DAIRY FUNDAMENTALS

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DAIRY FUNDAMENTALS

DIVISION ONE.

MILK AND BUTTER FAT.

Question. What is milk?

Answer. Milk is the special fluid secreted by the females of milk giving animals (the Class Mammalia)for the purpose of nourishing the young until they are capable of seeking for themselves the kind of food which they can easily digest.

Q. Of what is milk composed?

A. Of water and milk solids.

Q. Is water in milk any different from distilled water?

A. No.

Q. What are the milk solids?

A. The milk solids are fat, milk sugar, albuminoids, and ash.

Q. What is milk serum?

A. Milk serum is the water and all of the solids except the fat.

Q. What is milk fat or butter fat?

A. It is a mixture of a number of distinct fats found in milk and is the chief constituent of butter.

Q. Of what are these fats composed?

A. Fatty acids and glycerine.

Q. What are the different milk fats and the per cent. of each in butter fat?

A.

	Butyrin	3.85%
Volatile	Caproin	3.60%
	Caprylin	.55%
	Olein	35.00%
	Palmatin	25.70%
Non Volatile	Myristin	20.20%
	Laurin	7.40%
	Caprin	1.90%
	Stearin	1.80%
		100.00%

Q. What is a volatile fat?

A. A fat composed of a soluble volatile fatty acid and glycerine.

Q. What is a non-volatile fat?

A. A fat composed of an insoluble non-volatile fatty acid and glycerine.

Q. What is the chief function of butter fat when taken into the body?

A. It is to produce heat and fat.

Q. How does butter fat exist in milk?

A. In the milk serum in the form of very minute globules. This is called an emulsion. These globules vary in size under normal conditions, but average about 1/10,000 of an inch in diameter. It is estimated that in average milk there are 100,000,000 globules in a single drop.

Q. What is miik sugar?

A. In general appearance, milk sugar resembles confectioner's sugar, although it is not so sweet. When taken into the body, its function, like that oi fats, is to produce heat and fat. At high temperature, or on boiling, milk sugar caramelizes and is the principal cause of the peculiar scalded taste of boiled milk. In commerce, milk sugar is used principally in lactated foods and in medicines.

Q. What are the albuminoids?

A. The albuminoids, commonly known as proteids, sometimes spoken of as protein, contain the nitrogen of milk. Their function, when taken into the body, is to furnish food to blood, muscle, tendon, hair, nails, etc. In milk they exist in two forms, namely, the casein and albumen.

Q. What is casein?

A. Casein of milk is what is commonly known as curd. Curd is also proteid. It is that part which curdles or clabbers when milk sours. Casein exists in a semi-solid state in milk and is the constituent which gives to cheese its peculiar character.

Q. What is albumen?

A. Albumen is a clear, viscous substance of milk which resembles the white of egg, and coagulates by heat. It is coagulated by heat but not by rennet; while casein is coagulated by rennet but not ordinarily by heat. The scum which forms on boiled milk is albumen.

Q. What is ash?

A. The mineral constituents of milk are termed, collectively, the ash. When the ash is separated from the rest of the milk, it resembles ordinary wood ash. The ash is composed chiefly of the phosphates of calcium (lime), potassium, iron and magnesium, and the chloride of potassium and chlorides of sodium (common salt). The principal function of ash, when taken into the body, is to furnish food for bone and nerves. Most of the ash is in solution in the milk.

Q. What are the average per cents of the different constituents in milk?

A. Milk
- Water, 87.4%
- Total Solids, 12.6%
  - Fat, 3.7%
  - Solids not fat, 8.9%
    - Albuminoids, 3.2%
      - Casein, 2.7%
      - Albumen, .5%
    - Sugar, 5.0%
    - Ash, .7%

Q. How can you find the number of pounds of each constituent, if the weight of milk and the per cent. of each constituent is given?

A. Multiply the weight of milk by the per cent. of constituent and divide by one hundred.

Example.—Give the total number of pounds of each of the constituents in 200 pounds of milk containing the following per cents:

	Per cent of constituent divided by 100	No. lbs. Milk	
Water	.8740 ×	200 =	174.80 pounds of water.
Total Solids	.1260 ×	200 =	25.20 pounds of total solids
Fat	.0370 ×	200 =	7.40 pounds of fat.
Albuminoids	.0320 ×	200 =	6.40 pounds of albuminoids.
Milk Sugar	.0500 ×	200 =	10.00 pounds of milk sugar.
Ash	.0070 ×	200 =	1.40 pounds of ash.

Q. Does the per cent. of constituents vary in milk?

A. Yes.

Q. May it vary in the milk given from day to day by the same cow?

A. Yes. It may also vary morning and evening of the same day.

Q. What are some causes of variation in milk of individual cows?

A. 1. Treatment of the cow. 2. Health of the cow. 3. Excitement. 4. Manner of milking or change of milkers. 5. Length of time between milkings. 6. Length of time since calving. 7. Change of feed. 8. Composition of feed.

Q. Does the average per cent. of these constituents vary greatly in the milk of a herd from day to day?

A. No. The composition is quite constant in the mixed milk of a herd.

Q. Why?

A. Because a large number of cows giving milk of varying per cents. of solids tend to equalize the solids in the mixed milk. Hence, from day to day the difference of the per cent. of constituents in milk from a herd is small compared with that of an individual cow.

Q. What are the maximum and minimum per cents. of constituents in milk?

	Maximum	Minimum
Water	90.69	80.32
Fat	6.47	1.67
Casein	4.23	1.79
Albumen	4.44	.25
Sugar	6.03	2.11
Ash	1.21	.35

Note.—This is according to Koenig's analysis, collected from different parts of the world, and represents a fair maximum and minimum ratio. In a few cases cows have been known to yield 14 per cent. of butter fat in milk.

Q. Do the per cents. of constituents of different breeds vary?

A. Yes, to a certain extent; but it depends upon individual breeding. The following table gives results found at the New York Experiment Station for one year:

Breed.	Total Solids.	Fats.	Albumin-oids	Sugar	Ash.
Holstein-Friesian	11.80	3.46	3.39	4.84	.74
Ayershire	12.75	3.57	4.43	4.33	.70
Jersey	15.40	5.61	3.91	5.15	...
Shorthorns	14.30	....	....	....	...
Guernsey	14.90	5.12	3.61	5.11	.75
Devon	14.50	4.15	3.76	5.07	.76

Q. Do all cows of the same breed give the same per cent. of constituents?

A. No. There is much variation in the per cent. of constituents in milk from different cows of the same breed. The above table represents the average composition of milk of the different breeds.

Q. To what extent do the solids of milk vary in the different months of the period of lactation?

The following instance of the variation in the milk of an individual cow is probably a fair illustration:

First month	14.00 per cent.
Second month	13.50 per cent.
Third month	13.47 per cent.
Fourth month	13.46 per cent.
Fifth month	13.75 per cent.
Sixth month	14.00 per cent.
Seventh month	14.18 per cent.
Eighth month	14.33 per cent.
Ninth month	14.83 per cent.

From the above table it is seen that in the second, third, fourth and fifth months in the period of lactation of the average cow, the per cent. of solids is less than in the first, sixth, seventh, eighth and ninth months, but as a rule the greatest number of pounds of solids is found in milk given during the second, third, fourth and fifth months, due to the larger quantity given; so the total number of pounds of solids averages about the same.*

Q. To what extent does the average monthly composition of milk vary?

A. The average monthly composition is somewhat variable though not as much as one per cent., as the following table shows:

Month	Water.	Solids.	Fat.	Solids not fat.	Albumin-oids.	Sugar and ash
May	87.40	12.60	3.63	8.97	3.14	5.83
June	87.53	12.47	3.55	8.92	3.07	5.85
July	87.63	12.37	3.59	8.78	3.00	5.78
August	87.51	12.49	3.78	8.71	3.05	5.66
September	87.33	12.67	3.75	8.92	3.10	5.82
October	86.87	12.13	4.00	9.13	3.36	5.77

Q. Does the per cent. of constituents vary in the first and in the last milk of the same milking?

A. The solids not fat remain quite constant, but the butter fats vary decidedly. An experiment with two cows at the Minnesota Experiment Station brings out this point clearly, as the following tables show:

COW No. 1.

	First pint of milk.	Last pint of milk.
Total solids	9.42	19.49
Fats	.71	10.84
Solids not fat	8.71	8.65
Ash	.68	.72
Casein, albumen	3.44	3.51

COW No. 2.

	First pint of milk.	Last pint of milk.
Total solids	10.10	18.47
Fats	1.02	9.49
Solids not fat	9.08	8.98
Ash	.70	.74
Casein, albumen	3.35	3.65

Q. What is colostrum?

A. The milk secreted directly after parturition or giving birth to the calf. It has a peculiar odor, color and slimy appearance.

Q. What is the average composition of colostrum?

A. Water . . . . 74.6 per cent.
Fat . . . . 3.6 per cent.
Casein . . . . 4.0 per cent.

Albumin	13.6 per cent.
Sugar	2.7 per cent.
Ash	1.5 per cent.

Q. Is colostrum essential to the young calf?

A. Yes. It has a needed laxative effect.

Q. Is colostrum fit for human consumption?

A. No.

Q. How can colostrum be detected?

A. (a) Boiling precipitates or coagulates the albumin.
(b) The microscope shows large colostrum corpuscles.

Q. How soon after parturition does the milk become normal?

A. Usually in four or five days. In occasional cases it may remain abnormal for fifteen days.

DIVISION TWO.

CREAM.

Q. What is cream?

A. Cream consists of all the portions of milk after a part of the milk serum has been removed. Ordinarily cream is that portion of milk which rises to the top in a layer, upon letting milk stand for a time, or is separated from it by centrifugal force. Standard cream contains at least 18 per cent. of butter fat.

Q. Why does cream rise on milk?

A. Cream contains more butter fat than milk and since butter fat is the lightest constituent of milk, it rises for the same reason that wood floats on water.

Q. How is cream separated from milk?

A. By different systems:

(1) The Shallow Pan System.—Milk is set in shallow pans for 24 to 36 hours, during which time the cream rises to the top.

(2) The Deep Setting System.—Milk is set in deep narrow cans, 8 to 10 inches in width and 18 to 24 inches in depth. The cans are set in cold or ice water. The difference in temperature between the warm milk and the cold water in which it sets causes cream to rise rapidly in the milk, due to the fact that the extreme difference in temperature causes a vertical circulation at such a rapidity that the lighter parts of the milk are carried to the top with the current, and are prevented from being carried down on account of their lightness.

(3) The Centrifugal System.—Cream is separated by centrifugal force. The milk flows into a bowl, rotating very rapidly, causing the heavier constituents such as milk sugar, casein, albumen and ash, to fly to the outside, while the lighter butter fat flows toward the center of the bowl, carrying with it some of the other constituents.

Q. What is the composition of cream?

A. Cream (containing 18 per cent. to 30 per cent. of butter fat) has about the same per cent. of sugar, albuminoids and ash as milk. The fat varies decidedly and replaces the water in the cream. The per cent. of fat in cream may range from 18 per cent. to 80 per cent., according to the manner of skimming. An average cream contains about 22 per cent. of butter fat, 69 per cent. of water, 3.8 per cent. of albuminoids, 4.6 per cent. of sugar, .6 per cent. of ash. Retail cream averages lower in butter fat. It is desirable that cream for butter-making contain about 35 per cent. of butter fat.

Q. What gives the heavy consistency to some market cream which is low in butter fat?

A. It may contain condensed milk, it may contain viscogen or it may be homogenized.

Q. What is viscogen?

A. It is a 50 per cent. sugar solution mixed with lime water forming sucrate of lime.

Q. What is homogenized cream?

A. It may be cream which has been put through a homogenizer, a machine which forces the cream through a small opening under very high pressure against a hard surface. This divides the fat globules so finely that the friction on the surface of the globules is greater than the difference between the specific gravity of fat and milk serum and consequently they will not rise by gravity. The cream is rendered very viscous and appears richer than before homogenizing.

Homogenized cream is sometimes made from an emulsion of skim milk and butter fat from butter, run through a homogenizer. Some ice cream makers make use of the latter since it is a cream product which may be had from stored goods at any time.

DIVISION THREE.

BUTTER.

Q. What is butter?

A. Butter is the product of gathering in any manner the fat of fresh or ripened cream or milk into a mass with a small proportion of the other milk constituents. It may or may not contain salt.

Q. What is the average composition of butter?

A.

Water	13 per cent.
Butter fat	83 per cent.
Curd	1 per cent.
Ash and Salt	3 per cent.
	100 per cent.

Q. What is the variation in the per cent. of water in butter?

A. From 6 per cent. to 16 per cent. More than 16 per cent. of water can be incorporated but, according to the Federal standard, butter containing 16 or more per cent. of water is considered adulterated.

Q. What is the range in per cent. of butter fat in butter?

A. From 82½ per cent. to 94 per cent. Butter may contain less than 82¼ per cent. of fat but it is not standard butter according to the Federal standard. The Ohio standard calls for at least 80 per cent. of butter fat in butter.

Q. What is the range in per cent. of curd in butter?

A. From .5 per cent. to 4 per cent.

Q. What is the range in per cent. of salt in butter?

A. From none to 8 per cent. When there is more than 4 per cent., part of it is undissolved and the butter is gritty.

Q. What is the overrun in butter-making?

A. The difference between the weight of churned butter and the butter fat in the milk or cream.

Q. What causes overrun?

A. The incorporation of water, salt, curd and ash in the process of churning.

Q. What is the per cent. of overrun?

A. The per cent. that the overrun is of the butter fat in the milk or cream.

Q. How are the overrun and the per cent. of overrun calculated?

A. Suppose a butter maker secures 162 pounds of butter from 450 pounds of cream testing 30 per cent. of butter fat?

$.30 \times 450 = 135.00$ pounds butter fat in the cream.
$162 - 135 = 27.00$ pounds overrun.
$27 \times 100 = 2700$
$2700 \div 135 = 20\%$ overrun.

Q. What is the usual per cent. of overrun?

A. From 8 per cent. to 21.21 per cent., depending on the amount of water and curd incorporated. An overrun of 21.21 per cent. can be obtained in making standard butter containing 82½ per cent. fat only when there is no loss of fat in churning. This is not possible in practice.

Q. Can the amount of butter be calculated if the weight of the butter fat is known?

A. Approximately, if one knows the per cent. of overrun usually obtained. Ordinarily in calculating the amount of butter that may be made from milk the overrun is counted 17 per cent. or about 1/6; therefore adding 17 per cent. or 1/6 to the butter fat would give the amount of butter. In starting with cream it is usually taken as 20 per cent. or 1/5.

Q. How much butter may be made from 900 pounds of cream containing 30 per cent. of butter fat?

A. $.30 \times 900 = 270.00$ pounds of butter fat.

Suppose the usual overrun secured by the butter-maker is 18 per cent. Then

.18 × 270 = 48.6 pounds overrun
270 + 48.6 = 318.6 pounds butter
or 1.18 × 270 = 318.6 pounds butter

If we assume 20 per cent. to be the per cent. of overrun, then

.20 × 270 = 54.00 pounds overrun
270 + 54 = 324.00 pounds butter
or 1.20 × 270 = 324.00 pounds butter
or 1/5 of 270 = 54.00 pounds overrun
270 + 54 = 324.00 pounds butter
or 1 1/5 × 270 = 324.00 pounds butter

Q. If a cow gives 8,000 pounds of milk testing 5 per cent. butter fat in one year, how much butter fat will she produce and to how much standard butter containing 82½ per cent. of butter fat is it equivalent?

A. .05 × 8000 = 400.00 pounds butter fat in year
400 × 1000 = 40,000
40000 ÷ 82.5 = 484.84 pounds of standard butter containing 82½ per cent. of butter fat.

DIVISION FOUR.

OTHER MILK PRODUCTS.

Q. What is skim-milk?

A. Skim-milk is that portion of milk remaining after cream is extracted; or, in other words, it is the milk serum, though it may contain a small per cent. of fat. The amount of fat remaining depends upon how thoroughly the milk has been separated.

Q. Of what is skim-milk composed?

A. Skim-milk has about the same per cent. of solids not fat as whole milk, except about 2 per cent. to 2½ per cent. more water, and a small amount of butter fat (about .1 to .3 of one per cent.) which cannot be practically separated from the milk.

Q. What is skim-milk used for?

A. In foreign countries it is largely used for human food, but in the United States it is mostly fed to young farm animals. Some of the things made from skim-milk are certain kinds of cheese, fermented milks, cold water paints, skim milk powder, patent foods and a material for sizing paper. Condensed skim-milk is used largely in ice cream making.

Q. What function does it perform in the body?

A. Skim-milk contains all the constituents which furnish food for muscle and bone, and in the same form and per cent. as that of whole milk. It also contains one of the constituents that produce heat, namely, milk sugar.

Q. What is buttermilk?

A. Buttermilk is the residue of the cream after the butter is churned. In other words, it is cream with the butter fat taken out of it.

