DAIRY ARITHMETIC

Fundamental Dairying

and

Dairy Arithmetic

by

Oscar Erf
Professor of Dairying and Animal Industry
Kansas State Agricultural College

Manhattan, Kan.,
Printing Department, K. S. A. C.
1906.

FUNDAMENTAL DAIRYING AND DAIRY ARITHMETIC.

DIVISION ONE.

MILK.

1. 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.

2. Q. Of what is milk composed?

A. Of water and milk solids.

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

A. No.

4. Q. What are the milk solids?

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

5. Q. What is milk serum?

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

6. Q. What are the fats in milk?

A. The fats in milk are known as butter fats, and are so called because they are the chief constituents of butter. Fats are composed of fatty acids in combination with glycerine. Butter fats are a mixture of several distinct fats which have mainly as their fatty acids, stearic, palmitic, and oleic acids, in combination with glycerine. In connection with these there are a number of other fats that, when broken into their simple constituents, are volatile. The butter fats are the most variable constituents in milk.

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

A. It is to produce heat and fat.

8. Q. How do butter fats 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, from $\frac{1}{10000}$ of an inch to $\frac{1}{20000}$ of an inch in diameter. It is estimated that in average milk there are 150,000 globules in a single drop.

9. Q. What is milk 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 of 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.

10. 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.

11. 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.

12. 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.

13. 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.

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

A. Milk.
- Water, 87.50 %
- Total solids, 12.50 %
  - Fat, 3.60 %
  - Solids not fat, 8.90 %
    - Albuminoids, 3.40 %
      - Casein, 3.00 %
      - Albumen, .40 %
    - Sugar, 4.79 %
    - Ash, .71 %

15. 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...........	.8750	×	200	=	175.00 pounds of water.
Total Solids.....	.1250	×	200	=	25.00 pounds of total solids.
Fat..............	.0360	×	200	=	7.20 pounds of fat.
Albumen.........	.0340	×	200	=	6.80 pounds of albuminoids.
Milk Sugar......	.0479	×	200	=	9.58 pounds of milk sugar.
Ash..............	.0071	×	200	=	1.42 pounds of ash.

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

A. Yes.

17. 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.

18. 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.

19. 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.

20. 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 Kœnig's analysis, collected from different parts of the world, and represents a fair maximum and minimum ratio. It is a fact, however, that in one case of known record, a cow has given 11 per cent of butter fat. In a few cases cows have been known to yield 10 per cent of butter fat in milk

21. 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	Casein.	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

22. 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.

23. 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.*

24. 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.	Albumens.	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

25. 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

DIVISION TWO.

BUTTER FAT.

26. Q. What is the most valuable constituent of milk, from a commercial standpoint?

A. Butter fat.

27. Q. What is the range in percentage of butter fat in milk, cream and butter?

A. The range is as follows:

In milk, from 3 per cent to 10 per cent, average 3.8 per cent.
In cream, from 10 per cent to 80 per cent, average 20.0 per cent.
In butter, from 80 per cent to 92 per cent, average 85.0 per cent.

The minimum per cent of butter fat in milk and butter is fixed by law in some states.

*Generally the greatest number of pounds of butter fat are produced the second month and the greatest number pounds of milk in the third month of the period of lactation.

28. Q. What are the constituents, in connection with butter fat, that go to make up butter?

A. (1) Water, (2) salt, (3) casein, (4) small amount of ash, (5) small amount of sugar. These constituents make what is known to be the "overrun" in butter. The "overrun" is the difference in weight of butter made, over the butter fat in milk.

29. Q. What is the average per cent of "overrun" in butter?

A. From 12 to 18 per cent.

30. Q. What should be the per cent of water in butter?

A. The established lawful limit is 16 per cent.

31. Q. What should be the average per cent of salt in butter?

A. From $2\frac{1}{2}$ to 3 per cent.

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

Only approximately. It may be calculated by adding 14 per cent or 15 per cent or 16 per cent to the butter fat, or, the method which is more commonly followed, by adding $\frac{1}{5}$, $\frac{1}{6}$ or $\frac{1}{7}$ to the butter fat. This variation depends upon the amount of fat lost, and the amount of water, salt and casein incorporated into the butter during the process of manufacture.

EXAMPLE.

33. Q. How many pounds of butter can be made from 475 pounds of milk containing 3.8 per cent butter fat?

A. $475 \times .038 = 18$ (pounds butter fat).
$\frac{1}{6}$ of 18 or $18 \div 6 = 3$; then
$18 + 3 = 21$, the number pounds butter that can be made from 475 pounds of milk.

DIVISION THREE.

CREAM.

34. Q. What is cream?

A. Cream consists of all portions of milk after a part of the milk serum has been removed. It contains not less than 10 per cent nor more than 80 per cent butter fat. Ordinarily, cream is that portion of milk which rises to the top in a layer, upon letting milk set for a time, or is separated from it by centrifugal force.

35. 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.

36. 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.

37. Q. What is the composition of cream?

A. Cream (containing 10 per cent to 30 per cent butter fat) has about the same per cent of milk 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 10 per cent to 80 per cent, according to the manner of skimming. An average cream contains 22 per cent butter fat, 69 per cent water, 3.8 per cent albuminoids, 4.6 per cent sugar, .6 per cent ash.

DIVISION FOUR.

OTHER MILK PRODUCTS.

38. 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.

39. 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.

40. 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. In some localities, it is used in the manufacture of cheese, or in the manufacture of cold water paints and patent foods. A product, which is extensively used for sizing paper, is manufactured from skim-milk.

41. 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.

42. 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.

43. 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 buttermilk 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.

44. Q. Of what part of milk is cheese made?

A. Cheese contains a part of all the constituents of milk. The percentage of the constituents, however, has been decidedly changed. Roughly speaking, a well-cured cheese consists of 33 per cent water, 33 per cent casein, 33 per cent fat and about 1 per cent ash, sugar and lactic acid. As is noticed, cheese, if properly manufactured, is one of the richest foods for human consumption.

45. Q. What is the by-product of cheese?

A. Whey.

46. 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.

47. Q. What is condensed milk?

A. Milk from which one-half to two-thirds of the water of the original milk has been removed. Some brands contain about 25 per cent to 35 per cent of cane sugar in addition to the milk solids.

DIVISION FIVE.

Weight and Specific Gravity of Milk and Its Products.

48. 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.

49. Q. What is the weight of a gallon of cream?

A. The weight of a gallon of cream varies according to its percentage of butter fat. The more butter fat the lighter will be the cream; hence, on a commercial basis, it is sold under the three following weights: (1) Cream that contains less than 20 per cent butter fat is sold on the basis that one gallon of cream weighs 8.6 pounds. (2) If cream contains from 20 per cent to 40 per cent of butter fat, it should be sold on the basis of 8.4 pounds per gallon. (3) Cream containing from 40 per cent to 80 per cent of butter fat should be sold at the rate of 8.2 pounds per gallon, although there is only little of this kind of cream on the market.

