caramel, gelatine, junket, and cornstarch, each facilitated the whipping of cream to a small degree, and each to practically the same extent. None of them proved as effective as a low temperature and the development or addition of lactic acid. The addition of an excess of gelatine above 10 per cent, or of cornstarch above 20 per cent caused a lumpy cream when whipped.

10. The use of egg albumen with cream when whipped separately and mixed, produced a lighter foam, but had no effect upon the time required to whip. When mixed before the egg albumen was whipped, at temperatures above 40° F., the whipping was retarded.

11. The use of vanilla extract used in ordinary quantities had no effect upon the whipping qualities of cream.

12. The charging of cream with carbonic acid gas without pressure had no effect on its whipping qualities but caused it to remain sweet from 12 to 24 hours longer.

13. The use of cream from cows near the end of their lactation period whipped with slightly more difficulty than did cream from fresh cows.

14. Whipped cream will not keep sweet as long as unwhipped cream.

15. When any additions are made to cream to facilitate whipping it should be so labeled as to not deceive the purchaser."

PART III.

ICE-CREAM MAKING.

CHAPTER XIV.

HISTORY AND EXTENT OF ICE-CREAM MAKING.

ALEXANDER THE GREAT is said to have been very fond of iced beverages, and it is said that one of our modern varieties, the "Macedoine," was named after the ancient Macedonian. Wines and fruit juices were cooled with ice and snow at the courts of France and Italy in very early times. When and where the first water ices were made no one can say, but it seems probable that they were brought to France from Italy by Catherine de Medici in the sixteenth century. Marco Polo is reported to have brought recipes for water ice and milk ice from Japan in the thirteenth century.

Cream ice was served at a banquet given by Charles I of England. This ice was made by a French cook named De Mireo, and it is related that the king was so well pleased with the new dish that he pensioned the cook with 20 pounds a year on condition that the latter should not make the ice for any one but the king, and should tell no one else how to make it.

English cook books, published about the middle of the eighteenth century, gave recipes for making cream ices.

It can readily be seen how the making of ice cream has developed step by step from the cooling of wines and fruit juices to the freezing of similar liquids, and then to the freezing of milk and cream.

Ice cream is said to have been introduced to the city of Washington, by Mrs. Alexander Hamilton, at a dinner that was attended by George Washington.

The first ice cream advertisement on record is one that appeared in the "Post Boy," New York City, June 8,

FIG. 30. — View of large ice cream plant. (Ice Cream Trade Journal.)

1786. At this time, ice cream sold readily at one dollar per quart.

Jacob Fussell, so far as known, was the first man to make a wholesale business of ice-cream making. He was a milk dealer in Baltimore, Md., and adopted ice-cream making to utilize his surplus cream. A few years later, an ice company, becoming interested in the manufacture of ice cream, paid Fussell $500 for teaching one of their men the art of making this product.

American enterprise took up the new industry, and it developed steadily. However, it was not until after 1890 that the rapid growth began. Since that date the business has been growing with increasing rapidity, aided, to some extent, by the perfection of artificial refrigeration. This provided a way for these frozen dainties to be used in the south, and made possible the great wholesale factories found in some of our large cities.

The value of the ice cream consumed in this country has reached the enormus figure of $150,000,000[1] per annum and has outgrown the small and secret chamber in which the manufacturer of a few years ago performed his work.

The making of ice cream has been regarded, at least in part, as a secret process. During the few years that ice cream has been made on a commercial scale, and even today, in many places, the mixing and freezing of ice cream are carried on behind locked doors, too often in cellars. But it is the opinion of many of the large manufacturers that the time has come when secrecy is not necessary, nor even desirable. The making of ice cream in secret does not create a monoply for the manufacture, nor does it increase the popularity of or demand for the product. On the other hand, the making of ice cream in a modern, properly constructed, sanitary factory, open to the public, is a great advertisement for the manufacturer and is conducive to an increased demand for the product. Manufacturers of ice-cream supplies are scattering broadcast exact directions for making the mix, freezing the cream, etc. Several dairy schools are teaching commercial ice-cream making. Some large dealers are promulgating the opinion that ice-cream making is a scientific process, and that the

[1] John Gordon — Address at Second Annual Convention of Iowa Ice Cream Makers' Association.

more the subject is made public, is discussed and studied, the more perfect will the process become and the better will the product be. The better the product, the greater the consumption of the same.

Classification of Ice Creams and Ices. — Ice creams may be divided into many classes. Their differences are somewhat indefinite. However, there are three great divisions commonly known and recognized throughout this country. These are:

I. Philadelphia Ice Cream.

Made up of cream, sugar, flavoring, and usually a binder. Under this heading the following would be included: Plain ice cream, nut ice cream, fruit ice cream, chocolate ice cream, coffee ice cream, macaroon ice cream, etc.

II. Neapolitan Ice Cream.

This differs from the first class chiefly in that it always contains eggs. This kind of ice cream admits of wide varieties and may resemble in composition and consistency a frozen pudding more than an ice cream.

III. Fancy Ice Cream.

This kind of ice cream differs chiefly from the Philadelphia Ice Cream in the manner of molding or printing, and in the coloring.

1. Brick Ice Cream.

This is usually made up in pint, quart and two-quart sizes. It is made in layers. Any of the ice creams may be used for this purpose.

2. Individual Molds.

These molds are shaped to imitate some object (fruit or animal). The ice cream object may be colored in imitation of the object it represents.

Associated with ice cream are numerous other ices, none of which, however, are dairy products. These are usually considered under the following heads.

IV. Ices.

1. Water ice is fruit juice diluted with water to the proper degree, sweetened and frozen the same as is ice cream. Its texture is quite different from that of ice cream. The latter is smooth and velvety, while the former is grainy, being more like firm, wet snow in texture.

2. Sherbet sometimes closely resembles ice cream in appearance, body, and texture. However, no cream or milk is used in this ice. Its creamy appearance is due to the presence of beaten white of egg, gelatin, or other binders. Sherbet is composed of fruit juice, water, sugar, white of egg, and, sometimes, a binder. If beaten violently until frozen hard the result will be a fine, smooth, creamy ice. If frozen with but slight agitation or only half frozen, the result will be a more granular texture.

3. Sorbet is a name sometimes applied to sherbets of fine, smooth texture.

4. Granites are water ices only half frozen without much stirring, having a coarse icy texture.

5. Frozen Punches are made by adding one or more liquors or cordials like champagne, maraschino, Jamaica rum, etc., usually after the freezing is nearly or entirely completed.

The following classification has been adopted by Prof. Mortensen at the Iowa Experiment Station:[1]

I. Plain Ice Creams.
II. Nut Ice Creams.
III. Fruit Ice Creams.

[1] Ames, *Iowa Bul.* 123.

IV. Bisque Ice Creams.
V. Parfaits.
VI. Mousses.
VII. Puddings.
VIII. Aufaits.
IX. Lactos.
X. Ices.
   1. Sherbets.
   2. Milk Sherbets.
   3. Frappés.
   4. Punches.
   5. Soufflés.

I. Plain ice cream is a frozen product made from cream and sugar with or without a natural flavoring.

II. Nut ice cream is a frozen product made from cream, sugar and sound, non-rancid nuts.

III. Fruit ice cream is a frozen product made from cream, sugar and sound, clean, mature fruits.

IV. Bisque ice cream is a frozen product made from cream, sugar and bread products, marshmallows or other confections, with or without natural flavoring.

V. Parfait is a frozen product made from cream, sugar and egg yolks, with or without nuts or fruits and other natural flavoring.

VI. Mousse is a frozen whipped cream to which sugar and natural flavoring have been added.

VII. Pudding is a product made from cream or milk, with sugar, eggs, nuts and fruits, highly flavored.

VIII. Aufait is brick cream consisting of layers of one or more kinds of cream with solid layers of frozen fruit.

IX. Lacto is a product manufactured from skimmed or whole sour milk, eggs and sugar, with or without natural flavoring.

X. Ices are frozen products made from water or sweet skimmed or whole milk and sugar, with or without eggs, fruit juices, or other natural flavoring.

Ices may, for convenience, be divided into sherbets, milk sherbets, frappés, punches and soufflés.

1. Sherbet is an ice made from water, sugar, egg albumen and natural flavoring, and frozen to the consistency of ice cream.

2. Milk sherbet is an ice made from sweet skimmed or whole milk with egg albumen, sugar and natural flavoring, frozen to the consistency of ice cream.

3. Frappé is an ice consisting of water, sugar and natural flavoring, and frozen to a soft semi-frozen consistency. Same formulas as are given for sherbets will answer for frappé by omitting the egg albumen.

4. Punch is a sherbet flavored with liquors, or highly flavored with fruit juices and spice.

5. Soufflé is an ice made from water, eggs, sugar and flavoring material. It differs from sherbets mainly in that it contains the whole egg.

CHAPTER XV.

CREAM FOR ICE-CREAM MAKING.

In the manufacture of ice cream, the best cream to use is perfectly sweet, fresh cream. Cream of the highest quality must be produced by healthy cows, properly fed and cared for under perfectly sanitary conditions. It must be handled only in clean containers, kept cold and delivered daily to the factory.

Too much emphasis cannot be placed upon the subject of quality of cream. Ice cream is valued mainly because of its pleasing flavor and refreshing effect. Hence the presence of any undesirable flavor is much more objectionable in this product than in other staple foods.

Acidity. — An acidity of the cream above 0.25 per cent is too great for ice-cream making, and should not be used at all, or it may be reduced by the addition of very sweet cream. In dire need, cream not too sour and old may be partly reduced in acidity by adding some harmless neutralizer. Ice-cream made from such raw material should be labeled accordingly. The acidity of the cream may be reduced two-tenths per cent without greatly impairing the flavor, but too great an addition of alkali must be avoided because of the abnormal flavor it imparts to the cream. An excess of alkalinity is more objectionable than slightly acid cream. When reducing the acidity of cream, it is best to use an acid test, calculate the amount of neutralizer required, and add just enough to bring the per cent acid to the point desired, not lower than to 0.2 per cent acid.

One part of viscogen to 180 parts of cream will reduce the acidity of the cream about 0.1 per cent.

Homogenized Cream. — The process of homogenization consists of passing heated cream (140° F. to 180° F.), through a machine known as a homogenizer. The function of the machine is to break the fat globules into such tiny particles that they cannot be separated from the serum by gravity nor even by centrifugal force, except to a small extent. This insures an absolutely uniform emulsion of all the solids in the cream. Another effect of this process is a great increase in the viscosity of the cream. Homogenized cream containing fourteen per cent fat has about the same consistency as fresh, raw cream containing 18 per cent fat.

Homogenized cream may be produced in three different ways:

(1) By using natural cream.

(2) By mixing skim or whole milk and butter in such proportions that the resulting product will be cream of the desired per cent of fat.

(3) By mixing butter, milk powder and water in such proportions that the resulting mixture will have approximately the same composition as a natural cream.

Some large ice-cream manufacturers store quantities of unsalted "June Extras" butter to be used in the busy season, when it is difficult to secure an ample supply of fresh cream.

Pasteurization. — The thorough pasteurization of sweet cream destroys about ninety-nine per cent of the bacteria present, and hence causes the cream to keep sweet a much longer time. But the heating of the cream breaks down the clusters of fat globules, renders the cream less viscous, and apparently poorer or lower in fat content. The ice-cream maker desires a thick, viscous cream, so he generally objects to pasteurization. It has been found that when cream is allowed to stand at a low temperature (about 40° F.) for 24 hours after pasteurization, it yields as large a volume of good bodied ice cream as does raw cream kept under similar temperature conditions for the same length of time. Hence pasteurized cream may be used successfully in ice-cream making, if it is allowed to reëstablish its viscosity.

Aging and Cooling. — It is a recognized fact among ice-cream makers that, in order to obtain the proper yield and texture, it is necessary to hold the cream over night, and even for 24 hours, at a low temperature before freezing. During this time its viscosity is greatly increased. It is especially important to age pasteurized cream in order to secure good results. Cream that is to be held for 24 hours must be kept cold, first, in order to prevent souring, and second to increase the viscosity. Cream with such characteristics produces ice cream which has better body and texture, just as butter has a better grain and body if the cream is held at a low temperature for two or more hours before churning.

When aging cream, the aim should be to keep it as cold as possible without freezing. This can be done most readily by placing the cans of cream in a well-covered and well-insulated tank containing a mixture of water, ice and some salt.

Fat Content. — From the quality standpoint, the ideal per cent of fat in cream for ice-cream making is about twenty, (before the sugar, etc., is added, or fourteen to seventeen per cent in the mix). A much richer cream than this is likely to be too rich and buttery. Some people like the flavor of extra rich cream, but most prefer ice cream of medium richness. A large dish of exceedingly rich ice cream is likely to cause indigestion, and a smaller quantity of it is consumed. Insufficient fat in the cream, unless an excess of filler is used, produces a coarse granular icy texture, which is not desirable, and a lower overrun is also obtained from such cream. From a health standpoint ice cream containing about fourteen per cent of fat is preferable. From such cream, good palatable ice cream having a desirable body can be obtained. A proper overrun can also be obtained from cream of this richness.

From the manufacturer's standpoint, a low fat content may seem desirable. At places where ice cream is sold without the maker's name being known, and without legal restrictions, we find ice cream containing as low as four to six per cent of fat. This is commonly known as circus or picnic ice cream. However, the manufacturer trying to establish a favorable market for his goods must produce the best possible quality.

National and some state laws specify that ice cream shall contain a certain per cent of butter fat, usually fourteen per cent.

CHAPTER XVI.

PREPARING THE MIX. FILLERS AND BINDERS.

Flavor. — The flavor of ice cream is dependent chiefly upon three things: the cream itself, the flavoring extract or fruit added, and the sugar.

The necessity for good-flavored cream for ice-cream making has already been discussed.

The kinds of flavoring extracts that may be used are too numerous to mention. The quantity will depend upon the brand used. The concentration of extracts varies widely, and it is notable that the same firm occasionally makes single, double and triple strength extracts. Hence it is a good practice to find one suitable extract and use that brand exclusively; but most important of all is to have the very highest quality of extract that can be obtained. The different kinds of flavoring substances may be grouped as follows:

1. Crushed fruits with their juices.
2. Extract flavorings.
3. Sweetening.

1. The crushed fruits of the various kinds are at all times to be preferred. These, however, are not always obtainable, and when out of season they are expensive. For these reasons, the crushed fruits cannot always be used for flavoring ice cream. The extract flavorings are used largely in connection with the manufacturing of ice cream on a commercial scale. When ice cream is manufactured

for home use, in a small way, crushed fruits are to be preferred. During the season that ice cream is manufactured on a small scale, fresh fruits are usually obtainable. About two ounces of crushed fruit to each pound of cream will be found to produce the proper flavor. The amount will vary a little according to the likes and dislikes of the consumer and according to the degree of concentration of the fruit.

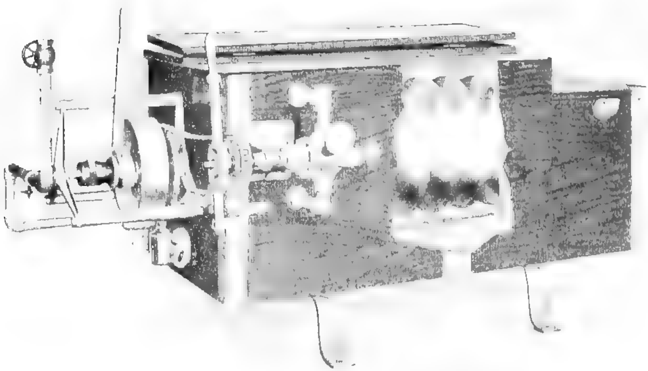

FIG. 31. — The Wizard ice cream mixer.

The crushed fruit may be added to the cream just previous to putting it into the freezing can, but at this time there is some danger of coagulating the cream. The acid in the fruit affects the cream to some extent. It is preferable to add the crushed fruit and juice to the ice cream after it has been partially frozen. As it begins to appear thick, the freezer is stopped and the crushed fruit added. At this stage, the ice cream is not so stiff that the fruit cannot be properly mixed with it and there is little or no danger of coagulating the cream.

2. The extract flavorings are used largely in commercial ice-cream making, chiefly because they are easily obtained, relatively cheap, and can be stored without spoiling. Some ice-cream makers claim that some of these extract flavorings impart disagreeable flavors to the ice cream. So far as the authors' experience goes, this claim cannot be substantiated. The poorer grades of extracts should never

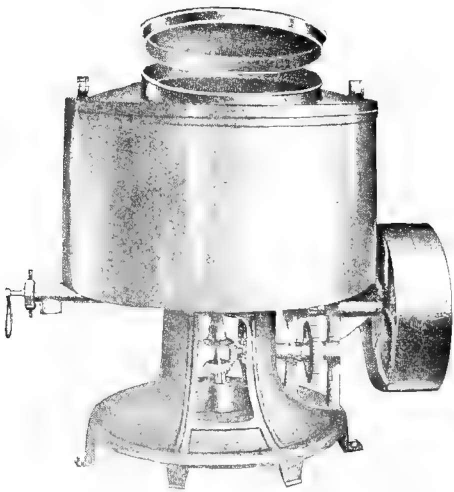

FIG. 32. — The Miller ice cream mixer.

be used. Supply houses keep several grades, and the best grade of flavoring extracts should invariably be added to the cream. The amount of flavoring extract to be used depends upon the degree of concentration of the extract. If the best extract is secured, one ounce to one gallon of cream or two small tablespoonfuls for every gallon of cream used is about the proper amount. The extract should ordinarily not be added until just previous to putting the mix into the freezing can. Especially is this important when the cream is pasteurized. Pasteurization is likely to drive off the extract flavors. These are mostly volatile. Some of the oil-flavorings are not so volatile, and it does not matter when they are added.

3. The quantity of sugar used in making plain ice cream is usually one pound of sugar to six of cream. The sugar should be of the best granulated variety and must be thoroughly dissolved before freezing.

"Salt[1] is not usually added to ice cream, purposely, at least; but careful and repeated tastings by many people proved that the unbiased consumer prefers a cream containing salt at the rate of half a teaspoonful per gallon of mixture to a cream which is not thus modified. The taste of the salt as such does not become evident until a much larger quantity is used."

Fillers and Binders. — The purpose of using fillers in ice-cream making is to give the product a firmer body with better standing up qualities. Fillers do not necessarily increase the swell and may even lessen it when large quantities of such materials are used.

Of the starchy fillers that may be used, rice flour, wheat flour and cornstarch give the best results, because of the smallness of their starch grains. Cornstarch is the least desirable. Starchy fillers must be thoroughly cooked before being added to the cream. If this is not done the starch grains can readily be detected when the product is eaten. This is undesirable in a high-grade product.

Condensed milk is being used to a great extent in ice-cream making, and with very satisfactory results. Some large factories have their own condensing machinery, by means of which they not only make their own filler, but convert any surplus milk into a product that may be

[1] *Vermont Bul.* 155.

stored until needed in their factory or disposed of through other channels. Plain evaporated milk in bulk is the grade of condensed milk commonly used for this purpose.

Egg fillers usually are not used in low-grade ice cream because they are expensive. In order that eggs may have the desired effect upon the body of the ice cream, they should be cooked. This is done by mixing the beaten eggs with milk or cream, then cooking it, so that it forms a thin custard. Such a custard, when added to thin cream and frozen, does not increase in volume so much as does a normal rich cream.

Rennet is sometimes used in ice-cream making, but has little or no effect unless the milk or cream be warm when the rennet is added in order that curdling may take place. Under these conditions the product shows a slightly smoother texture and firmer body. Rennet is seldom used in commercial ice-cream making.

Milk powder is used for ice cream both as filler, binder, and batch.

The chief functions of binders in ice cream are to bind the materials into one homogeneous mass, and prevent water crystals from forming after the ice cream has stood a day or more. Ice cream containing a binder or filler does not melt readily when served.

One of the fillers most widely used for this purpose is gelatin. This substance is prepared for use by dissolving it in hot skim milk or water, and stirring quickly into the cream. The manufacturer must carefully select the gelatin in order to be sure that it is perfectly pure and sanitary. According to Washburn[1] the higher-priced gelatin is cheaper in the end than the low-priced goods. He states that three and a half to four pounds of high-grade gelatin, cost-

[1] *Vermont Bul.* 155.

ing about a dollar, will produce the same results as will six to eight pounds of a cheaper grade costing 50 per cent more.

At the present time gelatin is being replaced to some extent by gum tragacanth. One reason for this change is that many people and some health officers object to the use of gelatin. They claim that it may be dangerous to health, because it may have come from diseased animals, or it may have been contaminated before or during the manufacturing process. Gum tragacanth is perfectly odorless and is very satisfactory as a binder, even in very small quantities. Stock may be made up as follows: "Dissolve 1 ounce of gum in 1 quart of hot water; add 3 pounds granulated sugar and mix thoroughly. This will produce about one and one half quarts of gum tragacanth stock. One quart of this stock is commonly used in making ten gallons of ice cream."

Tragacanth [1] is the gummy exudation from plants belonging to the genus Astragalus, family Leguminosæ. The gum is in ribbon-shaped bands, 1 to 3 mm. thick, long and linear, straight or spirally twisted.

"Indian gum" [2] has its origin in other plants and is usually found in lumps, never in ribbon-shaped bands.

Because of this difference in physical characteristics, adulteration of tragacanth with the cheaper Indian gum is probably not attempted. But large quantities of gum are sold in the pulverized form in which no physical difference can be detected. It has been found [3] that Indian gum has a volatile acidity $7\frac{1}{2}$ times as great as that of tragacanth. Or expressed as acetic acid, Indian gum contains about 15.8 per cent acetic acid and tragacanth, 2.1 per cent acetic acid.

[1] U. S. Pharmacopœia. [2] U. S. Dept. of Agr., *Bul. Chem. Cir.* 94.
[3] U. S. Dept. of Agr., *Bul. Chem. Cir.* 94.

Gelatin, gum tragacanth and other binders are prepared with sugar and sold under various commercial names. Powdered arrow root, sago, iceland moss, glycerine, etc., are occasionally used in ice-cream making, but have no great commercial importance.

Ice cream that is to be used in soda water must contain sufficient binder to prevent it from being broken up and dissolved by the jet of soda. Cream made especially for fountain use frequently is of lower fat content and higher gum or gelatin content than the product made for the regular trade.

Most ice-cream manufacturers use some one of the many prepared binders or fillers. These latter are usually obtained in powder form. A certain amount of this powder is thoroughly mixed with the dry granulated sugar. Then some cream is added and the whole stirred to form a thick paste. By first mixing the sugar and filler the danger of lumping is much lessened. More cream is gradually added to the sugary paste until a uniform emulsion is formed. This is then strained into the definite amount of cream to be frozen. The whole is thoroughly mixed and at once put into the freezing can. About five and one-half gallons of mix make ten gallons of ice cream.

Great care should be taken in preparing the mix not to add too much of the filler and binder at the expense of butter fat. Too much filler or binder is likely to cause a sticky and soggy body. Such ice cream is more like flavored tough pudding, and is not relished. Ice cream of this character is also more likely to coat the inside of the mouth of the consumer with a sticky and slimy layer.

CHAPTER XVII.

FREEZING THE MIX.

Ice and Salt. — Having held the cream at about 34° F., for from 12 to 24 hours, and having added the sugar, flavoring and binder, we are ready to strain and freeze the mixture.

A freezing mixture is made of ice and salt. The chief cause of the freezing is the attraction of salt for water. This causes the ice to melt rapidly and absorb heat. Whenever a frozen solid is reduced to a liquid, heat is absorbed, and when one pound of ice melts to water at 32° F., it absorbs 144 British Thermal Units (one B.T.U. being the heat given up by 1 pound of water in cooling 1° F.). This heat is absorbed, to a great extent, from the cream mixture in the freezing can, and finally the temperature is reduced below the freezing point.

Cream may be frozen by packing the mixture of ice and salt directly around the freezing can, or by making a brine in a separate receptacle and circulating the brine around the freezing can.

On a small scale the tub freezer is commonly employed, and the ice to be used should be finely crushed in order to expose to the salt the greatest possible amount of surface, and insure rapid freezing. When large chunks are put into the freezer, they do not pack close, large air spaces are formed, and the ice can not so well perform its function of extracting the heat from the cream. Furthermore, large pieces of ice are likely to jam and dent the freezing can. It is almost impossible to pound out a dent and make the surface as smooth as it was originally.

Ground rock salt is used in preference to the fine salt, because the former can be mixed more uniformly through the crushed ice, and does not dissolve too rapidly. Fine salt dissolves almost immediately, causes the pieces of ice to freeze together into chunks, and does not form so uniform a freezing mixture as does the crushed rock salt.

One part of salt mixed with about twelve parts of ice will freeze the cream in about the proper length of time, and give general satisfaction, but the amount must be varied to suit conditions. The maker needs to use his judgment in this respect.

Ice and salt are sometimes mixed on the floor in a manner similar to that of mixing feed, but this practice has two objectionable features: first, a great deal of the ice will melt before it can be used, thus causing a needless waste of ice; and secondly, just as great a quantity of salt will be put into the bottom of the tub as on top, thus causing a needless waste of salt.