Q. What is the composition of buttermilk?

A. Buttermilk is similar to skim-milk except in milk sugar. Its composition, however, like that of skim-milk, varies. Average butter milk contains about 9.3 per cent. solids, of which 4.6 per cent. is lactic acid and milk sugar, 3.7 per cent. casein and albumen, .3 per cent. butter fat, and .7 per cent. ash. Buttermilk, like skim-milk, is used for human food, for feeding young animals, and, to a small extent, is used in manufacturing buttermilk cheese. It is also used for medicinal purposes, and is considered one of the most wholesome drinks.

Q. How is artificial buttermilk prepared?

A. By heating skim-milk to 165 deg. F. for at least 10 minutes, cooling to 70 deg. F., and adding 5 to 10 per cent. of good starter or culture of lactic acid bacteria. As soon as the milk has coagulated it is cooled to about 50 deg. to 55 deg. F. It is then placed in a churn and churned for five minutes or until well emulsified.

Q. How are fermented milks prepared?

A. Skim-milk is pasteurized, then cooled, and a culture of acid producing bacteria added. Bacillus Bulgaricus is much used for this purpose in connection with other varieties. Bacillus Bulgaricus grows best at a temperature of 85 deg. F. to 100 deg. F. It is capable of producing much more acid than ordinary lactic acid bacteria.

Q. What is the percentage composition of cheese?

A. Roughly speaking a well cured cheese consists of 1/3 water, 1/3 butter fat and 1/3 curd.

A green Cheddar cheese contains about 37 per cent. water, 34 per cent. fat, 24 per cent. casein and 5 per cent. milk sugar, lactic acid and ash (chiefly salt).

Q. How much cheese can be made from 100 pounds of milk?

A. From 8 to 14 pounds, the average being about 10 pounds.

Q. Does the composition of the milk influence cheese yield?

A. Yes. The richer the milk in fat and casein the greater the cheese yield.

Q. How may approximate cheese yield be calculated?

A. (1) When the per cent. of fat and casein in milk are known, (per cent. of fat + per cent. of casein) × 1.63 = yield per 100 pounds of milk.*

(2) When only per cent. of fat is known, (2.3 × per cent. of fat) + 1.4 = yield per 100 pounds of milk*

Q. What is the by-product of cheese?

A. Whey.

*Van Slyke.

Q. What is the composition of whey?

A. Whey is composed of about 6.7 per cent. of solids, of which 5.7 per cent. is milk sugar, .8 per cent. albumen, .6 per cent. ash, and .3 per cent. fat. Whey is not so nourishing as skim-milk, since it is deprived of most of the albuminoids and fats. It is generally used for the feeding of farm animals.

Q. What is condensed or evaporated milk?

A. Milk from which a considerable part of the water of the original milk has been evaporated. Some brands contain about 40 per cent. of cane sugar in addition to the milk solids.

Q. What is the average composition of unsweetened condensed milk?

A. Water 71 per cent., fat 8.4 per cent., proteids 7.5 per cent., milk sugar 11.6 per cent., and ash 1.5 per cent.

Q. What is the average composition of sweetened condensed milk?

A. Water 26.5 per cent., fat 9 per cent., proteids 8.5 per cent., milk sugar 13.3 per cent., ash 1.8 per cent., and cane sugar 40.9 per cent.

Q. What is a milk powder?

A. A milk that has been evaporated to dryness and then pulverized. It is usually made from skim-milk, because the fat in whole milk tends to become rancid, while the powdered skim-milk will keep indefinitely. It contains about 2 to 2.5 per cent. of water.

Q. What is malted milk?

A. Milk that has been heated to a high temperature, partly evaporated and a small amount of malt added.

Q. What is modified milk?

A. Milk that has had its composition changed in regard to one or more constituents for a special purpose such as infant feeding. Lime water and barley water are often added in modifying for infants.

Q. What is certified milk?

A. Milk produced under rules prescribed and enforced by a Medical Milk Commission, in regard to health of cows and attendants, sanitary methods in production, bacterial content and composition.

Q. What is ice cream?

A. According to the government standard, ice cream is a frozen product made from cream and sugar, with or without a natural flavoring, and contains not less than 14 per cent. of milk fat. Market cream usually does not come up to this standard in butter fat. Condensed skim-milk is quite commonly used as one of the ingredients of commercial ice cream. Homogenized cream is also used by some makers. Gelatin is commonly used as a binder.

DIVISION FIVE.

WEIGHT AND SPECIFIC GRAVITY OF MILK AND ITS PRODUCTS.

Q. . What is the weight of a gallon, quart or pint of milk?

A. The weight of milk varies a trifle with its specific gravity, or the per cent. of solids. The weight of a gallon of milk is about 8.6 pounds; of a quart, 2.15 pounds; of a pint, 1.07 pounds; or an eight-gallon can should hold 68.8 pounds, or a ten-gallon can 86 pounds of milk.

Q. How much does a gallon of skim-milk weigh?

A. A gallon of skim-milk varies a trifle according to its specific gravity, but practically it may be taken as 8.65 pounds.

Q. What is meant by specific gravity?

A. The specific gravity of a substance is the difference between the weight of that substance and the weight of an equal volume of distilled water. Water is always considered as one, or the unit with which liquids and solids of the same temperature are compared; for instance:

One gallon of water weighs 8.3 pounds; the specific gravity is 1.

One gallon of milk weighs 8.6 pounds; the specific gravity is 1.032.

One gallon of butter fat weighs 7.7 pounds; the specific gravity is .93.

Hence, other conditions being equal, the weight of cream varies with its per cent. of butter fat.

Q. What is the specific gravity of cream containing different percents of butter fat?

A. The specific gravity of fresh separator cream, according to Farrington, is as follows: Cream containing 20 per cent. of butter fat, 1.008; 25 per cent., 1.002; 30 per cent., .996; 40 per cent., .996; 50 per cent., .947.

Q. Can you find the weight of a certain volume of any substance if the specific gravity is known?

A. Yes; by multiplying the specific gravity of the substance by the weight of water of equal volume.

EXAMPLE.

Problem 1.—Cream that contains 20 per cent. of butter fat has a specific gravity of 1.008 at 60° F. What is the weight of a gallon of this cream?

8.3 (the weight of a gallon of water) $\times$ 1.008, (the specific gravity) $=$ 8.366 or practically 8.4 pounds.

Q. If the butter fat in milk is lighter than water, what raises the specific gravity to 1.032?

A. It is due to the increased proportion of solids, not fat (such as albuminoids, milk sugar, and ash), which are heavier than water.

Q. Why must the temperature of any substance be the same as the temperature at which the specific gravity of water was taken?

A. Because liquids expand upon heating and contract when cooled. A gallon of water at 60° F. will, upon heating to 100° F., increase in volume so that it will occupy more than a gallon; hence, it is necessary to keep the same temperature in order to calculate the specific gravity of a substance.

DIVISION SIX.

NECESSITY FOR TESTING DAIRY PRODUCTS.

Q. What, then, is the just method for buying or selling milk or cream?

A. According to the above answers the proper way to buy milk and cream is by weight and the per cent. of butter fat, since this constituent has the greatest marketable value at the present time. Nearly all the milk bought from farms by creameries, cheese factories and condensing factories is bought by weight, but a much smaller amount is bought according to the butter fat. Retail dealers, as a rule, still adhere to the old method of buying by measure (gallons), yet many of them are establishing arbitrary standards, giving the amount of butter fat the milk should contain. Nearly all the milk and cream that is retailed for direct consumption in cities is sold by measure (quarts and pints), since the labor that is necessary to weigh into bottles costs more than is saved. Few city dealers guarantee the per cent. of fat in milk and cream; hence, milk or cream retailed in cities in small quantities can be justly sold by measure, but the price should be regulated according to the per cent. of butter fat it contains. For illustration, milk which contains 3 per cent. of butter fat and sells for 7 cents a quart is not worth as much as milk which contains 4 per cent. of butter fat, providing the latter is as sweet and pure as the former. It is far more important to buy and sell cream on a basis of the butter fat content. Hence, if 20 per cent. cream sells for 60 cents per gallon, 40 per cent cream should be worth $1.20 per gallon, providing the cream is of equal purity and sweetness.

Q. Can the quantity of butter fat in milk or cream be regulated?

A. Yes; the milk or cream should be tested for its butter fat content and then standardized according to the per cent. desired. (See rules for Standardizing.)

Q. What advantages are there for knowing the per cent. of

butter fat, other than that it serves as a basis for buying and selling milk and cream?

A. (1) One can determine the value of the individual cow. The greater the number of pounds of butter fat a cow produces during the year, the more valuable is the cow, providing the feed and care necessary to sustain her does not overbalance the value of butter fat. By determining the cost of the amount of feed and labor that is required by a certain cow, the cost of the production of milk or butter fat can be calculated. (2) One can determine the amount of butter fat lost in whey and buttermilk in the manufacture of cheese and butter. If the loss is too great, so that the business becomes unprofitable, the fault can be readily discovered and remedied.

DIVISION SEVEN.

TESTING MILK.

Q. How can you test milk?

A. By means of the Babcock test.

Q. Can you test other dairy products by this method?

A. Yes; milk, cream, skim-milk, buttermilk, whey, cheese, condensed milk, ice cream and butter.

Q. Is it practical to buy a Babcock tester?

A. The Babcock tester is as essential in buying milk or cream as the scale is in buying corn.

Q. Name the pieces of apparatus which are used in the Babcock test.

A. (1) Centrifuge (or whirling machine), (2) graduated Babcock milk test bottle, (3) pipette, (4) acid measure and (5) dividers.

Q. Are there any chemicals used in making the test?

A. Yes; one—commercial sulphuric acid.

Q. What are the different steps in testing milk with the Babcock test?

A. 1. See that the test bottles and pipettes are accurately calibrated (accurately marked).

2. See that the test bottles and pipette are clean.

3. See that the centrifuge is properly oiled and in order before starting.

4. See that the sample of milk to be tested is thoroughly mixed. (If a composite sample follow the details as explained below.)

5. See that the temperature of the sample of milk is not below 50° F. nor above 70° F.

6. Measure out 17.6 cubic centimeters of the milk with the pipette and put it into the test bottle.

7. See that the sulphuric acid is of the proper strength (sp. gr. 1.82 to 1.83).

8. Measure out 17.5 cc of sulphuric acid and pour into the test bottle with the milk.

9. Thoroughly mix the acid and milk.

10. Put the mixture into the centrifuge and see that the centrifuge is balanced.

11. Turn the centrifuge 5 minutes at the proper speed, then add hot water to the mixture until it reaches the base of the graduated neck.

12. Put into centrifuge and rotate the bottle two minutes more.

13. Fill with hot water to 7 per cent. or 8 per cent. mark.

14. Whirl 1 minute.

15. Remove bottles to hot water bath, with water at a temperature of 140° F. and deep enough to cover fat column.

Q. How are milk test bottles graduated?

A. They are graduated from 0 to 10 per cent. Each one per cent. is numbered and each one per cent. space is divided into five parts, each representing .2 of one per cent.

Q. What is the basis for the graduation of test bottles?

In calculating what quantity of butter fat could be conveniently read with the greatest accuracy and with the smallest cost, Doctor Babcock estimated that a space in a narrow glass tube holding two grams of water and representing 10 per cent. of a quantity of milk would best meet these conditions. Accordingly, a tube containing such a column of water was marked at the base and top of the column, and this space was divided into ten equal portions, representing per cents. Each division was then divided into five parts, each representing two-tenths of one per cent. Since this column of water weighs two grams, an equal volume of butter fat would weigh 1.8 grams (fat having a specific gravity of approximately .9). Then 1.8 grams represents 10 per cent. of a certain volume which must be 18 grams. Hence 18 grams of milk is the proper amount to use in testing for butter fat with the Babcock tester.

Q. Why are 17.6cc of milk used?

On account of the inconvenience of weighing, these weights have been reduced to their equivalent volumes. Considering the average specific gravity of milk as 1.032, the equivalent volume of 18 grams of milk is found to be nearly 17.44 cubic centimeters; e. g., $18 \div 1.032 = 17.44$. Allowing for the small quantity that adheres to the side of the pipette, 17.6 cubic centimeters has been taken as the proper amount to be measured out.

Q. Is the graduation of testing apparatus always correct?

A. No.

Q. How is the accuracy of graduation determined?

A. By calibration or measuring with water, mercury or a plunger.

Q. How are milk test bottles calibrated with water?

A. See that the bottle is cleaned thoroughly. Fill the bottle to the zero mark with distilled water. Remove any surplus water from inside of neck of bottle with a strip of blotting or filter paper. Measure into the bottle 1cc of distilled water from an accurately marked burette or pipette. This should fill to the 5 per cent. mark. One more cc of water should fill to the 10 per cent. mark. Each .2cc equals one per cent. on neck of bottle.

Instead of measuring the water, the bottle filled to the zero mark may be balanced on a delicate scale. Then it should take just one gram of distilled water to fill to the 5 per cent. mark and 2 grams to fill to the 10 per cent. mark. Each .2 gram equals 1 per cent. on neck of bottle.

Q. How may test bottles be calibrated by use of mercury?

A. See that the bottle is thoroughly cleaned and dry—especially free from fat. The space in the Babcock test bottle between the zero and the ten-per-cent. mark holds just two cubic centimeters. Pour two cubic centimeters of mercury (by weight 27.18 grams) into the test bottle. Insert a smooth cork into the bottle until the end reaches the ten-per-cent. mark. Invert the bottle. If it is correctly graduated, the mercury will just reach the zero mark.

Q. How may 10 per cent. bottles be calibrated by a plunger?

A. This tester consists of nothing more than a piece of metal of such a size that it will displace exactly two cubic centimeters of liquid. It is divided into two parts, connected with a thin wire, and each part displaces one cubic centimeter, which is equal to 5 per cent. on the graduated scale of the test bottle or the two parts are equal to 10 per cent. It is used as follows:

Fill the bottle with milk, alcohol or water so that its highest point is exactly even with the 0 mark. Slowly lower the tester into the bottle until the liquid rises about half way between the two sections. At that point should be the five-per-cent. mark.

That point having been established, slowly lower the entire tester into the bottle so that the liquid rises over the top of the upper section about one-eighth of an inch, and if the liquid is exactly even with the ten-per-cent. mark, and was the same at the five-per-cent. mark, the bottle is correct.

Before using again, the liquid adhering to the tester should be wiped off. See that the neck is practically free from adhering drops of liquid and that no air bubbles are located between the tester and the neck of the bottle.

Bottles of more than one-tenth of one per cent. out of the way may be considered unfit for use.

Q. How may 8 per cent. milk bottles be calibrated?

A. Most conveniently by distilled water, remembering that each .2cc or .2 gram equals 1 per cent. on neck of bottle.

Q. How may pipettes be calibrated?

A. A pipette may be calibrated by filling to the mark with water, dropping the water into a weighed vessel and finding the weight of the water. A 17.6 cc pipette should deliver 17.44 grams of water. It may also be calibrated by dropping the water into a burette which has previously been filled to the 17.6 mark. The water from the pipette should fill the burette to the zero mark.

Q. How may acid measures be calibrated?

A. The acid measure need not be calibrated with extreme accuracy, since the strength of the acid and the temperature tend to cause a variation in the amount.

Q. How may cream bottles be calibrated?

A. By the use of water or mercury in the same manner as in whole milk bottles. It requires the same volume and weight of material to fill a 10 per cent. space in an 18 gram cream bottle as in a milk bottle. In a 9 gram cream bottle it requires only one-half as much. For instance 1 c.c. of water will fill the 10 per cent. space instead of 2 c.c.

Q. How may skim-milk bottles be calibrated?

A. The only satisfactory way to calibrate skim milk bottles is by the use of mercury. The skim-milk bottle is graduated on the same basis as the whole milk bottle. A 10 per cent. space will contain 2 c.c. of water. A one per cent. space will contain 1/10 of 2 or .2 c.c. of water. The .25 per cent. space in the skim-milk bottle will hold .25 of 2 c.c. or .050 c.c. of water or mercury. Since the specific gravity of mercury is 13.6, the number of grams of mercury the .05 c.c. space will contain is $.05 \times 13.6 = .680$ grams. Weigh out .68 gram of mercury. Place this in the large tube of the bottle. Secure a small stiff wire and wrap enough cotton about the end of it to make it fit snugly the graduated tube of the bottle. Push wire with cotton to the base of graduated tube. Then invert bottle and draw wire out slowly. If the wire fits the neck tightly enough the mercury will follow it. The mercury should just fill the graduated space from 0 to 25/100 per cent.