50. 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.

51. 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.

52. 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.

53. 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 10 per cent of butter fat has a specific gravity of 1.023 at 60° F. What is the weight of a gallon of this cream?

8.3 (the weight of a gallon of water) × 1.023, (the specific gravity) = 8.49. or practically 8 5 pounds.

Problem 2.—25 per cent cream has a specific gravity of 1.002.

8.3 × 1 002 = 8.31, 8.3 pounds.

54. 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.

Method.

55. 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 5 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.

56. 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.)

DIVISION SEVEN.

Testing Milk.

57. Q. How can you test milk?

A. By means of the Babcock test.

58. Q. Can you test other dairy products by means of this tester?

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

59. Q. What advantages are there for knowing the per cent of butter fat, other than 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 the skim-milk when separated; also the amount of butter fat lost in whey in the manufacture of cheese. If the loss is too great, so that the business becomes unprofitable, the fault can be readily discovered and remedied.

60. 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.

61. Q. Does it require much time to test a sample of milk?

A. No; if everything is in readiness the work can be done in ten minutes. However, four or more samples of milk can be tested in nearly the same length of time.

METHOD OF OPERATION.

62. Q. Name the pieces of apparatus which comprise the Babcock tester?

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

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

A. Yes; one—sulphuric acid.

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

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.)

8. Measure out 17.5 cc. of sulphuric acid and put into the test bottle with 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 five minutes at the proper speed, then add hot water to the mixture until it reaches the 7 or 8 mark on the graduated neck.

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

13. Take out bottle and read it immediately.

Detailed Explanation of the Babcock Test.

Calibration (accurate marking, or graduation) of glassware.

Exactness in determining the per cent of butter fat in milk requires, among other things, the correct graduation of test bottles and pipettes. Sometimes there is a slight error in one or the other, leading to erroneous conclusions. It is therefore always advisable to calibrate the glassware used in testing milk. It may be done as follows. 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.

A more convenient way to calibrate test bottles is by means of the N-H milk bottle tester. 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 or alcohol (water may be used, but it is not recommended owing to its greater capillary attraction to the neck) so that its highest point is exactly even with the 0 mark. Then slowly lower the tester into the bottle until the liquid rises about half way between the two sections, and 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.

The easiest way to calibrate a pipette is to fill it to the mark with water, deliver it into a weighed vessel and find the weight of the water. This weight should be 17.44 grams. It can also be calibrated by dropping 17.4 cubic centimeters of water from an accurately graduated burette.

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.

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.

REASON FOR TAKING 17.6 CUBIC CENTIMETERS.

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.

CLEANING TEST BOTTLES AND PIPETTES.

The test bottles should be emptied of their contents while yet hot, in order that the fat may not stick to the sides. The bottles should be well skaken to remove any sediment. A thorough rinsing with boiling water is usually sufficient to complete the cleaning; but this is not practical, since it requires special apparatus to introduce into the bottle water that is hot enough to do the proper cleaning; it is, therefore, safer to use an alkali, such as salsoda or caustic potash, or a soap powder, to remove the fat. A little sulphuric acid and bichromate of potassium should be occasionally used to insure absolute cleanliness. At times a sediment accumulates on the bottom and sides of the bottle. This can be thoroughly removed by the use of No. 8 or No. 9 shot. Put the shot and alkali solution into the bottle and shake violently. By this means all sediment, which was not readily dissolved by acid or alkali, can be removed. All washing should be followed by a rinsing with boiling water and a thorough draining. Boiling water following a rinsing with cold water is sufficient, as a rule, for cleaning pipettes, but alkalies should be used occasionally to remove the grease.

HOW TO OBTAIN AN ACCURATE SAMPLE OF MILK FROM A COW.

The first milk given down by a cow is very low in butter fat, while the last milk or "strippings" is high in butter fat. For this reason it is essential to milk the cow dry first. Then mix evenly by thorough stirring and take a sample from the entire milking. If a composite test is to be made, put the sample into a milk jar and follow instructions given below.

SAMPLE FROM A HERD.

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.

A COMPOSITE TEST.

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. 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 take a sample from the composite test, 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.

HOW TO TAKE A SAMPLE FROM SOUR MILK.

When milk has become sour, 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 ($180 : 9 :: 100 : x = 5$). 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 ($3.9 + 0.195 = 4.095$).

ALIQUOT PART.

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 $\times$ .0033⅓, 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.

The error made by taking the same quantity for a sample, as is commonly done by means of a spoon or any other receptacle, where a constant quantity of milk is taken for the sample jar, regardless of the amount and quality of milk from which it is taken, can be proven by a problem.

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 3½ per cent. Hence, 3½ 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 $\div$ 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.

SAMPLING FROZEN MILK.

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 freezing.

SAMPLING MILK THAT HAS BEEN CHURNED.

One method is to dissolve the little lumps of butter fat with ether, shake the whole mass and mix into the milk. 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.

MIXING MILK TO BE TESTED.

Milk should be thoroughly mixed so that the fat may be evenly distributed throughout the whole mass, and an accurate test procured. This mixing should be done by giving the bottle a rotary motion, since a violent mixing will cause the butter fat to churn. Another way is to pour the milk back and forth from one vessel to another. This should not be done more than twice or three times, depending somewhat on the consistency of the cream.

HOW TO MEASURE OFF 17.6 CUBIC CENTIMETERS WITH PIPETTE.

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.

AMOUNT AND KIND OF ACID USED.

Sulphuric acid, having a specific gravity of approximately 1.82, should always be used. The amount needed should be, approximately, 17.5 cubic centimeters, depending somewhat on the strength of the acid and temperature of the milk. The proper temperature of the milk is from 60° to 80° F. for adding acid. If the milk is colder than 60°, more acid must be used. If the milk is warmer than 80°, 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 80° F. If the acid is too strong, less acid must be used or the milk must be lowered in temperature (below 50° F.).

If acid is too strong it can be weakened by diluting with distilled water. 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 of acid, then add water 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.

THE MANNER OF ADDING ACIDS.

Pour acid into the acid measure until it reaches the 17.5 cubic centimeter 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.

MANNER OF MIXING ACID WITH MILK.

The acid, being heavier, flows beneath the milk, and care should be taken that the mixing is 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.

TEMPERATURE OF SAMPLE AFTER MIXING.

When the acid and milk are added together, the mixture will become very hot. This decomposes the solids not fat and facilitates the melting of the fat, and tends to raise the fat more quickly. The temperature at which sample should be retained is about 130° to 140° F.