There is little or no necessity for putting salt into the bottom of the tub, because the salt above is being washed down by the melted ice. No salt need be added until the freezing tub has been half filled with ice. At this point a portion of the salt should be added, and then relatively greater proportions added as the tub is filled. Crushed ice, free from salt, may be first added, then the mixture of crushed ice and salt. In this manner the ice and salt may be mixed together in a box or on the floor.

The chief objection to the use of too much salt, aside from the needless expense, is that an excess of salt causes the cream to freeze too rapidly. This rapid freezing is likely to cause a grainy texture and a low overrun. A lack of sufficient salt causes smeary ice cream. Lumps of butter are also likely to form.

In the winter, when the freezer is in a very cold room, it is sometimes noticed that an unusually long time is required to freeze the cream. This is undoubtedly due to the low surrounding temperature retarding the melting of the ice. When the melting is delayed, the absorption of heat from the cream is delayed and, therefore, the freezing process is retarded. In the cold room the ice around the freezer does not melt and form brine rapidly; hence, heat can be conducted from the cream only at points where the ice particles are against the can, and this is but a relatively small proportion of the entire area of the can. When brine is formed, it is in contact with the entire surface of the freezing can, and hence conducts the heat from the cream more rapidly.

To overcome this slow formation of brine, it is recommended that some water be poured over the ice and salt mixture. Having the ice crushed into very fine pieces will also aid in overcoming this difficulty.

In the style of freezers in which the brine system is employed, the same general principles apply. The mixture of ice and salt must be in the proper proportion to produce a brine of such temperature that the cream will be frozen in the proper length of time to insure good quality of ice cream. Under average conditions a mixture of one part of salt to fifteen of ice will produce a brine of about 10° F., and will do satisfactory work in the freezer. Many brine freezers are provided with a compartment for this purpose, and the brine circulated by means of a pump driven by the shaft that drives the freezer. Factories equipped with artificial refrigeration commonly have a large, well-insulated tank, and the brine is kept cold by a coil of ammonia pipes.

Speed of Dasher. — The speed of the dasher must be such that the cream will be uniformly frozen, and be well whipped during the freezing process. If the cream is put into the freezer at a temperature under 40° F., it will be quickly frozen, and the freezer should be run at its maximum speed during the entire time. If the temperature of the cream is 50° F. or above, in order to avoid churning, the freezer should be run at slow speed at first, until the mix is brought down close to the freezing point; then the machine can be brought to full speed and the freezing completed. If it is impossible to run the freezer at low speed, then, intermittent freezing may be practiced. If this latter is resorted to, no salt should be added, at first, to the ice around the freezing can. The mixing of salt would cause the can to freeze fast, and the part of the cream next to the can would freeze solid, thus forming icy cream.

In the vertical batch freezers, the dasher commonly makes 90 to 100 revolutions per minute, and the can, revolving in the opposite direction, makes the same number of revolutions, the result being equivalent to from 180 to 200 revolutions per minute.

Freezing Period. — The time required for freezing is dependent upon (1) the temperature of the mix when put into the freezer, (2) the freezing mixture (size of pieces of ice and proportion of salt), and (3), to a limited extent, the composition of the mix. The composition and specific gravity of the mix are nearly constant for the same class of product, so that the maker must depend upon regulating the two other factors to control the duration of the freezing period. This latter cannot be varied widely without impairing the texture of the product.

A prolonged freezing period may be due to (1) insufficient salt, (2) coarse ice, and (3) warm mix. The result may be a greasy ice cream, perhaps containing granules of butter; this latter is very objectionable to the consumer.

Rapid freezing of the cream is due chiefly to an excess of salt, or to very finely crushed ice, well packed around the can.

The result of too rapid freezing is a coarse, granular texture, the ice cream frequently containing small crystals of clear ice.

When cream is put into the freezer at a temperature of 40° F., or less, the proper texture and swell will be secured by allowing 10 to 14 minutes for the freezing process. If the cream is 15° to 20° F. warmer than this, an additional five minutes should be allowed for the freezing. When cream, at 60° F., is frozen in eight minutes, it passes through the whipping stage so quickly that insufficient swell will be obtained, and the texture is likely to be coarse and granular.

Freezing Point. — The freezing point of ice cream, as commonly made commercially, is not a very variable factor; but when fruit ice cream and the various ices are made, the addition of the fruit and the extra sugar required lowers the freezing point. The freezing point of sherbets, water ices etc., is 5° to 8° lower than that of ice cream. A little colder freezing mixture and a lower storing temperature are necessary for these products.

The freezing point of the cream is not affected, materially, by the fat content, nor by the presence of fillers or binders; but all of these make the cream appear more firm at a given temperature than cream in which these things are lacking.

Effect of the Sugar Content on the Freezing Point.[1] — " Sugar goes into true solution and has a low molecular weight as compared to egg or gelatine. It lowers the freezing point very materially, and uniformly, in proportion to its presence. Similarly the milk sugar, a normal milk constituent, being in true solution, causes milk to freeze at a lower temperature than does pure water. Ice cream sweetened to average taste contains approximately 14 per cent added sugar, and has a freezing point of about $28\frac{1}{2}°$ F. When ice cream has frozen to the proper consistency for removing from the freezer to the packers, its temperature is about 28° to 27° F. The following table, prepared from the data obtained at this station, using a Beckmann's freezing-point thermometer graduated in $\frac{1}{100}$ of a degree, may be of interest as showing the freezing points of different sugar solutions.

Material.	Observed freezing point.
Plain skim milk	31.03° F.
5 per cent solution sugar in skim milk	30.40° F.
10 per cent solution sugar in skim milk	29.70° F.
14 per cent solution sugar in skim milk	28.60° F.
25 per cent solution sugar in skim milk	27.07° F. "

Swell. — The volume of ice cream obtained in excess of the amount of total mix put into the freezer constitutes the "swell" or overrun. This increase in volume is due almost wholly to the incorporation of air into the product and, therefore, can scarcely be called an overrun. Nothing of a tangible character is added during the freezing process.

The more viscous the cream is, the greater the swell that may be secured, because the viscous cream is able to retain the air that is beaten into it.

The amount of swell is influenced by the rate of freezing.

[1] *Vermont Bul.* No. 155.

When cream is frozen very quickly, less swell is secured. The reason for this seems to be that the swell is produced only while the cream is passing through a few degrees of temperature just before it freezes. Only during this short time is it sufficiently viscous to retain the air that is beaten into it. According to Washburn,[1] when the temperature of the cream reaches 34° F., the cream begins to foam up and continues to increase in volume until a temperature of 29° or 28° F. is reached. At this point the temperature remains constant for from four to fifteen minutes. During this time the latent heat is being extracted from the cream by the freezing mixture. The swelling of the cream, that begins at about 34° F., is most rapid toward the end of this period of lowering temperature. Just before the cream freezes, the swell is very rapid.

The effect upon the swell, of over-freezing, is reported by the same authority. A series of trials was made in a double-disc continuous freezer, run at the rate of 225 revolutions per minute. It was found that when the ice cream was drawn off at a temperature of 29° F., the swell was 70 per cent; at 28° F., 60 per cent; at 27° F., 50 per cent; at 26° F., 43 per cent; at 25° F., 40 per cent. The ice cream drawn off at 29° F. was too soft, but that at 28° was entirely satisfactory.

The speed of the rotator or beater also influences the overrun or swell. Some freezers have facilities for varying the speed, making it slow at first, then during the latter part of the freezing period increasing the speed. The higher the speed up to a certain limit (250 rev. per min.), the more air is beaten into the ice cream. High speed during the first part of the freezing period may cause the cream to churn.

[1] *Vermont Bul.* 155.

Stopping Point. — When frozen to the consistency of thick syrup the ice cream is dipped or poured out into packing cans, which have been previously iced. Care should be exercised in the transfer to avoid expelling the incorporated air. When the ice cream is put into packing cans that are not standing in ice, the relatively warm can melts some of the cream. This, when refrozen, is coarse and icy. Where hardening rooms are used, this is avoided by placing the packing cans in the hardening room for a while before filling. Twelve to twenty-four hours after being frozen the ice cream will be found to have a better and more uniform flavor because of the blending of the several flavors into one.

Hardening. — To prepare ice cream for delivery, it must be thoroughly hardened. This can be accomplished only by lowering the temperature of the product to from 14° to 17° F. The hardening may be done in the packing tubs that are used for delivery, setting the cans of ice cream in a tank of brine or in a room cooled by artificial refrigeration.

Just before being sent from the factory, the ice cream must be re-iced. The space around the can should be well filled, and the top well covered with the ice and salt mixture before the ice cream is shipped. Some manufacturers cover the can and tub with a blanket and finally with a neatly fitting oil cloth.

Returned Goods. — It is a good rule never to allow melted ice cream to be returned to the factory; but at times this cannot be avoided. A total loss may be prevented by churning such melted ice cream. Butter made from such cream makes satisfactory cooking butter. The melted ice cream should be mixed with skim milk and re-skimmed on a separator; a starter should then be added to the cream and the whole ripened and then churned as usual.

If the melted cream is of good flavor and fresh, it may be refrozen.

Fancy Ice Cream. — The most common of the fancy ice cream is brick, made up of several layers. These bricks are usually made up of three differently colored layers. Red, white and chocolate are common colors. The molds are of various sizes, such as one pint, one quart, etc. The molds are also of two kinds, those having a loose cover, both on top and bottom, and those having only the top cover loose.

Small or individual molds are also manufactured representing fruits, animals, soldiers, etc. Ice-cream molds of this kind are in demand especially for children's parties. If cream is colored in this connection it should imitate as nearly as possible the object it is supposed to represent.

To make the layer ice cream, about one-third of the mold is filled, say, with white ice cream. This is smoothed on the surface, then another third of the mold is filled with chocolate or dark-colored ice cream. This is smoothed off, and finally the last third of the mold is filled with the red ice cream. This is leveled off even with the top edge of the mold and the cover put on. Sometimes a sheet of paraffined paper is laid on the top of the ice cream before the cover is put on. This is perhaps most desirable when the mold is old and loose around the edge.

When the mold is filled and the cover is on, tie string around the mold to hold the cover tight.

Place the mold at once in a freezing temperature. This may be on shelves in a hardening room, or in a mixture of crushed ice and salt. If the latter, the mixture should rest on a perforated board to allow the brine to drain through into a lower jacket. The brine is cold and should be retained in the cooling tank or box. The box should be provided with a cover.

Allow the molds to remain here long enough to freeze solid. The hard frozen ice cream can be removed from the mold by dipping the mold and contents into cold water, and by wiping the mold on the outside with a dry towel. The ice cream may also be loosened from the mold by using a case knife around the edges.

Fat Content of Different Portions. — Some ice-cream dealers claim that ice cream which has stood in a packer for a week shows a differently distributed fat content than at the beginning of the week. This observed difference in the fat content in the different parts of the ice cream is evidently due to the rising of the fat, through the partially melted ice cream, and in some cases to the alternate freezing and thawing, crowding a large per cent of the solids toward the center.

Washburn[1] has found that the fat in semi-melted ice cream rises somewhat. He tested portions of a can of ice cream that had stood for one week in a mellow condition, and found that the top portion of cream contained 28 per cent fat, the middle 15 per cent and the bottom five per cent. The same authority states that gelatine and gum tragacanth had but little effect in preventing this rise of fat. Fruit ice creams separated more quickly than the plain flavors, due to the heavy fruit and rich syrup. However, when the cream was properly hardened, and held in that condition, the fat content of the different parts did not change.

[1] *Vermont Bul.* 155.

CHAPTER XVIII.

FORMULAS.

Vanilla Ice Cream. — Formulas for ice cream may be obtained from various sources, and are of infinitely great variety. A standard vanilla ice cream that gives general satisfaction is made as follows:

45 pounds 18-per-cent cream.
8 pounds sugar.
4 ounces vanilla extract.
4 ounces gelatine.

This will make ten gallons of ice cream testing 15.1 per cent fat. One of the commercially sold fillers may be substituted for the gelatine. These should be used according to directions and according to body desired in the ice cream.

This vanilla ice cream may be used as a stock cream for making small batches of other flavors. For instance, if a small quantity of chocolate ice cream is desired, it can be made by taking out the required amount of vanilla ice cream (mix) and adding the chocolate syrup to it.

Nut ice creams are commonly made by exactly the same formula as the vanilla, except for the addition of nuts. The nuts should not be added until the cream is partly frozen. This prevents settling of the added nuts.

Any ice cream in which a syrup or liquid flavoring is used may be made from the above formula, but, in some instances, more sugar will be necessary and the vanilla will be omitted.

Fruit Ice Cream. — Nothing is more justly popular than fruit ice cream in which the fresh fruit is used — especially strawberry or peach. To make 10 gallons of strawberry ice cream:

45 pounds 18-per-cent cream.
8 pounds sugar.
1 gallon crushed strawberries (sweetened).
4 ounces gelatine.

In adding fruit of any kind to any mixture containing milk and cream it is usually best to add it after the cream has been partly frozen. If added sooner the heavier fruit is likely to settle, and the acid in the juice is likely to cause some coagulation.

PARFAIT.[1]

4 gallons 30-per-cent cream.
Yolks of 10 dozen eggs (stirred and beaten).
14 pounds sugar.
4 ounces vanilla extract.
4 pounds ground walnut meats (or other nuts).

MOUSSE.[1]

2 gallons 30-per-cent cream (whipped).
4 pounds sugar.
1 quart cranberry juice (or other fruit or nuts).
$\frac{1}{4}$ pints lemon juice.

LACTO.[2]

6 gallons sour skim milk or buttermilk.
18 pounds sugar.
2 dozen eggs (yolks and whites beaten separately)
2 quarts cherry juice or cherry syrup (or other fruit).
3 pints lemon juice.

[1] *Iowa Bul.* 123. [2] *Iowa Bul.* 118.

SHERBET.

6 gallons water or milk.
6 quarts orange juice (or other fruit).
1 pint lemon juice.
2 dozen eggs, whites only.
23 pounds sugar.

Another recipe for a very delicious and rich sherbet, especially useful when made on a small scale, is as follows:

1 quart of water.
1 pound of sugar.
1 quart of fresh strawberries.
Whites of six eggs.
Juice of two lemons.

Boil sugar and water together to make the syrup. Pick over the strawberries and thoroughly mash them; then add the lemon juice and mix. When the syrup has been cooled, pour it over the mashed berries, mix and strain into the freezing can, and freeze. When about half frozen add the beaten whites of eggs and complete freezing.

CHAPTER XIX.

ICE-CREAM MACHINERY.

THE great growth of the ice cream industry has naturally been accompanied and aided by the invention of various

FIG. 33. — Davis milk-can drip saver.

pieces of machinery especially adapted to the needs of the ice-cream maker.

For the storage or holding of cream the small factory may employ common milk cans, but in the large factory, vats are necessary, and these may be ordinary jacketed tin vats or enameled iron tanks. The last mentioned are perfectly sanitary and easily cleaned, being lined with a thin coating of enamel, perfectly smooth and without a

Fig. 34. — Sweet cream storage rooms. (Ice Cream Trade Journal.)

seam or crack. A vat having cooling facilities attached is preferred, unless it be placed in a refrigerator room.

When pasteurization is practiced, the machines used are the same as those made for use in the creamery or city milk plant.

The ice-cream mixer is used, when large quantities of material are handled at one time, to secure a perfectly uniform mix. This machine is invariably a cooler as well as a mixer. One general style having a horizontal stirring device through which ice water or cold brine may be pumped, resembles many styles of cream ripeners commonly used in butter factories. Another style is the vertical mixer, having an upright dasher for a stirring device and a jacket for the circulation of ice water. This is similar in general make up to the starter can of the butter factory.

Freezers. — Ice-cream freezers are of many styles and designs, but may be classified under the following heads:

1. Batch Ice-cream Freezer or Tub Freezer, in which the freezing can is set into a wooden tub and the ice and salt packed around it. This is the old style freezer, the simplest and most primitive in construction and mechanism. Of this style are the small household freezers and also many power machines used in small factories. There are probably more freezers of this kind in use than all other kinds together. However, they are not adaptable to ice-cream making on a large scale; hence, in the large factory, machines of a more improved design are usually employed. The gear wheels of the power tub freezers are so arranged that the can is revolved in one direction and the dasher in the opposite direction at the same speed. In many of the hand freezers the dasher is stationary, and the can is not geared high, so it is difficult to attain sufficient speed on the crank to properly beat the cream during freezing.

Fig. 35. — The Little Giant ice-cream freezer.

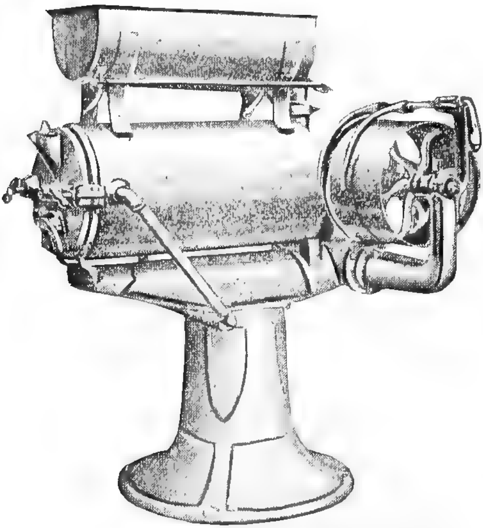

FIG. 36. — The Miller horizontal ice-cream freezer.

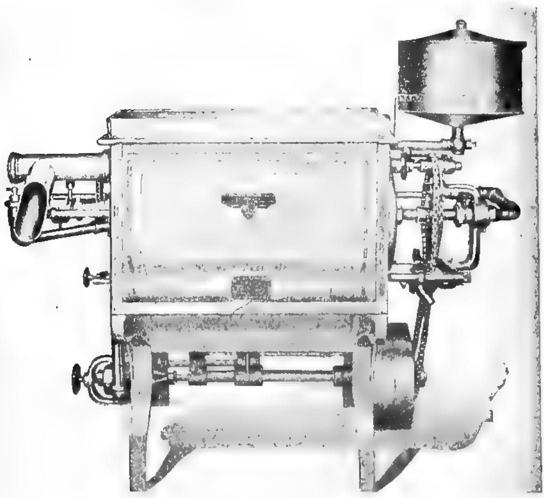

FIG. 37. — C. P. disc ice-cream freezer.

2. The Batch Brine Freezer is of two varieties, the vertical and the horizontal. In these freezers instead of packing ice around the freezing can, brine is made in a separate compartment and pumped through a jacket

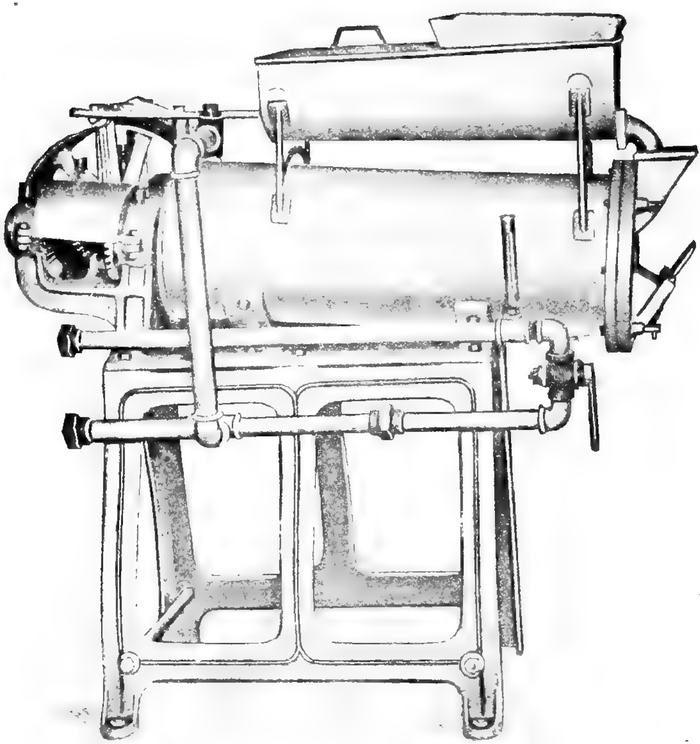

FIG. 38. – Improved Model D brine freezer.

surrounding the freezing can, circulating from end to end in order to freeze uniformly. The batch freezers are used in freezing products in which fruits of various kinds and beaten eggs are added after the mix is partly frozen.

3. The Continuous Brine Freezer is a machine permitting

the unfrozen mix to enter continuously at one end and the frozen product continuously to run out at the other end. A common form of these continuous freezers is the disk freezer consisting of two oblong tanks, side by side. In each tank are several revolving, hollow disks on a hollow shaft through which the brine for freezing is pumped.

The cream flows into the first tank or freezing compartment from the supply reservoir on to the revolving disks

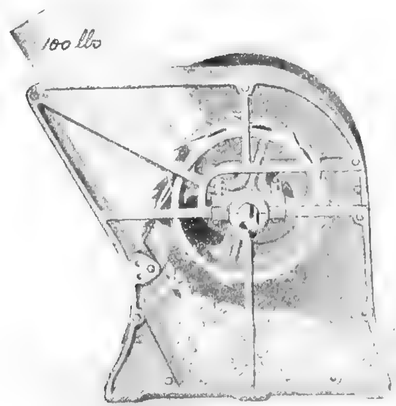

FIG. 39. — The Creasy ice breaker.

and the freezing process begins. At the far end of this tank the partly frozen mixture overflows into the second compartment and passes along over the freezing disks. (The smaller freezers have but one compartment.) In this compartment, just above the disks, is a screw that carries away the frozen cream and discharges it into the packing cans. The top of each freezing compartment is provided with a plate-glass cover, so that the cream is in view during the entire freezing process.

Ice Crusher. — This is a great labor-saving device and is indispensable where large quantities of ice are crushed. The machine breaks the ice into pieces of a more uniformly small size than can possibly be done by hand with an ax or stomper.

Homogenizer. - This is one of the latest inventions in ice-cream machinery. As its name indicates, it is a ma-

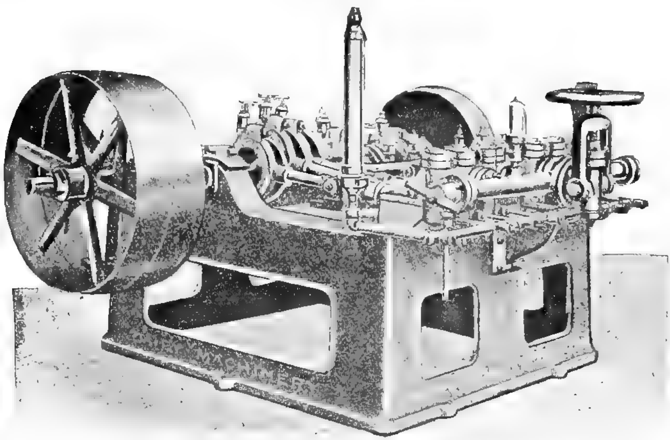

Fig. 40. — A six-cylinder Progress homogenizer.

chine for converting liquids such as cream into a homogeneous mass. This is accomplished by breaking the fat globules into such fine particles that they are unable to rise to the surface, but remain incorporated in the liquid. The machine consists of a pump or a series of pumps which discharge the liquid against the homogenizing valve. This latter may be compared to a safety valve which blows off at a pressure of from 2000 to 3000 pounds per square inch. The valve disk is made of agate and closes perfectly into the seat. When the pressure from the pump is sufficient, the valve is forced open, but the space between the disk and the seat is so small that when the fat

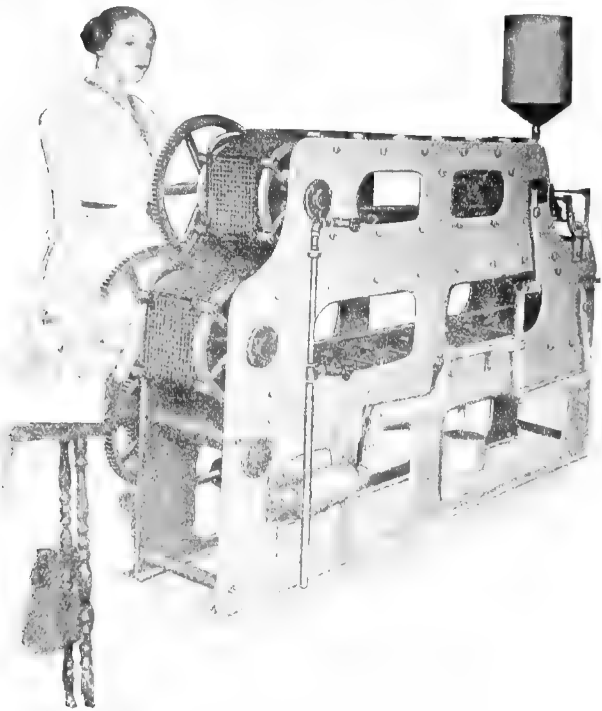

FIG. 41. — The Honey cone machine.

globules are forced through they are separated into tiny particles.

The homogenizer is and has been used for manufacturing cream from skim milk and butter. Some have even gone so far as to make the skim milk from milk powder and mixed it with unsalted storage or fresh butter. Finished products made and offered for sale in this manner must be labeled as such. This process makes the problem of getting sweet cream less difficult.

Sanitary Pipes and Fittings. — The only kind of pipes that should be used for transmitting cream and milk are the so-called sanitary pipes. The piping is perfectly smooth and heavily tinned. It is in short lengths and put together in a manner similar to that of connecting fire hose, so that the pipes may all be taken apart and cleaned very readily.