Q. Why is it necessary to mix milk for testing?

A. Because the fat rises to the top and the upper layers of the milk soon become richer than the lower.

Q. What is the best way to mix milk?

A. By pouring from one vessel to another.

Q. How many times is it necessary to pour?

A. At least four or five, depending on consistency of the cream which has raised on milk.

Q. How are 17.6 c.c. of milk obtained?

A. Immediately after the milk has been mixed, draw milk into a pipette above the mark indicating 17.6 cubic centimeters, then suddenly close the upper end of the pipette with the index finger. By slightly releasing the pressure, the milk is allowed to run down until it reaches the mark, when it is again stopped by pressing finger on pipette. It is then transferred into the test bottle and is delivered by holding the pipette at a slight angle in order to allow for the escape of the air which is replaced by the milk that flows into the bottle. Care must be taken to see that the index finger is dry when measuring out milk, and that all milk adhering to the pipette is blown into the bottle as thoroughly as possible. An exact amount of milk must always be taken. Special care must be exercised that milk of a previous sample may not be dropped into the bottle; also that no milk adhering to the outside of the pipette is discharged into the milk bottle.

Q. What kind and amount of acid should be used?

A. Sulphuric acid having a specific gravity of approximately 1.82 to 1.83 should always be used. The amount needed is approximately 17.5 cubic centimeters, depending somewhat on the temperature of the milk and acid and the strength of the acid. The proper temperature of the milk is from 60° F. to 70° F. for adding acid. If the milk is colder than 60°, more acid must be used. If the milk is warmer than 70°, less acid must be used. If the acid is too weak more acid must be used or else the milk must be heated higher than 70° F. If the acid is too strong less acid must be used or the milk must be lowered in temperature (below 50° F.).

Q. How can one determine whether acid is of the proper strength and the proper amount to use?

A. Take three or four test bottles with milk of the same quality and temperature. Use various amounts of acid in the various bottles and test each bottle under the same conditions and note which quantity gives clearest fat column. This will be the proper amount required. If 17.5 c.c. gives good results the acid is of proper strength. A special hydrometer or acidometer has been devised for determining the specific gravity. Strong acid has specific gravity above 1.83, weak below 1.82 at 60° F.

Q. If acid is too strong, may it be diluted?

A. Yes. This must be done very cautiously, since pouring water suddenly into a jug or bottle of acid causes the receptacle to heat and burst. A safe way is to fill a small glass three-fourths full water, then add acid until glass is full. This mixture, which becomes very hot, should then be set away and cooled gradually. When cold, the mixture may be turned into the carboy or the receiver. The amount of water required depends on the strength of the acid. It is best to start with a small quantity of water, as, for instance, one-half pipette of water to one gallon of acid.

Q. How should acid be added to milk?

A. Fill 17.5 c.c. acid measure to the mark. Transfer the acid into the test bottle, which contains the milk, by holding the test bottle at an angle of 45° and pouring the acid slowly so that it will run down the side of the neck; at the same time slowly rotating the test bottle so as to wash all the milk from the neck of the bottle.

Q. How should acid and milk be mixed?

A. The mixing should be done within five to seven minutes after the addition of the acid, since where the milk is left too long in contact with the acid, the casein of the milk becomes charred, and rises and mixes in with the fat in the graduated column. The mixing should be done by a rotary motion so that the curd will not lodge in the neck of the bottle and again influence the reading of the butter fat. The graduated portion of the test bottle must always be kept clean and free from curd.

Q. What precaution is necessary in placing bottles in centrifuge?

A. To see that they balance the centrifuge wheel. If there is an odd number fill another bottle with water. See that the bottles of the same size are opposite each other.

Q. What is the purpose of the centrifuge?

A. To whirl the bottles. The whirling of the bottles and the mixture produces a pressure known as centrifugal force. This is illustrated by taking a pail and swinging it arm's length in a vertical circle. If the pail is kept in motion, the water will not spill out even though the pail is in an inverted position. The reason this water does not spill out is due to the outward pressure, or centrifugal force. The heavier particles will go nearest to the outside (because their own weight produces a greater force) and crowd the lighter portions toward the center. The tendency of all particles of matter is to arrange themselves according to their weight, when acted upon by centrifugal force. Another illustration may be found in a piece of lead and a piece of cork of equal size. Tie each to a string of equal length and whirl them. Upon whirling it is found that the pull of the piece of lead is much greater than that of the cork, because it is heavier. Fat is the lightest constituent of the mixture of milk and acid in the test bottle, and for this reason it is crowded to the top, or separated out by the heavier particles by centrifugal force produced by whirling the centrifuge.

Q. What should be the speed of the centrifuge?

A. The centrifugal force of the centrifuge depends upon the diameter and velocity of the wheel. It is estimated that enough force must be generated to equal 30.65 pounds pressure on each bottle. The centrifugal force is increased directly in proportion to the increase in the diameter and directly with the square of the velocity of the centrifuge.

Q. What is the speed required for wheels of different diameters?

A.

Diam of wheel in inches.	Rev. of wheel per minute.
10	1074
12	980
14	909
16	840
18	800
20	759
22	724
24	693

Q. How is the speed of a power machine determined?

A. With speed indicator, either attached or separate.

Q. How may the speed of a hand tester be determined?

A. By counting the number of revolutions of the wheel to one turn of the handle and multiplying by the number of turns of the handle.

Q. Is heat necessary inside the centrifuge?

A. Yes. A temperature of 140° F.

Q. How may this be secured?

A. By escape of steam into the chamber, in a steam driven tester. In a hand tester or a tester driven by power other than steam, a hole may be drilled in side of tester and a steam pipe connected. Pouring boiling water into bowl of hand tester will do some good. A hand tester should never be operated in a cold room.

Q. What should be length of time of first run?

A. Five minutes, except for skim-milk which requires eight minutes.

Q. How is the test completed after the five minute run?

A. At the end of the first run hot water is added to bottom of neck of bottles. The centrifuge is run a second time for two minutes at full speed. Water is again added, this time to the 8 per cent. mark and the centrifuge whirled for one minute.

Q. What should be the temperature of water for filling and why is it added twice?

A. 140° F. in a steam centrifuge. If there is no means of keeping up heat in centrifuge bowl, use water as near boiling as possible. The hot water keeps the fat column liquid. Two fillings and two runs after the first gives two opportunities to wash sediment from the fat and gives a clearer fat column than one filling.

Q. What kind of water should be used to fill test bottles?

Soft water or distilled water. Boiling hard water or adding small amounts of sulphuric acid will make it safe to use.

Q. What should be temperature of fat column when read?

A. 140° F. Place bottles in water at this temperature at completion of third run and leave for four minutes. At 140° F. the fat has the desired specific gravity of .9 and a higher or lower temperature gives a high or low reading respectively.

Q. How is the fat column read?

A. By counting the graduated spaces between lowest point of fat column and extreme upper part of upper meniscus. This is correct because a certain amount of residual fat is not removed from the serum. A pair of dividers assists in reading.

Q. How is the amount of butter fat in the milk calculated from the per cent. of fat?

A. Multiply the per cent. of butter fat by the pounds of milk and divide by 100 as follows: If 450 pounds of milk tests 4 per cent. of fat, $\frac{450 \times 4}{100}$ or $450 \times .04 = 18.00$ pounds of fat.

Q. How may one be sure tests are correct?

A. Making tests in duplicate practically assures accuracy and should be done whenever possible. The two tests should not vary more than .2 per cent.

Q. What should be appearance of the fat column?

A. It should have a clear amber or yellowish color and contain no sediment. Foam on the top indicates hard water used in filling. A drop of alcohol removes the foam.

Q. What causes charred particles in or below fat column?

A. 1. Too strong acid. 2. Too much acid. 3. Milk or acid too warm. 4. Dropping acid through the milk. 5. Not mixing soon enough.

Q. What causes white particles in or below fat column?

A. 1. Too weak acid. 2. Not enough acid. 3. Milk or acid too cold. 4. Insufficient mixing. 5. Low speed of centrifuge.

Q. How are bottles marked to distinguish them while in tester?

A. With a lead pencil on etched surface on bowl of bottle. Glassware can be etched by the use of hydrofluoric acid.

Q. How should the centrifuge be cared for?

A. It should be kept clean and well oiled. It should stand level and be fastened to a solid foundation. A steam turbine should have the exhaust open wide enough to allow free escape of steam.

Q. How should test bottles and pipettes be cleaned?

A. Empty them while still hot to keep the fat from sticking. Shake them to remove sediment from bottom. Thorough rinsing with hot water is usually sufficient to complete the cleaning, if special apparatus is at hand so that the water can be introduced at near the boiling point. It is safer to use an alkali such as salsoda, caustic potash or a soap powder to remove the fat. Wyandotte washing powder is good. The occasional use of a mixture of sulphuric acid 1 gallon to bichromate of potash ½ to 1 pound is desirable. If a sediment collects on sides and bottom of the bottle put some No. 8 or No. 9 shot into the bottle with an alkali solution and shake vigorously. Always rinse with hot water and drain. Rinsing with cold water followed with hot water and an occasional use of an alkali is sufficient for pipettes.

Q. How is an accurate sample of a cow's milk obtained?

A. The first milk tests very low, the last or strippings very high in butter fat. Therefore, the cow must be milked dry. Then mix evenly by pouring from one vessel to another several times and take a sample from the entire milking.

Q. How can an accurate sample of milk be secured from a herd?

A. There are two ways to obtain an accurate sample of the milk from a herd of cows. First, mix the milk from all the cows together and take sample with usual precautions. Or, second, take equal or aliquot parts of each cow's milk and mix together in one sample.

Q. What is a composite sample and how is it taken?

A. A composite test is a test made from a number of samples which are taken at various times and mixed together in the right proportion, so that the amount of fat it contains is proportional to the amount of fat in the quantity of milk that it represents. To do this, each sample of milk taken must be an equal or aliquot part of each milking or of each quantity of milk. This sample can be taken with a brass tube of three-eights to one-half inch bore, and the receptacle into which the milk is placed when the sample is taken must always be cylindrical and of the same size in order to secure the proportional amount of milk. The milk should be slightly stirred and the tube lowered into the milk so it will take a sample from the different layers of milk. The milk may be retained by putting the finger over the end of the tube; then place milk in a jar and add a preservative to keep it sweet. A good way to secure a composite sample is to take one or more cubic centimeters of milk for each pound of milk in the different milkings or lots of milk from which the composite is being taken. The preservatives used may be formaldehyde, corrosive sublimate, or bichromate of potassium. The two latter substances are poisonous. The quantity of preservatives used varies with the quantity of milk to be preserved, and also with the temperature at which the milk is kept. About twenty to thirty drops of formaldehyde will preserve a quart of milk for five days at a temperature of 60° to 70° F., or 10 grains of corrosive sublimate or 20 grains of potassium bichromate will preserve the same amount of milk at the same temperature. More preservative should be used if more milk is added, and if kept at a warmer temperature. Care should be taken that the jars are covered and not exposed to too much light, for the cream becomes leathery and this makes it difficult to mix into the milk. To make a test from the composite sample, the milk must be heated to about 110° F. in order to get a thorough mixture of cream and milk. It must then be gradually cooled and mixed while cooling. Care must be taken not to churn sample. The shaking should be done by a rotary motion. The sample must be taken immediately after mixing and tested in the regular manner, except where bichromate of potassium has been used, in which case a little less acid must be taken in making the test.

Q. What is meant by an aliquot part?

A. An aliquot part is an exact division of any number, or an exact per cent. of any quantity. For illustration, if a composite test sample is started with a rate that one thirty-third part of a hundred is to be taken as the sample to be tested for the butter fat, all other samples for this individual test must be taken in the same ratio. For instance, cow No. 1 gives 25 pounds of milk at a milking; hence a proportionate quantity representing one-third of one per cent., or $25 \times .0033\frac{1}{3} = .08\frac{1}{3}$ pounds.

At another milking she gives 20 pounds; hence, the same proportion must be taken, which is $20 \times .0033\frac{1}{3}$, or .06 lbs. of the sample to be tested. In case of taking a composite sample in a creamery, where a man brings in 800 pounds one day and 400 pounds another, he should have exactly the same per cent. of the quantity of milk in his composite sample bottle as he had in the milk that he brought, namely, twice as much in the first as in the second.

Q. Can an accurate composite be secured by taking the same size sample from each of the different lots of milk regardless of their amount or quality?

A. No. The following problem will illustrate this:

A cow produces one day, 50 pounds of milk, which contains 4 per cent. of fat. On the second day she gives but 25 pounds of milk which tests 3 per cent. of butter fat. If an equal amount was taken from these two milkings, such as with a tablespoonful, the sample would indicate half 3 per cent. milk and half 4 per cent. milk. The Babcock test would show the average per cent. fat of the samples which, according to their amounts, would be 3 per cent. and 4 per cent. added together and divided by 2, or $3\frac{1}{2}$ per cent. Hence, $3\frac{1}{2}$ times the total quantity, or 75 pounds of milk, would amount to 2.625 pounds of butter fat, while if an aliquot sample had been taken the amount of fat would be $50 \times 4 = 2.00$ and $25 \times 3 = .75$. Total would be $2.00 + .75 = 2.75$, a difference of .125 of a pound of fat.

To obtain the true per cent. of butter fat, it becomes a problem in alligation as, for example, in the preceding problem, 2.75 pounds butter fat ÷ 75 pounds milk = .0366, the average per cent. of fat in the above quantity of milk. Hence, from the above it will be seen that the only just sample that can be secured is by taking an aliquot part. This can be done by means of tubes and milk receptacles of the same size or relative proportionate sizes. The proportional content of a cylinder can be calculated by a formula $\pi R^2 H$.

$\pi = 3.1416$.
R = radius of cylinder or ½ diameter.
H = height of cylinder.

Hence the relation between two cylinders of the same height varies with the radius.

Q. How may curdled milk be sampled for the Babcock test?

A. When milk has curdled, the casein may be redissolved by adding an alkali. Powdered potash, soda or liquid ammonia may be used. Care should be taken not to use too much alkali as it reacts with the acid and may throw some of the sample out of the bottle. It may at the same time cause an error in the sample by increasing the volume. The potash and soda may be dissolved in water before being used, and a volume equal to about five per cent. of the volume of milk will be sufficient to dissolve the casein. This amount of solution increases the volume of the milk, and thus necessarily decreases the per cent. of fat. If the volume of milk to be tested is measured and the solvent is also measured, the per cent. of decrease can be calculated in the following manner:

Example.—Nine cubic centimeters of alkaline solution has been added to dissolve the casein, which is five per cent. of the milk used ($180 : 9 :: 100 : \gamma = 5$). The mixture gives a test of 3.9 per cent. of butter fat. The test must be increased 0.195 per cent. ($3.9 \times .05 = 0.195$). Hence, the per cent. of fat in the original milk is 4.095)$3.9 + 0.195 = 4.095$).

Q. How may frozen milk be sampled?

A. Frozen milk should be heated to 130° F. and then thoroughly shaken and gradually cooled in order to incorporate the fat globules that have been churned by the freezing.

Q. How may milk that has been churned be sampled?

A. One method is to dissolve the little lumps of butter fat by adding 5 per cent. of ether and mix well. Then make a 5 per cent. correction in the fat. Another method is to heat the churned milk to a temperature of 110° to 120° F. until the fat is melted; then by shaking and cooling the fat can be remixed with the milk. The sample is then taken in the usual manner.

DIVISION EIGHT.

TESTING SKIM-MILK, BUTTERMILK AND WHEY.

Q. How are skim-milk and buttermilk tested for butter fat?

A. In the same manner as whole milk except that a special bottle is used, about 18 to 20 c.c. of acid is added and the centrifuge is whirled eight minutes for the first run instead of five minutes.

The special skim-milk bottle has a double bore neck, one of the tubes being large enough to receive the milk, acid and water, the other being very fine and graduated for reading the fat. The whole graduated space represents one-fourth or 25/100 of one per cent. This is sub-divided into five spaces each representing 5/100 of one per cent. Each of these is again sub-divided into five spaces representing 1/100 of one per cent. If it is suspected that the skim-milk or buttermilk contains more than 25/100 per cent. of butter fat, it is well to use a whole milk bottle as a check.

Q. How is whey tested for butter fat?

A. The same as skim-milk except that about 10 c.c. of acid is used.

DIVISION NINE.

TESTING CREAM.

Q. Is it of great importance for any farmer that produces milk to know how to test cream?

A. It is very essential if he sells cream.

Q. How may an accurate sample of cream be secured from the cream can?

A. The cream should be warm enough to pour readily. When it is practical to do so the cream should be poured from one vessel to another, as in sampling milk, and a sample taken with a dipper. Otherwise, a strong disc of tin or tinned metal, fastened to the end of a stiff rod long enough to reach to the bottom of the can, should be used for stirring. The upper portion of the cream is richer in fat than the lower, the same as in milk and the stirrer should be moved up and down until the upper and lower portions of the cream are thoroughly mixed. Thorough mixing cannot be too strongly emphasized. Care should also be taken to scrape from under the bulge of the can the heavy cream which collects there. If the disc used in stirring is concave the sample may be taken with it.