PLACING THE BOTTLE IN THE CENTRIFUGE.

After mixing, the bottles should be placed in the centrifuge (the machine which whirls the bottles) in such a position that the centrifuge wheel wili retain its equilibrium. A conveninet way to do this is to place an equal number of bottles of equal height on each side of the wheel. If an odd number is to be tested, fill another test bottle with water.

THE PURPOSE OF THE CENTRIFUGE.

A centrifuge is a machine constructed for the purpose of whirling the test 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.

The Speed of the Centrifuge.

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.

FORMULA FOR CALCULATING THE SPEED OF THE CENTRIFUGE WITH A GIVEN DIAMETER.

F = Centrifugal force (30.65).
W = Weight of bottle and contents ($\frac{3}{20}$ of a pound).
V = Velocity in feet per second.
R = Radius of wheel in feet.

To find velocity in feet per second:

$$V = \frac{\text{diam. in ft.} \times 3.1416 \times \text{No. of revolutions per min.}}{60}$$

How to find speed required to obtain necessary centrifugal force:

$$\text{Velocity} = \sqrt{\frac{32.2 \times F \times R}{\frac{3}{16}}} = \sqrt{5264\,R}$$

which equals velocity in feet per second.

To find the revolutions of wheel per minute:

$$\frac{60V}{2\pi R} \qquad \begin{aligned} V &= \text{velocity in feet per second.} \\ &= 2 \times 3.1416 \times \text{radius in feet.} \end{aligned}$$

Example.—How many turns should be given the handle of a tester to produce the proper centrifugal force, when the wheel is 16 inches in diameter?

$$V = \sqrt{\frac{32.2\,F \times R}{W}}$$

Substitute the value for F and W.

$$V = \sqrt{\frac{32.2 \times 30.60\,R}{\frac{3}{16}}} = \sqrt{5264\,R}$$

Substitute the value for R or radius in feet.

$$V = \sqrt{5264 \times \tfrac{2}{3}} = 59.24$$

To find the number of revolutions after the velocity in feet per second is found, apply the following formulas:

$$\text{Rev.} = \frac{60\,V}{2\pi R}$$

Substitute the value for V and R.

$$\text{Rev.} = \frac{60 \times 59.24}{2 \times 3.1416 \times \frac{2}{3}} = 855;$$ or number of revolutions of the centrifuge wheel per minute.

Find the corresponding number of revolutions of the wheel, to that of the handle turning it once around, and count the number of revolutions the wheel of the centrifuge has made, supposing it revolved 10 times. Divide this number by the number of revolutions the wheel made per minute ($\frac{855}{10} = 85.5$), which is the number of turns required at the handle to produce the necessary centrifugal force.

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

THE LENGTH OF TIME OF FIRST RUN.

The centrifuge should be run for five minutes at the regular speed calculated by the above formula to produce the proper force required to separate the fat perfectly from the mixture. Care should be taken that the above speed of the centrifuge is kept up for the required length of time. If, for any cause, the speed should slacken, the fat will not separate thoroughly, and the reading will be too low.

ADDING WATER TO THE TEST.

After the first run, add hot water and fill the bottle until the level of the water reaches the seven- or eight-per-cent mark.

TIME AND PURPOSE OF THE SECOND RUN.

After adding hot water, the bottle is put into the centrifuge and given a second run of two minutes more. The water must be approximately of 140° F. temperature if tested in a steam turbin centrifuge, or a temperature of 160° to 180° F. if tested with the hand tester. The hot water keeps the fat in liquid form and tends to facilitate the rise of the fat to the top of the water, and at the same time causes the fat and the water to separate definitely, leaving a clear line of distinction. Distilled water is the best to use for this purpose; if not at hand, boiled water should be used

APPEARANCE OF THE TEST.

The fat column in the neck of the bottle should have a clear, yellowish and uniform appearance. Specks or sediment indicates a wrong manipulation at some point, or it may indicate that some foreign material has been added to the milk before, or at the time it was tested.

Foam on the fat column usually indicates the presence of a small amount of alkali in the water that has been added to bring the fat up in the column. This can be eliminated by adding a drop of alcohol after the test is completed.

*According to Tarrington.

THE CAUSE OF A CHARRED TEST OR BLACK FAT IN THE BOTTLE.

This is caused by too much heat, which is due to the acid being too strong or the milk heated to too high a temperature before the acid is added; or the mixture of acid and milk was kept at too high a temperature for some time after mixing, or kept too long in a hot centrifuge.

CAUSE OF A WHITE OR CURDY APPEARANCE OF FAT.

This is due to insufficient heat caused by the temperature of milk being too low before acid is added, or acid being too weak; or the test was kept too cool during the operation.

HOW TO DETERMINE THE PROPER AMOUNT OF ACID REQUIRED FOR TESTING MILK.

Take three or four test bottles with milk of the same quality and temperature. Use various amounts of acid in the different bottles and test each bottle under the same condition and note which quantity gives clearest fat column, and this will be the proper amount required.

READING THE FAT COLUMN.

The per cent of fat is read by counting the spaces between the lowest point of the lines of separation of the fat and the water and the extreme upper part of the fat miniscus.

Experience and comparison with the gravimetric analysis shows that enough fat is left in the bottle to fill up the two spaces not filled with fat, caused by the capillarity of the fat and glass. From these extreme points the correct reading of fat in the milk is indicated.

HOW TO CALCULATE THE POUNDS OF BUTTER FAT IN MILK WHEN THE PER CENT OF FAT IS KNOWN.

The readings of the bottle indicate per cent. The per cent of butter fat in milk represents the number of hundredth parts of the whole quantity of milk. To find the amount of butter fat, multiply the per cent of butter fat by the pounds of milk and divide by one hundred. The product will equal the pounds of butter fat; thus: 144 pounds of milk testing three per cent butter fat, $144 \times .03 = 4.32$ (pounds of butter fat).

CARE OF THE CENTRIFUGE.

The centrifuge should always be kept clean and well oiled; it should be fastened to a solid foundation and should stand level so that it may run in perfect balance. If a steam turbin, it should have the exhaust open large enough for the exhaust steam to escape easily. Caution should be taken that the steam does not come in too direct contact with the bottles, for high heat introduces an error in the reading of the fat.

HOW TO PROVE THE CORRECTNESS OF A TEST.

The correctness of a test may be proven by testing duplicate samples. If the reading in the two samples is the same, it is almost certain to be accurate, providing the manipulations have been followed strictly according to these details.

MARKING THE TEST BOTTLES.

In testing two or more samples, it is necessary to mark the bottle which corresponds to the sample it contains. For this purpose nearly all Babcock test bottles have an etched portion either at the neck or on the bulge of the bottle. In case a bottle is not etched, the operator can easily etch it by applying hydrofluoric acid. The bottle can then be marked on the etched portion with a lead-pencil.