Ice-cream Can Washer. — This machine finds a place in large factories where a great many packing cans are used.

FIG. 42. — Fort Atkinson ice-cream can washer.

It is a contrivance in which brushes and jets of water and steam are used to cleanse and sterilize the cans in much the same way that bottles and cans are cleaned and sterilized in a city milk plant.

Packing Cans. — These are of great importance from a sanitary standpoint, because the ice cream remains in them often for several days. There should be no crevices or rough spots in the can and no exposed iron. Heavily tinned cans are extensively used, but enameled iron ones are better, being smoother, more easily and perfectly cleaned and hence more sanitary.

Sterilizer. — A large steam sterilizer is essential for a factory turning out a strictly sanitary product. Here all the freezing and packing cans and utensils used in handling the materials can be made perfectly sterile daily.

Many small utensils too numerous to mention are needed in the ice-cream factory.

CHAPTER XX.

ICE-CREAM FACTORIES.

Local Creameries. — The farmers' co-operative creamery of to-day is in keen competition with private enterprises that as a rule have a much larger working fund than the local creameries. These private enterprises are usually managed by better business methods, are better located

FIG. 43. — View of Collins Bros.' ice-cream freezing room. (Ice Cream Trade Journal.)

in relation to the markets, and, in most cases, are doing business on a larger scale than the local creamery plant. It therefore behooves the local creamery to adopt modern business methods, to cater to the markets and to find the most profitable method of disposing of their products.

The farmers' local creameries, on the other hand, have the advantages of having easier access to a large supply of fresh sweet cream at a minimum cost. These local creameries have the building and much of the costly machinery, such as engine, boiler, vats, etc., the initial expense of which does not need to be charged up against the ice-cream department. They also sustain a minimum loss on any surplus cream. In case that the ice-cream consumption is diminished, as is usually the case during cold weather, large city ice-cream manufacturers often lose money on their sweet cream. The creamery can turn this surplus cream into butter with scarcely any loss.

Since the price of butter is always low in summer, at the time when production is greatest, any method of converting the raw material at this time into a higher priced product would seem to be worthy of our consideration. The manufacture of ice cream has been tried and proven successful in the creamery.

Advantages. — The chief advantages of ice-cream making as a side line in local creameries are as follows:

1. The profits from this product are materially greater than those obtainable from butter during the summer.

2. The creamery is already equipped with steam, ice, power and a suitable building for the manufacture of ice cream.

3. The local creamery is in a position to secure fresh sweet cream direct from the producer.

4. The local creamery can supply its own and neighboring towns with this product with greater ease and efficiency than can a large factory in a distant city.

As in starting any new line of business, it must be taken up on a small scale to begin with. A suitable market must be found for the product. Some creameries are so located that they could not profitably take up this side line, but such conditions are rarely found. In many small towns ice cream is a rare delicacy, but when it is easily available the people soon acquire the ice-cream habit and consume large quantities of it, thus increasing the demand.

Cost of Equipment. — The machinery for making ice cream on a small scale need not be extensive or costly. Just as good a product can be made in the simple tub freezer as can be made in the most complex freezer on the market.

The machinery absolutely necessary for the manufacture of 60 to 500 gallons of ice cream per week would cost about as follows:

1 10-gal. tub freezer	$80.00	to	$110.00
1 ice crusher	1.50	to	50.00
1 pulley and 24 ft. of 4-in. belting	10.00	to	20.00
4 to 40 large packers or 8 to 80 small ones	30.00	to	400.00
2 to 20 10-gal. cream cans or a vat	4.50	to	50.00
Ice tools, ice-cream utensils, etc	10.00	to	20.00
Total	$136.00	to	$650.00

One hundred and fifty dollars will buy the necessary equipment for a creamery that is starting the manufacture of ice cream in a locality where the demand is small.

Profits from this Product. — The cost of making one gallon of ice cream may be calculated as follows: The creamery buys fat in sweet cream at 3 cents above the market quotation for butter. Let us assume that the average quotation during the summer is 25 cents per pound.

	Cents.
4.7 lbs. 18-per-cent cream at 28 cents per pound of fat	23.7
$\frac{8}{10}$ lb. sugar	6.0
Flavoring and binder	1.0
Ice and labor	3.3
	34.0

This ice cream that costs 34 cents per gallon to make, sells at 80 cents per gallon. The fat content of the above gallon of ice cream is .846 pound. The materials other than the cream cost 10.3 cents; hence 69.7 cents was received for the .846 pound of fat, or 82.4 cents per pound.

This pound of fat would have made about 1.2 pounds of butter which, at 25 cents per pound, would have brought 30 cents. This shows a difference of 52.4 cents per pound of fat in favor of ice-cream making. Making allowance for possible losses on ice cream, this product should, under favorable conditions, net about twice as much per pound of fat as butter. This cost will vary under different conditions.

Many local creameries have made ice cream during the past few summers and have made a success of this side line; they have been able to pay the farmers more for their cream than factories not making ice cream, and they have been better able to compete successfully with large private enterprises.

The Large City Factory. — Under the above-described conditions, ice cream can be made with a minimum outlay of money. The amount of machinery may be greatly increased to facilitate the handling of larger quantities of material. In some of the big ice-cream factories of the cities there is a large investment, both in building and equipments.

Owing to difficulties in securing an ample supply of fresh cream most large factories have installed homogenizers, and, especially during the summer, make homogenized cream from butter and milk.

Homogenized Cream. — Milk is received each morning direct from the farms. Each can is inspected and, if found fresh and clean, is accepted and emptied into the receiving vat. From here it runs through a pasteurizer, then over a cooler which brings it to a temperature of 34° to 38° F., thence to huge holding vats in a refrigerated room, where it is held until needed.

In another cold room is found sweet, unsalted butter, stored at a temperature of about 10° below zero Fahrenheit. This is usually secured by contract from whole milk

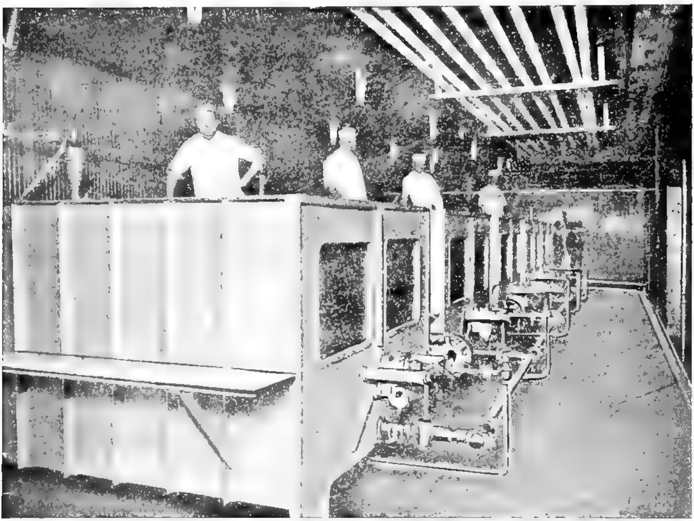

FIG. 44. — Sweet cream receivers in Collins Bros.' factory.

creameries, and is of very good quality being "June extras" and "Fall extras."

To prepare the materials for the freezer, butter and milk are placed in proper proportions in a mixing vat, heated to about 140° F., and agitated to form an emulsion, then passed through the homogenizer. The emulsion issues from this machine as a homogeneous cream, thoroughly pasteurized and with the fat thoroughly and permanently incorporated in the serum. The flavor of this cream, however, is not so fine as that of the fresh, natural product. Upon leaving the homogenizer, the cream is cooled nearly to the freezing point and pumped back into holding vats in the cold room just as is done with the milk.

In such a factory as this, operating on so large a scale, the difficulty of securing a sufficient quantity of fresh sweet cream can easily be comprehended. The advantage of using homogenized cream made from butter and milk is very evident. In addition to this, the homogenized cream is very viscous and can be used immediately, while ordinary pasteurized cream must be held at a low temperature for about a day in order to regain its viscosity. It would be very inconvenient and, in some instances, difficult to hold in storage such vast quantities of cream.

Making the Mix. — The cream is drawn from the storage vats as wanted, a definite quantity being placed in a mixing vat where the sugar, flavor, and binder are added, exact quantities being weighed in. These mixtures are dissolved and thoroughly mixed with the cream by means of an agitating device. The mixer is also a cooler, brine being pumped through the agitator.

Freezing and Hardening. — The mix being made, it is piped to the supply tanks of the freezers. Near these tanks are several freezers, some continuous and some batch brine freezers. During the rush season these machines are busy turning out their frozen delicacy for twelve or more hours per day. As soon as a packing can is full, a sheet of parchment paper is placed over the top, then the metal cover is put on, and the can is put into the hardening room, a room held at about the zero point, being cooled by artificial refrigeration. Here the cans remain for about twenty-four hours until the cream is thoroughly hardened all through and until taken out for shipment.

To prepare the cream for shipping, the cans are placed in a tub and packed with salt and ice.

Artificial refrigeration is employed for all the cooling,

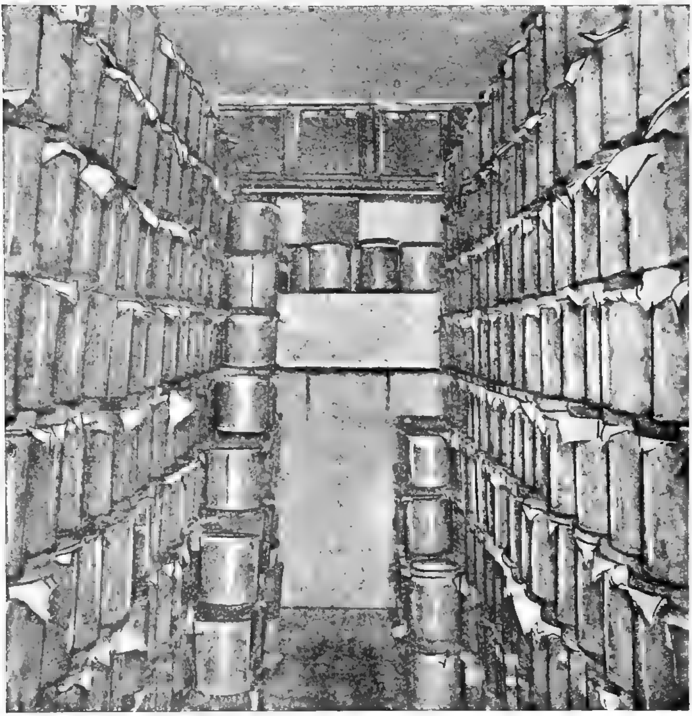

FIG. 45. — Ice-cream hardening room in Wheat's factory.

using the direct expansion in the storage and hardening rooms, and brine for the cooling coils and freezers. The factory makes all its own artificial ice used in the packing cans for shipment.

In one style of hardening room, the cans are placed upon shelves where small streams of brine play upon them. The brine drains to certain points, is pumped back to the tank, recooled and circulated again. Or the cans may be placed in tanks of brine until the cream hardens. Either style makes a more or less sloppy hardening room, and although the cooling is very efficient, these styles are not being used so widely as the dry hardening room.

A hardening room which employs the dry system is cooled by ammonia expansion coils. A uniform temperature is maintained and the rapidity of the hardening increased by continuous air currents generated by electric fans.

Standardization of Cream. — This topic is treated under "City Milk Supply," but some modifications are necessary when materials other than milk and cream are used. It must be remembered that the sugar, flavoring, etc., added to the cream have similar effects in reducing the percentage of fat as has the addition of skim milk. Therefore, if we add 8 pounds of sugar to 45 pounds of cream containing 20 per cent fat, the sweetened cream will contain a considerably smaller percentage of fat. 45 pounds of 20-per-cent cream contain 9 pounds of fat; then 53 pounds $(45 + 8 = 53)$ of the sweetened cream contain 9 divided by 53 times 100, which equals 17 per cent fat. Using the formula 45 pounds of cream, 8 pounds of sugar, 4 ounces of flavoring extract, 4 ounces gelatine, to make a 10-gallon batch of ice cream, if the maker wishes his finished product to contain 14 per cent fat, what per cent of fat should he have in his cream? The total weight of materials is 45 pounds of cream plus 8 pounds sugar, plus $\frac{1}{4}$ ounce flavor extract plus $\frac{1}{4}$ ounce gelatine. This equals 53.5 pounds. If the per cent of fat is 14, or the minimum law standard, this amount of ice cream mix contains 7.49 pounds of butter fat. Then the 45 pounds of cream must contain 7.49 pounds of fat or (7.49 divided by 45 times 100) 16.6 per cent of fat.

Every ice-cream factory should standardize the cream. The range between the minimum per cent of fat (usually specified by law) and the maximum per cent of fat desirable is rather narrow.

CHAPTER XXI.

SCORING ICE CREAM.

Proposed Score Cards. — There are two or more score cards being used tentatively in judging ice cream. One of them is as follows:[1]

Flavor	45
Body	20
Texture	20
Permanency	10
Package	5
Total	100

Flavor. To be that of clean, sweet cream sweetened to taste with cane sugar; the score to be cut for any flavor of sour cream and cut severely for any dirty flavor, and but little if too sweet or not sweet enough, or if the added flavor is too high or too low, for these are largely regulated by trade demands.

Body. To be firm, mellow and slightly elastic under pressure of the finger at a temperature of 18° F., or less. It must not be rubbery or too weak.

Texture. To be smooth, creamy and free from coarse water crystals; the score to be cut moderately if too coarse, and severely if inclined to be sticky or doughy.

Permanency. To have a reasonable standing-up power on an ordinarily cool dish, and to offer some resistance in the mouth, instead of melting and disappearing as liquid almost immediately upon being tasted.

[1] *Vermont Bul.* 155.

Package. To be clean, tidy and free from evidence of slovenly workmanship.

Another proposed score card is as follows:[1]

Flavor	45
Texture	25
Richness	15
Appearance	10
Color	5
Total	100

I. FLAVOR.

Definition of Good Ice-cream Flavor.

The cream flavor must be clean and creamy, and combined with flavoring material which blends with the cream to a full and delicious flavor.

Defects in Flavor.

1. Defects due to the use of flavors which will not blend with the other ingredients.

2. Defects due to cream used:
   Sour-cream flavor.
   Old-cream flavor.
   Bitter-cream flavor.
   Metallic-cream flavor.
   Oily-cream flavor.
   Weedy-cream flavor.
   Barn flavor.
   Unclean flavor.
   Burned or overheated flavor.

3. Defects in flavor due to filler used:
   Condensed-milk flavor.
   Starch flavor.
   Gum flavor.
   Gelatine flavor.

[1] *Iowa Bul.* 123.

4. Defects in flavor due to other ingredients:
   Too sweet.
   Lack of sweetness.
   Coarse flavor due to flavoring material.
   Stale-fruit flavor.
   Rancid-nut flavor.
   Mouldy-nut flavor.

II. TEXTURE:

Definition of a Good Texture.

The cream must be firmly frozen and be smooth and velvety.

Defects in Texture.

Icy. This defect is most noticeable toward the bottom of the container and may be due to improper packing or by holding too long ice cream which was manufactured without filler.

Coarse. This defect may be due to the use of too thin cream or to packing while too soft.

Sticky. This is due to fillers such as gelatine, sweetened condensed milk, glucose, etc.

Buttery. This defect is due to the use of cream which has been partially churned before freezing, or to cream which enters the freezer at too high a temperature. It may also be due to operating the freezer at too high speed or to some defect in the construction of the freezer.

Too Soft. Due to improper packing after freezing.

When judging cream containing nuts, fruits, etc., due allowance should be made for the presence of such ingredients.

III. RICHNESS:

Ice cream containing the amount of butter fat required by the state pure-food law should be considered perfect in richness.

The richness is determined by making chemical analysis for fat.

IV. APPEARANCE:

Ice cream scoring perfect in appearance should be clean and neatly put up and in a clean container.

Defects. Cream of unclean appearance; lack of parchment circle over ice cream; dirty container; rusty container; dirty ice-cream tub; old tag strings attached to handle of tub.

When judging brick ice cream special attention should be given to the uniformity of the layers, to the neat folding of the parchment wrapper and to cleanliness and general appearance of the package.

V. COLOR:

Ice cream of perfect color is such as contains only the natural color imparted to it by the flavoring materials used. If color is added it should harmonize with the particular flavoring used.

Defects in Color. Too high color; unnatural color such as colors different from the color of the natural flavoring material used.

Individual molds, if colored, should be as nearly as possible the same color as the object they represent.

CHAPTER XXII.

ICE-CREAM STANDARDS.

At the present time there is considerable agitation in the ice-cream world over the pure-food standards that relate to the composition of ice cream. Undoubtedly, the most important part of the laws pertaining to the manufacture of ice cream is that requiring that the product shall be made under sanitary conditions and shall contain nothing deleterious to health. This portion of the present laws is generally satisfactory to every one.

Binders and Fillers. — In some states and cities there are laws or ordinances providing for a fat standard and regulating the kind and amount of filler or binder used. The large city ice-cream manufacturers as a whole are opposed to standards. In regard to binders it may be said that, providing the binder is a healthful substance, there should be no ruling against it by any pure-food law. Gelatine and gum tragacanth are used in ice cream to give it a smooth texture and prevent granulation and crystallization of the watery parts while in storage, and there seems to be no good reason for classing them as adulterants. But the use of corn starch, rice and wheat flour, and other fillers to hide a lack of butter fat must be condemned, when the product is sold under the name of ice cream. Large amounts of fillers are seldom used when the fat standard is enforced.

Fat Standard. — The fat content of ice cream is a much-discussed subject. The justice of a fat standard seems to depend upon whether the consumer, the people as a whole, consider ice cream to be frozen cream, or merely a frozen delicacy with a creamy consistency. Many ice-cream manufacturers maintain that the latter is the case, and that there is no more necessity for a fat standard for ice cream than there is for a fat standard for cream gravy or creamed potatoes. They claim that since the product is not necessarily purchased because of its food value, there should be no standard for the amount of nutrients contained therein. But if the first-mentioned definition holds, then the fat standard for ice cream is perfectly just and legitimate. However, under any conditions, it seems hardly fair to the consumer or to the manufacturers to sell a product containing 7 per cent of butter fat under the same name as that containing 14 per cent of butter fat.

If another material (milk) is used in the manufacture of a frozen product, an appropriate name should distinguish it from other frozen products, just as the name "Water Ice" is used to distinguish that product from ice cream. A frozen product made of milk can be manufactured and sold at a much lower cost than that made of cream. Such a product could be called "Ice Milk." The consumer might then obtain a cheap refreshment at a proper price; and he may also, if he desires, obtain a product of higher quality and be certain of getting it by paying the higher price for the richer product, properly called ice cream.

In South Dakota, the 14-per-cent fat standard is being enforced. Several cases were brought to the attention of the dairy inspection department in which some factories located in large cities were selling so-called ice cream at a very low price. This product contained from 6 to

10 per cent of butter fat. The local and small ice-cream factory made a product containing 14 per cent of fat. It was impossible for this latter factory to compete with the other factories manufacturing the inferior article. The product shipped in from the large plant contained from 6 to 10 per cent of fat, and contained an excess of filler. A good product can thus easily be driven from the market by a cheap substitute. It is apparently proper that there should be a law to protect the consumers as well as those who desire to place a superior article on the market. Under a proper classification these two products would have been sold under different names and would not have come into such sharp competition with each other.

The increasing magnitude of the ice-cream industry makes necessary the adoption of appropriate trade names for all the various ices. Several classifications, varying in complexity, have been proposed. This may be taken as an indication of a general desire to establish well-defined classes of frozen products, and it seems eminently fitting to make a distinction in name between the products made of milk and those made of cream.

Testing Ice Cream. — The presence of sugar, gelatine and gum in ice cream makes necessary some modification of the Babcock Test in order to secure good results.

The following method is suggested; it is comparatively simple and produces a very clear reading.

1. *The Hydrochloric and Acetic-acid Method.* — Nine grams of the sample are weighed into the test bottle and 30 cubic centimeters of a mixture of equal parts by volume of concentrated hydrochloric acid and 80 per cent acetic acid are added. Mix thoroughly and heat on the water bath till the mixture darkens, but avoid charring. Whirl in the centrifuge, add hot water as

in the regular testing and read the percentage of fat directly.

If charring has interfered with the fat reading, add ether after whirling to dissolve the fat, and draw off the ether solution into another bottle. Evaporate off the ether, fill with hot water and again whirl and read. This latter method should not be resorted to except in cases of necessity. It is always better to run the test over, provided there is enough left of the original sample.

2. *Modified Babcock Method.* — Ice cream can be tested successfully by using sulphuric acid, provided certain precautions are observed. The writers have obtained good results by using the following method. Melt the sample slowly at a low temperature to a creamy consistency; quickly weigh 9 grams of it into a milk bottle. Add about twelve cubic centimeters soft water, mix, then successively add small quantities of sulphuric acid, mix and let stand to permit the acid to act. The action of the acid is indicated by the color of the mixture, and when this assumes a strong coffee color the reaction has gone far enough and no more acid is required. If the color continues to darken, add a small quantity of soft water to prevent charring.

Bacteria in Ice Cream. — The subject of bacteria in ice cream has received attention only during the past few years. There is a popular belief that, because cream is frozen, it cannot decompose and that the organisms originally in the cream are either killed or rendered harmless by the continued low temperature. However, experiments show that bacteria do remain virile and that certain types even proliferate at sub-freezing temperatures. The bacterial content of ice cream, then, is a matter of importance from a hygienic standpoint.

We have previously noted that the conditions of the milk and cream supply in many localities are far from ideal. Since milk and cream are the main constituents of ice cream, this latter product cannot be of any better quality than the materials of which it is made. However, all methods of improving milk and cream are just as applicable to the ice-cream industry as to city milk supply.

Investigations of conditions in Washington, D. C., reported in Bulletin 56 of the Hygienic Laboratory, show that, in 1907, in 130 samples of cream examined, the average number of bacteria per cubic centimeter was 12,130,080. At the same time, 381 samples of milk were subjected to a bacteriological examination and the average number of organisms per cubic centimeter was 3,415,533. Samples of ice cream at the same time contained from 100,000 to 400,000,000 bacteria per cubic centimeter.

Dr. George W. Stiles of Washington, D. C., investigated the bacterial flora of ice cream in cold storage, and secured the following results:

Four samples of ice cream were secured from different dealers and placed in storage at a temperature varying from 0° to 10° F. The bacterial content of these samples averaged on the

	Per c.c.
Initial count	70,000,000
3rd day	120,000,000
6th day	65,000,000
9th day	80,000,000
11th day	50,000,000
14th day	13,000,000
17th day	21,000,000
20th day	85,000,000
23rd day	90,000,000
27th day	225,000,000
30th day	22,000,000
34th day	13,000,000

Just what significance should be attached to these bacterial counts depends chiefly upon the types or kinds of organisms that are present in the ice cream. Certain varieties may produce toxins, while others are harmless.

Cases are on record where ice cream caused digestive derangements, headache, diarrhea and symptoms of poisoning soon after the eating. Such cases of illness are commonly explained as ptomaine poisoning and are usually due to unsanitary conditions of the raw material (cream, gelatine, etc.), the ice-cream factory, or prolonged storage of the ice cream.

The owners of one large ice-cream factory guarantee their product sold to be absolutely free from tubercle bacilli, and other disease-producing bacteria, and to contain no more than 25,000 germs per cubic centimeter when delivered to the consumer. At this particular plant a bacterial count is made of all the cream to be frozen. Separate counts are made (1) of the cream after homogenization, (2) of the mix before freezing and (3) of the frozen product ready for shipment. The counts run, on an average, about as follows: cream, 2000 bacteria per cubic centimeter; mix, 12,000 per cubic centimeter, and ice cream 24,000 per cubic centimeter. The ice cream is also tested for gas-producing organisms, any bacteria of the B. Coli type being considered a very objectionable contamination. The analysis report card used in this work is as follows:

BACTERIOLOGICAL ANALYSIS OF ICE CREAM.[1]

Ice cream examined..........................
No. of Plates used for each dilution ....
Average number of Bacteria in dilution......1- 100......Per c.c.
" " " " ......1- 1,000...... " "
" " " " ......1- 5,000...... " "
" " " " ......1- 10,000...... " "
" " " " ......1-100,000...... " "
Total average of Bacteria.............. " "
Gas.....% CO_2......% H_2....% B. Coli Communis...............
Date cream made...................19..
Date of analysis...................19..
Date plates "counted"..............19..*Signed*...................
Bacteriologist.

[1] Collins Bros., Chicago, Ill.

CHAPTER XXIII.

MECHANICAL REFRIGERATION.

MECHANICAL refrigeration has been considered expensive and impracticable on a small scale until within a few years. The science of producing cold artificially has been simplified and reduced to such a practical basis that it is now used in many large as well as small plants where formerly natural ice was used altogether. The chief factors affecting the cost of mechanical refrigeration may be said to be similar to those affecting the economic running of the remaining machinery, such as kind of fuel used, skill of fireman, style and condition of boiler, proportion of boiler power to work done, upon the correlative size of all machinery, upon kind of insulation and care of cooling-rooms and upon efficiency of compressor and whole refrigerating system.