Q. Are sampling tubes satisfactory for sampling cream?

A. No.

Q. Can frozen cream be sampled?

A. Yes. If all the particles of ice are first melted.

Q. Can churned cream be sampled?

A. No.

Q. Is it as satisfactory to take composite samples of cream as to test each sample separately?

A. No. Because it is not usually convenient to take composites of cream proportionately or by aliquot parts.

Q. Will the test of a composite sample of cream increase as it gets older?

A. Yes. Unless very tightly stoppered and kept in a cool place. The same is true of milk samples but does not amount to so much because of the smaller per cent. of fat.

Q. Is the testing of cream by composite samples to be recommended?

A. No.

Q. How is a cream sample prepared for testing?

A. If cream is in good condition pour from one vessel to another. If it is thick warm slightly before pouring. If the sample is churned or has a tough layer on top, warm to 110° F. to melt butter fat, shake vigorously and cool to 60° F., continuing the shaking until cool. There is so much fat in cream that when it has once been separated it rises to the top too rapidly to sample accurately unless reincorporated as above.

Q. How may sour cream be tested?

A. It may be tested the same as sweet cream unless chunks of curd have formed. To destroy these it may be necessary to force the cream through a sieve, pressing the lumps through with the fingers.

Q. How does testing cream by the Babcock test differ from testing milk?

A. The cream must be accurately weighed instead of measured. A special cream bottle is used. Less acid is required for cream. The fat column is not read to the top of the upper meniscus.

Q. Why is it necessary to weigh cream?

A. First, the Babcock test bottle has been so graduated that a sample to be tested should weigh 18 grams or a fraction thereof. Cream is lighter than milk, and thus a larger volume is required to weigh 18 grams. Hence, the pipette that is graduated to 17.6 cubic centimeters, and which will discharge 18 grams of milk, will not discharge 18 grams of cream. The greater the per cent. of fat in cream, the greater will be the error in the per cent. of fat by the use of the pipette. This can best be illustrated by a bushel of wheat which weighs 60 pounds. Fill the bushel measure with oats and you will find that it weighs 32 pounds. Comparing the bushel measure with the pipette, the wheat with the milk, and the oats with the cream, it will readily be seen that it is impossible to get 60 pounds of oats into one bushel measure. Neither can 18 grams of cream be put into a 17.6 cubic centimeter pipette.

Second, cream is apt to incorporate a great deal of air, and this again decreases the weight per volume.

Third, cream is also thicker or more viscous than milk, and when drawn into the pipette and discharged a considerable quantity will adhere to the pipette and lessen the weight of the cream discharged into the bottle. Hence, for accurate work, especially if heavy cream is to be tested, it is necessary always to weigh the sample.

Q. How is cream weighed for testing?

A. On a delicate balance, by dropping the cream from a pipette after the bottles have been balanced and the proper weight applied.

Q. What is the construction of the special cream bottles?

A. Various types are on the market. The most satisfactory are the nine-inch, nine-gram 50 per cent., and the six-inch, nine-gram 50 per cent. bottles. The difference between these two types is that the neck of one is longer than that of the other and therefore smaller in diameter, making accurate reading of fat column less difficult. These bottles are built for using a nine-gram instead of an eighteen-gram sample, as in the whole milk bottle. In a nine-gram bottle a space representing 10 per cent. on the graduated portion will contain one-half as much as on the eighteen-gram bottle, or only 1 c.c. These bottles are graduated to one-half of one per cent.

Another satisfactory bottle is the nine-inch, eighteen-gram, 30 per cent. cream bottle. As is indicated, this bottle is nine inches long and is built for using eighteen-gram samples, the same as a whole milk bottle. This bottle is graduated to .2 per cent., the same as a 10 per cent. whole milk bottle. Six-inch, eighteen-gram bottles are used, but the fat column cannot be read with the same accuracy as in the bottles with longer necks.

Q. Is it necessary to use 9 grams of cream in a nine-gram bottle and 18 grams in an eighteen-gram bottle?

A. No. Smaller amounts may be used. When less than 9 grams are used in a nine-gram bottle the fat reading is corrected by multiplying by nine and dividing by the size of the sample. Example—Suppose 6.5 grams of cream are used and the fat reading is found to be 30.5 per cent., then $(30.5 \times 9) \div 6.5 = 42.2$ per cent. When less than 18 grams are used in an eighteen-gram bottle, the same rule will hold, substituting 18 for 9. When a ½, ⅓ or ¼ sample is used in either case the fat reading is corrected by multiplying by 2, 3 or 4 respectively.

Q. How much acid is added to cream in testing?

A. Use a little less acid than cream if no water is added. If a sample of cream smaller than 18 grams is used, best results are secured by adding enough cool water to make the total contents of the bottle approximately 18 grams and add acid as for milk. This lessens the danger of burning the fat and a clearer fat column is obtained than when no water is added. The bowls of some bottles are not large enough to add as much water as recommended above. It is an advantage to add at least a few c.c. in any case. A good rule is to add enough acid to produce a red-brown or coffee brown color when mixed. A rich cream does not need as much acid as a thin cream because there is more fat and a smaller amount of other solids. Too much acid will char the fat column and make the fat reading too low.

Q. Can the cloudiness sometimes found in the fat column be overcome?

A. Reshaking at the end of the first run, mixing the layer of fat with the acid will usually prevent this, provided the acid is of proper strength and the temperature in the tester is high enough. If the cloudiness is present at completion of the test, running an extra length of time in a steam heated tester will sometimes correct it, or the bottles may be set in cold water to solidify the fat, then put in hot water to heat and melt it, and run again for a few minutes.

Q. Is it possible to test cream in a whole milk bottle?

A. Yes. By making a definite dilution by weight with water and multiplying the fat reading at the completion of the test, by the number of times the cream was diluted. The dilution must be great enough so that the fat may be read on the 10 per cent. scale.

Q. How should the fat column in a cream test be read?

A. The most accurate reading is secured by adding some colored glymol or white mineral oil to top of fat column, as suggested in Indiana Bulletin 145. This is best added just as bottles are taken from hot water bath to read. Tests should always be read from hot water bath at 140° F. The glymol is lighter than the fat and remains on the top of it, destroying the meniscus. If glymol is not read the reading should be taken at bottom of clear portion of upper meniscus.

Q. How is glymol prepared for use?

A. In one quart of glymol suspend one ounce of crushed alkanet root wrapped in a piece of cheese cloth. In a day or two the glymol will absorb the red color from the alkanet root. The alkanet root can be secured from druggists. The glymol may be used uncolored but the line between the fat and the glymol is more distinct when the glymol is colored.

DIVISION TEN.

TESTING BUTTER AND CHEESE.

Q. How may an accurate sample of butter for testing be secured?

A. Take samples of uniform size from various parts of the churn or package. Place these in a vessel with tight cover. A glass stoppered bottle is best. Melt by holding the vessel in hot water. When butter becomes the consistency of thick cream and all lumps are gone, cool by holding under a stream of cold water and constantly agitating until it solidifies. The above operation furnishes a representative sample, which is uniform in composi-

In the last sentence of the third answer on page 32, the word "read" should be changed to "used."

tion. The test sample is weighed from the resolidified mass. If one works quickly and carefully the test sample may be weighed from the melted sample by drawing it up in a pipette and weighing like cream. Great rapidity in manipulation is necessary to prevent error because the heavier material so quickly settles in the butter fat.

Q. How is butter tested for butter fat?

A. (a) Weigh 9 grams of butter into an 18-gram 50 per cent. cream bottle. Add 10 c.c. of hot water, then add 17.6 c.c. of sulphuric acid diluted one-half. Proceed with test as for cream, multiplying fat test by 2.

(b) Weigh 4.5 or 5 grams of butter into a 9-gram cream bottle. Add about 5 to 6 c.c. of water and about a half a measure of one-half sulphuric acid and one-half water. Proceed with test as for cream. Correct the reading by multiplying by 9 and dividing by the size of sample used. If a small glass funnel is at hand it may be placed in top of cream bottle and balanced with it on the scale. Then butter may be weighed into the funnel, and run into the bottle by slight heating. The water and acid added to bottles should be poured through funnel to rinse it.

(c) A special butter test bottle may be used. This has a double neck, one for adding butter and acid and one for reading fat column. In using this bottle 9 grams of butter are weighed into it, 9 grams of water are added and 9 c.c. of acid. Proceed as usual with the Babcock test. It is more difficult to secure an accurate test of butter by the Babcock test than other dairy products.

Q. How is butter tested for moisture by the Irish method?

A. Prepare sample as for testing for fat. Dry an aluminum cup over a gas or alcohol flame, the alcohol flame is better. Then balance on delicate scale. Weigh into the cup ten grams of butter. Evaporate over the alcohol flame until all water is gone. This point may be determined by holding a small mirror over the cup. When moisture ceases to condense on the mirror, the evaporation is complete. The sediment in cup will also turn a slight brown and the crackling will cease. Reweigh the cup and calculate the per cent. of moisture driven off. The accuracy of this test depends on gtting a fair sample of butter, careful weighing and evaporating to just the correct point.

Example—Suppose a 10-gram sample of butter is used in either the Irish or the Farrington oven test. On reweighing the loss of moisture is found to be 1.4 grams. Multiply 1.4 by 100 and divide by 10, or $\frac{1.4 \times 100}{10} = 14$ the per cent. of water in the butter.

Special moisture per cent. weights have been devised which will determine the per cent. of moisture without calculation. These are added to the side of the balance containing the sample cup after the evaporation and the value of weights necessary to bring to original weight will show per cent. of moisture driven off.

Q. How is butter tested for moisture by the oven method?

A. Weigh into a shallow aluminum dish from 10 to 50 grams of butter. The size of dish will govern the size sample used. The larger the sample the less the chance for error. Place the dish in the oven. Turn on enough steam to give a temperature of 250° F. and leave until moisture is evaporated, which will usually be from 45 minutes to one hour. Reweigh and calculate the per cent. of water from the loss in weight as in the Irish test.

Q. What is Ames-Cherry butter Moisture Test?

A. The manipulation is the same as in the Irish test except that the two aluminum cups are used, the one containing the butter sample sitting within the other during evaporation and the two sitting in a paraffine bath. The advantage claimed for this test is that the heating may be more easily controlled.

Q. How may the per cent. of salt in butter be determined?

A. Prepare butter sample as usual. A method devised by Vivian is as follows. Weigh 3.5 grams of butter on a small piece of parchment paper. Add butter and paper to 180 c.c. of boiling water in a flask and shake to dissolve the salt, removing the stopper frequently to release the steam. Let stand until cool. Then by means of an ordinary 17.6 c.c. pipette transfer 17.6 c.c. of the fat free liquid to a clean beaker or white cup. The pipette may be forced through the layer of fat without any fat entering if the upper end is closed by placing the finger over it. If a separatory funnel is at hand the contents of the flask may be transferred to it before cooling and the salt solution drawn from it after the fat has risen. To the 17.6 c.c. of solution in the beaker add two drops of potassium chromate for indicator and then add a solution of silver nitrate from a burette until the contents of the beaker become red. The number of c.c. of silver nitrate solution used indicates the number of tenths of one per cent. of salt. For instance, if 25 c.c. of silver nitrate solution are used the per cent. of salt is $25 \times .1 = 2.5$ per cent. of salt. The silver nitrate solution is prepared by dissolving 1.018 grams of pure silver nitrate in 1 liter (1000 c.c.) of distilled water.

Q. How may oleomargarine and renovated butter be distinguished from butter?

A. Melt a small piece of the suspected material in a spoon or other small dish over a flame. Boil vigorously. Oleo and renovated butter sputter and crackle noisily and form little foam, while butter makes little noise and much foam. The oil rising on melted butter when allowed to stand is clear, while that rising on oleo and renovated butter is cloudy.

Q. How may oleomargarine and renovated butter be distinguished?

A. Heat about one pint of sweet skim milk to about 140° F. Add about a teaspoonful of the material to be tested and stir until it melts. Then cool quickly by setting the cup in ice water and stir with a wooden spatula until the fat hardens. Oleomargarine will collect in a lump while butter and renovated butter will remain separated in small granules.

Q. What is the Hart casein test?

A. A test for determining the per cent. of casein in milk.

Q. What special apparatus is necessary for the Hart casein test?

A. A high-geared centrifuge which will give 2,000 revolutions per minute for a 15-inch wheel, a special test bottle, a 5 c.c. pipette for measuring the milk, a cylinder for measuring the chloroform.

Q. What principles are involved in performing the test?

A. The casein of the milk is precipitated by a dilute solution of acetic acid. Chloroform is used to extract the fat and make a solution heavier than the milk serum. Centrifugal force is used to separate the chloroform containing the fat, the casein and the milk serum into three separate layers.

Q. How is the acetic acid solution prepared?

A. It must be a .25 per cent. solution. Add 10 c.c. of pure glacial acetic acid to 90 c.c. of distilled water, making 100 c.c. of solution. To 25 c.c. of this solution add 975 c.c. of distilled water, making 1000 c.c. This will be a .25 per cent. solution.

Q. How is the Hart casein test made?

A. The temperature of the milk and acetic acid must be between 65° and 75° F., 70° F. being the temperature desired. The correct temperature is very important, a low temperature giving too high a reading of casein and a high temperature giving too low a reading. The room should be near 70° F. in temperature. To the special test bottle add 2 c.c. of best chloroform, then 20 c.c. of the acetic acid solution and last 5 c.c. of milk accurately measured. As soon as the materials are in the bottle, place the thumb over the opening, invert and shake somewhat vigorously for no less than 15 seconds and no more than 20 seconds. Place the bottles in the centrifuge and whirl at 2,000 revolutions per minute for a 15-inch wheel for eight minutes. The chloroform with the fat should then be found in the bottom of the test bottle, the layer of white casein next and on top the acetic acid and milk serum. Allow the bottles to stand in an upright position for 10 minutes before reading.

Q. How is a cheese sample prepared for testing?

A. Preparing sample—As in butter great care is needed to secure sample representing average composition. A narrow wedge reaching from the edge to the center will do this. This should be cut quite fine with a sharp knife, taking care not to squeeze out moisture and fat, and thoroughly mix. If a plug is taken with a cheese trier it should be taken perpendicularly one-third of the way from the edge to the center. It should reach completely through or only one-half way through. This should be cut and mixed in the same manner as the wedge. It is better when it can be done to take two or three plugs on different sides of the cheese and mix the whole plugs or split them lengthwise and mix one-half of each.

Q. How is cheese tested for butter fat?

A. Weigh into a cream bottle 4.5 to 6 grams of the macerated cheese. Add about 15 c.c. of hot water and shake until the cheese is dissolved. Keeping the bottles warm and adding a few c.c. of acid will sometimes hasten the process. When the curd is dissolved add acid as for cream and proceed as in testing milk. To correct the reading multiply by 9 or 18 depending on whether a 9 or 18-gram bottle is used and divide by the number of grams in sample.

Q. How is cheese tested for water?

A. Prepare sample as in testing for fat. Weigh 10 grams of the prepared cheese into an aluminum dish. Place in an oven at a temperature of 250° F. for at least one hour or until weight is constant. Reweigh and calculate the per cent. of water from loss of weight as in testing butter for water.

DIVISION ELEVEN.

TESTING ICE CREAM AND CONDENSED MILK.

Q. How may ice cream be tested for butter fat?

A. The sample of ice cream should be melted and mixed by pouring from one vessel to another as with ordinary cream. Weigh 9 grams of the ice cream into a 10 per cent. whole milk bottle. Add a mixture of equal parts hydrochloric acid and glacial acetic acid until the bottle is filled nearly to the neck. Mix and heat over a flame until the contents turn black. Place in centrifuge and proceed as with milk. Correct reading by multiplying by 2.

Q. How is unsweetened condensed milk tested for butter fat?

A. Carefully weigh 4.5 grams of well mixed evaporated milk into a 10 per cent. test bottle. Add one 17.6 c.c. pipette of water. Add 17.5 c.c. of sulphuric acid and shake until the curd is completely dissolved. Whirl at usual speed for five minutes. Mix equal parts of water and sulphuric acid in a glass beaker and fill test bottle to zero mark, while the mixture is still hot. Whirl for two minutes in tester, fill bottles to 8 per cent. mark with hot water and whirl for one minute. Read tests from hot water bath, at temperature of 140° F. reading from bottom to top of fat column as in whole milk. Multiply reading by 4 to secured correct per cent. of fat.*

Q. How may sweetened condensed milk be tested for butter fat?

A. By the same method as recommended for ice cream.

*According to Hunziker.

DIVISION TWELVE.

STANDARDIZING MILK AND CREAM.

Q. What is meant by standardizing milk or cream?

A. To standardize milk is to bring the butter fat content to a given per cent. regardless of the quality of milk produced by the cow. If the milk as drawn from the cow contains less butter fat than is desired, it can be brought to the desired standard by adding cream or extracting some skim-milk. If, on the contrary, milk that is yielded by the cow contains more butter fat than is necessary, it can be reduced to the desired standard by extracting cream or adding skim-milk.