DIVISION EIGHT.

TESTING SKIM-MILK, BUTTERMILK AND WHEY.

64. Q. Why is skim-milk tested?

A. Skim milk is tested for its butter fat, to show how much has been lost by skimming or separating the cream from the milk. Other things being equal, the best system of skimming is that which leaves the least amount of butter fat in the skim-milk.

Examples.—(1) The average skim-milk that is skimmed by the shallow-pan system contains from .6 per cent to .7 per cent of butter fat. (2) The average skim-milk from the deep setting system contains from .4 per cent to .5 per cent of butter fat. (3) The average skim-milk from the centrifugal system (cream separator) contains about .1 per cent butter fat. Hence, it will be seen that the centrifugal method of separation is far more efficient than either of the other methods.

65. Q. Is money well invested in purchasing a cream separator with the above saving over the shallow-pan system?

A. This depends somewhat upon the quantity of milk to be separated, which directly depends upon the number of cows.

Example.—An average cow produces 5000 pounds of milk a year. If .5 of one per cent is saved by the centrifugal system over the shallow pan system, it means that there has been recovered 5000 times .005, or 25 pounds of butter fat, which will make about 29 pounds of butter. Twenty-nine pounds of butter at 22 cents equals $6.38, the amount saved in one year, which amount indicates 10 per cent on an investment of $63.80. This saving becomes large in a creamery in which a considerable amount of milk is handled.

EXAMPLE.

66. Q. What is the saving in butter fat of a creamery handling 10,000 pounds of milk per day, by the centrifugal method (or cream separator) over the shallow-pan system, calculating that the saving is .5 of one per cent of butter fat in the skim-milk?

A. $10{,}000 \times .005 = 50$ pounds of butter fat per day, or about 58 pounds of butter, which, if sold at 20 cents a pound, equals $11.60, the saving for one day. A creamery operates 365 days; the saving therefore amounts to $4,230.00 in a year, which amount represents 10 per cent of an investment of $42,300.00.

67. Q. Of what importance is it to know the per cent of butter fat in buttermilk?

A. For the same reason that it is necessary to know the per cent of butter fat lost in the skim-milk. It is estimated that the average buttermilk produced on the farm contains from one to one and a half per cent of butter fat. With science applied to churning, this per cent of fat can easily be reduced to .2 of one per cent. To illustrate the loss that occurs by inefficient churning, we will say that a cow produces 5,000 pounds of milk, which contains on an average 4 per cent of butter fat. If the cream skimmed from this milk contained 20 per cent of butter fat, there would have been about 980 pounds of cream, providing the loss in the skim-milk was not over .1 of one per cent. If the average loss of the buttermilk on the farm is 1.2 per cent, the amount that can be saved through efficient churning would be one per cent (980 pounds of cream minus 233 pounds of butter equals 747 pounds of buttermilk), or 7.5 pounds butter fat, which would make about 8.7 pounds of butter, which, if sold at 22 cents, equals $1.91, the loss for one year.

68. Q. Of what importance is it to know the per cent of butter fat in whey?

A. For the same reason as in buttermilk—to determine the amount of fat lost in the manufacture of cheese.

69. Q. How can you test skim-milk, buttermilk, and whey?

A. Skim-milk, buttermilk and whey can be tested with the Babcock tester, and with the same manipulation as in testing the butter fat in whole milk, except that a trifle more sulphuric acid is added (making 18 c. c.) and the sample should be run in the centrifuge for eight minutes instead of five minutes. The reading of the fat with the common milk bottle in the case of these by-products is very unsatisfactory, hence, skim milk bottles, made especially for this purpose, have been put on the market. These are constructed with two tubes, one for pouring acid and milk into the bottles and the other for reading the column of fat. This second tube is very fine, the whole column of ten marks representing only one half of one per cent, or one mark representing .05 of one per cent. To do accurate work, a skim-milk test bottle should always be used for testing the above by-products.

DIVISION NINE.

TESTING CREAM.

70. 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; and this will probably be the way to sell butter fat to a creamery in the future.

71. Q. What difference is there in testing cream and milk with a Babcock test?

A The operation is the same, except that the sample of cream should be correctly weighed into a test bottle rather than measured in with a pipette. There are three reasons why cream should be weighed rather than measured in a test bottle.

First, the Babcock test bottle has been so graduated that a sample to be tested should weigh 18 grams. 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.

The amount to be weighed out into a test bottle does not necessarily have to be 18 grams. Any quantity can be weighed out, providing the per cent is calculated on an 18-gram basis.

Example.—The weight of the cream in the test bottle is 6.5 grams. After testing it is found that the sample contains 8.2 per cent of butter fat. The sample of cream on an 18-gram basis would contain 8.2×18, or $147.6 \div 6.5 = 22.7$ per cent of butter fat.

72. Q. If a smaller quantity of cream is weighed into a test bottle, is it necessary to take a smaller amount of acid?

A. The amount of cream in the test bottle should always be diluted with water to about 18 grams weight.

Example.—If 8 grams are weighed into a test bottle, the difference between 8 and 18, or 10, grams of water should be added, after which the same amount of acid should be used as in testing milk. The 10 grams used need not be weighed out, but only approximately measured into the bottle. The water that is to be added to the cream must have a temperature of about 60° to 70° F. and should be distilled.

73. Q. How can you overcome the cloudiness in the butter fat column which frequently occurs in testing cream.

A. It is frequently necessary, in order that the fat column in the test bottle comes up clear, instead of filling up the bottle three-quarters or more on the graduated scale with water after the first five minutes run, to fill the bottle only to the neck. Then by reshaking the fat, mixing it slightly with the acid below, the impurities are brought down and the fat becomes clear. Instead of running the Babcock tester for two minutes in the second run, run it three minutes, then stop and add water high enough in the neck of the bottle so that the fat can be properly read; after this run again for one minute. If the acid is not too strong or too week, or the cream is not too cold or too warm, the fat will come up clear.

74. Q. Can you use a milk bottle for testing cream, or is it necessary to have a special bottle for this purpose?

A. Cream can be tested with a whole-milk bottle, but with a certain amount of inconvenience. First weigh out 18 grams of cream, and add to this 36 grams of distilled water; then by taking 18 grams of the mixture, the per cent of fat can be determined by multiplying the per cent of fat in the bottle by three.