Chemicals Used. — The most common substances used in mechanical refrigeration are ammonia and carbonic acid. A number of others are in use, but from a creamery standpoint these only are of importance. Ammonia is used chiefly. It is efficient, cheap, and not so dangerous to life and property as are some of the others. Anhydrous ammonia has a boiling-point of 27° below zero at atmospheric pressure. The latent heat of ammonia is also great. Ammonia has great chemical stability and is not explosive in nature. Ammonia attacks copper and brass, but has no effect upon iron and steel pipes.

If ammonia should escape through a leak into a room, the operator can protect himself from the effects of the gas by breathing through a wet sponge held in the mouth.

Ammonia leaks may be detected by holding a glass rod dipped in hydrochloric acid to the places where the leaks are suspected. When ammonia comes in contact with hydrochloric acid, white fumes are formed.

Principles of Producing Cold Artificially. — The chief principle involved in producing artificial cold is that when a substance passes from a liquid into a gaseous state, a definite amount of latent heat is absorbed. When water in a kettle on the stove begins to boil and passes off into steam, no higher temperature can be reached. No matter how much heat is applied under those same conditions, the temperature remains the same. This extra heat is used in transforming the water into steam. If this steam were confined, and that heat removed by cooling, the steam would again pass into a liquid state. We are familiar with the coolness produced by rapid evaporation of perspiration from the body. Mechanical refrigeration is virtually a process of evaporation of the cooling medium during which heat is absorbed; and then again liquefying the cooling medium by compression and cooling to remove the absorbed heat. To increase the ability of the cooling medium to absorb heat the cooling medium is compressed and liquefied. So we might say that any compression refrigerating system has three separate operations necessary to form the complete cycle of mechanical refrigeration, viz.:

1. Compression of the ammonia gas.
2. Condensation of the ammonia gas.
3. Expansion of the ammonia gas.

1. The machine which causes the compression of the ammonia gas is called the compressor. In construction it is much like a steam engine. Small machines are single but large machines are double acting. Gas is drawn in

on the suction stroke, compressed and discharged on the return stroke. The pressure generated varies between 120 and 175 pounds per square inch. During the compression, heat is developed in proportion to pressure exerted. The greater the pressure, the higher the temperature of the gas. Part of the heat of compression is carried off by means of a continuous stream of water running through a jacket around the cylinder.

2. From the compressor the gas is forced through the pipes into the condensing coils, in which the warm compressed gas is cooled still more. When sufficient heat has been removed from this gas, it assumes a liquid condition and is ready to expand into a gaseous form for the purpose of absorbing heat and producing cold. During the cooling and condensing processes each pound of ammonia parts with about five hundred and sixty units of heat, which amount can again be absorbed when it expands into gas at the lower pressure.

3. This liquefied gas, which is still under great pressure, is then admitted through what is termed the expansion valve. This valve is especially constructed for that purpose, and has only a very minute opening in it for the admission of the liquid ammonia. On the expansion side the pressure is low (20 to 30 pounds). As the liquid ammonia emerges from the high-pressure side through the expansion valve into the expansion side it forms a gas. This expanded gas may then be circulated through coils for cooling purposes. From there it passes back into the suction side of the compressor ready to go through another similar cycle.

From the above description it will be seen that there are two sides to the system, the expansion side and the compression side. The compression side extends from the compressor to the expansion valve; the expansion side from the expansion valve to the suction side of the compressor, inclusive.

Transferring the Cold. — The methods of transferring the cold to the different places in the building vary. There are two systems:

1. Direct Expansion.
2. Brine System.

1. By the direct-expansion system the condensing pipes of the system are extended to the room or place at which the cooling is to be done. An extended set of expansion coils then conveys the gas which absorbs the heat. A lower temperature can be produced by this method than with the brine system.

2. In the brine system a large brine tank is placed somewhere in the creamery or ice-cream plant at a place most convenient with respect to cooling. This tank contains a strong solution of brine. The chief reason why brine is used in preference to water is that brine has a very low freezing-point. This varies with different degrees of saturation.

Either sodium chloride (common salt) or calcium chloride may be used for brine. The latter is considered best chiefly because it is not so hard on the pipes, and it keeps the brine pipes cleaner than does a salt brine. The following tables give properties of brine made from these two substances.

The expansion coils pass through the brine tank and cool the brine. Special pumps force the cold brine through pipes to the cooling room, cream vat, cooling coils, ice-cream freezer, etc.

SHOWING PROPERTIES OF SOLUTION OF SALT. (Siebly.)
(Chloride of Sodium.)

Per cent of salt by weight.	Pounds salt per gallon of solution.	Degrees on salometer 60° F.	Weight per gallon at 39° F.	Specific gravity at 39° F. 4° C.	Specific heat.	Freezing-point Fahr.	Freezing-point Celsius.
1	0.084	4	8.40	1.007	0.992	30.5	−0.8
2	0.169	8	8.46	1.015	0.984	29.5	−1.5
2.5	0.212	10	8.50	1.019	0.980	28.6	−1.9
3	0.256	12	8.53	1.023	0.976	27.8	−2.3
3.5	0.300	14	8.56	1.026	0.972	27.1	−2.7
4	0.344	16	8.59	1.030	0.968	26.6	−3.0
5	0.433	20	8.65	1.037	0.960	25.2	−3.8
6	0.523	24	8.72	1.045	0.946	23.9	−4.5
7	0.617	28	8.78	1.053	0.932	22.5	−5.3
8	0.708	32	8.85	1.061	0.919	21.2	−6.0
9	0.802	36	8.91	1.068	0.905	19.9	−6.7
10	0.897	40	8.97	1.076	0.892	18.7	−7.4
12	1.092	48	9.10	1.091	0.874	16.0	−8.9
15	1.389	60	9.26	1.115	0.855	12.2	−11.0
20	1.928	80	9.64	1.155	0.829	6.1	−14.4
24	2.376	96	9.90	1.187	0.795	1.2	−17.1
25	2.488	100	9.97	1.196	0.783	0.5	−17.8
26	2.610	104	10.04	1.204	0.771	−1.1	−18.4

PROPERTIES OF SOLUTION OF CHLORIDE OF CALCIUM.
(Siebly.)

Per cent by weight.	Specific heat.	Specific gravity at 60° Fahr.	Freezing-point in degrees Fahr.	Freezing-point in degrees Cels.
1	0.996	1.009	31	−0.5
5	0.964	1.043	27.5	−2.5
10	0.896	1.087	22	−5.6
15	0.860	1.134	15	−9.6
20	0.834	1.182	5	−14.8
25	0.790	1.234	−8	−22.1

Use of Brine. — For all general cooling purposes, the brine system is more economical and satisfactory because the brine may be kept cold by running the compressor just a few hours each day. The cold is stored and used when wanted. In the direct-expansion system, as soon as the compressor stops refrigeration ceases. However, for dry hardening rooms the direct-expansion system is absolutely necessary to secure and maintain a sufficiently low temperature.

Strength of Brine. — The proper degree of concentration of the salt solution depends upon the temperature desired. Low temperatures demand a stronger brine to prevent freezing; but an unnecessarily strong brine is undesirable, because the stronger the brine is, the less is its specific heat; that is, it has less ability to absorb heat, and too concentrated brine is likely to clog the pipes.

Size of Compressor. — The size of a refrigeration machine is expressed as a certain number of tons' capacity. For instance a machine of four tons' capacity means that that machine would produce in 24 hours as much cold as is given off by four tons of ice melting to water at 32° F. Its actual ice-making capacity is about half this much; a four-ton machine will make about 2 tons of ice per day.

In selecting the size of machine needed it must be remembered that the capacity is rated on a 24-hour run. If conditions are such that it will be desirable to run the compressor only four hours per day then the machine must have six times the daily capacity needed. The larger machines produce a ton of refrigeration at less cost than small ones, but in a general way, for small and medium-sized machines, the power required is about two and one-quarter horse power per ton of refrigeration.

Operation of an Ammonia Plant. — Charging and operating an ammonia plant are very ably discussed by H. H. Kelley in *The Engineer*, from which the following is taken.

"When about to start an ice or refrigerating plant, the first thing necessary is to see that the system is charged with the proper amount of ammonia. Before the ammonia is put in, however, all air and moisture must be removed; otherwise the efficiency of the system will be seriously interfered with. Special valves are usually provided for discharging the air, which is removed from the system by starting the compressor and pumping the air out, the operation of gas cylinder being just the reverse of that when it is working ammonia gas. It is practically impossible to get all the air out of the entire system by this means, so that some other course must be taken to remove any remaining air after the compressor has been started at regular work. This can be accomplished by admitting the ammonia a little at a time, permitting the air to escape through a purge valve, the air being thus expelled by displacement. The cylinder containing the anhydrous ammonia is connected to the charging valve by a suitable pipe, and the valve opened. The compressor is then kept running slowly with the suction and discharge valves wide open and the expansion valve closed. When one cylinder is emptied put another in its place, being careful to close the charging valve before attempting to remove the empty cylinder, opening it when the fresh cylinder is connected up.

" From sixty to seventy-five per cent of the full charge is sufficient to start with so that the air may have an opportunity of escaping with as little loss of ammonia as possible. An additional quantity of ammonia may then be put in each day until the full charge has been introduced. When the ammonia cylinders have been emptied and a charge of, say, seventy-five per cent of the full amount has been introduced, the charging valve is closed and the expansion valve opened. The glass gauge on the ammonia receiver will indicate the depth of ammonia. The appearance of frost on the pipe leading to the coils and the cooling of the brine in the tank will indicate that enough ammonia has been introduced to start with. It is sometimes difficult to completely empty an ammonia cylinder without first applying heat. The process of cooling being the same when the ammonia expands from the cylinder into the system as when leaving the expansion valve, a low temperature is produced and the cylinder and connections become covered with frost. When this occurs the cylinder must be slightly warmed in order to be able to get all the ammonia out of it. The ammonia cylinders, when filled, should never be subjected to rough handling and are preferably kept in a cool place free from any liability to accident. The fact that ammonia is soluble in water should be well understood by persons charging a refrigerating system, or working about the plant. One part of water will absorb about 800 parts of ammonia gas and in case of accident to the ammonia piping or machine, water should be employed to absorb the escaping gas. Persons employed about a plant of this kind should be provided with some style of respirator, the simplest form of which is a wet cloth held over the mouth and nose.

"After starting the compressor at the proper speed and adjusting the regulating valve note the temperature of the delivery pipe, and if there is a tendency to heat, open it wider, and vice versa. This valve should be carefully regulated until the temperature of the delivery pipe is practically the same as the water discharged from the ammonia condenser. With too light a charge of ammonia the delivery pipe will become heated even when the regulating valve is wide open. As a general thing when the plant is working properly the temperature of the refrigerator is about 15° lower than the brine being used, the temperature of the water discharged from the ammonia condenser will be about 15° lower than that of the condenser, the pointers on the gauges will vibrate the same distance at each stroke of the compressor and the frost on the pipes entering and leaving the refrigerator will be about the same. By placing the ear close to the expansion valve the ammonia can be heard passing through it, the sound being uniform and continuous when everything is working properly.

"When air is present the flow of ammonia will be more or less intermittent, which irregularity is generally noticeable through a change in the usual sound heard at the expansion valve. The pressure in the condenser will also be higher and the effect of the apparatus as a whole will be changed, and, of course, not so good. These changes will be quickly noticed by a person accustomed to the conditions obtaining when everything is in order and working properly.

"The presence of oil or water in the system is generally detected by shocks occurring in the compressor cylinder.

"In nearly all plants the presence of oil in the system of piping is unavoidable. The oil used for lubricating purposes, especially at the piston rod stuffing boxes, works into the cylinders and is carried with the hot gas into the ammonia piping, where it never fails to cause trouble. The method of removing the air from the system has already been referred to, but the removal of oil is accomplished by means of an oil separator. This is placed in the main pipe between the compressor and the condenser, and is of about the size of the ammonia receiver. Sometimes another oil separator is placed in the return pipe close to the compressor which serves to eliminate any remaining oil in the warmer gas and to remove pieces of scale and other foreign matter which, if permitted to enter the compressor cylinder, would tend to destroy it in a very short time.

"The oil, which always gets into the system sooner or later and in greater or less quantity, depending upon the care exercised to avoid it, acts as an insulator and prevents the rapid transfer of heat from the ammonia to the pipe, and also occupies considerable space that is required for the ammonia where the best results are to be obtained."

Insulation. — Where mechanical refrigeration is used the insulation of cooling rooms, brine tank and pipes is of great importance from an economic point of view.

The insulating material must be a non-absorbent of moisture, a poor conductor of heat, and of sufficient strength and durability to remain for many years without crumbling or decomposing.

All ammonia and brine pipes passing through rooms where refrigeration is not desired should be covered with insulation two inches thick for temperatures of zero or below, and one to one and a half inches for higher temperatures.

According to the H. W. Johns-Mansfield Co., there is a loss of nine tons of refrigeration on account of radiation in 24 hours on 500 feet of $3\frac{1}{2}$-inch brine pipe with temperature of zero and outside temperature of 70° F. Figuring the cost of refrigeration at 50 cents per ton, the loss would be $4.50 per day of 24 hours.

PART IV.

BY-PRODUCTS OF THE CREAMERY AND CHEESE FACTORY.

CHAPTER XXIV.

COTTAGE CHEESE.

Cottage Cheese. — Cottage cheese (Dutch cheese, or Schmier-kase) is a product that usually finds a ready sale on the market at a price that insures a good profit to the manufacturer. Especially is this true in large cities and in mining districts during hot weather.

In the past this product was made mostly in the home, and varied greatly in quality and general characteristics. But at the present time, large quantities of it are being manufactured in whole milk creameries, large dairies, etc. In order that a manufacturer may turn out a uniform product, a definite method of manufacture should be followed. The process admits of a number of variations in its details, hence judgment must be used by the manufacturer in adopting the process most suitable to his particular conditions, kind of raw material, and market demands.

Milk to Use. — In making cottage cheese, just as in all other dairy products, it is essential to have a fresh, clean, pure raw material to start with. Undesirable odors and flavors in the milk seriously affect the finished product.

Skim milk rather than whole milk is used in cottage-cheese making, because in the use of whole milk a large percentage of the fat is lost in the whey. If a rich, creamy cheese is desired, it can be secured more economically by using skim milk, and then adding cream to the finished product.

A good quality of cottage cheese can be manufactured from good buttermilk. Skim milk and buttermilk together may be used in various proportions.

Use of Starters. — In order to insure a uniform product the fermentation must be controlled, and to do this, a pure culture of lactic-acid bacteria is important. These cultures, or "starters" as they are commonly called, are used extensively in butter and cheese making, and may be secured from various manufacturers. Directions for their use accompany each package, or may be found in the various texts on butter and cheese making.

A better control of the fermentation can be secured by using pasteurized milk than by using raw milk, but in either case a good starter should be used to insure a uniform and desirable flavor in the cheese.

Souring the Milk. — The common method of making cottage cheese is to sour the skim milk by a lactic acid fermentation, rather than by the addition of commercial acid. The fermentation of the skim milk may be carried on in milk cans or in a vat, depending upon the quantity. The milk is warmed to about 70° F., and sufficient starter added to insure the coagulation of the milk at the desired time. If the milk is pasteurized, a small percentage of starter is sufficient; but with raw milk, a larger percentage, 20 to 25 per cent, of starter, will be better able to overcome any undesirable ferments that may be present. This will cause the milk to curdle in a much shorter time.

When a firm curd has been formed it is broken up by cutting with cheese knives or stirring with a common stirring rod.

Heating the Curd. — This is a very important process and must be done carefully. Heat is applied gradually, and the curd stirred continually, but gently, until a temperature of 96° to 100° F. is reached, which should require about thirty minutes for a large vat. This temperature is maintained for about twenty minutes, or until the curd feels fairly firm and the whey appears clear.

Different conditions require different temperatures. Too low temperatures produce a soft pasty cheese that drains with difficulty, and soon develops a high acid flavor. Too high temperatures produce a dry, granular and corky cheese, for which there is slight demand.

Draining the Curd. — The common method of draining a small quantity of curd is to put it into a cheese-cloth bag, and hang it up until all the free whey has run out. For large quantities, a fine strainer is more satisfactory. This may be of perforated tinware, or a frame or box with a bottom made of small meshed wire netting. A piece of cheese cloth is placed in the bottom of the strainer and the curd poured upon it. Most of the whey quickly runs through the cloth. But in order to permit the curd to drain thoroughly, it is left on the strainer with occasional stirring for about five hours, or until whey ceases to run off.

Seasoning the Curd. — When the curd is taken from the strainer, it is in a single mass. This should be thoroughly broken up with a wooden masher or with the hands. At this time salt is added in the proportion of about one ounce to five pounds of curd. If a rich cheese is desired, cream or butter may be added. Too much salt causes a dry, granular cheese. In some instances cumin or caraway seeds are added.

Yield of Cheese. — The yield of cottage cheese varies somewhat, depending upon its moisture content, the per cent of casein in the milk and the amount of curd lost in the whey. On an average, seven pounds of skim milk produce one pound of cottage cheese.

For retailing this product, the common ice-cream pail has been found to be a convenient package. It is cheap, sanitary and attractive. The package may be marked on the outside to describe suitably its contents. These small packages are not sealed air-tight. For this reason the cheese should not be put into the retail packages sooner than necessary. Cottage cheese may be kept in larger bulks in earthen jars. Cottage cheese to be most palatable should be made every other day.

Use of Rennet in Cottage-cheese Making. — This product may be made by curdling the milk with rennet instead of with the natural acid. However, in order to have the proper flavor, the milk should have an acidity of at least $\frac{3}{10}$ per cent when the rennet is added. The proportions used are 1 ounce of rennet to 1000 pounds of milk. Having curdled the milk, the rest of the operation is the same as described above. Cheese made in this way is apt to be a trifle dry and rubber-like, and mild in flavor.

Use of Hydrochloric Acid. — Much time can be saved by adding acid direct to fresh milk instead of waiting for it to be developed by fermentation. The milk is heated to from 70° to 80° F. Hydrochloric acid (sp. gr. 1.20) is added at the rate of 10 ounces to 100 pounds of milk. This acid is diluted with ten times its bulk of water, and added gradually, the milk being stirred constantly. The stirring is continued until the curd fully separates, leaving a clear whey. Then the whey is drained from the curd and the process completed as described above. Acid used should be chemically pure, not the commercial.

Such cheese lacks the peculiar characteristic flavor of that made by lactic fermentation, but this can in a measure be restored by the addition of sour cream.

The average composition of cottage cheese is as follows:[1]

	Per cent.
Water	73.1
Fat	2.8
Nitrogenous Matter	19.8
Non-nitrogenous Matter	2.2
Ash	2.1

BUTTERMILK CHEESE.

In past years buttermilk was hardly considered an asset in a creamery; but by the manufacture of buttermilk cheese, this by-product of butter making may be made a source of considerable income.

Heating the Buttermilk. - As the buttermilk comes from the churn it is run into a jacketed vat or can, heated to 80° F. and allowed to stand undisturbed for an hour.[2] During this time the buttermilk coagulates, forming a soft, flocculent curd.

The contents of the vat are then heated, with slight stirring, to from 130° to 140° F., and again allowed to stand undisturbed for an hour. It should be kept close to this temperature until placed on the draining rack, since the curd drains faster if warm, but it should not be re-heated or stirred again before draining.

In one large creamery where all the buttermilk is manufactured into cheese, the buttermilk is placed in a jacketed vat and gradually heated to about 120° F. This heating period extends over a period of between 2 and 3 hours. The buttermilk is gently stirred at intervals. At the end

[1] Flieschman — The Book of the Dairy.

[2] *Bul.* No. 211. Wisconsin.

of this period the curd has settled and the whey is drained off from the top through gate valves at different heights at the end of the vat.

Draining the Curd. — The vat having stood at a temperature of 130° to 140° F. for about an hour, the curd will have gathered at the bottom of the whey. The next step is to transfer this curd with as little whey as possible to a draining rack or strainer, such as is used in cottage-cheese making.

If the curd is floating, the whey may be drawn out through the vat gate, being passed through the strainer to catch the particles of curd it may contain. If the curd is at the bottom of the vat then most of the whey may be drawn off through a siphon and the thick mass in the bottom finally run out into the cloth. Thus, most of the whey may be run off, and the curd may be put upon the draining rack as a thick mush. If the curd and whey are run into the strainer together, much of the curd will pass through the cloth with the whey.

In either case, as soon as all the curd is on the draining rack, it is covered and left undisturbed for about twelve hours to drain.

It is very important to have a uniform consistency. It will need some manipulation occasionally to prevent whey from gathering on the surface or in pockets.

The curd is sufficiently drained when it can be removed from the rack and retain its shape.

Seasoning the Curd. — The curd, being sufficiently drained, is removed from the draining rack, granulated or mashed, to break all lumps, then salted and packed. Salt is added in the same proportion as in cottage cheese, one ounce to about five pounds of cheese.

Sometimes butter is mixed with the curd. This produces a richer cheese, and at times it is sold as Neufschatel cheese.

The yield of cheese, the method of marketing, the market value, etc., are practically the same as for cottage cheese.

The main difference in the characteristics of these two products is that the buttermilk cheese has a smoother texture than the cottage cheese.

Kind of Buttermilk. — The cheese made from buttermilk coming from old, stale, off-flavored cream will retain those undesirable qualities. None but the best quality of buttermilk should ever be used.

Sweet buttermilk, or buttermilk having a very low acid content, will not curdle on heating; at least a longer time is required for coagulation. In making cheese from such buttermilk a temperature of between 80° F. and 100° F. should be maintained longer. This will permit of the development of the lactic-acid-producing bacteria, and thereby bring about proper coagulation.

Pasteurization of the cream does not materially affect the quality of buttermilk cheese. However, cream containing more than 0.4 per cent of acid is likely to curdle in very fine grains in the pasteurizer, and it is difficult to gather these fine curd particles. Many of these run through the strainer cloth with the whey and are lost. However, this can be overcome by the addition of some skim milk to the buttermilk. The curd from the skim milk apparently acts as a sort of a filter.

For some unexplained reason, buttermilk curd from cream containing more than 50 per cent of fat is very fine grained and is difficult to collect on the cheese cloth strainer, as it runs through the meshes with the whey. This also may be overcome by the addition of skim milk to the buttermilk.

Emphasis should be placed upon the necessity of observing closely the different steps in the processes of the manufacture of buttermilk cheese. It does not admit of the variations that cottage cheese does, because of the fine and almost soluble condition of the curd.

Buttermilk Cream. — Buttermilk cream is made in a manner similar to that of making buttermilk cheese; but by employing a lower temperature the final product has the consistency of thick cream and is quite smooth and free from grains or lumps. The only change in the process of manufacture as described above is that instead of heating to 130° at the second heating, the curd is heated only to 100°. Because of the soft consistency of this product it requires a longer time to drain.

It was found at the Wisconsin Station that this product has a market value.

CHAPTER XXV.

WHEY BUTTER.

In the manufacture of all kinds of cheese whey is a by-product. It is commonly returned to the farmers and fed to hogs, but in some cases valuable products are recovered from it. The composition of whey is fairly constant, except that the fat content varies between wide limits. The average composition of whey is about as follows:

	Per cent.
Water	93.0
Sugar	5.0
Albumen	0.7
Fat	0.3
Casein	0.3
Ash	0.7

The largest percentage of solid matter in whey is milk sugar, the recovery of which will be described in a subsequent chapter.

The solids remaining in whey are sometimes recovered by heating or evaporating the water, the residue being made into a kind of cheese (mysost). The main constituent of this cheese is milk sugar, which is in marked contrast to all our common varieties of cheese, the principal constituents of which latter are casein and fat.

The milk solid in the whey that may be most easily recovered is the fat. In cheddar-cheese making the quantity of fat left in the whey seldom exceeds 0.3 per cent, and may be only one-third this much. In the manufacture of Swiss cheese the whey contains from 0.7 to 1 per cent of fat.

Hence it was in factories manufacturing this type of cheese that whey-butter making originated.

Original Methods of Making Whey Butter. — Until within the present decade, little attention was paid to whey butter. It was manufactured to some extent in Swiss cheese factories, but the product was more like lard than butter and sold for a low price.

There were two methods of recovering the fat from the whey, the "cold process" and the "hot process."

In the former the whey, when drawn from the curd, was run into vats or barrels and allowed to stand for 24 hours. The "cream" was then skimmed off and churned. This method of skimming is not very efficient, as it recovers but about two-thirds of the fat. By this process the whey cream was very sour, sometimes containing as high as 0.9 per cent acidity. Hence the resulting butter was of a poor quality and had very poor keeping properties.

In the "hot process" the sweet whey in the kettle was heated to a temperature of about 176° F. and stirred constantly for about half an hour. Soon after the stirring had begun, small, white, flocculent pieces of cream appeared on the surface. When all the cream had come to the surface, it was skimmed and dipped off into tubs, and, after standing for some time, a considerable quantity of whey was drawn off through a hole in the bottom of the tub. Even then the remaining cream contained but 12 per cent fat. It also contained a quantity of coagulated albumen.

This method recovered almost as much of the fat as can be removed by a centrifugal separator; but the prolonged high temperature is very injurious to the body of the butter made from this cream. This cream is sweet and pasteurized, and can be made into a fair quality of butter if proper methods are employed.