Q. Is it just to standardize milk?

A. Yes, because the producer can not afford, for example, to produce milk containing five per cent. butter fat and receive pay for milk which contains only four per cent. butter fat (providing it is produced under equal sanitary conditions). To be legitimate the per cent. of fat must be indicated on the container.

Q. Can this reduction of fat not be secured by the addition of water?

A. Yes. But this is not permissible, for it also reduces the percentage of the solids not fat; that is, casein, milk sugar, and ash; whereas standardizing with cream or skim-milk does not materially alter the proportion of solids other than butter fat.

Q. Is there a definite standard to which milk or cream is standardized?

A. The butter fat in milk or cream is increased or decreased to an arbitrary per cent. or standard which may be fixed by law or an agreement between parties in which one guarantees to furnish the other with a definite quantity of butter fat in every pound of milk or cream sold for a stated price. This price should vary with the per cent. of butter fat in the milk—the more butter fat for the same quantity of milk the higher the price, and vice versa.

Q. How can the fat in milk or cream be reduced?

A. If milk contains a higher per cent of butter fat than is desired, this fat can be reduced either by separating the cream out of a portion of the milk or by adding skim-milk. In case all the milk is separated for clarification, the same result may be obtained by mixing with the skim-milk a smaller portion of the cream than was contained in the original milk. Again, there may be an instance in which no skim-milk is on hand, but instead, an ample supply of milk with a lower per cent of butter fat than is desired. This milk will answer the same purpose as skim-milk, but a larger proportion is required to bring the per cent down to the proper standard.

Q. How can the fat in milk or cream be increased?

A. Milk of a lower per cent. of fat than is desired may be standardized by taking out a portion of the skim-milk by means of a separator, or by adding reserved cream; or, as in the above case, if the milk is separated for clarification, by mixing with the skim-milk a greater portion of cream than there was in the original milk. Here, as in the above instance, if circumstances should arise in which there is no cream on hand, but instead, milk of a higher per cent. of butter fat than the desired standard, this will then answer the same purpose for increasing the percentage of fat to the proper standard.

Q. How can you determine the amount of skim-milk to be added or removed from the whole milk to obtain the desired per cent. of butter fat?

A. According to the following rules:

Rules for Standardizing Under Different Conditions Are as Follows:

Rule I.

Multiply the number of pounds of milk by the per cent. of fat in the milk and the product will be the number of pounds of butter fat in the milk. Divide the number of pounds of butter fat in the milk by the decimal representing the desired per cent. of fat, and the quotient will be the number of pounds of standardized milk.*

Part 1. Where the Percentage of Fat is too High.—From the number of pounds of standardized milk take the number of pounds of original milk and the result will be the number of pounds of skim-milk to be added to the original milk.

To illustrate: 1000 pounds of milk containing 4.5 per cent. of butter fat are to be standardized to 4 per cent.; how many pounds of milk must be added?

Since 4.5 per cent. equals the decimal .045 then,

$1000 \times .045 = 45$, the number of pounds of fat in 100 pounds of 4.5 per cent. milk.

$45 \div .04 = 1125$, the number of pounds of 4 per cent. or standardized milk.

$1125 \div 1000 = 125$, the amount of skim-milk to be added.

*This answer is sufficiently accurate for ordinary practice. As a matter of fact, the amount of butter fat in the cream to be standardized is less than the amount of butter fat in the milk, on account of some butter fat left in the skim-milk by separating. Again, when skim-milk is added, butter fat is also added, the amount depending upon the amount of skim-milk added and the per cent. of fat contained therein.

To formulate this problem:

A : 1000 : : 4.5 : 4

A = the pounds of standardized milk.

$$B = \frac{1000 \times 4.5}{4} - 1000$$

B = the number of pounds of skim-milk to be added.

Part 2. Where the Percentage of Fat is too Low.—With milk that is to be standardized from a lower to a higher per cent. the same rule holds true; but in this case take the number of pounds of standardized milk from the number of pounds of original milk and the result will be the number of pounds of skim-milk to be removed from the original milk.

To illustrate: 1600 pounds of milk containing 3.2 per cent. of butter fat are to be standardized to 4 per cent.; how much skim-milk must be taken from the whole milk?

$1600 \times .032 = 51.2$, the number of pounds of butter fat in the original milk.

$51.2 \div .04 = 1280$, the number of pounds of standardized milk.

$1600 - 1280 = 320$, the number of pounds of skim-milk to be separated from the original milk, or

$$A = \frac{1600 \times 3.2}{4} = 1280.$$

A = the number of pounds of standardized milk.

$B = 1600 - 1280 = 320.$

B = the number of pounds of skim-milk to be removed.

Rule II.

The same results may be reached by the following rule, which is often more convenient than the one above given. Divide the per cent. of butter fat that is in the original milk by the per cent. that is desired in the standardized milk. The quotient multiplied by the given number of pounds of milk will be the amount of standardized milk. If the quantity of standardized milk is greater than the original amount of milk the difference must be added in the form of skim-milk; if less then that difference must be separated out as skim-milk.

Part 1. Where the Percentage of Fat is too High.—To illustrate: 200 pounds of milk containing 6 per cent. of fat are to be standardized to 4 per cent.; how many pounds of skim-milk must be added?

$.06 \div .04 = 1.5$, hence 200 pounds of 6 per cent. milk must be increased by one-half with skim-milk, or to 300 pounds. The difference between 200 pounds and 300 pounds is the amount of skim-milk that must be added, or

$$A = \frac{.06}{.04} \times 200,$$ in which A = final amount of standardized milk.

.. **Part 2. Where the Percentage of Fat is too Low.**—To illustrate: 652 pounds of milk containing 3.1 per cent. of butter fat are to be standardized to 4.5 per cent.; how many pounds of skim-milk must be extracted?

$3.1 \div 4.5 = .691$, or the fractional part of 652 pounds of 3.1 per cent. milk to which the amount must be reduced in order to have the milk contain 4.5 per cent. butter fat.

$652 \times .691 = 450$, the number of pounds of 4.5 per cent. milk.

$652 - 450 = 202$, the number of pounds of skim-milk to be removed, or

$$A = \frac{3.1}{4.5} \times 652,$$ in which A = final amount of standardized milk.

Rule III.

Occasionally there may be a quick demand for milk of a per cent. of fat which is not common ly produced, as is often the case with city dairy companies. However, milk of a known standard is always on hand. In this case a definite quantity of milk is wanted and the exact proportions of milk or cream to be added to the skim-milk may be calculated in percentage or amount as follows:

Divide the per cent. of fat in the milk that is desired by the per cent. of fat in the milk that is 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.

To illustrate: 120 pounds of milk containing 4 per cent. of butter fat is desired and milk of 6 per cent. fat and skim-milk are on hand to be used. What per cent. of the standardized milk must be milk with 6 per cent. fat and what portion must be skim-milk; that is, how much of each must be taken in order that the mixture may be 4 per cent. milk?

$.04 \div .06 = .66\frac{2}{3}$ or $66\frac{2}{3}$ per cent., which is the portion of 6 per cent. milk that the 120 pounds of standardized milk should contain. The remaining $33\frac{1}{3}$ per cent. must be skim-milk which it is necessary to add to bring the fat down 4 per cent.

$66\frac{2}{3}$ per cent. of 120 pounds = 80 pounds, the amount of 6 per cent. milk which must be mixed with 40 pounds of skim-milk to bring the mixture to 120 pounds of 4 per cent. milk.

Rule IV.

Part 1.—The actual number of pounds instead of the per cent. of the different kinds of milk to be added may be ascertained as follows: Multiply the number of pounds of standardized milk desired by the per cent. of butter fat that the milk is to contain. This gives the number of pounds of butter fat in the mixture. Divide this amount by the per cent. of butter fat contained in the milk on hand and the result will be the number of pounds of that milk which the standardized milk should contain. The remainder would be skim-milk.

To illustrate: 50 pounds of milk containing 3 per cent. fat is wanted, and milk containing 5 per cent. fat is to be used.

$50 \times .03 = 1.5$, the number of pounds of butter fat in the 3 per cent. milk.

$1.5 \div .05 = 30$, the number of pounds of 5 per cent. milk which the standardized milk should contain.

$50 - 30 = 20$, the number of pounds of skim-milk to be added.

Part 2.—In case there is no whole milk on hand but instead skim-milk and cream of a known per cent. of butter fat, then the cream may be substituted and the fat reduced to the desired per cent. with skim-milk. The proportionate amounts may be calculated as in the two foregoing methods.

To illustrate: To make 50 pounds of milk containing 3 per cent. of fat or 1.5 pounds of butter fat as in the above illustration. If 25 per cent. cream is to be substituted for 5 per cent. milk then the standardized milk would have to contain 6 pounds of 25 per cent. cream and 44 pounds of skim milk.

As a matter of convenience the results of the above rules calculated on the per cent. or 100 pound basis can be tabulated in such a manner as to reduce the calculation to a minimum.

Table 1 Indicates Quantity of Skim-Milk to be Added to or Subtracted from 100 Pounds of Milk to Make the Desired Per Cent.

*A †B	3.25	3.50	3.75	4.0	4.25	4.50	4.75	5.0
3.0	— 7.693	—14.285	—20.000	—25.000	—29.412	—33.333	—36.842	—40.000
3.1	— 4.616	—11.423	—17.333	—22.50	—27.059	—31.111	—34.737	—38.000
3.2	— 1.539	— 8.571	—14.666	—20.000	—24.706	—28.888	—32.632	—36.000
3.3	+ 1.539	— 5.714	—12.000	—17.50	—22.353	—26.666	—30.527	—34.000
3.4	+ 4.616	— 2.857	— 9.333	—15.00	—20.000	—24.444	—28.422	—32.000
3.5	+ 7.693	— 0.000	— 6.666	—12.50	—17.647	—22.222	—26.317	—30.000
3.6	+10.760	+ 2.857	— 4.000	—10.00	—15.294	—20.000	—24.212	—28.000
3.7	+13.837	+ 5.714	— 1.333	— 7.50	—12.941	—17.777	—22.107	—26.000
3.8	+16.914	+ 8.571	+ 1.333	— 5.00	—10.588	—15.555	—20.000	—24.000
3.9	+19.991	+11.428	+ 4.000	— 2.50	— 8.235	—13.333	—17.897	—22.000
4.0	+23.068	+14.285	+ 6.666	— 0.00	— 5.882	—11.111	—15.792	—20.000
4.1	+26.145	+17.142	+ 9.333	+ 2.50	— 2.429	— 8.888	—13.687	—18.000
4.2	+29.222	+19.999	+12.000	+ 5.00	— 0.076	— 6.666	—11.582	—16.000
4.3	+32.299	+22.856	+14.666	+ 7.50	+ 0.076	— 4.444	— 9.477	—14.000
4.4	+35.376	+25.713	+17.333	+10.00	+ 2.429	— 2.222	— 7.372	—12.000
4.5	+38.453	+28.57	+20.000	+12.50	+ 5.882	— 0.000	— 5.267	—10.000
4.6	+41.530	+31.427	+22.666	+15.00	+ 8.235	+ 2.222	— 3.162	— 8.000
4.7	+44.607	+34.284	+25.333	+17.50	+10.588	+ 4.444	— 1.057	— 6.000
4.8	+47.684	+37.141	+28.000	+20.00	+12.941	+ 6.666	+ 1.057	— 4.000
4.9	+50.761	+39.998	+30.666	+22.50	+17.647	+ 8.888	+ 3.162	— 2.000
5.0	53.838	42.855	33.333	25.000	20.000	11.111	+ 5.267	— 0.000

*Top line A represents the per cent. of fat that is desired in milk.

†Left-hand column B represents the per cent. of fat in milk on hand.

To find the pounds of skim-milk to be added or removed, trace the vertical column of the per cent. of fat you desire down to where the horizontal column representing the per cent. of fat in the milk on hand intersects and the result will be the number of pounds of skim-milk to be added or removed, as indicated by a plus or minus sign before the result.

To illustrate: If milk containing 4.5 per cent. is desired and milk containing 3.8 per cent. fat is on hand, then 15.5 pounds for every hundred pounds or 15.5 per cent. of the quantity must be separated out as skim-milk.

To Standardize with Whole Milk or Cream Instead of Skim-Milk.

Rule V.

Part 1.—An instance may occur in which milk is to be raised to a higher per cent. with milk of a still higher per cent. of butter fat. The quantity to be added may be found in the following manner: From the desired per cent. of fat in the standardized milk subtract the per cent. of fat in the milk that is on hand which contains the lower per cent. of fat. Subtract the per cent. of fat that is desired in milk from the per cent. of fat in the milk that is on hand which contains a higher per cent. of butter fat. Divide the difference between the lower per cent. and the per cent. desired by the difference between the higher per cent. and the per cent. desired. The quotient will be that part of any given quantity of milk containing the higher per cent. that should be taken. Multiply the quotient by the quantity of milk of the lower per cent. This will equal the quantity of milk of the higher per cent. to be added to the milk of the lower per cent. and the sum will equal the amount of the mixture containing the desired per cent.

To illustrate: Standardize 20 pounds of milk containing 3 per cent. butter fat to 4 per cent. fat with 5.2 per cent. milk; how many pounds of the latter must be added to bring the fat up to 4 per cent.?

$.04 - .03 = .01.$

$.052 - .04 = .012.$

$.01 \div .012 = 833.$

$200 \times .833 = 166.6$, the number of pounds of 5.2 per cent. milk to be added.

$200 + 166.6 = 366.6$, the number of pounds of 4 per cent. milk to be used.

Part 2.—To standardize milk of a higher per cent. than is desired with milk of a lower per cent. of fat, the same rule applies except that the difference between the desired per cent. and the higher per cent. must be divided by the difference between the desired per cent. and the lower per cent. of butter fat.

To illustrate: 54 pounds of milk containing 5.3 per cent. of butter fat are to be standardized to 4 per cent. with milk containing 3.1 per cent. butter fat; how many pounds of the 3.1 per cent. milk will be required?

.053 — .04 = .013.
.04 — .031 = .009.
.013 ÷ .009 = 1.44.

54 × 1.44 = 77.76, the number of pounds of milk containing 3.1 per cent. of fat to be added to the 54 pounds to decrease the fat content to 4 per cent.

Rule VI.

To find the ratio of the number of pounds of milk of the different per cents., subtract the per cent. of fat in the milk of the lower fat content from the per cent. of fat desired in the standardized milk and divide this result by the difference between th fat per cents. in the milk of the higher fat content and the lower fat content, the quotient represents the per cent. of milk of the higher fat content to be used in standardizing.

To illustrate: Find the ratio of the pounds of milk for mixing 5 with 3.5 to give 4 per cent. milk.

4 — 3.5 = .5
5 — 3.5 = 1.5

.5 ÷ 1.5 = .33⅓ or 33⅓ per cent. which is that part of the standardized milk containing 5 per cent., which is used in mixing with milk of 3.5 per cent. fat content. Supposing 400 pounds of milk of 4 per cent. butter fat is desired then 33⅓ per cent. of the 400 pounds or 133.3 pounds are to be milk containing 5 per cent. butter fat and 400 — 133.3 = 266.6, the number of pounds of milk of 3.5 per cent. butter fat that are to be taken to bring the fat content to 4 per cent.

Where whole milk is used for standardizing the results can be tabulated equally as well as when skim milk is used. In this case the whole milk has a constant per cent. in each table.

Table 2. To Standardize Cream with Milk Containing 4 Per Cent. of Butter Fat.

*A	17	20	22	25	27	30
†B						
30	50.0000	61.5385	69.2308	80.3461	88.4615	100.00
18	92.857	....	....	....	....	......
19	86.666	....	....	....	....	......
20	81.250	100.	....	....	....	......
21	76.4706	94.706	....	....	....	......
22	72.2222	88.8888	100.	....	....	......
23	68.4222	84.2222	94.2125	....	....	......
24	65.0000	80.0000	90.0000	....	....	......
25	61.905	76.1905	85.7143	100.	....	......
26	59.0909	72.7272	81.8181	95.4545	....	......
27	56.5217	69.5651	78.2608	91.3044	100.	......
28	54.1666	66.6666	75.0000	87.5000	95.8333	......
29	52.0000	64.0000	72.0000	84.0000	92.0000	......
30	50.0000	61.5385	69.2308	80.3461	88.4615	100.00

*A represents the per cent. of fat that is desired in cream.

†Left hand column B represents the per cent. of fat in cream on hand.

If cream is to be standardized with whole milk the result found by the intersecting columns represents the pounds per hundred or the per cent. of the quantity which is cream of the per cent. of fat on hand.

To illustrate: If cream containing 20 per cent. of butter fat is desired and cream containing 26 per cent. of butter fat is on hand then 72.7 per cent. of the quantity desired must be cream containing 26 per cent. of butter fat and 27.3 per cent. of the quantity must be 4 per cent. milk.