Example.—If the mixture tests 8 per cent and 36 grams of distilled water has been added to the original cream, the actual per cent of fat in the cream would be 3 × 8, or 24 per cent. Fifty-four grams can be added and the result multiplied by 4; or even 72 grams can be added and the result multiplied by 5. Multiply the test by the number of times it is diluted. Ordinarily a special cream bottle is used for testing cream. This bottle has a greater capacity in the neck and is hence graduated to a greater scale. There are two kinds of cream bottles on the market. One is known as the "bulb-necked" cream bottle, which is graduated in two-tenths per cent marks to 25 per cent of fat. The neck of the bottle is shortened by means of the bulb, which has a capacity of 10 per cent of butter fat. Care must be taken, in filling this bottle, that the top or bottom level of the fat column does not extend into the bulb, since there is no graduation on the bulb. The other cream bottle is known as the "Winton Cream Bottle" and has a neck of usual length and sufficiently wide to measure thirty-five per cent. The scale of the neck is divided into half per cents, but readings of a quarter of one per cent can easily be estimated.

75. Q. Does the diameter of the neck of the tube effect the reading of the fat?

A. Yes. Owing to the fact that the capilary attraction of fat and glass is proximately the same height, regardless whether it is a small or large tube, there will be an error, due to the different graduation which varies with the diameter, if read from the extreme top to base of the fat column. Therefore, it is preferable to use narrow-neck bottles for testing cream. If a wide bottle is used the fat column should be read from the fat level rather than from the top of meniscus.

DIVISION TEN.

76. 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.

77. Q. Is it just to standardize milk?

A. These processes are not only legitimate, but necessary—first in the interest of the consumer, and second in the interest of the producer, because the latter 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 they are produced under equal sanitary conditions).

78. 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.

79. 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*. This is not only because the richer milk is more nutritious and more palatable, but also because the cost of production is greater.

80. 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.

81. 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.

82. 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 × 045 = 45, the number of pounds of fat in 1000 pounds of 4.5 per cent milk.

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

1125 ÷ 1000 = 125, the amount of skim-milk to be added.

To formulate this problem:

A : 1C00 :: 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 × .032 = 51.2, the number of pounds of butter fat in the original milk.

51.2 ÷ .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 multi-

*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.

plied 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 ÷ .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 ÷ 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 × .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 commonly 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 ÷ .06 = .66⅔ or 66⅔ per cent, which is the portion of 6 per cent milk that the 120 pounds of standardized milk should contain. The remaining 33⅓ per cent must be skim-milk which it is necessary to add to bring the fat down 4 per cent.

66⅔ 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	+41.607	+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 or 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 200 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?

$.053 - .04 = .013$

$.04 - .031 = .009$

$.013 \div .009 = 1.44.$

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 the fat per cents in the milk of the higher fat content and the lower fat content, the quotent 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						
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	94.2'25	...	...	...
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.

DIVISION 11.

STANDARDIZATION OF CREAM.

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.

83. Q. What apparatus is necessary for standardizing?

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

DIVISION 12.

Rules for Calculating Butter-Fat Equivalent in Different Products.

84. 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?

As stated before, a gallon of 20 per cent cream weighs 8.3 pounds.

8.3 × .20 = 1.66, the pounds of butter fat in one gallon which is worth 50 cents.

$.50 ÷ 1.66 = $.30, the price of one pound of butter fat.

85. 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.

86. 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

$15 \div .20 = 75$, 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 13.

DETECTION OF ADULTERATION IN MILK.

87. Q. Can adulteration of milk with water be detected?

A. Yes. This can be determined by means of the lactometer (Quevenne being the best), as 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 1.014 to 1.040; thus a milk which has a specific gravity of 1.032 would show on the lactometer as reading of 32. 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° when the reading is taken, corrections may be made for slight variations (not more than 10°) by adding to the lactometer reading .1 ($\frac{1}{10}$) for each degree of temperature above 60°, or substracting .1 for each degree below 60°. For example, the lactometer reading is 29 and the temperature 68, then the correct reading or specific gravity for 60° would be $29 + .8 = 29.8$. Had the temperature been 56°, the correct reading would be $29 - .4 = 28.6$.

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.

The specific gravity or lactometer reading of pure milk ranges from 28 to 34, skim-milk 33 to 36.

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 specific gravity, the per cent of solids not fat may be calculated by the following formula:

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

L = Lactometer reading or specific gravity at 60°.

F = Per cent of fat.

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 $9\frac{1}{2}$ 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:

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

$$\frac{7.5 \times 100}{9} \left(\text{per cent solids not fat in pure milk}\right) = \frac{750}{9} = 83.3 \text{ per cent pure milk;}$$

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

88. Q. What is the function of the lactometer?

A. The lactometer displaces the milk, or in other words 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.

89. Q. What precautions are necessary in taking the lactometer reading?

A. (1) It is necessary to mix the milk well before taking the lactometer reading. Do this in such a manner that it will not froth or foam. (2) If it is necessary to change the temperature of the milk, do so in such manner that the temperature will be uniform throughout. (3) Always let milk stand an hour after being drawn from the cow before testing with the lactometer, as it is saturated with air and has not reached its maximum density.

90. Q. What is indicated when the lactometer reading is too high and the per cent of fat too low?

A. If the reading is 33 and upwards, and the per cent of fat is 3 or below, it indicates skimming.

91. Q. What is indicated if the lactometer reading is too low and the per cent of fat is low?

A. If the lactometer reading is 28 or below, and the fat is correspondingly low, it indicates watering.

92. Q. What is indicated when the lactometer reading is normal, or slightly below normal and the per cent of fat very low?

A. If the lactometer reading does not correspond with the per cent of fat as given above, it indicates that the milk is both skimmed and watered.

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 proportionally; 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 FOURTEEN.

THE ACID TEST.

93. 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.

94. 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.

95. 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.

96. 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.

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

A. By neutralizing the acid with alkalies.

98. 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.

99. 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.

100. 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.

101. Q. What are the names of the tests on the market?

A. There are four tests in use at the present time: One devised by Professor Mann, known as the Mann's test; the second by Professor Farrington, known as the Farrington Alkaline Tablet test; the third by Professor Van Norman, known as the Van Norman Alkali test, and the fourth, the Marschall Acid test.

102. 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. This makes what is commonly known as a 10th normal 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, then with the same pipette add 500 cubic centimeters of water. Then add five drops or more of indicator. Fill the burette to the zero mark with netralizer, 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:

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

103. 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, each tablet containing 3.8 cubic centimeters of a 10th normal solution, and if the solution is made by dissolving 10 tablets in 100 cubic centimeters of water, each cubic centimeter of the solution will be equal to .38 of a tenth normal alkali, and will therefore neutralize .38 of .009 grams, or .0034 grams of lactic acid. Therefore by multiplying the number of cubic centimeters of tablet solution used by .009, and dividing by the same number of grams of milk taken, will give the per cent of acidity. The grams of milk must be calculated according to the specific gravity. Example: 20 cubic centimeters of cream require 36 cubic centimeters of tablet solution to neutralize the acid.