Poor Methods Employed. — The one great reason for the poor quality of much of the whey butter at the present time as well as in the past is that the cheese makers many times spoil the butter in the manufacturing process. The whey cream is usually not properly cooled and cared for, but is left to cool slowly in the curing room, or is ripened at a temperature of 90° F., and churned at a temperature as high as 70° F. The resultant product, when such methods are employed, is grease rather than butter; and because of the high temperatures employed it occasionally contains as high as thirty-two per cent water. Some of the old Swiss-cheese makers work the butter by taking a couple of handfuls of it on a cheese board, sprinkling some salt on it, and kneading it as dough is kneaded in bread making.

Because whey butter is usually made on such a small scale and is a side line in a cheese factory, it is not given sufficient attention to insure a high grade product. Many cheese makers have never learned the art of butter making, and hence are not qualified to turn out a high grade of whey butter.

Modern Whey-butter Making. — That a very high quality of butter may be made from whey cream, has been demonstrated on numerous occasions. At Brockville Exhibition, Ontario, Canada, in 1907, in the butter contest, the exhibit that carried off first prize was whey butter. This was in competition with creamery butter. Whey butter has been made by one of the authors and submitted to several dairymen for examination. It could not by any physical test be distinguished from creamery butter. (This butter did not include drippings from the milled curd.)

In order to make whey butter a profitable product, the cheese factory should have at least 10,000 pounds of milk daily. A separator is necessary in order to secure the cream in good condition. The whey should be run through the separator while hot, as soon as possible after being drawn from the curd. A cream of not less than thirty per cent fat should be secured, pasteurized and cooled, ripened with a starter, and treated in every way the same as cream in a whole-milk creamery.

The butter can be made more economically by gathering the cream from several cheese factories and taking it to one central point for proper ripening and churning. But it is essential that each factory take proper care of the cream and deliver it in a sweet, clean condition.

The skimming of whey is practiced commonly in factories making cheddar or American cheese, as well as in Swiss-cheese factories. Some authorities claim that cheddar cheese when made under most favorable conditions leaves so little fat in the whey that the cost of recovering it would hardly be met by the value of the fat secured. When the cheese maker is deriving direct profit from the whey cream, he may so handle the curd while in the whey that a very considerable portion of the fat that should go into the cheese is left in the whey to be recovered by the separator.

Disposal of Whey Butter. — It is very evident that whey butter must be so branded as to distinguish it from creamery butter. So much whey butter is of poor quality that this product, no matter how good it is, brings a lower price on the market than does creamery butter. To some extent the local patrons of the cheese factory may, however, use the whey butter. This latter is of the same value to them as a similar grade of creamery butter. However, if whey butter of high quality be offered on the market for some time, it will soon gain a favorable reputation and be able to compete with butter made from natural cream.

Profits from Whey-butter Making. — Each succeeding year shows an increase in the volume of whey butter manufactured. Last year (1910) Lafayette County, Wisconsin, alone, produced 84,000 pounds of this product. The various separator companies have constructed separators especially adapted to the separation of whey.

A cheese factory receiving, on an average, 6000 pounds of milk per day would handle 2,190,000 pounds of milk per year. On a basis of 3 pounds of whey butter from each thousand pounds of milk made into cheese, 6570 pounds of butter would be made in one year. If this butter is properly made it should sell for an average price of 25 cents per pound. The income from this butter would be $1642.25.

In many places one half the gross income from whey butter is divided among the patrons. This would leave $821.125 as the cheese factory's share. From this must be deducted about $500, which includes the interest on the extra investment, depreciation in value and the charge for labor and fuel. The net profit to the cheese factory would amount to about $321.25 for the year.

CHAPTER XXVI.

MILK SUGAR.

MILK SUGAR or lactose ($C_{12}H_{22}O_{11} + H_2O$) is probably found in the milk of most mammals, and, so far as known, is found nowhere else in nature. Richmond has shown that the milk of the goat, the ass and the Egyptian gamoose or water-buffalo contain lactose. Richmond and Pappel also found that the sugar in the milk of the gamoose in winter differed from lactose. This sugar they called "Tawfikose." Sugar of mares' milk has the property of easily undergoing alcoholic fermentation, a property not possessed by lactose from cows' milk. According to Richmond and Pappel, sugar of human milk is not identical with that of cows' milk. The milk sugar of commerce is derived from cows' milk of which it forms about five per cent. It is but slightly sweet, hardly a hundredth as sweet as cane sugar.

This product is used in modifying milk for feeding infants and invalids, as a diluent in various strong drugs, in the preparation of medicinal powders, and in the manufacture of pentanitro-lactose, which forms a part of some high explosives.

History and Development of Milk-sugar Manufacturing. — Milk sugar is said to have been discovered by accident early in the eighteenth century by a peasant in Switzerland who was making cheese. The cheese having been hung up in a bag to drain for some time, this observing Swiss noticed a few crystals that had been formed by the evaporation of the whey. A druggist, to whom these crystals were shown, predicted that, if the product could be manufactured in quantities, it would become an important article of commerce. In the first half of the nineteenth century, milk sugar was being manufactured by very crude methods in Switzerland, Holland and Germany. The sugaring processes occupied about fourteen days and the product then contained many impurities. But there was great demand for even this impure product and the industry grew. Switzerland controlled the milk sugar industry, and supplied the markets of the world. In time the United States became the chief customer of Switzerland, taking about three-fourths of the $60,000 worth annually exported from that country.[1]

The first attempt to manufacture milk sugar in this country was made in 1881 by Dr. Gerber. He worked for about two years in Little Falls, N. Y., and then gave it up, declaring that, on account of the poor quality of milk produced in the United States, Switzerland need never fear competition in the milk-sugar industry from that source.

However, by 1890 the milk-sugar industry was fairly well established in this country and was developing rapidly. American improvements in the process of production have made possible a product of much higher purity than the sugar formerly imported from Switzerland. To-day milk sugar is exported from this country to Europe and has to a considerable extent replaced the Swiss product.

Milk-sugar Making in the United States. — Alvord, in 1897, reported four or five milk sugar factories in Illinois, New York and Ohio, using whey from neighboring cheese factories, for which they paid from 4 to 7 cents per hun-

[1] Alvord in *United States Dept. of Agriculture Yearbook,* 1897.

dred pounds. The largest factory of this kind in the world is located in Illinois and has a capacity of one and a half tons of milk sugar per day. They get on an average 3.4 pounds of sugar from 100 pounds of whey. At this factory the whey from casein making as well as the whey from cheese factories is used, the sugar from the former source being of just as high quality as that from the latter.

The Process of Manufacture. – Whey, acidified to about one per cent of hydrochloric acid, is heated in large vats to the boiling-point with steam. This precipitates the albumen. The solution is then made neutral with calcium hydroxide, evaporated in a vacuum pan to a syrupy consistency (22° to 25° Baumé), and filtered through a series of cloths in a high-pressure filter press. When sufficient syrup has accumulated, it is again run into the vacuum pan and evaporated, at about 110° F., to a much richer syrup. This latter is drawn out into shallow boxes, where it cools and crystallizes, in 24 to 48 hours, into what appears to be a yellow sand. This is crude sugar, and must be passed through several processes of purification.

This mass is first washed with cold water in a centrifuge. The centrifuge is a combination of drums with perforated walls and fine sieves. The syrup is thrown out through the sieves and the sugar crystals are retained within them. The crystals are here washed with cold water to remove calcium chloride and other soluble impurities. The washings and the syrup thrown out by the centrifuge are saved and the contained sugar recovered. The sugar crystals are redissolved in hot water, certain chemicals are added and the solution is allowed to stand over night. In the morning the clear liquid is siphoned off. The settlings in the bottom of the tank are filtered and the filtrate is added to the solution previously siphoned off.

This is then heated to about 170° F., and filtered through bone black to remove coloring matter and other impurities. This filtered solution is now condensed to the proper point in a vacuum pan. The resulting pasty mass is passed through the centrifuge and washed, and put upon tray frames with cloth stretched over them to dry. These trays are placed upon racks in a drying room and the sugar dried at 60° C. (140° F.). When dry it is powdered in a ball mill and bolted in a manner similar to that of bolting flour in a flour mill. The product is a fine white powder, and is put into barrels holding about two hundred pounds for shipment.

By-Products of Milk-sugar Making. — The raw material used in the manufacture of milk sugar is a by-product of another industry, yet the sugar industry itself produces a by-product. This is the proteid matter, mainly albumen, that is taken from the filter press. This proteid matter is placed on cloth racks, kiln dried, and sold as food for poultry and stock.

Alvord reports the use of milk-sugar-factory by-products for pig feeding. Young pigs just weaned were bought and fed on nothing but waste from the sugar factory. They thrived and fattened so that they were ready to kill at six to seven months of age. This feed is highly nitrogenous, and evidently a very narrow ration. It seems probable that even better results would be secured by using a highly carbonaceous food in combination with the sugar-factory waste.

Mysost. — Instead of using the whey from cheese factories for the manufacture of milk sugar, it may be converted into a kind of cheese known as Mysost. Although made in this country to some extent, this cheese is more especially a product of cheeseries in Norway, Sweden and Denmark. It has a yellowish-brown color, the consistency of firm butter, and a sweet, characteristic flavor similar to a concentrated evaporated milk flavor. In this country it is marketed in paraffined pound cubes, or in cylindrical shapes, wrapped in tinfoil.

The method of manufacture is as follows:[1]

"As soon as the curd of the regular cheese is removed from the whey, the whey is strained and is put in a kettle or large pan over the fire and the albuminous material which rises to the surface is skimmed off. The whey is evaporated as rapidly as possible with constant and thorough stirring. When it has reached about one-fourth its original volume the albumin previously skimmed off is returned and stirred thoroughly to break up all possible lumps. When the whey has attained the consistency of thickened milk it is poured quickly into a wooden trough and stirred with a paddle until cool to prevent the formation of sugar crystals. This can then be molded into the desired form."

Its composition, according to Dahl, is: Water, 23.57 per cent; Fat, 16.26 per cent; Proteids, 8.88 per cent; Milk sugar, Lactic acid, etc., 44.84 per cent; Ash, 4.76 per cent.

[1] *Bu. An. Ind., Bul.* 105.

CHAPTER XXVII.

CASEIN.

THE separation of casein from milk for cheese-making purposes has been practiced for over two thousand years, but only during the last few decades has scientific research revealed the multitude of uses to which this product may be put in the technical industries. Casein to-day is manufactured on a large scale and used in the preparation of paint, glue, paper, dress goods, as imitation ivory, horn, etc., and as a concentrated foodstuff.

Casein exists in milk not in true solution, but in suspension. It may be separated out by the following means: (1) filtration through a porous clay filter, (2) centrifugalizing, (3) precipitation by dilute acids, (4) precipitation by ferments, and (5) precipitation by salts. Casein, when dried, forms a horny mass insoluble in water or dilute acids, but soluble in alkalis and concentrated acids.

Statistics show that the use of dry casein has increased 100 per cent during the last five years, and that Germany consumes about four thousand tons annually. The entire consumption in Europe and America is placed at about fifteen thousand tons. The United States Census of 1909 places the casein production in this country at almost seven thousand tons, an increase of 12 per cent in five years.

Preparation of Casein. — In the chemical laboratory, casein is prepared by diluting the milk to about five times its volume, and adding sufficient acetic acid to make the acidity of the solution one tenth per cent. This causes the precipitation of the casein. It is then filtered and washed well with distilled water. This latter will dissolve out the acid and sugar in the residue. This residue on the filter is dried and redissolved in the least possible amount of ammonia, and upon standing awhile, the fat will rise to the top. The liquid can then be siphoned off and filtered. The filtrate is again precipitated by acetic acid. This precipitate is redissolved in ammonia and the process is repeated three or four times until it is pure and white. This casein is now rubbed in a mortar with 80 per cent alcohol and the alcohol poured off. This treatment with alcohol is repeated several times, absolute alcohol being used the last time. This is followed by treatment with ether until all the alcohol is removed. The product is pure casein which, when thoroughly dried, is in a powdery condition. However, the preparation of casein for commercial purposes is quite a different process.

Commercial casein is prepared from skim milk on quite a large scale, usually in a room or building adjoining a large whole-milk creamery.

Five thousand or more pounds of skim milk are placed in a jacketed vat and heated to about 130° F. Then sufficient acid is added to precipitate the casein. In some cases commercial sulphuric acid is used in the proportion of one pint of acid diluted in water to one thousand pounds of milk. At other factories the kind and quantity of acid used are considered trade secrets. The curdling should take place under proper conditions. If an excess of sulphuric acid or too strong acid is used, the curd will be discolored.

When the milk has been coagulated, the whey separates and is drawn off. To facilitate and hasten this process, the curd is broken into small chunks and piled on a draining table or rack covered with coarse cloth. Here the whey and acid are washed out by streams of cold water. The curd is then allowed to drain for two or more hours until it becomes dry enough to be ground. Or it may be placed in a press similar to an upright cheese press and left there over night. The next morning the curd is passed through a curd mill, such as is used in the manufacture of cheddar cheese, and ground into small pieces.

The curd is then placed upon drying trays, which consist of coarse cloth stretched over a wooden frame. These trays of curd are placed in the drier and left there until the pieces of curd are quite dry and horny. The drier may be either of the horizontal or vertical type. In both cases it consists of a heated space in which the trays are placed in tiers. At one end, or at the bottom of the drier, is a power-driven fan that forces a current of air over a hot radiator and thence to the trays of curd. A temperature of about 120° F. is maintained for about twenty-four hours.

At the end of this time the curd is dry and is taken from the trays, put into sacks holding about one hundred pounds each, and shipped. At this stage the curd is in small, yellowish white, irregular lumps. If the curd is not thoroughly washed before drying, the presence of milk sugar and heat will cause a discoloration and a flinty appearance of the curd. This greatly lessens its solubility and commercial value.

One hundred pounds of skim milk will yield about $3\frac{1}{2}$ pounds dried casein, which contains about twelve per cent of moisture. For this dry curd the casein companies pay about seven cents per pound, which is equivalent to 24.5 cents per 100 pounds of skim milk.

According to the Union Casein Company the following equipment is needed for the manufacture of casein from skim milk:

"The machinery is not expensive; it consists of a skim-milk vat, unlined; a press, one curd mill and wooden drying closet. The kiln covers a space of about four feet high, twenty-two feet long and six feet wide, built along the wall of (preferably) the second floor. This size is suitable for drying curd or casein from 24,000 pounds of skim milk. (A larger or smaller size can be made proportionately.) The radiator and ball-bearing fan are the principal parts required for the making of the drier. Radiator costs $48.00; fan $35.00. In addition to the dryer you will require 12 trucks, each of which holds 30 wire trays. One truck and one set of trays are required for drying the wet curd extracted from 2000 pounds of skim milk. The trucks cost $2.50 each and the trays $9.00 per dozen. The curd flaking machine costs $55.00; press $35.00. One press is required for each 12,000 pounds of milk."

This commercial casein must be purified if intended for certain technical uses. To accomplish this the casein is macerated, and dissolved in dilute alkali at a high temperature, cooled, reprecipitated with an acid, drained and washed repeatedly with water, and finally pressed and dried.

Casein from Buttermilk. — The large central creamery plants of to-day are taking up side lines, and manufacturing several by-products. One of these is casein from buttermilk.

The process of recovering casein from buttermilk is similar to that of recovering casein from skim milk. But the physical and chemical condition of the buttermilk casein necessitates certain modifications. At different factories slightly different methods are used, but in a general way the processes are the same.

The buttermilk, when drawn from the churn, is pumped into large vats or tanks, steam is turned directly into the buttermilk, and the temperature is brought to about 160° F. The hot buttermilk is left undisturbed for several hours, or over night. It is then run over a cooler into a smaller vat, for convenience in handling, and the temperature brought to about 100° F. Sulphuric acid is added in the proportion of about six quarts of acid to 300 gallons of buttermilk. The proportion is varied with the season of the year, the acidity and the condition of the buttermilk. An excess of acid will produce a dark-colored casein that has a low market value. Insufficient acid causes incomplete gathering of the curd; hence, many small particles are lost in the whey. Within one hour from the time the acid is added the whey may be readily drawn off and the curd put to press. The pressing, grinding and drying of the curd is carried on in a manner similar to that of handling curd from skim milk.

Casein from buttermilk differs from casein from skim milk in the following particulars:

Buttermilk casein is darker in color, contains a higher percentage of fat, is less soluble, and cannot be used so extensively nor for such high-grade products as can skim-milk casein. The former has a market value from ten to sixty per cent lower than that of the best-grade skim milk casein.

Casein Glue. — The crude casein may be converted into a glue by the following simple process: To the casein add one-fourth of its weight of distilled water and one to four per cent of bicarbonate of soda. Mix thoroughly, then add a quantity of distilled water equal to the original amount used, to complete the solution, and let it stand from five to six hours. At the end of this time the glue will be ready for use. An antiseptic should be added to prevent fermentation.

There are many patented formulas for the manufacture of casein glue. Borax, ammonia, lime, and various alkaline salts are used in this connection singly or in combination.

Closely allied to the casein glues and of similar composition are several kinds of casein putties and stopping. These materials are employed in wood working and cabinet making.

Casein Paints. — It has long been recognized that the addition of milk to whitewash increases its adhesiveness and durability. This result is principally due to a combination of the casein and lime. This compound, formed by the combination of casein with certain other substances, forms the basis of all the numerous casein paints of to-day.

Scherer gives the following formula for a paint for outside work:

100	parts	by	weight	of	casein, soluble in alkali.
100	"	"	"	"	caustic lime from marble.
800	"	"	"	"	levigated chalk.
2 to $2\frac{1}{2}$	"	"	"	"	ultramarine (for white only).
1	part	"	"	"	borax.

On the market to-day are casein paints of all kinds and colors, liquid and powder, some of which are: Casein Enamel Paint, Kalsomine Wash, Quick-Drying Casein Paint, Cold Water Paint, Boiled Oil Substitute, Waterproof Paint for Playing Cards, Casein Cement Paint, etc. Similar paints are prepared by the use of the whole milk instead of merely the casein constituent.

Milk-cement Paint. — A most effective and durable paint can be made from milk and cement by mixing one gallon of milk and about four pounds of Portland cement, adding sufficient Venetian-red paint powder (cost, 3 cents per pound) to give a good color. Any other paint powder of a different color can be used as well. This should be stirred thoroughly. The only objection to this is that the milk will not hold the cement in suspension on account of the great weight of the cement. It has to be thoroughly stirred all the time during its use.

About six hours after applying, the coat of paint will be dry, and it is not affected by water. The authors have used this paint with satisfaction. It seems to petrify the surface of the wood, which is evidently the reason why it is so preservative in its effect.

If water is used instead of milk, the paint will not adhere so well to the wood.

The paint when mixed with a little extra cement is a good substance for painting trees which have been injured. When painted on the bottom of the trunk of trees, it protects against rabbits gnawing them.

Plastic Masses from Casein.[1] — "Like all substances possessing strong adhesive properties, casein is specially adapted for the preparation of plastic masses, which can be molded, either in a mixture with organic substances like sawdust, wood meal, paper, etc., or alone in the form of paste or a more or less dry powder, and set hard when dry. Casein mixed with lime or other alkaline material can be converted, by the addition of a little water, into a plastic mass which, though very gradually, dries in the air to a transparent mass as hard as bone, and can be stained any color. In this condition it can be turned in the lathe or worked with any other cutting tool. When plastic casein is mixed with other substances, such as organic or finely powdered inorganic materials, the resulting masses are endowed with the property of drying quickly, especially under the influence of warmth. Care must, however, be

[1] Robt. Scherer. — *Casein, Its Preparation and Utilization.*

taken in the drying process, owing to the fact that all masses containing much water shrink and easily crack while drying.

"The adhesive properties of casein have already met with extensive industrial application. Great success has attended, for example, the attempts made to render celluloid uninflammable by admixtures of casein; and special mention will be made later of the newest celluloid substitute, galalith. This affords an instance of how modern ingenuity has enabled a raw material, hitherto of but slight use technically, to become of great industrial utility."

And so we have an imitation ivory and horn, and insulating preparation, and antiradiative and anticorrosive substance for covering steam and refrigeration pipes, a covering for floors that resembles linoleum, imitation leather, etc.

Consul General O. G. D. Huges of Coburg, Germany, reports the following:

"At the Hygienic Milk Suppiy Exhibition which was lately held at Hamburg, the Vereinigten Gummiwaren-Fabriken, of Hamburg and Vienna, exhibited a number of objects which seemingly had nothing to do with the Hygienic Milk Supply. There were shown nicely arranged in glass boxes, combs, seemingly made of bone, cigar holders with amber-colored mouthpieces, knives and forks with handles similar in appearance to ebony, ferrules for umbrellas and canes, and bells, rings, chess figures, dominoes, etc., also a small table with an inlaid marble slab, and finally a number of thick slabs and staves of every imaginable variation of marble colors, but of considerably less weight than marble. These objects were made of galalith, or milk stone."

Manufacture of Galalith. — This peculiar substance known as milk stone is prepared, according to Scherer, by the following method: Casein, prepared by precipitation with rennet instead of an acid, is mixed with 13 times its weight of water. This contains in solution $2\frac{1}{2}$ parts of caustic soda per 100 parts of dry casein. This produces a milky liquid, which may be cleared by adding a larger quantity of 5-per-cent caustic soda. The clear solution is treated with an acid to precipitate the casein, is dried and then moistened with a little acid to restore its plasticity. To prepare a hard casein mass (milk stone), the casein is treated with formaldehyde, pressed or molded into any desired form. Any desired coloring matter may be added to the casein before its treatment with formaldehyde, to produce imitation ebony, marble, etc. The final drying must proceed very slowly in order to prevent cracking.

Galalith, in a general way, resembles celluloid. The specific gravities of the two substances are about the same. Galalith is harder and less elastic than celluloid; it is hard to cut, and inclined to chip; it takes a higher polish than the celluloid; it cannot be made into so thin transparent sheets, and it absorbs some water when soaked.

Casein in the Textile Industry. — Casein is used largely in calico printing, and more rarely in the finishing. Finish refers to a glossy dressing like starch. The gummy ammoniacal solution of casein is employed as a medium for printing and fixing powdered pigments that will stand alkali. Fairly well fixed colors are obtained, when the ammonia has been driven off by vigorous drying and steaming. Casein dissolved in lime water may be used for the same purpose as the ammoniacal solution. In this case the colors are fixed by the action of the carbonic acid in the air, the products being calcium carbonate and insoluble casein.

Following are some of the casein products used in this industry: caseo gum, to assist fibers in absorbing dyestuffs; glutin, a glaze for dressing certain fabrics; and a product for waterproofing cloth and for loading silk (making it appear heavier than it really is).

Casein Foodstuffs. — The importance of proteids in the food of man is generally recognized. This essential is usually furnished to a large extent in the form of meat, but the proteids of milk may form a very satisfactory substitute for meat, and there are on the market for this purpose a number of casein products. Lactarine, Sanatogen and Galactogen are made up mostly of casein. Eulactol is an evaporated milk similar to our common milk powder. Plasmon, Nutrium, etc., are products consisting of casein, milk sugar, and salts.

Casein in the Paper Industry. — "An important part is played by the adhesives in the industries wherein paper is employed, both in order to inseparably fasten together individual sheets of paper, convert paper pulp into a mouldable condition, and also for the application of thin layers of colouring matter or other coatings may be either mat or more or less glossy, but in any event must be able to withstand to a certain extent the influence of moisture. For all these purposes casein is admirably adapted, since it will stick sheets or bands of paper together and forms thin coatings of considerable elasticity both alone or in association with other substances, colouring matters in particular. When a solution of casein is treated with small quantities of formaldehyde, and the article coated with the preparation exposed to the air, a number of new products can be obtained. Thus, for instance (by patented processes), we obtain waterproof cardboard boxes and cartridge cases, washable wall papers, washable paper garments, coloured papers, art papers, transfer papers and so on. Utensils, more particularly basins, dishes and the like, made of paper pulp or millboard, can be rendered waterproof by treatment with formaldehyde, and used for a variety of purposes, e.g., as developing dishes in photography. Similarly, cardboard treated in the same way can be used for stereotype matrices, and will keep for any length of time, by reason of its lightness and durability. It is thus evident that the field of application open to casein is practically illimitable."[1]

Other Uses for Casein. — Photographic plates may be made of casein and have some advantages over glass and celluloid, being lighter in weight and less fragile than glass, non-inflammable, and less likely to curl during developing than celluloid.

Casein even forms an important part in a brand of shoe polish. It is used to treat pulp board roofing and makes a fireproof covering that is not softened by the heat of the sun. Wooden casks used for beer, wine, etc., may be coated inside with a solution of casein and formaldehyde. This makes an impervious seal. Artists and scene painters require that their canvas be primed before it is painted. For this purpose casein gives better results than chalk, driers, etc., because it does not crack with age. The soap-making industry claims its share of casein for use in toilet soaps, perhaps because the casein aids in holding and re-enforcing the perfumes.

Buttermilk Poultry Food. — A poultry food, concentrated and high in protein, is made as follows:

Buttermilk is heated in tanks to about 160° F., and allowed to stand until the curd has settled. The whey is then drawn off, and the sediment, a mass of curd with a thick, creamy consistency, is run into barrels and sold as poultry food. This product, though heated to a high temperature, is not sterile, but, because of its thick consistency, has good keeping qualities. Like sweetened condensed milk, it contains insufficient moisture for bacterial growth.