Q. How is cream standardized?

A. The principal difference between milk and cream is that in cream a larger portion of the water is displaced with butter fat and since the variations lie mainly between the butter fat and the water the same methods that apply to the standardization of milk will apply to the standardization of cream.

Q. What apparatus is necessary for standardizing?

A. The apparatus necessary for standardizing milk or cream is a cream separator, a Babcock tester, scales, and a mixing vat.

Q. What is the parallelogram method of standardizing?

A. It is a method devised by Professor Pearson, formerly of Cornell and may be illustrated as follows:

A ———————— C — B or B — C

B

C ———————— B — A or A — B

A Per cent. of fat in milk to be mixed.
B Per cent. of fat in standardized milk.
C Per cent. of fat in cream or milk to be mixed with A,
C — B or B — C Pounds of A to use.
B — A or A — B Pounds of C to use.

The per cent. of fat desired in the standardized mixture is always placed in the center of the parallelogram and the per cents. of fat in the milks to be mixed at either of the two left hand corners. Then subtracting diagonally we secure the proportions of A and C to be mixed to secure mixture containing per cent. of fat indicated by B. In other words A — B or B — A depending on which is the larger, will give the number of pounds of C to be taken for the mixture. In like manner B — C or C — B will show the number of pounds of A to be taken for the mixture. The problems in the following questions will illustrate the method.

Q. How much cream containing 30 per cent. butter fat must be added to milk containing 3 per cent. butter fat to standardize it to milk containing 5 per cent. butter fat?

A. 3 ———————— 25 (30 — 5)

5

30 ———————— 2 (5 — 3)

Placing the per cent. of fat desired in the standardized milk in the center of the parallelogram and the per cents. of fat in the materials to be mixed at the left hand corners and subtracting diagonally we have 30 — 5 = 25 and 5 — 3 = 2. This means that the milk containing 3 per cent. butter fat and cream containing 30 per cent. butter fat must be mixed in the proportion of 25 to 2 or 12½ to 1, to produce milk containing 5 per cent. butter fat, that is for every 25 pounds of milk containing 3 per cent. butter fat in the mixture, there must be 2 pounds of cream containing 30 per cent. butter fat. Therefore, 25 : 2 :: 500 : x = 40 pounds of cream containing 30 per cent. butter fat to add or $\frac{2 \times 500}{25} = 40$ or (2 × 500) ÷ 25 = 40.

Q. How much milk containing 3 per cent. butter fat and how much cream containing 30 per cent. butter fat are to be mixed to secure 500 pounds of milk containing 5 per cent. butter fat?

A. (See the parallelogram above, since the figures are the same.)

25 + 2 = 27

27 : 25 :: 500 : x = 462.96 + pounds of milk containing 3 per cent. butter fat.

27 : 2 :: 500 : x = 37.04 — pounds of cream containing 30 per cent. butter fat.

Q. How much milk containing 3 per cent. of butter fat must be added to a cream containing 30 per cent. of butter fat to reduce the test to 25 per cent.?

A.

30		22 (25 — 3)
	25	
3		5 (30 — 25)

The cream containing 30 per cent. butter fat and the milk containing 3 per cent. butter fat must be mixed in the proportion of 22 to 5; or, for every 22 pounds of cream containing 30 per cent. butter fat 5 pounds of milk containing 3 per cent. butter fat must be used. Therefore, 22 : 5 :: 500 : x = 113.63 = pounds of milk containing 3 per cent. butter fat to be added.

500 + 113.63 = 613.63 total number of pounds of cream containing 25 per cent. butter fat secured.

Q. How much skim-milk containing .1 per cent. butter fat should be added to 1000 pounds of milk containing 5.5 per cent. butter fat to reduce the test to 3.5 per cent.?

A.

5.5		3.4 (3.5 — .1)
	3.5	
.1		2 (5.5 — 3.5)

The proportion should be 3.4 to 2 or 3.4 pounds of the milk containing 5.5 per cent. butter fat to 2 pounds of the skim-milk containing one-tenth of one per cent. butter fat. If it is desired to consider the skim-milk as containing no fat this can be done by using 0 in the same manner as .1 in the above example. Therefore 3.4 : 2 :: 1000 : x = 588.23 pounds of skim-milk to add. 1000 + 588.23 = 1588.23 pounds of milk containing 3.5 per cent. fat.

Q. How much milk containing 5.5 per cent. butter fat and how much skim-milk containing one-tenth of one per cent. butter fat will be needed to produce 1000 pounds of milk containing 3.5 per cent. butter fat?

A. (See parallelogram above.)

3.4 + 2 = 5.4

5.4 : 3.4 :: 1000 : x 629.6 pounds of milk containing 5.5 per cent. butter fat.

1000 — 629.6 = 370.4 pounds of skim-milk containing one-tenth of one per cent. butter fat, or

5.4 : 2 :: 1000 : x = 370.4 pounds of skim-milk containing one-tenth of one per cent. butter fat.

Q. How much skim-milk must be removed from 780 pounds of milk testing 3 per cent. butter fat to increase the test to 4 per cent.?

A. 3 |————| 3.9 pounds of milk containing 3 per cent. butter fat to use.

4

.1 |————| 1 pounds of skim-milk to remove from 3.9 pounds of milk containing 3 per cent. butter fat.

Place the per cent. desired in the center of the parallelogram as usual, the per cent. of fat in milk on hand at upper left hand corner and per cent. of fat in skim-milk at lower left hand corner. Subtract diagonally as usual. The difference between the per cent. of fat desired and the per cent. in the skim-milk will indicate the number of pounds of milk containing 3 per cent. butter fat to use and the difference between the per cent. of fat desired and the milk to be skimmed will indicate the number of pounds of skim-milk to remove. In this problem from every 3.9 pounds of milk containing 3 per cent. butter fat 1 pound of skim-milk must be removed to increase the per cent. of fat to 4. Therefore,

3.9 : 1 :: 780 : x = 200 pounds of skim-milk to remove, or

$\frac{1 \times 780}{3.9} = 200$ pounds of skim-milk to remove.

780 — 200 = 580 pounds of milk containing 4 per cent. butter fat.

Q. How much milk containing 3 per cent. butter fat will be required to produce 780 pounds of milk containing 4 per cent. butter fat?

A. (See the diagram above.)

The 780 pounds of milk containing 4 per cent. butter fat will be the number of pounds of milk containing 3 per cent. butter fat less the number of pounds of skim-milk removed. Since 3.9 represents the amount of milk to use and 1 the skim-milk removed, 3.9 — 1 or 2.9 will represent the 780 pounds of milk containing 4 per cent. butter fat. Therefore, we have the proportion

2.9 : 3.9 :: 780 : x = 1048.96 pounds of milk containing 3 per cent. butter fat to make 780 pounds of milk containing 4 per cent. butter fat; or

$\frac{3.9 \times 780}{2.9} = 1048.96$ pounds of milk containing 3 per cent. butter fat to make 780 pounds of milk containing 4 per cent. of butter fat.

DIVISION THIRTEEN.

RULES FOR CALCULATING BUTTER-FAT EQUIVALENT IN DIFFERENT PRODUCTS.

Q. How can the price per gallon of cream equivalent to the price of butter fat be found?

A. 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. Divide the number representing the price per gallon of cream by the number of pounds of butter fat, the quotient will equal the price per pound of butter fat.

To illustrate: What is the price per pound of butter fat if cream containing 20 per cent. fat sells for 50 cents per gallon?

A gallon of 20 per cent. cream weighs approximately 8.4 pounds.

8.4 × .20 = 1.68 the pounds of butter fat in one gallon which is worth 50 cents.

$.50 ÷ 1.68 = $.297, the price of one pound of butter fat.

Q. How can the price per gallon of cream at a certain price per pound of butter fat be found?

A. Multiply the pounds of cream per gallon by the per cent. of fat in the cream, the product will be the number of pounds of butter fat in one gallon of cream. Multiply this product by the price per pound of butter fat you desire, the product will be the price per gallon for cream.

To illustrate: At 32 cents per pound of fat what would be the price per gallon of cream containing 27 per cent. butter fat?

8.3 × .27 = 2.241 pounds of fat in 1 gallon.

2.241 × 32 = 71.712, or 72 cents, the price of the 27 per cent. cream.

Q. How can the equivalent price per gallon for cream containing different per cents. of butter fat be found?

A. This is best calculated on a basis of proportion. Divide the means by the extremes.

To illustrate: If cream containing 20 per cent. butter fat is worth 60 cents per gallon what is cream worth containing 25 per cent. butter fat?

.20 : .25 :: .60 : x

60 × .25 = 15

15 ÷ .20 = 75, or 75 cents, the equivalent worth of 25 per cent.

cream in comparison to the worth of 20 per cent. cream at 60 cents a gallon.

DIVISION FOURTEEN.

DETECTION OF ADULTERATION IN MILK.

Q. How can adulteration of milk with water be detected?

A. By means of the lactometer. The Quevenne is the best, since it has a scale corresponding to the specific gravity of milk. The graduated scale from 15 to 40 being equivalent to a specific gravity of 1.015 to 1.040; thus a milk which has a specific gravity of 1.032 would show on the lactometer a reading of .32. The upper scale of the lactometer is a thermometer scale. These lactometers are to give the specific gravity at a temperature of 60° F., and as it is not always convenient to have the temperature of the milk at 60° F., when the reading is taken, corrections may be made for slight variations (not more than 10°) by adding to the lactometer reading .1 (1/10) for each degree of temperature above 60° F. or subtracting .1 for each degree below 60° F. For example, the lactometer reading is 29 and the temperature 68° F., then the correct reading for 60° F. would be 29 + 8 = 29.8. Had the temperature been 56 degrees, the correct reading would be 29 — .4 = 28.6, and the specific gravity would be 1.0286. The specific gravity is obtained by prefixing 1.0 to the corrected lactometer reading.

The reading of pure milk ranges from 28 to 34, of skim-milk from 33 to 36, and the specific gravity of pure milk from 1.028 to 1.034 and of skim-milk from 1.033 to 1.036.

The average composition of milk is as follows:

Water........................87 to 88 per cent.
Fat..................3.0 per cent. and upwards
Solids not fat................8.5 to 9.5 per cent.

Q. What is the function of the lactometer?

A. The lactometer compares the weight of milk with the weight of an equal volume of water. Milk becomes heavier as the per cent. of solid not fat increases. Fat being lighter than water causes an error which must be taken into consideration.

Q. What precautions are necessary in taking a lactometer reading?

A. (1) Milk should stand at least one hour after milking to allow escape of gases. (2) The temperature must be between 50° and 70° F. (3) Milk should be mixed just before the reading but in such manner as not to cause froth or foam. (4) Milk should be placed in a cylinder and lactometer carefully lowered into it and let stand for 30 seconds and not more than one minute. (5) Read lactometer scale at level of milk and take thermometer reading. (6) Readings to one-half a lactometer degree are close enough.

Q. How is the per cent. of solids not fat calculated?

A. The next step to be taken is to determine the per cent. of fat, which is done by means of the Babcock tester. Then, having obtained the per cent. of fat and the lactometer reading, the per cent. of solids not fat may be calculated by the following formula:

$$\frac{L + F}{4} = \text{per cent of solids not fat.}$$

L. Lactometer reading at 60°.
F. Per cent. of fat.

While the above formula is most convenient and is satisfactory for all practical purposes a more accurate formula is as follows:

$$\frac{L}{4} + .2F = \text{per cent. of solids not fat.}$$

L. Lactometer reading at 60°.
F. Per cent. of fat.

Q. How is the per cent. of total solids calculated?

A. By adding the per cent. of fat and the per cent. of solids not fat.

Q. How can the per cent. of foreign water contained be determined?

To find the extent to which a known sample of milk has been watered, multiply the per cent. of solids not fat in the adulterated sample by 100, and divide by the per cent. solids not fat in pure sample. The result will be the number of pounds of pure milk in 100 pounds of the sample examined, and the remainder will be the number of pounds of water. Pure milk contains not less than 8.5 per cent. solids not fat, and often as high as 9 and 9½ per cent., and where it is not possible to get a sample of the pure milk for testing, use 8.5 as a standard for the first half of the season and gradually increase to 9 as the season advances and as the period of lactation advances. To make the foregoing more plain, take the following example:

Lactometer reading 28, temperature 54°, per cent. fat 2.6, and suppose the pure milk to test 9 per cent. solids not fat. Find the per cent. of water added.

The correct lactometer reading is 28 minus .6, or 27.4. Substituting for formula we have:

$$27.4 + 2.6 = \frac{30.0}{4} = 7.5 \text{ per cent. solids not fat; then}$$

$$\frac{7.5 \times 100}{9} = \frac{750}{9} = 83.3 \text{ per cent. pure milk:}$$

then 100 — 83.3 = 16.6 per cent. water in the adulterated sample.

Q. What is the specific gravity of the solids of milk?

A. From 1.25 to 1.34 for whole milk. The specific gravity of the solids of completely skimmed-milk is about 1.56.

Q. What does the specific gravity of the milk solids indicate as to skimming and watering of milk?

A. When the specific gravity of the milk solids is above 1.34, skimming is to be suspected and when it is above 1.40 it is conclusive.

Q. How may the specific gravity of milk solids be determined?

A. By the following formula:

$$S = \frac{t}{t - \frac{100s - 100}{s}}$$

S, the specific gravity of the milk solids; s, that of the milk, and t, the total solids of the milk. Example.—Suppose the total solids of a milk were found to be 13 per cent. and the specific gravity of the milk 1.032. Then,

$$\frac{(100 \times 1.032) - 100}{1.032} = 3.101;\ 13.0 - 3.101 = 9.899;$$

$$\frac{13}{9.899} = 1.31, \text{ the specific gravity of the milk solids.}$$

Q. When is adulteration by skimming indicated?

A. When the lactometer reading is 33 or above and the per cent. of fat is 3 or below, or when the lactometer reading, the specific gravity of the milk and the per cent. of solids not fat are high and the per cent. of fat is low. The specific gravity of the milk solids is high in skim-milk.

Q. When is adulteration by watering indicated?

A. When the lactometer reading is 28 or below and the per cent. of fat is correspondingly low, or, when the lactometer reading, the specific gravity of the milk, the per cent. of solids not fat and the per cent. of fat are low. The specific gravity of the milk solids is normal in watered milk.

Q. When is adulteration by both skimming and watering indicated?

A. When the lactometer reading and the specific gravity are normal or slightly below and the per cent. of solids not fat is low and the per cent. of fat lower in proportion than the solids not fat.

EXAMPLE.

27.4 is the corrected lactometer reading. 1.6 per cent. is the per cent. of butter fat in the above samples of milk. 27.4 is 85.6 per cent. of 32, which is the normal specific gravity of milk, or in other words the sample has been reduced 14.4. Hence, if this sample of milk had been adulterated with water only, the per cent. of butter fat would be reduced proportionately; or, for example, 85.6 per cent. of 3 = 2.56 per cent., which should be the per cent. of butter with the above per cent. of dilution. However, from the above it will be noticed that the butter fat, 1.6 per cent., has been reduced 53.3 per cent., hence the difference between 85.5 and 53.3, or 32.3 per cent. of butter fat must have been skimmed off the milk, aside from being adulterated.

DIVISION FIFTEEN.

THE ACID TEST.

Q. What causes milk to sour on standing for eighteen to twenty hours at a temperature of 60° to 70° F?

A. This change is brought about by bacteria converting the milk sugar of the milk into lactic acid. It generally takes about 18 to 20 hours at 65° to 70° for them to grow in sufficient number to turn the milk sour enough so that it clabbers.

Q. Why does milk clabber?

A. Clabbering of milk is due to the formation of lactic acid, which causes the casein of the milk to coagulate.

Q. Has lactic acid any value in milk from a commercial standpoint?

A. It is chiefly responsible for the flavor of butter and cheese, but great care must be taken in their manufacture that a proper amount of this acid be developed.

Q. If too much acid is developed how would it affect the butter?

A. Butter would not have such a good keeping quality and would not have the proper flavor.

Q. If the acid exists in milk in solution with other liquids, how can the amount be readily determined?

A. By neutralizing the acid with alkalies.

Q. What is meant by alkalies?

A. An alkali is a substance that has its chemical properties directly opposite to an acid. Either of these is a powerful agent for disintegrating and corroding much of the organic and inorganic matter, but when the two are united they lose this power. Alkalies are such substances as lime, lye, soda, etc. However, for testing purposes they must be chemically pure. Hence, if lime is added to sour milk, the acid unites with the lime, forming a substance which is neutral, neither alkaline nor acid.

Q. Does a certain amount of alkali neutralize a certain amount of acid?

A. Yes; if the per cent. of alkalinity of a solution is known, and the amount added to an acid substance, the per cent. of acid in the solution can be calculated.