104. Q. What will be the per cent of acid in the milk?

A. It will be .0034 times 36, divided by 20 times 1.032, times 100, or the specific gravity of milk.

$$\frac{.0034 \times 36}{20 \times 1.032} \times 100 = .59+$$

A simpler method is to 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.

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.

105. Q. How can you obtain the per cent of acidity by means of the Van Norman test?

A. The operation again is the same as in the preceding tests, except in this particular test a normal solution of caustic soda is used. The apparatus required is a 17.6 cubic centimeter Babcock pipette, a 100 cubic centimeter cylinder, and a two quart bottle, graduated at 1850 cubic centimeters, and 37 cubic centimeters of normal solution of caustic soda. A few drops of indicator must be used the same as in the Mann's acid test. The caustic soda solution must be prescribed by a reputable chemist, one who can be depended on to furnish it of standard strength and accurately measured. A two-quart bottle, with a long sloping neck such as is used for mineral water, may be graduated by measuring into it carefully with a 100 cubic centimeter cylinder, 1850 cubic centimeters of water, and then with a fine file marking the point on the neck to which the water rises. To prepare the solution, pour into this large graduated bottle 37 cubic centimeters of normal caustic soda solution, rinse the little bottle, empty this, rinse water into the large bottle, then fill with water condensed from the steam pipe, if it is free from boiler compounds and oil; if not use rain water, and fill the large bottle to the mark on the neck. This makes a 50th normal solution ready for use. With a Babcock pipette measure out in a white cup, or in a common composite sample jar 17.6 cubic centimeters of cream or milk to be tested which has been well stirred, rinse the pipette out with clean water, put the rinse water into the cream sample, and add four or five drops of phenolphthalein indicator. Having filled the cylinder to the top or 100 cubic centimeter mark with what is known as 50th normal alkali solution, pour slowly into the cream sample, mixing with a rotary motion of the hand, or stirring with a glass rod until there is a pink color noticeable, which does not disappear immediately by continued stirring. Note the number of cubic centimeters of alkali solution required to bring about this result. This will indicate the number of hundredths per cent of acid, since one cubic centimeter of the alkali will neutralize .01 per cent of acid when 17.6 cubic centimeters of milk or cream are used.

106. 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 $\frac{1}{10}$ normal alkali, which can be obtained from all dairy supply houses and experiment stations.

The A. Marschall acid test contains the following parts:

Combined burette and bottle for the neutralizer.
9 cubic centimeter pipette.
Bottle of indicator.
$\frac{1}{2}$ 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 has 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 $\frac{2}{10}$ of one cubic centimeter only, but $\frac{1}{10}$ 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.

107. 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.

108. Q. What amount of acid should there be in milk when it is no longer known as sweet milk?

A. Milk received at the factory 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.

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

A. Cream ready to churn should contain .5 to .65 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.

110. 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.

111. 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.

Dairy Bookkeeping.

112. Q. What is meant by dairy bookkeeping?

A. It is keeping a record of all transactions conducted in the dairy business.

113. Q. What is the object of bookkeeping?

A. The object of bookkeeping is to show in detail the money spent for certain articles, the income from certain articles, and the profits or loss of the business.

114. Q. How do you proceed to keep books?

A. The first step is the recording of every business transaction. The records of milk and cream are usually kept on milk and cream sheets. All other accounts are generally recorded in a day book. The second step is to transfer these entries into a journal or ledger. There are two systems of bookkeeping. One is known as the single entry system, and the other is known as the double entry system. In the single entry system accounts are kept with persons only, while in the double entry accounts are kept with persons and articles.

115. Q. Which is the more practical system for dairy bookkeeping?

A. The single entry system, for the reason that we have few articles to deal with in creamery work.

116. Q. Can the single entry system be used where whole milk is purchased on the butter-fat basis as well as where the cream is purchased on the same basis?

A. Yes; ordinarily where milk is purchased it is the custom to pay once a month, but where cream is purchased it is paid for every day. The daily check system, in which the cash is paid to the party that brings in the cream the day after the cream is delivered, is probably the most satisfactory. The following is an illustration where whole milk is purchased.

The following persons, A, B, C, and D delivered milk to a creamer:

A delivers 2,100 pounds of milk in the month of December.
B delivers 1,500 pounds of milk in the month of December.
C delivers 2,700 pounds of milk in the month of December.
D delivers 600 pounds of milk in the month of December.

A composite test is taken daily and tested every fifteen days. A delivers 1,300 pounds of milk the first fifteen days, which tested 4 per cent, or 1,300 times .04 = 52, No. pounds of butter fat. He delivers 800 pounds the last part of the month, tested 4.4, or 35.2 pounds of butter fat.

B delivered the first half of the month 800 pounds, which tests 3.4 and contains 27.2 pounds of butter fat. The last half he delivers 700 pounds, which contains 3.6 per cent of butter fat, or 25 pounds.

C delivers 1,800 pounds of milk the first half, which contains 3.5 per cent of butter fat, or 63 pounds, and 900 pounds the last half, which tests 3.8 per cent, or 34.2 pounds of butter fat.

D delivers 300 pounds the first half of the month, testing 4.7, or 14.1 pounds of butter fat, and the second half 300 pounds, testing 4.9, or 14.7 pounds of butter fat.

The following summary shows the total amount delivered by each and the grand total:

A	87.2
B	52.2
C	97.2
D	28 8
Total	262.6

SALES OF BUTTER FOR DECEMBER.

Date.	Pounds.	Price per lb.	Total.
December 10	50	$0 24	$12 00
" 16	60	25	15 00
" 28	105	23	24 15
January 1	100	22	22 00
Totals	315	....	$73 15

From the above statement of butter sales it will be seen that 315 pounds of butter were made from the 262.2 pounds of fat, which sold for $73.15. The charge for making a pound of butter was 3 cents. For 315 pounds it would be $9.45, which, deducted from the butter value $73.15, leaves $63.60 to be distributed among A, B, C, and D. Since the patrons receive their money according to the pounds of butter fat delivered, it would be necessary to reduce this to a butter-fat basis. Hence, $63.60 divided by 262.6 would be 24.3 cents, the value of a pound of butter fat.

According to the above, A would receive for his share 84 times 24.3, or $20.41.

B would receive 54.2 times 24.3, or $13.17.

C would receive 97.4 times 24.3, or $23.66.

D would receive 28.8 times 24.3, or $6.99.

Whenever the plant is run independently or for a stock company, and where a certain price for butter fat is guaranteed, all such items as labor, coal, ice, oil, butter color, salt and packing and investments on capital must be itemized separately.