[1] Robt. Scherer — *Casein, Its Preparation and Utilization.*

CHAPTER XXVIII.

FERMENTED MILKS.

DURING the past few years there has been a great increase in the consumption of buttermilk and other fermented milks. Buttermilk tablets and numerous other milk preparations have appeared on the market, for most of which a certain medicinal as well as food value is claimed. These are sold under various names, such as Zoulak, Vitallac, Yoghurt, Matzoon, Bacillæ, Kefir, Kumiss, Lacto-Bacilline, etc.

In practically all these fermented milks, lactic-acid fermentation is the main one. This may or may not be accompanied by a fermentation causing alcohol and carbon dioxide to be formed. This latter is brought about chiefly by yeast ferments acting on the milk sugar and other added sugars.

Food Value. — Since these products are all made of milk, either whole or skimmed, the composition of which is but slightly changed by the fermentation it undergoes, it is evident that the food value of these fermented products is practically the same as that of fresh milk. There is possibly an increased digestibility of the casein, due to the fact that it has been precipitated and is in a very finely divided condition. Those products containing alcohol and carbon dioxide are said to have a stimulating action upon the digestive organs.

Principles Involved. — In Metchnikoff's book "The Prolongation of Life" there is a chapter on "Lactic acid inhibiting intestinal putrefactions." He states that the use of fermented milks in combating autointoxication — toxic fermentations in the intestines — is based on the principle that the presence of lactic acid bacteria, and the products of their growth, prevent or inhibit the growth of the toxin-producing germs in the intestinal tract. It is probable that the beneficial results secured by the use of fermented milks are due to a combination of causes: First, the subduing influence of the lactic-acid-producing germs on undesirable ferments; second, the inhibiting effect of the lactic acid on toxin-producing germs; third, the influence of substances not necessarily acid in nature, secreted or produced by the milk ferments; and fourth, the stimulating effects and nutritive value of all the milk components.

Whatever the physiological action may be, it is certain that there are certain benefits to be derived from the use of fermented milks.

Tablet and Capsule Cultures. — Rogers[1] reports that some brands of tablets and capsules, sold under various trade names, purporting to contain great numbers of the Metchnikoff bacillus or Bacillus bulgaricus, were examined in the Dairy Division laboratory, and were found to contain very few of these desirable bacteria. When these tablets were introduced into sterile milk, the resulting fermentation was not of the desirable type. The milk was curdled, but the curd showed evidence of the presence of peptonizers and gas producers. One tablet which was advertised to contain "5,000,000 active Metchnikoff units" was found to contain about a million bacteria, nearly all of which were of the class usually considered undesirable inhabitants of the digestive tract. The findings of this and other laboratories indicate that little reliance can be placed on dried cultures of B. bulgaricus.

[1] *U. S. Dept. of Agri., Bu. An. Ind., 26th An. Rept.*

However, this does not apply to dry cultures of B. acidi lactici, because these are in daily use in butter and cheese factories throughout the country, and are known to contain a sufficient number of virile lactic bacteria to insure a desirable fermentation. So-called buttermilk tablets are simply dry cultures pressed into tablet form.

The germ Bacillus bulgaricus is capable of producing about two per cent of lactic acid in the milk, while the ordinary lactic-acid-producing bacteria in milk produce only a maximum of about one per cent acid.

Buttermilk. — Most common of all fermented milks is the by-product of the butter-making industry. Buttermilk is the milky portion of the cream that remains after the fat has been churned out of the cream. As cream is normally churned sour, the casein of the buttermilk is in a precipitated and very finely divided condition. The casein remains suspended in the liquid for several hours, but gradually settles to the bottom, leaving a transparent whey on top; occasional stirring keeps the buttermilk in its homogeneous milky condition. This universally common beverage needs no further description. When it comes from fresh and properly ripened cream it is a most refreshing and delicious drink.

Composition. — The composition of buttermilk does not differ essentially from that of skim milk. Its fat content is the one variable factor, and this depends upon the completeness with which the fat was churned out. The following is a fair example of the composition of average buttermilk:

	Per cent
Water	90.39
Fat	0.50
Casein and albumen	3.60
Milk sugar	4.06
Lactic acid	0.80
Ash	0.75

Artificial Buttermilk. — Natural buttermilk from fresh cream ripened with a lactic culture is perhaps the best quality of this product that can be secured; but in many places this cannot be obtained at any price. Much of the buttermilk of to-day has undesirable flavors in it. Because

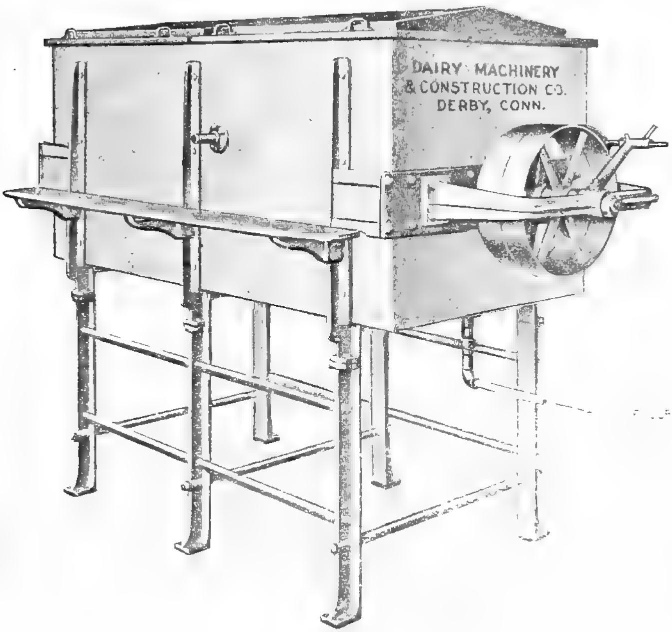

FIG. 46. — Progress milk fermenting machine.

of this fact, preparations are now found on the market which have all the characteristics of good buttermilk, but are not by-products of butter making. These preparations are made of whole milk, of partly skimmed milk, or of wholly skimmed milk. A method of making a so-called "skim-milk buttermilk" is as follows:

Milk to be used may be, 1, skim milk fresh from the separator; 2, pasteurized skim milk; or, 3, skim milk to which 5 per cent of whole milk has been added, to make the fat content similar to that of natural buttermilk. A large quantity of a good starter or pure culture of lactic-acid bacteria is next added, and the temperature brought to 70° F. Enough culture is added to have the milk curdled at a time when it will be convenient to churn it. The development of too much acidity or the ripening at too high a temperature causes the skim milk to "whey off" after it has curdled.

When thoroughly curdled the skim milk is placed in a churn and churned for forty minutes, just as cream is churned in making butter. The churning process thoroughly breaks up the curd particles and produces a smooth, thick liquid, which cannot be distinguished from ordinary good buttermilk.

Immediately after the buttermilk leaves the churn, it should be cooled to 50° F., or less, to prevent further development of acidity. Ordinary milk and cream coolers with enlarged holes in the distributing receptacle may be used satisfactorily for cooling buttermilk.

It is well to strain the buttermilk through one thickness of cheesecloth to remove any pieces of curd that may not have been broken up. The buttermilk is then put into bottles or cans and held at a low temperature until delivered.

Bacillus Bulgaricus for Buttermilk. — One objectionable property possessed by both natural and artificial buttermilk is that the precipitated casein settles out in a few hours, leaving clear whey on top. The casein is easily mixed with the whey again, but the settling of the casein may be prevented by using the Bacillus bulgaricus as the active ferment. This produces a viscous curd, that will not settle out.

If, in making artificial buttermilk, the skim milk be inoculated with cultures of both the common lactic-acid producer and the Bulgarian type, good results will not be obtained, because the two types of organisms have different optimum temperatures for growth. The common lactic-acid producer gives best results at about 70° F., while the Bulgarian type should be grown at about 100° F.

To get the best results, then, a batch of pasteurized skim milk is inoculated with a lactic-acid culture, and the milk ripened exactly as is done when making a starter in a creamery. An equal quantity of pasteurized skim milk is inoculated with the Bulgarian type of starter and incubated at about blood heat from twenty-four to thirty hours. It will then contain about two per cent acid (as much as 3 per cent acid will develop in 3 days). These two batches of sour milk are then mixed by pouring them both into a churn and churning the milk until the curd is all broken up and a smooth product is secured.

Buttermilk Tablets. — There are several brands of buttermilk tablets sold under various trade names. These are useful in making imitation buttermilk on a small scale in the home. One method of using these tablets is described by the manufacturers as follows:

" Take a quart of fresh, rich milk, put it in a clean jar or other vessel of glass or earthenware, and add thereto one-third of a quart of hot water. The amount of water may be varied according to the richness of the milk, the taste of the individual who is to be served, or the requirements of the patient if it is to be used in the sick-chamber. The purpose in adding hot water is to raise the temperature of the milk to body heat. A pinch of salt is now stirred into the mixture together with one " Lactone " tablet which has been previously powdered, the whole being well mixed until the tablet is dissolved. The jar is then covered and set aside where it will be subjected to an even temperature, such as that of the average kitchen. In twenty-four to forty-eight hours, depending upon the temperature, the buttermilk will be ready for use. One can easily tell, by the appearance and flavor of the milk, when the process of thickening and fermentation has proceeded far enough. The buttermilk should then be set away in the ice-box or cellar. Before using, it should be thoroughly stirred with a spoon or egg-beater until perfectly smooth."

This artificial buttermilk is sometimes modified at soda fountains by the addition of vichy or seltzer, by beating an egg into it, or by adding vanilla, lemon or other flavors.

Kefir. — Fermented milks have been used by the people of southern Russia, Turkey and the Balkan countries, for many centuries. There are no records and but few traditions of the origin of the fermented milks they use, and it is probable that their preparation and use developed gradually by cumulative experience.

One of the first fermented drinks known to Europeans was kefir. This was first made in the Caucasus Mountains from milk of cows, sheep and goats. Different tribes made this drink under different names [1] such as " Hippe," " Kepi," " Khapon," " Kephir " and " Kapher," all of which names are said to be derived from a root signifying a pleasant taste.

The fermented milk forms a large part of the food of the Caucasian mountaineers. The milk is prepared in leather bottles made of goat skins. These bottles are hung where the atmosphere is supposed to have the temperature favorable to the proper fermentation of the milk. This may be in or out of doors, in the sun or in the shade. A favorite place for hanging the bags is near a doorway where they may be shaken by each passer-by.

[1] *U. S. Dept. of Agr., Bu. An. Ind., An. Rept.*, 1909.

In order to prevent the escape of gas when drawing milk from the bag, a string is first tied around the neck so that the quantity wanted is between the stricture and the mouth of the bottle.

One characteristic of kefir that especially distinguishes it from other fermented drinks is the so-called kefir grain, which is used to start the proper fermentation. These kefir grains are small, yellowish, convoluted masses, consisting largely of bacterial threads and yeast cells, held together by more or less dried milk. When these grains are added to milk they induce a fermentation of the lactose, forming alcohol and carbon dioxide.

Freudenreich[1] describes four organisms that he isolated from kefir grains. Of these, one was yeast to which he gave the name "Saccharomyces kefir"; this organism was found to grow best at 22° C. (72° F.); but not at all at 35° C. (95° F.). This yeast ferments maltose and cane sugar, but not lactose. It produces a peculiar flavor in milk. The same investigator found two organisms of the lactic-acid type, but they formed gas in lactose media. Another organism described is a long, slender bacillus to which Freudenreich gave the name "Bacillus caucasica." The properties of this organism indicate that it resembles very closely the well-known Bacillus bulgaricus. If Freudenreich's description is accurate, B. caucasicus differs from B. bulgaricus in forming gas from lactose and in being feebly motile. No one of these organisms grown alone produced kefir, but when the four together were grown in milk, typical kefir was produced on the first or second transfer.

Various investigators have found different organisms in the kefir grain. It seems probable that kefir may be produced by any combination of bacteria and yeasts that

[1] *U. S. Dept. Agr., Bu. An. Ind., An. Rept.*, 1909.

produces a lactic acid and an alcoholic fermentation in milk. Certain organisms may be necessary for the development of the typical kefir flavor.

Hammarsten shows the changes brought about in cows' milk, by this fermentation, in the following table:

CHEMICAL ANALYSIS OF KEFIR.

	Two days old.	Four days old.	Six days old.
Casein	2.570	2.586	2.564
Lactalbumen	0.425	0.405	0.390
Peptones	0.071	0.089	0.120
Lactose	3.700	2.238	1.670
Fat	3.619	3.630	3.628
Ash	0.641	0.624	0.630
Lactic acid	0.665	0.832	0.900
Alcohol	0.230	0.810	1.100

As indicated in the table, the only constituent of the milk appreciably affected is the lactose. By its fermentation, lactic acid, alcohol and carbon dioxide are formed. The physical condition of the casein is changed, and it may be more easily digestible because of its finely divided condition.

The following directions are given for making kefir when the grains are obtainable. Soak the grains in warm water to soften them, changing the water several times. The grains are ready for use when they become gelatinous and whitish and rise to the surface. The grains are then added to bottles of pasteurized milk held at a temperature of 57° to 60° F., and stirred or shaken occasionally. After 8 to 10 hours, the grains are strained out and the milk put into tightly stoppered bottles. The fermentation is continued at the same temperature and the bottles shaken occasionally to prevent the formation of hard lumps of curd. After about twenty-four hours, the kefir is ready for use. The relative amounts of alcohol and lactic acid are dependent upon the temperature of fermentation. A high temperature favors the alcoholic fermentation and a slightly low temperature favors lactic-acid fermentation.

The grains are used merely to start the fermentation. After their removal, the process continues without their aid. The grains may be washed free from curd, dried and laid aside until wanted again. In their dry state, they are said to retain their vitality for several years.

Kumiss. — When explorers and missionaries first visited the plains of European Russia and central and southwestern Asia, they found the native nomadic tribes living to a large extent on a fermented milk now known as kumiss. This food was prepared from mares' milk. It is said that the proper fermentation was induced by the addition to the fresh milk of pieces of decaying flesh or vegetable matter. These tribes are great horsemen, and they have developed mares that give an unusually large quantity of milk.

Mare's milk is lower in nutritive value than cows' milk, as the following table shows: [1]

AVERAGE COMPOSITION OF COWS' MILK AND MARES' MILK.

<table>
<tr><th></th><th>Water.</th><th>Fat.</th><th>Sugar.</th><th>Casein.</th><th>Albumen.</th><th>Ash.</th></tr>
<tr><td></td><td>Per cent.</td><td>Per cent.</td><td>Per cent.</td><td>Per cent.</td><td>Per cent.</td><td>Per cent.</td></tr>
<tr><td>Cow</td><td>87.10</td><td>3.90</td><td>4.75</td><td>3.00</td><td>0.40</td><td>0.75</td></tr>
<tr><td>Mare</td><td>90.06</td><td>1.09</td><td>6.65</td><td colspan="2">1.89</td><td>0.31</td></tr>
</table>

[1] Richmond — *Dairy Chemistry.*

The composition of kumiss varies somewhat with the age, the rapidity of the fermentation, and the nature and extent of contamination with extraneous organisms.

COMPOSITION OF KUMISS MADE FROM MARES' MILK.[1]

	One day old.	Eight days old.	Twenty-two days old.
	Per cent.	Per cent.	Per cent.
Water	91.43	92.12	92.07
Alcohol	2.67	2.93	2.98
Lactic acid	0.77	1.08	1.27
Sugar	1.63	0.50	0.23
Casein	0.77	0.85	0.83
Albumen	0.25	0.27	0.24
Albumose	0.98	0.76	0.77
Fat	1.16	1.12	1.30
Ash	0.35	0.35	0.35

The fermentative changes in kumiss are very similar to those in kefir. The main difference between these two products is the origin of the milk.

American Kefir or Kumiss. — Several dairy companies that cater to fancy city trade make a fermented milk and market it under the name kefir or kumiss. This product is, strictly speaking, not kumiss, because it is made of cows' milk instead of mares' milk. Nor is it kefir, because this latter product is the result of fermentation induced by kefir grains. However, the prefix "American" might be used to distinguish it from that of Asiatic origin. This American product is hygienic, being prepared from sanitary milk and fermented by carefully selected organisms.

The best results are secured by inducing an alcoholic fermentation in good buttermilk. The use of buttermilk insures a finely divided casein and a smooth, homogeneous product.

For the alcoholic fermentation, ordinary bread yeast

[1] Richmond — *Dairy Chemistry*.

may be used; but this yeast cannot ferment lactose, hence cane sugar must be added to the milk. The yeast may be added directly to the buttermilk, but better results are secured as follows: To four ounces of boiled water, add about ten grams of cane sugar and one third of a yeast cake. Do not add the yeast till water is cooled. Keep in a warm place (70° to 80° F.) over night, or for about ten hours. This produces an active culture of the yeast. To each quart bottle of buttermilk add 15 grams of cane sugar and 2 c.c. of yeast culture. Cap the bottles with patent stoppers or other tight caps that will withstand gas development within the bottle. Keep at a temperature of about 60° F. for from three to four days with occasional shaking to break up the curd. At the end of this time, the product will be ready for use. Fermentation at a high temperature, and continued for too long a time, produces a strong undesirable flavor. The amount of alcohol and carbon dioxide developed depends upon the amount of sugar added to the buttermilk. The theoretical quantity of alcohol formed is about one half the quantity of sugar fermented. The carbon dioxide, rather than the alcohol, is the desirable product of the yeast fermentation. The quantity of sugar to be added is governed by the quantity of carbon dioxide desired. Fifteen grams of sugar in one quart of buttermilk (1 per cent of sugar) produces the desirable effervescence, and the sharp taste of charged water, but will not cause an excess of gas.

A similar product may be made from skim milk instead of buttermilk. In this case the milk should be pasteurized and a slightly larger percentage of sugar (two to three per cent) be used. This product lacks the sharp acid flavor of the buttermilk product, but has the pleasant gas-charged flavor.

Yoghurt. — The people inhabiting the countries bordering the eastern end of the Mediterranean prepare a milk that is quite different from those previously mentioned. Yoghurt is a thick curdled milk, high in acid, but containing little or no alcohol. It is prepared from goats', buffalos', and cows' milk. This is usually boiled, and sometimes the boiling is continued until the milk is evaporated to one half its original volume. In the latter case the product has the consistency of pudding and instead of being used as a drink, is eaten, sometimes with the addition of dates, bread or other food.

The different people of this region have various names[1] for their prepared milks, but the products are all very similar. The Turks use the names "yoghurt," "yahourth" and "jugurt"; the Balkan people, "kisselo melko"; the Armenians, "mazum"; the Sardinians, "gioddu"; and the Egyptians, "leben" or "leben raib."

Several investigators have studied these fermented milks from a bacterial standpoint, and have isolated certain organisms and applied various names to them. But the opinion generally held by investigators, at the present time, is that the various organisms necessary for the production of milks of the yoghurt class, all may be included under the name Bacillus bulgaricus.

This Bacillus bulgaricus has a very characteristic action when grown in milk. In a few hours at the optimum temperature (about 100° F.) a curd is formed that is rather soft, sometimes shiny, and does not settle to the bottom or "whey off" upon long standing. The acidity of the milk may reach two per cent in twenty hours and three per cent after several days.

[1] *U. S. Dept. of Agr., Bu. An. Ind., An. Rept.,* 1909.

Ropy Milk. — Fermentation of milk by Streptococcus hollandicus produces a slightly sour milk with a thick slimy consistency.

In Norway and Sweden, and also in Finland, it is a commercial article, and is brought into the towns by the peasants to be sold in much the same way as butter is brought into the towns to be sold here, only on not so large a scale. In Holland it is called "langewej," and is there used chiefly as a starter to control the gassy fermentation in the manufacture of Edam cheese.

Moscow Sour Cream. –This product is made from cream that has undergone a good acid fermentation. Having been thoroughly mixed in the starter, the mass is allowed to stand undisturbed at a temperature between 77° and 90° F., for six or more hours until ripe. When it reaches such a point that an acid flavor can just be detected, it is taken to a cold room or ice box. While it is being cooled all the cream thickens to a uniform mass without clots, and has a pleasant, acid taste. This sour cream is thick and solid. It may be cut with a knife like butter. The fermentation is effected in wooden or glass vessels, never in metal vessels. The latter would give it a metallic taste. There is no need whatever to press the sour cream, for the whole of the cream is used without any separation of whey. The sour cream must not be agitated. When putting it into boxes or casks, care must be taken to put it in layer on layer. It can be quite safely transported in wooden boxes lined with parchment. As the sour cream is solid, there is no necessity to add any preservative. With a temperature in the cellar of 48° to 55° F. when the casks or cases are put in, the sour cream will keep for three or four months.

There are some milk preparations which are allied to fermented milks, but which have undergone no special fermentation. Carbonated milk and Devonshire cream come in this class.

Clotted or Devonshire Cream. — Devonshire cream used to be a special product of the West of England. However, it can be made anywhere, provided the milk be rich and the treatment correct. The milk should be strained while warm into the pans in which it is to be scalded. These pans are from 6 to 8 inches deep and about eighteen inches in diameter, and are made to fit into a pan of water, which in turn fits on to a stove.

The milk sets for twelve hours until the cream has risen. Then the fire is lighted and the cream is scalded. The water jacket prevents the temperature rising too high, which would give a cooked taste to the product; and when the process is complete, handles on the side of the pan enable it to be lifted off easily. The great art in scalding is to get a thick unbroken layer of cream on the surface with a wrinkled, yellow appearance. The heating should be done slowly, until a temperature of from 180° to 185° F. is attained, at the rate of about 2° per minute for an hour.

The cooling is accomplished either by raking out the fire for slow cooling, or by setting the pan in cold water for quick cooling, after which the cream is ready for use or for putting into jars. For quick work, on a large scale, the cream is sometimes separated, and then a thick layer put back onto pans of separated milk, and then scalded. The cream must be scalded on the milk, as it cannot be done satisfactorily alone. Both the milk and the cream keep well, because the process is equivalent to pasteurization. For small quantities, any kind of a pan on any kind of a stove will do if conditions are observed and the process carried out carefully.

Carbonated Milk. — Van Slyke and Bosworth,[1] in making a study of the chemical changes in kumiss made from cows' milk, noticed that lactic acid formed in it much more slowly than in ordinary milk. This was found to be due to the action of carbon-dioxide gas under pressure.

A series of experiments was conducted in order to ascertain the effect of carbon dioxide under pressure upon the development of lactic acid in milk. The results of these experiments are reported in the New York Geneva Station Bulletin 292.

The milk used was (1) fresh, separator skim milk; (2) fresh whole milk, drawn and handled under good hygienic conditions; (3) fresh skim milk pasteurized at 185° F., and (4) fresh whole milk pasteurized at 185° F.

The pressures of gas employed were 71, 150 and 175 pounds per square inch.

The most effective method of treating the milk was to charge it with carbon-dioxide gas at the desired pressure in a tank such as is used in bottling establishments in preparing carbonated drinks, and then to fill into bottles.

The carbonated milk was kept at temperatures varying from 35° to 70° F.

Pasteurized milk, carbonated, kept for five months with little increase of acidity. Fresh, raw whole milk, carbonated, kept in one experiment for about the same length of time.

Carbonated milk makes a pleasant beverage and may find practical use as a healthful drink. It may also be found useful for invalids and children.

The effect of carbonating milk upon organisms other than lactic has not yet been studied.

Milk carbonated under a pressure of 70 pounds comes

[1] *Geneva, N. Y., Bul.*

from the bottle as a foamy mass, more or less like kumiss that is two or three days old. It has a slightly acid, pleasant flavor, due to the carbon dioxide, and tastes somewhat more saline than ordinary milk. In the case of carbonated milk pasteurized at 185° F., there is something of a "cooked" taste. Though the cream separates in the bottle, it is thoroughly remixed by a little shaking as the milk comes from the bottle, and there is no appearance of separate particles of cream. All who have had occasion to test the quality of carbonated milk as a beverage agree that it is a pleasant drink. Milk bottled under a pressure of 150 pounds of carbon dioxide is about the consistency of whipped cream. On standing a short time, it changes into a readily drinkable condition. From the authors' experience it would seem that carbonated milk might be made a popular beverage.

CHAPTER XXIX.

CONDENSED AND EVAPORATED MILK.

The purpose of condensing milk is twofold: to improve its keeping property, and to lessen its bulk. These two objects must be attained without changing any of the essential properties of any of the milk components and still have these components soluble again when water is added. In this latter form, it should have all the flavor and appearance of fresh normal milk.

Extent of the Industry. — The United States Census Report of 1905 reports 81 milk-condensing factories in the United States during that year. These factories were distributed over 17 states and manufactured about 320,000,000 pounds of condensed milk. During the past six years this industry has been making very rapid strides. The number of condenseries has about doubled, and the pounds of finished product have reached the half-billion mark.

The consumption of condensed milk is increasing rapidly, not only in the tropic and arctic regions, on shipboard, in mining and lumber camps where little or no milk is produced, but also in our local home markets. The ice-cream industry is responsible for a considerable demand on the condensed milk supply. The baker and candy maker also use their share, and many housewives, especially in our large cities, find the canned product more reliable than that furnished daily by the city milk plant. This is true mainly in cities that have had no pure milk crusade.