Q. How can one tell when the alkali has neutralized the acid?

A. By means of an indicator. This indicator is colorless in appearance if added to the acid, but turns pink when added to alkali, hence if a few drops of this indicator (which is commonly known as phenolphthalein) be added to the milk, the same will remain colorless until sufficient alkali has been added to neutralize the acid, and by adding a slight amount more the solution changes to a pink color.

Q. How do you determine the acid by means of the Mann's test?

A. The Mann's test consists of a 50 cubic centimeter burette, a 50 cubic centimeter pipette, a white porcelain cup, and a glass stirring rod. This alkali can be bought in gallon bottles, and is made by dissolving four grams of sodium hydroxide, to which enough distilled water is added to make one liter of solution. Each cubic centimeter, containing .004 of a gram of sodium hydroxide, will neutralize .009 of a gram of lactic acid. This is obtained from the fact that a normal solution of lactic acid contains 90 grams of acid in each liter, or 1,000 cubic centimeters. A 10th normal solution would then contain one-tenth as much, or 9 grams to each liter, and a cubic centimeter, which contains .001 as much as a liter, would contain .009 of a gram of lactic acid. With the apparatus and solution on hand, measure 50 cubic centimeters of cream with a pipette into a beaker. Rinse the pipette with distilled water adding same to the beaker. Add five drops or more of indicator. Fill the burette to the zero mark with neutralizer, but before doing this be sure and see that the burette is absolutely free from water and acids. Probably the best way is to rinse the burette with a little of this solution. Now add the solution to the cream in a very slow manner until you notice that the solution appears very reluctant in destroying the pinkish color on stirring. Then this neutralizing solution should be added drop by drop only. The moment the cream remains pink, the acid has been neutralized. The number of cubic centimeters of alkali added to the cream is read on the burette, and from this the percentage of acid is calculated in the following manner: The number of cubic centimeters of alkali multiplied by .009, divided by the number of cubic centimeters of cream, and multiplied by 100.

Example.—It required 32 cubic centimeters of alkali to neutralize 50 cubic centimeters of cream; what per cent. of acid is in the cream?

The formula would be like this:

$$\frac{32 \times .009}{50} \times 100 = .576.$$

It is not essential to use 50 cubic centimeters of material. Any other amount may be used substituting the same for 50 in the above formula. When 17.6 cubic centimeters are used a result, accurate enough for all practical purposes may be obtained by dividing the cubic centimeters of alkali by .2. Suppose 4.4 cubic centimeters of alkali were used to neutralize 17.6 cubic centimeters of milk or cream. Then $4.4 \div .2 = .22$ per cent. of acid.

Q. How do you determine the acid by means of the Farrington Alkaline Tablet test?

A. The Farrington Alkaline Tablet test works on the same principle as the Mann's test. Instead of the neutralizer being in a solution form, as in the Mann's test, it is put up in tablets. Dissolve five tablets in enough water to make 97 cubic centimeters solution. The tablets must be dissolved so that it becomes a perfect solution. Measure out with a Babcock pipette 17.6 cubic centimeters of the milk or cream to be tested into a white porcelain cup (a white cup is preferable because one can more easily see the pink color). Add solution to milk or cream until a permanent pink color is obtained, the same as in the Mann's test. Read the number of cubic centimeters solution used to change the color, and this will indicate the number of hundredths of one per cent. of acidity in milk or cream.

It is convenient to make up the Farrington solution in a 100 c.c. graduated cylinder fitted tightly with a stopper. Then the solution may be poured directly from the cylinder and the c.c. used, read from the cylinder graduation. Example.—If it requires 50 cubic centimeters of tablet solution to neutralize the acid of the cream, then the acidity would be .5 per cent.

Q. How may acidity be estimated approximately by the Farrington tablets?

A. For some purposes it is advantageous to determine whether milk contains more or less than .2 per cent. of acid. The solution for this test is prepared by dissolving tablets at the rate of 2 to each ounce of water used. The test is made by mixing equal parts of the tablet solution and the milk to be tested in a white cup. If the milk remains white it contains more than .2 per cent. of acid while if it turns pink it contains less than .2 per cent. of acid. The deeper the pink color the sweeter the milk.

Q. How can you obtain the per cent. of acidity by means of the Marschall test?

A. In this acid test the neutralizer used is the regular standard 1/10 normal alkali, which can be obtained from all dairy supply houses and experiment stations.

The Marschall acid test contains the following parts:

Combined burette and bottle for the neutralizer.
9 cubic centimeter pipette.
Bottle of indicator.
½ gallon bottle of neutralizer.

It is necessary only to fill the burette bottle with neutralizer, place it on a small box or shelf at a convenient height, and the acid test is ready for use.

After carefully mixing the milk or cream, fill the 9 cubic centimeter pipette, empty it in the cup and add a couple of drops of the indicator. If heavy cream is tested, it is preferable to fill the pipette again with water, and add the rinsing water to the contents of the cup. Fill the graduated burette by tipping the bottle and place level again. Adjust the burette and rubber stopper so that the neutralizer will stand at the zero mark in the burette, then let the neutralizer run into the cup a little at a time, shaking the cup by circular motion, until the contents has attained a pink shade and does not turn white again within five to ten seconds. The number of cubic centimeters of the neutralizer used will then directly show how much acid the milk or cream contained, giving it in 0.1 per cent. acid. If 2 cubic centimeters of neutralizer have been used, the milk contained two-tenths of one per cent, and if, for instance, a sample of cream takes 5.6 cubic centimeters of neutralizer, it contained 56 hundredths of 1 per cent. of acid, generally written as .2 per cent. acid and .56 per cent. acid. To facilitate the readings, the burette is graduated in 2/10 of one cubic centimeter only, but 1/10 cubic centimeter can easily be read off when required. As all tests start at the zero mark, there are no calculations necessary to determine how much neutralizer has been used, with the resulting possible errors.

Before starting the test, lift the rubber stopper in the neck on top of the bottle and replace securely. This operation releases the pressure in the bottle, and should be repeated each time the neutralizer does not run freely from the burette. The burette valve is a ball valve, and is worked by pressing the rubber tubing between the fingers.

Q. Is there a more convenient way to test a great number of samples of milk?

A. If many samples of milk are tested at the receiving platform with the Marschall test, it is convenient to get a couple dozen 2 oz. bottles, with wide mouths, and in each fill 2 cubic centimeters of neutralizer from the burette, and also a couple of drops of indicator. The 9 cubic centimeters of the milk taken as sample is then simply added to one of the bottles and shaken. If the mixture does not turn white the milk contains less than .2 per cent. acid. This is generally taken as a standard.

Q. What per cent. of acid will the acid test show in freshly drawn milk?

A. About .07 per cent. due to acid phosphates, free carbonic acid gas and an acid reaction of the casein. Lactic acid develops after the milk is drawn.

Q. What is the per cent. of acid in milk when it begins to taste sour?

A. About .30 to .35.

Q. What amount of acid is allowable in market milk?

A. Retail milk should contain less than .2 per cent. of acid.

Milk reecived at the factories should not contain more than .2 per cent. acid, and milk containing .25 per cent. acid and over can not be pasteurized. Most butter makers would refuse milk showing more than .2 per cent. acid.

Q. Does a change in the per cent. of acidity change the flavor?

A. Yes; the greater the amount of acid developed in cream the more sour it will taste.

Q. What per cent. of acid should there be in cream for butter making?

A. Cream ready to churn should contain .4 to .55 per cent. acid, according to whether mild or highly flavored butter is wanted, and also depending upon the per cent. of fat in the cream. The higher the per cent. of fat the less acid is needed.

Q. What per cent. of acid should there be in starters used for butter and cheese making?

A. Starter for butter or cheese should be used immediately, or else cooled down quickly, when it shows .7 to .85 per cent. acid.

DIVISION SIXTEEN.

DETECTION OF PRESERVATIVES.

Q. How may formalin be detected in milk?

A. To about 10 c.c. of milk in a test tube or in the Babcock test bottle, add an equal amount of well water. Pour concentrated sulphuric acid down the side of the tube, taking care not to mix with the milk. If formalin is present a distinct purple ring will form at the junction of the milk and acid. The purpose of the well water is to add iron. This may be supplied by adding 4 or 5 drops of a 10 per cent. solution of ferric chloride. It will not be necessary when commercial sulphuric acid is used.

(b) A more delicate test is made as follows: Prepare a solution of concentrated hydrochloric acid (sp. gr. 1.2) containing 2 c.c. of 10 per cent. ferric chloride ($Fe\ cl_3$) per liter. To 10 c.c. of milk add 10 c.c. of this solution in a white dish. Bring slowly to the boiling point. If formalin is present a violet color appears.

Q. How may bi-carbonate of soda be detected in milk or cream?

A. To 10 c.c. of milk in a test tube add 10 c.c. of alcohol and a few drops of a one per cent. solution of rosolic acid and mix. If a carbonate is present a rose red color appears, while pure milk shows a yellowish red color.

Q. How may borax and boracic acid be detected in milk or cream?

A. Pour 15 or 20 c.c. of milk into a porcelain dish, make it alkaline with sodium hydrate, evaporate and burn to an ash. Add a few drops of diluted hydrochloric acid to the ash. Soak a strip of tumeric paper in this solution and dry with heat. If borax or boracic acid is present, the paper will be a distinct cherry red when dry and turn olive green on the addition of dilute ammonia.

DIVISION SEVENTEEN.

BACTERIA IN MILK.

Q. What are bacteria?

A. The lowest form of plant life. They are single celled and microscopical.

Q. How do bacteria reproduce?

A. By fission or by one bacterium simply dividing into two.

Q. What are spores?

A. When some bacteria come under unfavorable conditions for growth they form spores. A small bright spot appears within the bacterium and gradually becomes larger. The old cell breaks up and disappears, leaving the spore. This spore is very resistant to heat, drying and the various things which usually destroy bacteria. A comparatively small number of different species of bacteria are capable of forming spores.

Q. What things are necessary to bacterial growth?

A. Food, moisture, and heat between certain limits. Some species demand the presence of air, others the absence of air, while still others will grow either in its presence or absence. The common lactic acid bacteria which cause milk to sour belong to the last class.

Q. What is the most favcrable temperature for bacterial growth?

A. Most bacteria grow most rapidly between 80° and 100° F. Some will grow rapidly between 60° and 70°, the common lactic acid bacteria of milk being in this class. Most species are injured by a temperature above 100° but a few types will grow at 140° F. There is very little bacterial growth below 50° F.

Q. How may bacteria be killed?

A. The practical means are heat, direct sunlight and chemical disinfectants.

Q. How much heat is necessary to kill bacteria?

A. A temperature of 140° F. for one-half hour will kill most growing bacteria. Higher temperatures will kill them more quickly. Bacterium tuberculosis is killed by 140° F. for 20 minutes. A temperature of 160° F. for one minute or less will kill the germs of tuberculosis, diphtheria, typhoid and most disease producing germs.

Q. How may bacterial spores be killed?

A. By heating under 15 pounds steam pressure for 15 minutes. This gives a temperature of about 240° F. Heating in a dry oven at a temperature of 300° F. for one-half to one hour will kill them.

Q. What are some chemical disinfectants?

A. A 5 per cent. solution of carbolic acid.

A 1 per cent. solution of mercuric chloride.

A 5 per cent. solution of formalin.

Slaked lime.

These are of value in stables and in any place where the milk will not come in direct contact with them.

Q. What is pasteurization?

A. Pasteurization is the application of sufficient heat to kill all growing or vegetative bacteria and then cooling to a low temperature. Pasteurization does not kill spores. The most satisfactory way to pasteurize milk is to heat to 140° F. for 20 to 30 minutes.

Q. What is sterilization?

A. Sterilization is accomplished by the application of sufficient heat to kill all bacterial life. It is not practical to sterilize milk for market purposes. Heating under 15 pounds steam pressure for 15 minutes or steaming for one-half hour on three consecutive days will sterilize liquids. Glassware and tinware may be sterilized by heating under 15 pounds steam pressure for 15 minutes. In laboratory work glassware is sterilized by heating to 150° C. or 300° F. for one hour in a hot air oven.

Q. How should milk utensils be washed?

A. They should first be rinsed in cool or luke-warm water, then washed in boiling water containing an alkali, such as bicarbonate of soda, sal soda or sodium borate. They should then be steamed or rinsed with water which has been heated above the boiling point for at least one hour. It is very desirable to sterilize under 15 pounds steam pressure when this is possible.

Q. What are the sources of bacteria in milk?

A. Dirt and dust from the cow, dust in the air, imperfectly sterilized utensils, impure water, the hands and clothing of persons milking and handling the milk.

Q. What are the sources of disease germs or bacteria?

A. The handling of milk by persons diseased or who have come in contact with diseased persons; imperfectly sterilized milk bottles or other utensils returned from homes where contagious diseases exist; contaminated wash water; diseased cows.

Q. What means may be employed to secure a low bacterial content of milk?

A. Healthy cows; healthy milkers; clean milkers, both as to hands and to clothing; clean cows; clean stables; brushing cows and cleaning stables long enough before milking to allow the dust to settle, handling hay and bedding after milking and not before; wiping the cow's udder and flanks with a damp cloth before milking; washing the udder with soap and water when badly soiled; using small top milk pails; using clean sterilized utensils; cooling milk below 50° F. as soon as milked and keeping it cool.

Q. What are the effects of bacteria on milk?

A. The most common effect is the souring of milk by the lactic acid bacteria which produce lactic acid from the milk sugar. Others produce gas which is troublesome to cheese makers. Still other effects are the production of sweet coagulation, the production of undesirable flavors, the production of ropy or slimy milk, the production of abnormal color.

Q. Are all bacteria harmful to milk?

A. No. Some varieties are neutral or have no effect. The lactic acid are of great value to the butter maker, cheese maker and maker of fermented milks. When lactic acid bacteria are developing they tend to check the growth of undesirable species.

Q. What is a starter and how made?

A. A starter is a culture of lactic acid bacteria in milk. It may be made by letting clean milk sour naturally at a temperature of about 65° F. It may be made from a commercial or pure culture of lactic acid bacteria secured from various firms which prepare them. The starter may be made from the same by pasteurizing one quart of milk at 180° F. for 30 minutes and cooling to 65° F. Then add the pure culture and hold at 65° F. until curdled. This will not have the good flavor desired but may be used to inoculate a second culture prepared in the same manner. This and following cultures will have a clean acid flavor if proper care has been used to prevent contamination.

DIVISION EIGHTEEN.

FERMENTATION TESTS.

Q. What are fermentation tests of milk?

A. Tests in which fermentation is allowed to take place in the milk or the curd to detect bad flavors, odors and gas production. They are of special value to cheese factories and milk dealers for testing out the milk of different patrons and to dairymen for testing the milk of different cows.

Q. How may the Gerber fermentation test be made?

A. Secure samples of the milk to be tested in sterile bottle with stoppers or caps. Warm to from 98° to 104° F. and hold at that temperature until curdled, by placing in water bath. The length of time required to curdle, the odors developed and presence or absence of gas holes in the curd will indicate the quality of the milk.

Q. How may the curd test be made?

A. Secure samples of the milk to be tested in sterilized wide mouth bottles fitted with a cover. At least one-half to two-thirds of a pint of milk should be used for each test. Warm the milk to 98° F. and add about 10 drops of rennet to each bottle. Mix by giving the bottle a rotary motion and let stand until curdled, which will be about 20 minutes. Cut the curd into small cubes, using a clean, sterile case knife. Stir occasionally for 30 to 45 minutes to keep the curd from matting and then pour off the whey. It will be removed more completely by pouring it off two or three times. Then set the bottles in water which should be kept at 98° F. for 6 to 12 hours. The quality of the different milks will be indicated by examining the different curds for odors and by cutting through them with a knife, noting the gas holes. Gas should not form in the curd of sweet milk.

DIVISION NINETEEN.

RENNET.

Q. What is rennet?

A. An extract obtained from the fourth stomach of a young calf. It is supposed to contain enzymes, rennin and pepsin. The former has a coagulating action on milk casein and the latter a digesting action.

Q. For what is rennet used?

A. For precipitating the casein of milk in cheese making.

Q. Does the curd thus formed contain constituents other than casein?

A. Yes. It contains water, the greater part of the butter fat of the milk, a small amount of milk sugar, albumen and ash.

Q. What factors influence the action of rennet?

A. It acts most satisfactorily for cheese making at 86° to 87° F. Increase of temperature hastens and decrease of temperature retards its action. Rennet extract is rendered inactive if exposed to a temperature of 140° F. for some time. Weak solutions are affected by a temperature as low as 105° F. Generally speaking the greater the acidity the more rapid the action of acid on milk. It acts slowly if at all on pasteurized milk, because the soluble calcium salts have been precipitated.

Q. What is the action of rennet in cheese ripening?

A. The pepsin aids in breaking down the casein into more soluble compounds.

DIVISION TWENTY.