117. Q. How do you calculate where milk and cream are both taken at the same factory?

A. Ordinarily a half cent more per pound is paid for butter fat in cream than for butter fat in whole milk.

118. Q. How can you calculate what price is to be paid to the producer by the cash system, where the butter fat is paid for immediately after its delivery to the factory?

A. This fat is generally paid for in such cases according to the New York market or some private market. Due allowance must be made for any decline in price before the butter reaches the market.

119. Q. How is butter graded on the market?

A. By the terms "extras," first grade, second grade, and third grade.

120. Q. What are the rules governing these grades of butter?

A. EXTRAS.—Shall consist of the highest grade of butter produced during the season when made, scoring 93 points or higher.

Flavor.—Must be quick, fine, fresh and clean if of fresh make, and good, sweet and clean if held.

Body.—Must be firm and solid, with a perfect grain or texture, free from salviness.

Color.—Must be uniform, neither too light nor too high.

Salt.—Well dissolved, thoroughly worked in, not too high nor too light salted.

Package.—Good and sound as required in classification.

FIRSTS.—Shall be a grade just below Extras, scoring 87 points or higher, lacking somewhat in flavor, which, however, must be good, sweet, and clean. All other requirements same as in Extras.

Package.—Good and uniform.

SECONDS.—Shall consist of a grade just below Firsts, scoring 80 points or higher.

Flavor.—Must be fairly good and sweet.

Body.—Must be sound and smooth boring.

Color.—Fairly good, although it may be somewhat irregular.

Salt.—May be irregular, high or light salted.

Package.—Same as required in Firsts.

THIRDS.—Shall consist of butter below Seconds. scoring 75 points or higher.

Flavor.—Reasonably good, may show strong tops and sides.
Body.—Not smooth boring.
Color.—Mixed or streaked.
Salt.—Irregular.
Package.—Miscellaneous.

121. Q. Do you calculate the dividends in the cheese factory the same as in the creamery?

A. In this case the milk is paid for according to the fat it contains, the same as in creameries. But ordinarily the cost of making cheese is figured on a basis of $1\frac{1}{2}$ cents per pound of green cheese. This is deducted from the total amount of money received from cheese and divided among the patrons according to the pounds of butter fat they deliver, the same as in the creamery.

122. Q. Approximately how much cheese can be made from a hundred pounds of milk?

A. This is ordinarily found by multiplying the per cent of fat in milk by 2.7.*

For example, 100 pounds contains 3 per cent of butter fat. The same, under average conditions, would make 8.1 pounds of cheese. This is, however, estimated on an average milk basis.

123. Q. Is there a more accurate method of determining the pounds of green cheese made from milk?

A. Yes. If the percentages of solids not fat (s) and the per cent of fat (f) is known, the same can be calculated with the following formula:

Yield of green cheese $= 1.58 (\frac{s}{3} + .91\ f)$

Assuming that 4,000 pounds of milk, containing 3.5 per cent of butter fat, were delivered to a cheese factory. This milk also contains 9 per cent of solids not fat. From the above formula for every 100 pounds of milk we substitute the following values: $158(\frac{9}{3} + .91 \times 35)$. This equals 9.67, which is the number of pounds of cheese that can be made from 100 pounds of milk, since from the 4,000 pounds of milk the yield of green cheese would be 40 times 9.67, or 386.8, the number of pounds of cheese.

DIVISION FIFTEEN.

Dairy Management.

124. Q. Does the per cent of butter fat and other constituents in cow's milk vary?

A. Yes. They vary for several reasons. (1) They vary in the average milk given by different breeds of cows. (2) They vary in milk of individual animals.

The following are the causes which influence this individual cow: (1) Composition of feed. (2) Change of feed. (3) Treatment of the cow. (4) Health of the cow. (5) If the cow is unusually excited. (6) If the milkers are changed, or manner of milk-

*According to Van Slyke.

ing. (7) Length of time between milking. (8) Length of time since calving.

125. Q. Does a cow manufacture milk from food?

A. Yes. A cow is a machine, so far as the manufacture of milk is concerned. She takes crude feeds, such as hay, cornstover, silage, grass, corn, bran, gluten-meal, etc., and converts them into a refined product which is milk.

126. Q. What is a food?

A. A food is anything capable of digestion by the animal that will sustain or help to sustain life.

127. Q. What is a nutrient?

A. One of the constituents of fodders or feeds, or any substance which nourishes by sustaining life and repairing body waste.

128. Q. What are the chief nutrients necessary in a food?

A. Water, ash, protein, carbohydrates, and fats.

129. Q. What is protein?

A. The name of protein, like that of casein in milk, is applied to a series of complex compounds containing nitrogen, carbon, oxygen, hydrogen, sulphur and sometimes phosphorus. Practically all the nitrogen of fodder is in the protein. Blood and muscle are rich in nitrogen. The white of an egg is rich in nitrogen.

130. Q. Of what special use is protein to the animal?

A. It furnishes the material out of which both the cell walls and the life-giving fluids (protoplasm) are made. It is absolutely essential to the blood, muscles, bones, nerves, hair, and hoof, because no other nutrient of foods possesses this property. Protein can, also, perform the same function as the carbohydrates and fat.

131. Q. What are carbohydrates and their special use to the animal?

A. Carbohydrates contain carbon, oxygen, hydrogen, but *no* nitrogen. They are such material as starches, sugars, and gums. They produce heat in the body, practically in the same way as the ordinary combustion in the air. They may also be changed into fats and stored in the body. For illustration: In fattening swine a large quantity of corn is fed which contains mostly starch.

132. Q. What difference is there between fats and carbohydrates?

A. Fats perform the same function in the body as carbohydrates, except that they are worth two and a quarter times more than carbohydrates.

133. Q. What is ash?

A. Ash in a feed is a mineral constituent the same as the ash in milk and performs the same function of supplying food for the various tissues. The larger quantity but not all of the ash of the body is to be found in the bones.

134. Q. Is it desirable to have the quantity of each of these nutrients furnished according to the work the animal does?

A. Yes. A cow weighing 1000 pounds and giving 35 pounds of milk should have approximately 2½ pounds of protein per day, 12½ to 13 pounds of carbohydrates, .8 of a pound of fat, and .7 of a pound of ash. This depends somewhat on the individual cow.

135. Q. Will corn and corn-stalks produce a maximum amount of milk if fed alone to a cow?

A. Corn alone is found not to induce a cow to give a large quantity of milk, because the nutrients are not in the right proportion. Corn is composed principally of starches and fats; hence, an insufficient quantity of protein is supplied to produce milk and at the same time properly nourish the body. If enough corn is fed to supply the proper amount of protein, the digestive organs will be overtaxed with carbohydrates. This is wasteful feeding.

136. Q. What crops and grains are rich in protein, and which will help to correct the deficiency of this particular nutrient when corn is fed?