United States Standards. — In the Federal Food and Drug Act that went into effect January 1, 1907, condensed and evaporated milk are classified as follows:

"*Condensed Milk*, *Evaporated Milk*, is milk from which a considerable portion of water has been evaporated and contains not less than twenty-eight (28) per cent of milk solids of which not less than twenty-seven and five-tenths (27.5) per cent is milk fat.

"*Sweetened Condensed Milk* is milk from which a considerable portion of water has been evaporated and to which sugar (sucrose) has been added, and contains not less than twenty-eight (28) per cent of milk solids, of which not less than twenty-seven and five-tenths (27.5) per cent is milk fat.

"*Condensed Skim Milk* is skim milk from which a considerable portion of water has been evaporated."

Evaporated milk is unsweetened condensed milk put up in hermetically sealed cans holding from six and one-half to twenty ounces, and also in quart and gallon cans. This product is somewhat deceiving to the eye. It appears to be very thick and rich, while, as a matter of fact, the milk is condensed only from about two or two and one-half parts of the fresh milk, to one of evaporated milk. It contains no cane sugar to act as a preservative, but is sterilized by steam under pressure.

Plain condensed milk is made in a similar manner, but is not sterilized. It is usually marketed in ordinary milk cans in the same general manner as fresh milk. It will keep in good condition for from ten to thirty days, if kept at a low temperature. It is intended for early consumption, and is used by hotels, restaurants, and candy and ice-cream makers, as starter milk in butter factories, and to some extent in private houses.

Sweetened condensed milk is that to which sufficient sugar has been added to prevent fermentation. This is a very thick syrupy product containing about forty per cent cane sugar and twenty-eight to thirty-six per cent milk solids.

Quality of Raw Product. — The quality requirements of milk for condensing purposes, especially for evaporated milk, are higher than for any other purpose. The condensary usually keeps an inspector on the road all the time, and the patrons are required to follow his suggestions. Some condenseries require all patrons to use a certain style of milk cooler, and require the milk to be below a certain temperature — 55° to 60° F. — when delivered at the factory. Bad odors or dirt in the milk is not tolerated.

The condensery operator claims that milk from cows fed on silage, brewers' grain and similar feeds, curdles much more readily than that from cows not fed on these feeds; hence where evaporated milk is made, such feeds are usually forbidden. In some instances these feeds are permitted, but the time of feeding and the amount fed are restricted.

The following rules and regulations are enforced by the Pacific Coast Condensed Milk Company:

"1. All cows must be healthy and in good flesh at all times, be milked at regular hours, morning and evening, and in a cleanly manner. They must be kindly treated and no milk will be accepted from cows that are overheated or excited from any cause.

2. The milk must be cooled and aërated immediately after milking, and put into tin cans which have been rinsed in clean, cold water. Both milk and cans must be kept where they will be free from filth or bad odors.

3. The cans of milk must be left with the lids off, in cold water to prevent rise in temperature, until ready for delivery. They should be covered with wire screen or clean cloth to prevent foreign substances from getting into the milk.

4. By the use of coolers milk can be reduced immediately to within a few degrees of the temperature of the water used. Milk higher than 65° F. will not be accepted at the factory.

5. Tin pails only are to be used to milk in, and they must be thoroughly washed and scalded every time they are used, and allowed to dry in the open air, in the sun if possible, and must not be used for any other purpose.

6. The night's and morning's milk shall not be mixed, and no milk shall be kept over to be delivered at a subsequent time.

7. The evening's milk must be kept at or below a temperature of 55° F., and out of contact with dirt or bad odors.

8. When the cans in which the milk is transported to the factory are not in use, they shall be turned down on a rack with the covers off, except only when in transit.

9. All milk, including the strippings, shall be delivered. No milk shall be delivered which is taken from cows that have calved within twelve days, nor from any cow that is to calve within thirty days.

10. If there is good reason to suspect that water has been added, or cream removed, or that milk has not been properly cooled, or that it has been injured by carelessness or from filth, or if the cans are filthy, such milk will be refused.

11. Cows must not be allowed to eat sour, noxious grasses and weeds, or other objectionable food. No still or brewers' grains, or slops, sorghum or glucose refuse, cabbages, ensilage or other damaged or decayed food of any kind shall be fed under any circumstances, and sugar beets, turnips and red carrots only in small quantities and soon after milking.

12. Stables and sheds where cows are kept must be clean and free from foul odors.

13. Our inspector shall have the right to visit the premises of our patrons at any time, and all suggestions made by him must be carefully carried out.

14. We shall refuse milk from anyone violating these rules."

The Condensing Process.—The condensing of milk has been developed to its present state of perfection only by the expenditure of much time and money in experimenting. To be a high-grade marketable product, the milk must be condensed under very exact conditions, and brought to the proper degree of condensation. Milk

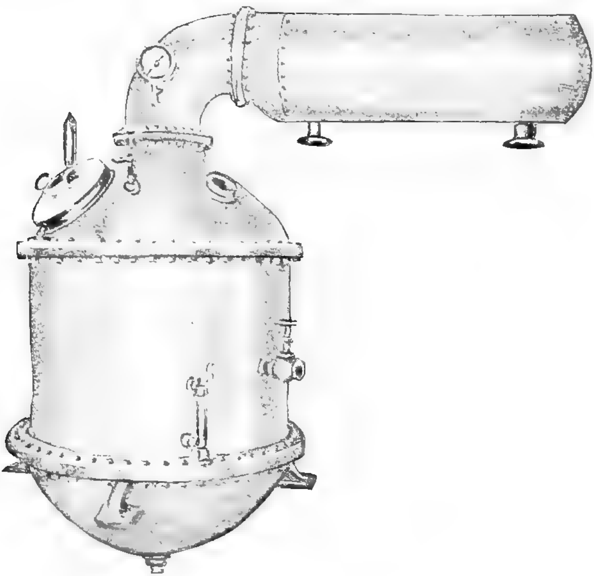

FIG. 47.—Milk condensing pan.

not properly condensed may have a marked cooked flavor, or be curdy, or contain lumps of butter, instead of being smooth and homogeneous.

To avoid the cooked flavor and to prevent the milk from burning to the inside of the condenser it is necessary to condense or evaporate at a low temperature.

The boiling-point of milk, like that of other liquids, varies according to atmospheric pressure. The boiling-point of milk is a little higher than that of water, viz., about 214° F. At such a temperature, during so long a time as is necessary for evaporation, the milk assumes a marked cooked flavor, and some natural characteristics of the milk components change. For instance, the sugar caramelizes, the fat melts into oil so as to make remixing difficult, some albumen coagulates, and a portion of the calcium phosphate salts separates from the casein. If the atmospheric pressure is reduced so as to bring the boiling-point to from 120° to 130° F., evaporation takes place and the undesirable changes incident to higher heat are absent. This is effected in the apparatus known as a vacuum pan. Such a pan consists usually of four chief parts:

1. The pan or kettle, which holds the milk and which is usually lined with bright copper.

2. A steam jacket, around the pan or steam coils, or both, to supply the heat necessary for evaporation.

3. The condenser, connecting with the top part of the pan for condensing the steam and creating additional vacuum. Cold water constantly circulates through the condenser.

4. The vacuum pump, used for reducing the atmospheric pressure in the pan by pumping out the air and for removing steam and water in case a wet vacuum is used. If a dry vacuum is used, the pump removes only the air, and the water flows out by its own gravity.

So far as known, Mr. Gail Borden of the United States was the inventor of the vacuum method of milk condensation. A patent was taken out by him in the United States in 1856. One objection to this first condensed milk was that it would keep only a few weeks.

Mr. C. A. Page, then United States consul at Zurich, improved the Borden method by adding sugar. This made the concentration of nutrients so great that bacteria did not develop in it, even if constantly exposed to the air. Mr. Page started a factory in Switzerland. In 1866 he was succeeded by the Anglo-Swiss Milk Company, which located a large factory on Lake Zug in the canton of that name. This company prospered and so far as known still exists and has branches in the United States, Germany, England and Switzerland. It supplied practically the whole of Europe with condensed milk. The Borden Condensed Milk Company is one of the largest in this country.

Before the milk is put into the vacuum pan, it is heated and run through a clarifier to remove all physical dirt and some of the objectionable odors. Then it is passed on to the vacuum pan, where the condensation takes place.

Enough air is pumped out of the vacuum pan so that it will show a vacuum or air pressure of 24 to 28 inches as measured by a mercurial column vacuum gauge. In such a vacuum, milk boils at a temperature of from 105° to 135° F. It is very essential to keep the vacuum pump working uniformly in order to maintain a constant vacuum. Should the vacuum be greatly lessened, evaporation would cease, the temperature of the milk would rise, and the entire batch of milk might be spoiled. Condensation is continued until a sample drawn from the pan shows the proper degree of concentration as determined by a Baumé hydrometer.

Degree of Concentration. — This is undoubtedly the most important point in the process. When concentrated too much, the result may be curdled milk. When not sufficiently concentrated, the fat separates and may churn in subsequent processes. In either case the commercial value of the product is greatly lessened.

By concentrating the milk by evaporation of water the per cent of acid and other non-volatile chemicals are increased. This may be illustrated as follows: Supposing the milk to be condensed contained 0.2 per cent acid, and this milk was condensed to one half its volume, the per cent acid contained in the finished product would be twice its original per cent, or 0.4 per cent. By further condensation, the per cent acid will increase proportionately. The great importance of having milk with a low acid content for condensed milk is readily understood. This increased per cent of acidity after condensation and increased heat during the condensation period are likely to cause the milk to curdle and become lumpy. This latter is very undesirable. Condensed milk should have a uniformly smooth body. If it has not, the trade rejects it. It is possible that other components of milk affect the properties of the finished product similarly to the acid on concentration and heating.

The following table[1] shows the results of evaporating fresh milk to different degrees of concentration.

Lot No.	Concentration.	Per cent of acid.	Condition of casein.
1	1.58 : 1	0.30	Not precipitated.
2	1.74 : 1	0.34	Not precipitated.
3	1.9 : 1	0.40	Not precipitated.
4	1.99 : 1	0.43	Not precipitated.
5	2.11 : 1	0.48	Small lumps of curd.
6	2.25 : 1	0.54	Large lumps of curd.

The different lots of evaporated milk were made from the same batch of fresh milk.

Another kind of undesirable condensed milk is that which is churned. It is important that the butter fat be properly emulsified with the remainder of the milk com-

[1] *Indiana Bul.* 143.

ponents. Butter lumps in the condensed milk are due chiefly to the condensed milk being too thin when put into the shaker. This condition of the fat may also partially be caused by allowing the condensed milk to cool without shaking immediately after it has been taken out of the sterilizing oven. Except in case of accidents to machinery, this factor seldom enters in as a cause of churned condensed milk.

A third factor causing losses to the condenseries is improper sterilization. Even though the milk is sterilized in steam-pressure ovens, some ferments are not destroyed. In order to be sure that the sterilization has been complete, the sealed cans containing the condensed milk are put into a testing room. The temperature of this room is kept uniform and high enough for rapid growth of germs. If any ferments remain, the cans show it in a few days by bulging or distended sides. This latter is due to the development of gas. The cans showing this characteristic are discarded.

Hunziker[1] carried on some experiments in connection with the Indiana Condensed Milk Company at Sheridan, Indiana, to demonstrate the effect of different degrees of concentration on the marketable properties of evaporated milk. The results are tabulated below:

JUNE EXPERIMENT.

No.	Concentration.	Milk solids, per cent.	Condition of sample one month after manufacture.
1	1.61 : 1	20.40	Fat separated and churned, no curd.
2	1.96 : 1	24.87	Smooth, no separation, no curd.
3	2.00 : 1	25.38	Smooth, no separation, no curd.
4	2.20 : 1	28.02	Curdy, lumps of curd, fat not separated.
5	2.52 : 1	31.99	Curdy, lumps of curd, fat not separated.

Total solids in fresh milk, 12.68 per cent.
Acidity in fresh milk 0.16 per cent.

[1] *Indiana Bul.* 143.

AUGUST EXPERIMENT.

No.	Concentration.	Milk solids, per cent.	Condition of sample one month after manufacture.
1	1.94 : 1	22.79	Fat separated and churned, no curd.
2	2.11 : 1	24.81	Fat separated and churned, no curd.
3	2.21 : 1	26.01	Smooth, no separation, no curd.
4	2.33 : 1	27.33	Curdy, small lumps of curd, no separation.
5	2.5 : 1	29.37	Curdy, lumps of curd, no separation.

Total solids in fresh milk, 11.75 per cent.
Acidity in fresh milk, 0.12 per cent.

NOVEMBER EXPERIMENT.

No.	Concentration.	Milk solids, per cent.	Condition of sample one month after manufacture.
1	1.58 : 1	21.12	Fat separated and churned, no curd.
2	1.74 : 1	23.25	Fat separated and churned, no curd.
3	1.9 : 1	25.48	Smooth, no separation, no curd.
4	1.99 : 1	26.62	Smooth, no separation, no curd.
5	2.11 : 1	28.23	Curdy, small lumps of curd, no separation.
6	2,25 : 1	30.10	Curdy, lumps of curd, no separation.

Total solids in fresh milk, 13.40 per cent.
Acidity in fresh milk, 0.17 per cent.

The following conclusions are drawn by the investigator:

"These experiments show that, in this particular factory, a hard curd is formed in the evaporated milk when the concentration is carried as far as 28 per cent solids. They further show that there is a distinct difference in the behavior of the milk at different times of the year. In spring or early summer there is a greater tendency for curdy milk than later in the season. It has been experimentally shown that, in some localities and at certain seasons of the year, a marketable evaporated milk cannot be made when the product is condensed sufficiently to contain over 24 per cent solids."

When the milk is drawn from the condensing pan it is ready to be canned, but as this requires some time, the milk is first cooled to prevent acid development and other fermentations. The cooling is usually accomplished by means of a coil in a manner similar to that of cooling fresh milk in a city milk plant. The cooled milk is stored in sanitary tanks, drawn out a little at a time, and run into the can fillers, which are operated in a manner similar to the operation of the common milk-bottle filler. The canning process is completed with the soldering on of the tops.

Sterilization. — This canned evaporated milk quickly undergoes fermentation unless absolutely sterilized. In order to effect sterilization it is necessary to heat the milk under steam pressure. The sterilizers used are similar in construction and principle to the autoclave used in the bacteriology laboratory, except that they are larger. They are so arranged that trucks loaded with cases of milk may be run into them on a track.

The degree of heat employed and the duration of the heat exposure of the condensed milk are very important factors. Even perfectly sweet, normal milk curdles at a temperature of 269° F., and the more concentrated the milk the lower the temperature required to curdle it. There are other factors, such as the per cent of casein present, the relative amounts of the different ash constituents, etc., which influence, to a greater or less degree, the curdling point of milk. Temperatures ranging from 226° to 245° F. are used to sterilize condensed milk.

The greater the degree of heat, and the longer the exposure, the more intense is the action on the condensed milk, and, therefore, the harder the coagulum formed. Since absolute sterility of the milk is necessary, and since heat is the only agent that can be used to bring this condition about, the milk must be exposed to such degree of heat, and such duration of that heat as will accomplish complete sterilization.

Shaking the Canned Milk. – The condensed milk having been sterilized in sealed cans, the next process in order

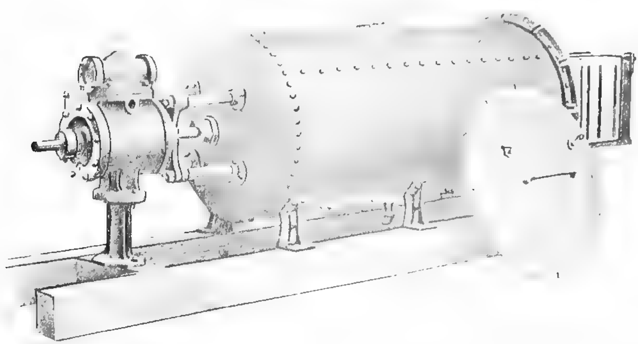

FIG. 48. — Combined machine for sterilizing and shaking condensed milk.

is the shaking of the cans to break any lumps of curd or fat that may have formed, and to insure a smooth, homogeneous mixing of the fat. The shaking machine may be combined with the sterilizer or it may be a separate piece of apparatus.

After the shaking process, the cans are placed in the testing room, or incubator, as it might be called, where they are kept at about blood heat for several days. If any live spores are present in the milk, they will germinate and multiply rapidly at this high temperature. Any cans of milk that have fermented are readily detected on account of distended sides and are thrown out when the cans are removed from the store-room. The cans are so arranged that the oldest ones can be removed first.

Composition of Evaporated Milk. — When milk is concentrated in the ratio of two parts of fresh milk to one part of condensed milk, it is evident that the percentage of the various milk constituents in the evaporated product would be just double that in the fresh milk.

The following, from Leach, is a fair example of a good quality of evaporated milk:

Total solids.	Water.	Milk sugar.	Proteids.	Fat.	Ash.	Number of times condensed.
28.16	69.24	9.85	8.66	8.1	1.55	2.2

Composition of Sweetened Condensed Milk. — In the manufacture of sweetened condensed milk, the process employed is similar to that used in the production of evaporated milk. The great difference is the addition of cane sugar. This addition of cane sugar obviates the necessity for sterilization and hence enables the manufacturer to omit that very delicate process.

Another difference between evaporated and sweetened condensed milk is that the latter is carried to a greater degree of concentration, commonly 32 per cent of milk solids and often more than this. When milk is too thin the sugar deposits in the bottom of the cans, and this greatly decreases its commercial value. The greater the degree of concentration, the better are the keeping qualities. Thin milk is more prone to undergo fermentation than the highly concentrated product. Hence we find sweetened condensed milk usually concentrated in the proportion of two and three-fourths to one.

The composition of this product varies between wide limits, but a fair example of a good quality of sweetened condensed milk is, according to Leach, as follows:

Total solids.	Water.	Milk solids.	Cane sugar.	Milk sugar.	Proteids.	Fat.	Ash.	Number of times condensed.
74.29	25.71	32.37	41.92	11.97	8.46	10.65	1.29	2.3

Relatively Large Investment Needed. — The establishment and operation of a milk condensery is a much larger proposition than the manufacture of butter or cheese. More milk is also necessary within a given radius. A condensing plant is usually not very prosperous unless there is a milk supply of 50,000 pounds per day. An expensive building and expensive machinery are required. A good supply of cold water is a requisite. Roughly speaking, a supply of ten times as much water as there is milk to be condensed should be assured. The steam required is also a large item. For each 1000 pounds of milk to be condensed per day, about six horse power of steam is needed. However, the profits are proportionately great, and a properly conducted factory with an ample supply of milk usually prospers.

The large condensery finds it economical to use all possible labor-saving devices. Cases are nailed with a nailing machine and the labeling is done automatically. Cans are fed in at one end of the labeling machines, are carried along, a label is pasted on, and the cans are delivered at the other end directly into the shipping cases without further handling.

However, milk condensing as a side line for the ice-cream manufacturer, city milk dealer, and creamery man has been adopted in a few instances. Machinery is on the market for condensing as small quantities as 250 to 6000 pounds of fresh milk daily. This apparatus may be installed for about one thousand dollars, and may be of value in turning surplus milk into bulk, condensed milk, provided a market for this product is assured.

CHAPTER XXX.

MILK POWDER.

Some economist has calculated that because milk is nearly nine-tenths water the transportation of this natural product costs ten times as much as it should. Figuring on a basis of 2,000,000 quarts per day as New York City's daily milk supply, he finds that the people are losing about $17,500 per day. This is the expense of the shipping, carting, hauling, bottling, etc., of the watery portion of the milk. This means an annual loss, in N. Y., of $6,500,000 from this source. On this basis the national loss is estimated to be about $63,000,000 per annum.

Without accepting or discussing the accuracy of the above calculations, or the necessity for bringing to the consumer a natural, uncondensed product, we must admit that there are many places where a good concentrated milk could replace the bulky natural product, and where milk in that form would be and is used when the natural milk cannot possibly be utilized.

One pound of condensed or evaporated milk represents but two to two and one-half pounds of raw milk, while one pound of milk powder represents about eight pounds of natural milk.

Advantages of Milk Powder. — The chief desirable results of reducing milk to powder may be summed up as follows. This refers to milk powder made from skim milk.

1. It is concentrated, making cost of package and transportation the minimum.

2. It has good keeping properties. Germs do not multiply in skim-milk powder, even at ordinary room temperature.

3. It is a dry substance, making it handy to carry on long sea and land journeys.

4. A milk of any consistency or richness can be made from it by adding water, making it of special value in baking, candy making, and ice-cream manufacture.

History and Development of Milk Desiccation. — The problem of inventing a proper system of milk desiccation has been worked upon to some extent for more than a century, but more especially during the past sixty years.

As early as 1810, a man by the name of Appert produced milk tablets, but they did not become of any commercial importance. In 1856 a Mr. Grimwade published a method of manufacturing dried milk. It consisted of sweetening the milk with sugar and at the same time adding carbonate of soda. These substances were added to produce granulation in the latter stages of dryness. This mixture was put into a jacketed pan, which was pivoted and kept in constant motion during time of drying. The surrounding jacket was filled with hot water, the temperature of which never went above 129° F. When the mixture became pasty, it was poured off into smaller pans, stirred and dried still more; then this paste or dough was passed between marble rollers and pressed into thin sheets. These sheets were then dried with hot air and finally ground to powder. Later the vacuum pan was used in condensing.

Another process consisted of precipitating the casein and fat by the use of acetic acid or rennet. This curd was drained and then dried on plates at a temperature of between 120° F. and 160° F. The solubility of this powder was restored by adding a little soda. The widely advertised "plasmon" is made in this manner. The process was not economical as some of the milk nutrients (sugar and albumen) were lost in the whey. This substance (plasmon) does not contain all of the elements of milk, and therefore could not serve as a substitute for milk.

Milk powder became of commercial importance when the Just-Hatmaker machine and process of drying came into use. The patent for this process is dated May 23, 1902. The desiccating machine consists of two large revolving polished rollers or cylinders placed parallel in a frame. The rollers are about sixty inches in length and twenty-eight inches in diameter. They revolve in opposite directions at about six revolutions per minute. Steam is introduced through the end of the spindle and a pressure of 40 pounds is maintained. This insures a constant temperature of 285° F. The condensed steam is removed at the other end at the corresponding place.

The two cylinders are about one eighth of an inch apart. When the milk falls and spreads in thin sheets on these revolving hot cylinders, it dries almost instantaneously. The residue remains on the cylinders and is scraped off in a powder-like consistency by means of scrapers attached to the machine. The powder is now passed through a fine sieve and is then ready for packing.

Drs. George Doellner, Buttler and J. Maggo have all patented homogenization of the milk previous to drying. It is claimed that this improves the keeping property. The process reduces the size of the fat globules to such an extent that decomposition proceeds very slowly. This latter, however, is by no means a well-established fact.

Dr. Eckenberg of Sweden has invented an ingenious system of milk drying at a low temperature and in vacuum.

The machine consists of a cylindrical device inside of which rotates slowly a nickel-plated drum. The interior of the drum is steam-heated. An air pump creates a vacuum. The milk is put into the bottom. The rotating drum picks up a film of the milk and dries it practically instantaneously, although the temperature is only about 104° F.

Scrapers take off the dried milk from the drum and discharge it into a receiver on the side, through valves which open and close intermittently.

The Modern Method. — A description of the latest and, so far as known, the most successful method of milk desiccation is given by L. C. Merrell in a paper read before the Syracuse Section of the American Chemical Society, 1908.

"Fresh whole milk is drawn into a vacuum pan and a portion of its water removed. This condensation is halted while the milk is still in a fluid condition and before any of the milk albumen has been cooked on to the walls of the vacuum chamber. The milk is then drawn from the vacuum pan and sprayed into a current of hot air. The moisture of the milk is instantly absorbed by the air and the particles of milk solids fall like snow. Upon examination, they are found to contain less than two per cent of moisture. The hotter the air is, the more rapid the drying effect and the less danger there is of injuring the milk solids by heat.

"This method of desiccation does not destroy the globular condition of the butter fat, it does not burn the milk sugar, nor does it coagulate the albumen of the milk. It is not necessary to neutralize the acidity of the milk, for the moisture is removed so quickly that there is no chance for chemical action, and neither the casein nor the albumen is effected in any way by the concentration of the acid. The difficult pasty condition of the milk solids is passed while the milk particle is suspended in the air and not in contact with heated metal. As nearly as I can estimate, one pint of milk presents about two acres of surface when sprayed into the air. The individual dried particles are from one two-thousandth to one ten-thousandth of an inch in diameter.

"No bacterial action has been discovered in milk powder containing less than 3 per cent moisture, and no chemical deterioration takes place. It is, therefore, evident that the milk powder product described above fulfills my definition of an ideal preserved milk, for decomposition is prevented merely by dryness and without the use of preservative substances and without changing the chemical composition of the milk. This whole milk powder is in use in place of fresh milk at several of the United States soldiers' homes and military posts as well as in the navy. It has been subjected to the most exhaustive tests by the United States Department of Agriculture, Bureau of Chemistry, and by the Experiment Stations of different states. The Pacific fleet carried a ton of it around the Horn under an absolute guaranty as to keeping quality and has since re-ordered largely. A 10 cent package makes one and a half quarts of milk, at $\$0.06\frac{2}{3}$ a quart. With these results in mind it is not too much to assume that the reduction of milk to powder offers a satisfactory solution of the universal milk question."