FEDERAL STANDARDS FOR DAIRY PRODUCTS.

The following are the standards for milk and its products as given in Circular No. 19, Standards of Purity for Food Products, U. S. Department of Agriculture.

Milk is the fresh, clean, lacteal secretion obtained by the complete milking of one or more healthy cows, properly fed and kept, excluding that obtained within fifteen days before and ten days after calving, and contains not less than eight and one-half (8.5) per cent. of solids not fat, and not less than three and one-quarter (3.25) per cent. of milk fat.

Blended milk is milk modified in its composition so as to have a definite and stated percentage of one or more of its constituents.

Skim-milk is milk from which a part or all of the cream has been removed and contains not less than nine and one-quarter (9.25) per cent. of milk solids.

Pasteurized milk is milk that has been heated below boiling sufficiently to kill most of the active organisms present and immediately cooled to 50° F. or lower.

Sterilized milk is milk that has been heated to the temperature of boiling water, or higher for a length of time sufficient to kill all organisms present.

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 the 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 the water has been evaporated.

Buttermilk is the product that remains when butter is removed from milk or cream in the process of churning.

Goat's milk, ewe's milk, etc., are the fresh, clean, lacteal secretions, free from colostrum, obtained by the complete milking of healthy animals, other than cows, properly fed and kept, and conform in name to the species of animal from which they are obtained.

Cream is that portion of milk, rich in milk fat, which rises to the surface of milk on standing, or is separated from it by centrifugal force, is fresh and clean and contains not less than eighteen (18) per cent. of milk fat.

Evaporated cream, clotted cream, is cream from which a considerable portion of water has been evaporated.

Milk-fat, butter-fat is the fat of milk and has a Reichert-Meissel Number not less than twenty-four (24) and a specific gravity not less than 0.905 $\left(\frac{40^\circ \text{ C.}}{40^\circ \text{ C.}}\right)$

***Butter** is the clean, non-rancid product made by gathering in any manner the fat of fresh or ripened milk or cream into a mass, which also contains a small portion of the other milk constituents, with or without salt, and contains not less than eighty-two and five-tenths (82.5) per cent. of milk fat. By acts of Congress approved August 2, 1886, and May 9, 1902, butter may also contain added coloring matter.

Renovated butter, process butter, is the product made by melt-
or any substance except milk, cream, or salt, and contains not more
ing butter and reworking, without the addition or use of chemicals
than sixteen (16) per cent. of water and at least eighty-two and five-tenths (82.5) per cent. of milk fat.

*The inspection of butter and renovated butter is done by the Internal Revenue Department. All butter containing 16 per cent. of moisture or more is classed as adulterated butter by the Internal Revenue law. If it is otherwise entitled to the name, it will pass inspection if it contains less than 16 per cent. of moisture.

Cheese is the sound, solid and ripened product made from milk or cream by coagulating the casein thereof with rennet or lactic acid, with or without the addition of ripening ferments and seasoning, and contains, in the water-free substance, not less than fifty (50) per cent. of milk fat. By act of Congress, approved June 6, 1906, cheese may also contain added coloring matter.

Skim-milk cheese is the sound, solid and ripened product made from skim-milk by coagulating the casein thereof with rennet or lactic acid, with or without the addition of ripening ferments or seasoning.

Goat's milk cheese, ewe's milk cheese, etc., are the sound, ripened products made from the milks of the animals specified, by coagulating the casein thereof with rennet or lactic acid, with or without the addition of ripening ferments and seasoning.

Ice cream is a frozen product made from cream and sugar, with or without a natural flavoring, and contains not less than fourteen (14) per cent. of milk fat.

Fruit ice cream is a frozen product made from cream, sugar, and sound, clean, mature fruits, and contains not less than twelve (12) per cent. of milk fat.

Nut ice cream is a frozen product made from cream, sugar and sound, non-rancid nuts, and contains not less than twelve (12) per cent. of milk fat.

Whey is the product remaining after the removal of fat and casein from milk in the process of cheese-making.

Kumiss is the product made by the alcoholic fermentation of mare's milk or cow's milk.

The standard for unsweetened evaporated or condensed milk as given on page 60 has recently been changed by Food Inspection Decision No. 131, as follows:

"(1) It should be prepared by evaporating the fresh, pure, whole milk of healthy cows, obtained by complete milking and excluding all milkings within 15 days before calving and 7 days after calving, provided at the end of this 7-day period the animals are in a perfectly normal condition.

(2) It should contain such percentages of total solids and of fat that the sum of the two shall be not less than 34.3 and the percentage of fat shall be not less than 7.8 per cent. This allows a small reduction in total solids with increasing richness of the milk in fat.

(3) It should contain no added butter or butter oil incorporated either with whole milk or skimmed milk or with the evaporated milk at any stage of manufacture."

DIVISION TWENTY-ONE.

LABORATORY EXERCISES

GENERAL DIRECTIONS.

1. Each student must be supplied with a dairy outfit. The key for the locker containing the same may be secured from the chemical store room after the laboratory deposit has been made and assignment received from the instructor in charge.

2. Each student must be supplied with a white suit for laboratory work.

3. Each student must clean his desk and all apparatus used by him before leaving the laboratory.

4. The breakage or loss of any glassware or other apparatus placed in the laboratory for general use will be charged to the class as a whole unless replaced by the student responsible.

For references read: Farrington and Woll's "Testing Milk and its Products;" Van Slyke's "Modern Methods of Testing Milk and Milk Products."

EXERCISE I.

Check all glassware and report at once any missing or broken pieces. Wash all glassware in hot water, using Wyandotte Washing Powder.

A good solution for occasional use in cleansing glassware is made by dissolving 1 pound of potassium bichromate in 1 gallon of sulphuric acid. This may be diluted with water or used full strength.

EXERCISE II.

CALIBRATION.

For methods see Division 7.

(a) Calibrate all whole milk bottles with the plunger or Trowbridge Calibrator.

(b) Calibrate skim-milk bottles by the use of mercury.

(c) Calibrate cream bottles and pipettes by the use of burette and distilled water.

Report all inaccurate pieces to instructor in charge.

Record all pieces calibrated and results.

EXERCISE III.

TESTING WHOLE MILK.

For method see Division 7.

(a) Test a sample of milk in duplicate (using two bottles).

(b) Test another sample of whole milk in duplicate.

In each case read the fat column immediately on taking from centrifuge. Then place in water at temperature of 140° for 4 minutes and read again. Let the bottles stand at room temperature and take readings every ten minutes until the fat solidifies.

Record the test of each bottle at the three different readings. If the per cent. in duplicate bottles when read from the hot water bath varies more than .2 per cent. test must be made again. This rule will hold in all Babcock tests for milk.

What is the color of the fat column and other contents of the bottle?

Record any other facts noted.

Problems.—How many pounds of butter fat in 475 pounds of the milk tested in (a)?

How many pounds of butter fat in 360 gallons of the milk tested in (a)?

Solve the same problems for the milk tested in (b).

EXERCISE IV.

EFFECT OF DIFFERENT AMOUNTS OF ACID AND DIFFERENT TEMPERATURES ON THE BABCOCK TEST.

Make 7 duplicate tests of a sample of whole milk as follows:

(a) Use the regular amount of acid.

(b) Use one-half the usual amount of acid.

(c) Fill the bowl nearly to base of neck with acid.

(d) Warm both milk and acid to 110° F. before mixing. Use the usual amount of acid.

(e) Cool both milk and acid to 40° F. before testing.

(f) Test milk as usual but use chemically pure acid instead of the commercial.

(g) Very carefully add 2 or 3 cubic centimeters of water to 17.5 c.c. of commercial acid. Use 17.5 c.c. of this mixture in making one test.

Record the per cent. of fat in each bottle, the color of the fat column in each case and any other differences you may note.

EXERCISE V.

COMPARISON OF STEAM AND HAND TESTERS AND DIFFERENT SPEEDS OF TESTER.

(a) Test a sample of whole milk in duplicate in power tester.
(b) Test same milk in duplicate in hand tester.
(c) Test same milk in duplicate running at one-half usual speed.
(d) Test in duplicate a sample of skim-milk.

Record the test of each bottle and note any differences between tests in hand and power testers and at different speeds.

EXERCISE VI.

SKIM-MILK AND CREAM TESTING.

For methods see Divisions 8 and 9.

(a) Test a sample of skim-milk, using two whole milk and two skim-milk bottles. Note and record results from both kinds of bottles.

(b) Test a sample of cream in duplicate using 9 grams in 9-gram bottles.

(c) Test the same cream in duplicate, using 9 grams of cream in 18-gram bottles. What must be done to the fat reading when using 9 grams of cream in an 18-gram bottle?

Use glymol in reading cream tests.

Record results in full in regard to per cent. of fat, color of fat column, etc.

Problems.—(a) How many pounds of butter fat in 650 pounds of the above cream?

(b) How many pounds of butter fat in 300 gallons of the above cream?

(c) How many pounds of butter fat were lost in 600 pounds of the above skim-milk?

EXERCISE VII.

CREAM TESTING.

(a) Test a sample of cream in duplicate in 9-gram 50 per cent. bottles.

(1) Read the per cent. of fat directly after the tester has stopped.

(2) Place in hot water at a temperature of 140° F. for 4 minutes and read again, placing back into the water.

(3) Add glymol to top of fat column and read again.

(b) Test the same cream, using 18 grams in an 18-gram cream bottle. Follow out (1), (2), (3) as above.

(c) Test a sample of buttermilk in duplicate using skim-milk bottles.

Record results in detail.

Show the number of pounds of butter fat a creamery would pay for in buying 464 pounds of cream by the different readings of per cent. of fat in the above experiment.

NOTES

EXERCISE VIII.

TESTING CREAM, BUTTERMILK AND SKIM-MILK.

(a) Take a sample of cream from a cream can and test it for butter fat.

What precautions are necessary to get a fair sample of cream from the can? See Division 9.

How much butter can be made from 100 gallons of this cream if the overrun is 18 per cent.?

(b) Test a sample of buttermilk for butter fat using 2 whole milk and 2 skim-milk bottles.

How much butter fat did the butter maker lose in 840 pounds of this buttermilk?

(c) Test a sample of skim-milk in 2 skim-milk and 2 whole milk bottles.

What was the loss of butter fat in 940 pounds of this skim-milk?

EXERCISE IX.

TESTING BUTTER.

For methods see Division 10.

(a) Prepare a sample of butter for testing.

(b) Test for butter fat using two cream bottles and one special butter test bottle.

(c) Make 3 tests of the same butter for moisture by the Irish method.

(d) Test the same butter for salt, making 3 titrations of the salt solution.

(e) If your tests are correct what is the per cent. of constituents other than salt, water and butter fat in this butter?

How near to the legal limits are the per cents. of water and butter fat?

EXERCISE X.

TESTING CHEESE.

For methods see Division 10.

(a) Secure a sample of several different kinds of cheese. Take three small pieces of each and put into as many test tubes. Then add a few c.c. of water to one of each kind, a few c.c. of sulphuric acid to one of each kind, a few c.c. of hydrochloric acid to one of each kind. Note the effect of the different solvents on the different kinds of cheese during the class period and set away until the next period and examine again.

(b) Test a sample of cheese for moisture.

(c) Test the same cheese in duplicate for butter fat.

(d) Test a sample of whey for butter fat, using 2 whole milk and two skim-milk bottles.

(e) How much butter fat was lost in 560 pounds of this whey?

EXERCISE XI.

TESTING CONDENSED MILK AND ICE CREAM FOR BUTTER FAT.

For methods see Division 11.

(a) Test a sample of ice cream in duplicate.

(b) Test one bottle of ice cream in same manner as ordinary cream and compare results with (a).

Why does (b) not give good results?

(c) Test a sample of unsweetened condensed milk in duplicate.

(d) Test a sample of sweetened condensed milk in duplicate.

EXERCISE XII.

ACIDITY TESTS.

For methods see Division 14.

(a) Test a sample of sweet milk for acid by both Mann's and Marschall's tests, making two determinations by each method.

(b) Repeat (a) with sour milk.

(c) Repeat (a) with sweet cream.

Be sure to rinse the pipette with distilled water when testing cream, running the rinsings into cup with the cream.

(d) Repeat (a) with sour cream.

(e) Repeat (a) with buttermilk.

(f) Repeat (a) with some milk soured by Bacillus Bulgaricus.

EXERCISE XIII.

THE USE OF THE LACTOMETER.

For methods see Division 13.

(a) Make the following determinations with a sample of milk and in the order given: (1) Per cent. of fat. (2) Lactometer reading. (3) Temperature of milk. (4) Lactometer reading corrected to 60° temperature. (5) Specific gravity of the milk. (6) Per cent. of solids not fat. (7) Per cent. of total solids. (8) Specific gravity of the total solids.

(b) Add 10 per cent. of water to the above milk and again make the same determinations.

EXERCISE XIV.

DETECTION OF ADULTERATION.

Test four different samples of milk in same manner as in Exercise XIII.

Determine which samples are adulterated and in what manner See Division 13.

EXERCISE XV.

HART CASEIN TEST AND FERMENTATION TESTS.

For methods see Divisions 10 and 17.

(a) Test in duplicate a sample of whole milk for butter fat.

(b) Test the same milk for casein by the Hart Casein Test.

(c) At the beginning of laboratory period sterilize two pint bottles for fermentation tests, by putting them in autoclave under 15 pounds steam pressure for 15 minutes. When bottles have cooled prepare sample of milk for Gerber fermentation test in one and for curd test in the other. Examine on the two following days for odors and gas production.

(d) How much cheese per hundred pounds may be made from the milk tested in (a) and (b)? Use both formulas given.

EXERCISE XVI.

PRESERVATIVES.

For methods see Division 15.

(a) Test each of the samples of milk provided for formaldehyde, borax or boracic acid, and sodium carbonate.

EXERCISE XVII

DETECTION OF OLEOMARGARINE AND RENOVATED BUTTER.

For methods see Division 10.

(a) Examine the samples of material furnished and determine which are butter, which are oleo and which renovated butter.

(b) Test one sample of each product for moisture, by one of the tests given for determining moisture in butter.

EXERCISE XVIII

COMPOSITE TESTS.

See composite tests under Division 7.

(a) Test for butter fat each of 9 samples furnished. Divide the 9 samples into three groups of three each. Take three composite samples, one from each of the three groups at the rate of 1 c. c. for each pound of milk represented by the different samples. The pounds of milk will be noted on the label of each sample.

Place a corrosive sublimate preservative tablet in each composite sample, shake until dissolved, stopper tightly and set aside until next period for testing.

(b) Determine the number of pounds of fat in the milk represented by each of the above samples. Determine the average per cent. of fat in the 9 samples and the average per cent. in each of the groups. Compare these averages with the tests of the composites at the next period.

(c) Beside the composite samples tightly stopper two other samples and set away without preservative until the next testing period. Record the tests of these samples to be compared with their tests at the next period.

EXERCISE XIX.

TESTING COMPOSITE SAMPLES AND CREAM.

(a) Test the three composite samples saved from last period and compare tests with average of the individual tests.

(b) In taking these composite samples, why was it necessary to take them proportionately, or 1 c.c. for each pound instead of an equal amount, such as 15 c.c. from each sample?

(c) Test the two samples held over from last period without preservative. If they are curdled, test as recommended for curdled milk in Division 7, and compare per cent. of fat with that obtained in former tests.

(d) Test a sample of cream for butter fat in duplicate.

EXERCISE XX.

EXPERIMENTS WITH RENNET.

Note Division 18.

Dilute some rennet by putting 5 c.c. of rennet into a 50 c.c. glass flask and filling the flask to the mark with water.

(a) Warm some sweet milk to 86° F. Add two 17.6 c.c. pipettefuls to a beaker or porcelain cup. Add one cubic centimeter of the dilute rennet and give a quick stir with the thermometer or shake the beaker in such manner as to give contents a rotary motion. Note the length of time it takes to coagulate.

(b) Repeat the experiment with milk just beginning to taste sour or add a small amount of very dilute hydrochloric or sulphuric acid to the milk.

(c) Repeat with milk neutralized with sodium hydroxide.

(d) Repeat (a) with sample of the original milk at 95° F., 106° F., 120° F., 140° F., 70° and 60° F.

(e) Repeat (a) with the same milk diluted at the rate of 1 part water to 3 of milk.

(f Repeat (e) with 1 part water and 2 parts milk.

(g) Repeat (e) with 1 part water and 1 part milk.

EXERCISE XXI.

Effect of salt and soluble salts on rennet.

(a) Action.—Make a test of rennet action as in (a) Ex. 20.

(b) Repeat (a) with the same milk, three times, adding one per cent. of salt to the milk in the first, 3 per cent. in the second and 5 per cent. in the third test.

(c) Repeat (a) with the same milk, adding a small amount of dilute solution of calcium chloride.

(d) Repeat (a) with milk heated to 190° F. for 10 minutes and cooled to the usual temperature of 86° F.

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