Use of Milk Powder. — This product is being used to replace fresh milk by bakers, confectioners and ice-cream manufacturers. It was used as a food by the Shackleton South Polar expedition, and was one of the main foods of the party that reached the magnetic pole.

The authors[1] have found milk powder to be of great value for starter-making purposes in creameries so located that a supply of fresh milk is not easily obtainable.

The milk powder was dissolved in pure water, making a 10-per-cent solution. Pasteurization, inoculation, ripen-

[1] *So. Dakota Bul.*, No. 123.

ing, etc., of the milk-powder starters were all carried on in the same manner as when fresh-milk starters were made and the results secured by the use of milk-powder starters were as good as those when fresh-milk starters were used.

Milk powder is used in the preparation of commercial cultures of lactic-acid bacteria, the culture material being mixed with sterile-milk powder, bottled and distributed for use in butter and cheese factories. In this medium the lactic bacteria retain their vitality for more than a year.

Composition. — Three kinds of milk powders are manufactured: whole-milk powder, half-skimmed-milk powder and skimmed-milk powder. The butter fat in the whole-milk powder interferes with its keeping properties.

The composition of these dried milks is as follows:

	Whole milk	Half-skimmed.	Skimmed.
	Per cent.	Per cent	Per cent.
Casein	26.92	33.30	37.00
Milk sugar	36.48	39.70	47.00
Butter fat	29 20	15 10	1.00
Milk salts (ash)	6.00	6.90	8.00
Moisture	1 40	5 00	7 00

Whey Powder or Dried Whey. — Whey is reduced to a powder by exactly the same process as that employed in the reduction of milk to powder. This powder is used in the diet of infants and invalids, in cases where the presence of casein interferes with proper digestion. Many dietary formulas call for whey as one of the ingredients. Fresh whey is not always obtainable, but whey powder may be kept on hand at all times and is ready for use upon the addition of water.

CHAPTER XXXI.

RENOVATED BUTTER.

STATISTICS show that more than a billion pounds of butter are made on farms in this country every year. Some of it is consumed at home, but most of it is taken to the local grocer. Of this latter, the best grades usually find ready sale to consumers in town. Unfortunately, dairy butter varies so greatly in quality, and so much of it is poor, that vast quantities of this product are unsalable as butter.

The production of farm butter is much greater during the summer than it is during the winter. This results in an overproduction during the hot summer months, when it is difficult to control quality, under average farm conditions. As a consequence, much of it is finally marketed at the renovating plant.

Ladles. — The chief method of disposing of this farm butter in the past was to add color and salt if needed, and work it into a homogeneous product. This reworking converted the various colors and qualities of butter into one batch having a uniform color, degree of saltiness, and quality. Heavy salting was usually practiced to conceal the undesirable flavors. This reworked butter is known commercially as ladles or ladled butter. Only the best farm butter, of most uniform color and salt content, is now used for ladles. The remainder is manufactured into renovated or process butter.

Origin of Renovated Butter. — The chief drawbacks to ladled butter was that the bad flavors were still in the finished product, and the body was weak. This gave rise, in the early eighties, to some experiments for the purpose of finding a method of eliminating the bad flavors from the raw product.

Melting butter, separating out and canning the fat for use in tropical countries, had been practiced in some sections of Europe for many years; but recovering the pure butter fat and again converting this substance into butter is an American invention. In 1883 butter was renovated by this method in Memphis, Missouri.

In the early nineties renovated butter began to appear in considerable quantities on the markets of this country. It was commonly sold as creamery butter, usually as "seconds," but in time of scarcity of creamery butter some of the best grades would sell as "creamery extras." In Philadelphia it was often called "boiled" butter, and in Boston, "sterilized" butter.

In 1897 the dairy and food commissioner of Pennsylvania attempted in a legal way to compel a manufacturer of renovated butter in Philadelphia to sell his product for what it was, instead of selling it as creamery butter. This company finally agreed to discontinue selling its product as creamery butter, and to print on the wrappers a name satisfactory to the commissioner. The name "renovated" was selected as most proper for defining this product. This name has been generally adopted, but the name "process" butter is used synonymously with it.

Extent of the Industry. — In 1905, 78 factories were manufacturing renovated butter. Each factory has its own system, which the operator claims is superior to any other system; but the general process is similar in all cases, the differences being in the details only.

These factories manufacture about 60,000,000 pounds of renovated butter per annum.

Only the best grades of packing stock are used in this product; the manufacturers have learned that it is impossible to make a marketable article from old rancid stock. Such material is of value only when used for soap-grease.

The tendency to-day is toward selling cream from the farm; while some years ago it was largely made into butter which finally went to the renovating factories. The former method is more profitable and handier to the farmer, and is more in accordance with general economical principles.

The Processes of Manufacture.

Melting. — The butter is brought into the factory in barrels and dumped into the melting tank. These melting tanks are of many different designs, one form of which is a tank having a coil near the bottom through which passes hot water. The vat is also jacketed and surrounded with hot water. The butter is emptied from the barrels into the vat, where it remains until completely melted; then the butter-fat oil is run out at one end through a strainer to remove the paper, wood and other foreign matter occasionally found in the raw material. As this oil runs from the vat and through the strainer it is pumped into steam-jacketed, cylindrical iron tanks, where it is held at a temperature of about 120° F. for two to three hours to permit the curd to settle out. This "slush," as the settlings are called, is drawn out through a valve at the bottom of the tank, and run through an old-style, hollow-bowl, Danish-Weston separator, and the recovered oil added to the main batch.

Refining the Oil. — This clear oil is run into a second set of tanks, or kettles, kept at a constant temperature of about 120° F. for several hours. During this time, pure, hot air is continuously pumped through the fat. The air is conducted to the bottom of the kettle through a pipe extending through the oil from the top. This air rises and causes a constant ebullition of the oil. This aëration at a high temperature removes practically all the bad odors and flavors, and leaves an almost tasteless, clear, yellow oil.

Making the Emulsion. — This oil is emulsified with sour milk, in order to reincorporate into it a natural butter flavor and the components of normal butter. For this purpose a quantity of good fresh skim milk is ripened with a commercial culture of lactic-acid bacteria, just as a starter is made in a butter or cheese factory. To this sour milk is added about twice its volume of sweet skim milk; then this mixed milk is added to the molten oil in the ratio of about one part milk to one and one-half parts oil. The milk and oil are mixed and emulsified in a cylindrical tank or kettle in which there is a rapidly revolving dasher. In some factories the emulsion is made in the same kettle in which the renovating process occurred. The mixing is accomplished by passing air through the mixture.

Crystallizing the Fat. — This emulsion is then run into a large vat of water at a temperature of 36° to 46° F., which crystallizes the fat. Even though such a large percentage of milk is present it is all incorporated in the fat crystals. The water shows no trace of milkiness.

The crystallizing vat is usually placed directly underneath the bottom of the renovating or mixing kettle. This latter tapers at the bottom to a small mouth. A valve at this place enables the operator to govern the size or amount of fat that runs into the crystallizing tank. The water used in the crystallizing process is kept cold by the use of crushed ice or by mechanical refrigeration.

The butter crystals are scooped from the surface of the water, piled on trays or trucks and run into a cooler to drain and ripen over night. Holding this for several hours at a low temperature before salting and working improves the body of the final product and enables the fat to absorb the milky flavors.

Working and Salting. — On the following morning, the butter granules are put into a combined churn and worker, worked in brine several revolutions to work out the excess of buttermilk, then drained, dry-salted, worked until the salt is dissolved, and finally removed from the churn and packed into tubs, $62\frac{1}{2}$ pounds being weighed into each tub.

The word " Process " or " Renovated " is imprinted in the butter and also marked on the outside of the tub in accordance with the requirements of Internal Revenue Department. As the flavor of the butter is better when a week old than when fresh it is usually kept in the refrigerator several days before it is shipped out.

Extracts from United States Laws Relating to Renovated Butter. — " Manufacturers of process or renovated butter shall pay a special tax of $50 per year, and manufacturers of adulterated butter shall pay $600 per year. Every person who engages in the production of process or renovated butter or adulterated butter as a business shall be considered to be a manufacturer thereof.

That every person who carries on the business of manufacturer of process or renovated butter or adulterated butter without having paid the special tax therefor, as required by law, shall, besides being liable to the payment of the tax, be fined not less than $1000 and not more than

$5000; and every person who carries on the business of a dealer in adulterated butter without having paid the special tax therefor, as required by law, shall, besides being liable to the payment of the tax, be fined not less than $50 nor more than $500 for each offense.

That every manufacturer of process or renovated butter or adulterated butter shall file with the collector of internal revenue of the district in which his manufactory is located such notices, inventories, and bonds, shall keep such books and render such returns of material and products, shall put up signs and affix such number of his factory, and conduct his business under such surveillance of officers and agents as the Commissioner of Internal Revenue, with the approval of the Secretary of the Treasury, may by regulation require. But the bond required of such manufacturer shall be with sureties satisfactory to the collector of internal revenue, and in a penal sum of not less than $500; and the sum of said bond may be increased from time to time and additional sureties required at the discretion of the collector or under instructions of the Commissioner of Internal Revenue.

Renovated butter having 16 per cent or more of moisture will be held to contain 'abnormal quantities of water, milk or cream,' and be, therefore, classed as 'adulterated butter.'

All renovated butter may be packed by the manufacturer thereof in firkins, tubs, or packages of wood or other suitable material not before used for that purpose; but each package must contain not less than 10 pounds; and, when packed in a solid body or mass, there shall be stamped or branded into the upper surface of the butter the words 'Renovated Butter' in one or two lines, the letters to be gothic style, not less than one-half inch square and depressed not less than one-eighth inch.

Manufacturers will be permitted to pack prints, bricks, or rolls of renovated butter not less than one pound in weight; but each print, brick, or roll must have stamped thereon the words 'Renovated Butter' in two lines, the letters to be depressed, of gothic style, not less than three-eighths inch square and sunken not less than one-eighth inch. The contents of any package less than ten pounds will be considered as a brick or roll."

Test for Renovated Butter.

Spoon Test. — Heat about five grams of the sample to be tested in a large spoon over a small flame. Genuine butter will boil quietly, but with the production of considerable froth and foam. Renovated butter or oleomargarine will sputter noisily, but will not foam much. The curd in the former will be small and finely divided: while in the latter it will be found in larger masses or lumps.

To distinguish renovated butter from oleomargarine it is necessary to use the butyro-refractometer or the chemical tests as described under "Oleomargarine."

CHAPTER XXXII.

OLEOMARGARINE.

Oleomargarine, Butterine, Dutch Butter and Margarine are terms that are used synonymously. All refer to articles which are manufactured as butter substitutes. They are all made chiefly from beef fat, and are made to imitate butter as nearly as possible. To some of the better grades (as butterine), a definite amount of real butter or cream is added. Beef fat is chiefly composed of tissue and fats belonging to the non-volatile and insoluble group, such as stearin, palmatin and olein. The chief difference between butter and margarine is that the butter contains fats of the lower series which belong to the volatile and soluble group, of which butyrin is the chief one. Margarine does not contain any noticeable amount of the volatile fats unless butter has been added, as is sometimes the case. Oleomargarine is therefore not a dairy product, but is briefly mentioned here because dairy products are used in connection with its manufacture.

Origin of Margarine. — According to history, margarine was first manufactured in France. It is said that a French chemist named M. Mege-Mourier was requested by the French Emperor, Napoleon III, to investigate the problem of getting a good, wholesome and cheap substitute for butter. This was evidently done to reduce the expenses during the France-German war of 1870. In a short time he had prepared a quality of goods which resembled butter to such an extent that it required an expert to distinguish it from that product. The new article was named after the discoverer and the fat from which it was made, viz., "Margarine-Mourier." The new substitute for butter had many good qualities, and could be prepared from ox tallow in a very simple way.

The Paris Health Counsel on April 12, 1872, admitted the sale of the new fat, provided it was not brought into the commercial market under the name of "butter."

The Original Process. — The process which M. Mourier used was an excellent one. Nothing but the very best of fat was used. The stearin was separated from it, thus leaving a fat with a relatively low melting-point, similar in that respect to butter. The raw fat possessed a peculiar and undesirable animal taste which his particular process of manufacture eliminated.

The thoroughly washed and finely chopped fat was put into a tank. For every 1000 parts of fat, 300 parts of water, 1 part of carbonate of potash and two well-cleaned stomachs of pigs or sheep were added. The mixture was held at a temperature of 113° F. for a few hours to digest the fatty tissue. It was then allowed to cool to effect the crystallization of the stearin and palmatin, after which it was put into a press. The term "oleomargarine" was applied to this new expressed fat. The product was pure, wholesome and nutritious. The manufacture of it soon became an established industry in France, America, Germany, Austria, Russia, Holland and other countries. It was an excellent cooking fat, containing a greater percentage of fat, and possessing better keeping qualities than average butter, and excelling poor butter in flavor.

Developments in the Industry. — The result of this extended use of the oleomargarine was that not enough raw material could be secured. As a result, the ox tallow, which was formerly purified and melted at a temperature of 113° F., was now exposed and melted at 140° F. This included more of the fats having a high melting-point, in the margarine oil.

This new process overthrew the desirable Mege-Mourier process of manufacture of oleomargarine. According to his method, 100 pounds of raw material yielded only about twenty-two pounds of margarine, and, according to the new method, 100 pounds of a raw tallow yielded about sixty-one pounds. The latter product, however, was of an inferior quality. It was more solid and richer in stearin. It had a melting-point of about 110° F., which was a very serious objection to its healthfulness.

In order to lower the melting-point of this substance and apparently to improve its usefulness, the cheaper kinds of vegetable oils were used, such as cottonseed oil, rape oil, the purer grades of olive oil, sesame oil, cocoa oil, etc. The increased use and consequent demand for oleomargarine forced the manufacturers to make use of other fats than ox tallow. According to patents taken out in Europe, the following fats were used: Bacon fat, goose fat, veal tallow, stearin fat from soap manufacturers, slaughter house fat and fat from flaying houses. Some of the fats had a very undesirable smell, and were purified by treating with strong mineral acids.

From this it will be seen that oleomargarine became a cheap adulterated food. In the face of this, the sale and manufacture of it continued to increase and became very extensive. Especially was this so in the United States, where in the large cities, at the big slaughtering houses, so much animal fat accumulated.

Manufacture of Oleomargarine. — It is impossible to describe in a precise detailed form each specific operation which the raw material for oleomargarine must undergo, because the processes of manufacture, especially in the United States, are considered to be trade secrets.

The caul fat of freshly killed beeves is, after a thorough washing, first in tepid water, then in ice water, allowed to stand in a cold room until thoroughly chilled. It is then rendered between a temperature of 130° and 175° F. The resulting oil is allowed to cool slowly until a considerable portion of the stearin and palmitin has crystallized out. This pasty mass is then subjected to hydraulic pressure. The oil or fluid part (about two-thirds of the whole) flows out into a tank of cold water, where it solidifies into a granulated mass known to the trade as "oleo" oil, or simply "oleo." The name "oil" is somewhat misleading, as the product is a granular solid of a dull whitish color. Fresh leaf fat treated in exactly the same way as the beef tallow yields the "neutral" lard or "neutral" of the trade, also a granular solid of a white color.

The objects of this treatment are twofold: to produce fats as free as possible from taste and odor; and to remove some of the stearin and palmitin, in order that the finished product may have a lower melting-point.

The "oleo" and the "neutral" are then mixed. The proportions vary according to the marketing place of the product (a warm climate calling for more "oleo," a cold one for more "neutral") and the amount of butter with which the mixture is flavored. This mixing is done in large, steam-jacketed vessels provided with revolving paddles, by which their contents can be easily mixed. Here the "oleo" and the "neutral" are thoroughly agitated with a certain proportion of milk (soured by inoculation with a pure culture of lactic-acid bacteria), and sometimes with cream, butter and cottonseed oil, depending upon the grades of the product to be manufactured.

Having been brought into a perfect emulsion, the mixture is run into a vat of ice water, which causes the formation of crystals or granules of fat similar to small granules of butter, such as are formed in the churning of cream.

The fat granules are held at a low temperature several hours to ripen, then put into a churn, worked and salted just as in the manufacture of renovated butter.

The proportions in which these raw materials are mixed are given by the 12th Census Report of the United States for each of the three high grades of oleomargarine manufactured as follows:

	High grade, pounds.
Oleo oil	100
Neutral lard	130
Butter	95
Salt	32
Color	00.5
	357.5

will produce about 352 pounds of oleomargarine.

	Medium high grade, pounds.
Oleo oil	315
Neutral lard	500
Cream	280
Milk	280
Salt	120
Color	1.5
	1496.5

will produce from 1050 to 1080 pounds of oleomargarine.

	Cheap grade, pounds.
Oleo oil	495
Neutral lard	265
Cottonseed oil	315
Milk	255
Salt	120
Color	1.25
	1451.25

will produce from 1265 to 1300 pounds of oleomargarine.

The following formulas are taken from "The Modern Packing House," by F. W. Wilder, former general superintendent of Swift & Co., and Schwarschild & Sulsberger:

"Neutral or No. 1. oleo oil is made from the following:
Gaul fat, ruffle fat, gaul piece of gut end, briskets trimmed from the bed pickings, crotch trimming from the bed pickings, paunch trimmings, pluck trimmings, reed trimmings, heart casing fats.

No. 3 or third grade oil:
Head fat, fat trimmed from cattle heads when checking, plucking sweet-bread trimming, liver trimmings, bladder trimmings, fat from chilled beef tongues when they are trimmed, miscellaneous fats from other departments which are kept clean, the first washings from the oleo press cloths before soda has been used, scrap vat skimmings from the second grade oil."

The following formulas are for making butterine or oleomargarine of three different grades:

FORMULA FOR AND COST OF HIGH GRADE OLEOMARGARINE.

Material and quantities.	Cost per pound.	Total cost.
526 lbs. No. 1 oleo oil	$0.0875	$45.19
476 lbs. No. 1 neutral oil	0.08125	38.57
50 gals. 30 per cent cream	0.42	30.24
300 lbs. creamery butter	0.28	84.00
Labor and package	0.01	15.00
Salt and color	0.00	1.00
Total	....	$214.00

This formula will yield 1500 pounds of butterine. Therefore the cost is $0.1426 per pound.

FORMULA FOR AND COST OF MEDIUM GRADE OLEOMARGARINE.

Material and quantities.	Cost per pound.	Total cost.
525 lbs. No. 1 oleo oil	$0.0875	$45.93
475 lbs. No. 1 neutral lard	0.08125	38.60
40 gals. 30 per cent cream	0.42	40.32
Labor and package	0.01	12.00
Salt and color	0.00	1.00
Total	....	$137.80

This formula will yield 1200 pounds of oleomargarine. Therefore the cost is $0.1142 per pound.

FORMULA FOR AND COST OF LOW GRADE OLEOMARGARINE.

Material and quantities.	Cost per pound.	Total cost.
350 lbs. No. 2 oleo oil	$0.08	$28.00
250 lbs. cottonseed oil	0.04	10.00
450 lbs. neutral lard	0 08125	36.54
60 gals. 2½ per cent milk	0.12	7.20
Labor and package	...	12.00
Salt and color	....	1.00
Total	....	$94 74

This formula will yield 1200 pounds of oleomargarine. Therefore the cost of producing and packing for shipment will be $0.0789 per pound.

From the above it will be seen that the extra prime, yellow cottonseed oil, known as butter oil, is not used in the best grades of oleomargarine. This agrees with what Mr. Jelke, a manufacturer of oleomargarine, stated before the agricultural committee, that they did not use cottonseed oil in their best grades of oleomargarine, as it injured the flavor. Consequently, he stated that the best grades of oleomargarine were white or light in color.

Quantity of oleomargarine produced,[1] 1888 to 1911 inclusive:

Year.	Pounds of Oleomargarine.
1899	83,130,474
1900	107,045,028
1901	104,943,856
1902	126,316,427
1903	73,284,096[2]
1904	50,199,642
1905	51,987,336
1906	554,34,900
1907	71,366,775
1908	81,525,600
1909	92,282,815
1910	141,862,280
1911	121,162,795
Total, pounds	739, 106, 239

For two years, from 1902, the production of oleomargarine decreased. This, no doubt, is attributable to the act of May 9, 1902, which went into effect July 1 of that year.

(Annual Report, Commissioner of Internal Revenue, 1911):

A great deal of oleo oil is manufactured in this country and exported to Europe. It is said that in Holland there are 70 factories which get their oleo oil largely from the United States.

Food Value. — Oleomargarine, when made in compliance with the laws of the land, is a legally recognized prod-

[1] *Bureau of Statistics*, U. S. Dept of Agr.

[2] First year new Oleo Law, imposing 10-cent tax on colored margarine, was in force.

uct which has its place on the market. The lower grades are used in place of cooking butter and the higher grades (composed partly of butter) as a substitute for table butter.

There is some difference of opinion among authorities as to the healthfulness of oleomargarine as compared with butter. We quote two authorities as follows:

In record No. 7 from United States Department of Agriculture H. Lubrig discusses the relative digestibility of oleomargarine and natural butter. The author reviews the literature on the subject and reports results of four experiments on the digestibility of oleomargarine and butter, made with a healthy man 29 years old and weighing 175 pounds. Holstein butter and three sorts or grades of oleomargarine were used, named according to their qualities — Nos. 1, 2 and 3. The tests were similar, the fat in each case forming part of a mixed diet of meat, bread, vegetables, etc. In the author's opinion the true undigested fat was not oleomargarine or butter fat, and accordingly he believes it is safe to conclude that butter and oleomargarine are completely digested. From a physiological standpoint the two fats are thought to be completely digestible and of equal value.

On the other hand H. W. Wiley, former chief chemist of the Department of Agriculture at Washington, who testified before the House Agricultural Committee when the Grout bill was being considered, said: "This is exactly what I said in my testimony before the senate committee. They asked me if I thought oleomargarine was as digestible as butter. I do not think it is. I do not think it digests so well as butter, because it contains more of the higher series of fatty acids, and practically none of the lower acids which are more easily decomposed under the influence of ferments. All digestion is fermentation."

Oleomargarine Law. — Congress passed a law which became effective July 1, 1902. The principal features of this law are as follows: Tax on colored oleo is increased from 2 to 10 cents per pound. Tax on uncolored oleo is reduced from 2 to $\frac{1}{4}$ cent a pound. Wholesale and retail dealer's license for the sale of colored oleo was not changed, but remained $480.00 and $48.00 per year respectively. Wholesale dealer's license for the sale of uncolored oleo was reduced from $480.00 to $200.00 per year. Retail dealer's license for the sale of uncolored oleo was reduced from $48.00 to $6.00 per year. A license costing $480.00 entitled the holder to wholesell either colored or uncolored or both; and a license costing $48.00 entitled the holder to retail colored, or uncolored or both.

Hotels, restaurants, boarding-houses, railroad contractors, and soldiers' homes, schools and other public institutions are prohibited from buying the uncolored oleo and coloring it. A family (not keeping boarders) is permitted to buy the uncolored article and color it.

Since the passage of this law, the manufacturers have learned to use fats that will give their product a yellow color without the addition of any artificial coloring matter. This is done by using fat from pasture-fed animals and June butter having a natural high color.

However, many of the States have enacted laws prohibiting the sale of yellow oleomargarine, regardless of whether the color be artificial or natural. Another provision adopted by several States is that when a substitute for butter is used for cooking or served as a food in hotels, restaurants, etc., a placard shall be placed opposite each table or counter, which placard shall have the words "Substitute for butter used here" printed in large, legible type.

Detection of Oleomargarine. — The spoon test: This test is described in the chapter on "Renovated Butter."

Waterhouse test: Add about 5 grams of the sample to be tested to 50 cubic centimeters of hot skim milk, cool slowly, and stir with a small wooden stick while cooling. In solidifying, the fat, if oleomargarine, will mass into a lump or clot; but if butter, it will not, but will remain in small particles distributed throughout the milk.

Chemical tests: In the chemical laboratory oleomargarine may be distinguished from butter by determining the amount of volatile and soluble acids in each.

The Reichert-Meisel number (number of cubic centimeters N/10 alkali required to neutralize the volatile acids in 5 grams of fat) is the most reliable indication of the kind of fat. The Reichert-Meisel number for butter may vary from 25 to 32; for oleomargarine, from .5 to 10, depending upon the percentage of butter used in the process of manufacture.

In butter fat the soluble acids constitute from 3 to 6 per cent of the whole: in oleomargarine, from .1 to 1.5.

Butyro-refractometer reading: Owing to the difference in the refractive indices of various fats and oils, butter may be distinguished from oleomargarine by means of the butyro-refractometer. This is a very simple method, requires but little time, and, with few exceptions, is reliable. The refractometer reading of butter is normally 50 to 54 at 25° C. Higher readings indicate the presence of oleo oil. According to Wollny, samples having a reading higher than 54 will, upon chemical analysis, be found to be adulterated. Pure oleomargarine will show a reading of 58 to 66.

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