A. Clover, alfalfa, peas, vetches, gluten-meal, linseed meal, and cottonseed-meal, etc.

137. Q. What is roughage?

A. Those food materials which contain a considerable amount of bulk in proportion to their digestible nutrients, such as straw, hay, corn stover, etc., are called coarse fodders or roughage.

138. Q. What are concentrates?

A. Concentrates are those foods which have little bulk in proportion to the nutrients they contain, such as gluten meal, corn-meal, cottonseed-meal, etc.

139. Q. What is a nutritive ratio?

A. A nutritive ratio is a ratio between the digestible protein on the one hand and the digestible carbohydrates plus 2.4 times the digestible fat on the other hand.

140. Q. What is the nutritive ratio of corn?

A. On the average, 1 of digestible protein to 9.7 of digestible carbohydrates and fat.

141. Q. What should the proper ratio be for the proper milk production?

A. About 1:65 or 1:7.

142. Q. How many pounds of the nutrients are necessary to manufacture a pound of milk with the average cow?

A. About: .021 pounds of protein plus food of maintenance .07 per cwt. live weight.
.220 pounds of carbohydrates plus food of maintenance .7 per cwt. live weight.
.018 pounds of fat plus food of maintenance .01 per cwt. live weight.*

143. Q. Are more nutrients required if a cow produces more milk?

*According to Prof. T. L. Heacker.

A. Yes. The nutrients required in milk production depend, first, on weight of cow, greater weight requiring more nutrients; second, on milk yield, the greater the yield, the more nutrients required; third, on quality of milk, the richer the milk, the more nutrients necessary; fourth, on age of cow.

144. Q. Is there such a thing as an all-round food that contains the nutrients in the proper proportion for the production of milk?

A. Yes. Pasture grass, because it is nature's food, supplying each of the necessary food constituents in nearly the proper proportion.

145. Q. May hay or grain contain the nutrients in the proportion required by animals?

A. Very seldom. Perhaps clover or alfalfa hay or oats come nearest to it.

146. Q. How can you make a ration that contains all the nutrients in proper proportion?

A. By looking up the composition of each feed that is convenient and cheap to obtain in a certain locality, and compiling them in such quantities that the total should contain 23 to 26 pounds of dry matter to every 2 pounds of digestible protein and 14 pounds digestible carbohydrates and fat. Foods selected in this way and put in rations are known as balanced rations.

147. Q. Give an example of a balanced ration.

A.

Food.	Lbs.	Digestible Protein.	Digestible Carbohydrates.	Digestible Fat.
Wild hay	10	.35	4.98	.14
Corn silage	30	.27	3.39	.21
Barley	4	.35	2.62	.06
Gluten food	6	1.40	3.04	.16
Totals	50	2.37	14.03	.57

148. Q. What is a maintenance ration?

A. It is a ration furnishing sufficient nutrients to maintain the animal, without gain or loss in body weight, but not enough to furnish material for the production of milk.

149. Q. What is a productive ration?

A. It is one furnishing nutrients in excess of maintenance requirements.

150. Q. Do all cows pay for their keep?

A. No. This can be easily discovered by adding the cost of feed consumed by the cow and comparing it with the money value of her products.

151. Q. How does the treatment of the cow govern the per cent of solids?

A. The more the cow is abused by being chased or beaten or kept in cold stables or out in severe storms, the more severe it is on her system and the more feed or nutrients are required to repair the resultant losses.

152. Q. Will heavy grain feeding improve the quality of the milk?

A. No, unless the cow is starved or underfed.

153. Q. Do cows grazing in luxuriant pastures produce milk which is richer in quality of solids?

A. The increase in the amount of butter fat, which is often noticed and is the result principally of the change of feed, doubtless comes from the fact that more, but not richer, milk is produced. This rise of solids in milk during spring pasturing lasts only a short time with cows that have been properly fed.

154. Q. Is the capacity of a cow to produce butter fat or milk limited?

A. Yes. Each individual cow has her capacity to produce milk and butter fat.

155. Q. How can the herd be improved or made to yield more and better milk?

A. By selling the poor cows and by selecting calves from good cows, and bulls, to replace the poor cows.

156. Q. How can the butter-fat value of a cow be determined?

A. By weighing the milk of a cow for two days each week, and during this time taking a composite sample of the milk.

Example.—A cow gives $14\frac{1}{2}$ pounds of milk the first morning's milking and $13\frac{1}{2}$ pounds the second morning's milking; 16 pounds the first evening's milking and 15 pounds the second evening's milking; or 59 pounds, which is the total for two days, or $29\frac{1}{2}$ pounds, the average for one day of that week. An aliquot sample of the milk must always be taken from the above milking. If the sample tests 4.1 per cent butter fat, it would indicate that 4.1 per cent is the average of the above milk, or $4.1 \times 29.5 = 1.2$, the pounds of butter fat yielded per day.

This scheme requires much less work than to test and weigh the milk every day and does not contain an error of more than 5 per cent.

157. Q. What amount of butter fat should a cow produce to pay for the feed she consumes for the year?

A. This depends upon the amount of food she consumes, on the price of feed, and on the price of butter fat. According to a recent census, it requires about 215 pounds of butter fat to pay for the keeping and food of a cow for one year, with the average prices that existed for feed and products the past ten years.

158. Q. How much butter fat should a cow produce in one year?

A. A good cow should produce 240 or more pounds. Some cows have produced 700 pounds.

159. Q. How can you calculate the cost of the food of a cow for one year?

A. By finding the weight and the value of each food fed in the ration. The food fed to each cow need not be weighed daily, but by means of a measure the proper amount can be estimated.

EXAMPLE.

A cow is fed a ration of:

Ensilage, 30 pounds at $1.50 per ton	$0.0225
Alfalfa hay, 15 pounds at $4.00 per ton	.03
Bran, 3 pounds at $18.00 per ton	.027
Corn-meal, 5 pounds at $12.50 per ton	.03125
Total cost	$0.11

If a cow was fed the above ration or a similar one, it would cost 11 cents per day. The total amount of the ration should vary somewhat according to the period of lactation. A cow eats more at the beginning of the period of lactation than is provided for in this ration, consequently more ought to be fed, but in the same proportion. However, she needs to consume decidedly less toward the end of the lactation period, so an average ration is here given that a good cow ought to consume. It is estimated that cows can be pastured in Kansas for five months at a cost of approximately 65 cents to 75 cents per month. However, from the experience of the average dairyman it is thoroughly proven that a cow cannot do well on dry pasture, such as is frequently the case, without the addition of some feed, so in order to give a cow feed sufficient to supply her needs either the area of the pasture must be increased or an additional quantity of feed added, which has been averaged as a total of $1.00 per month for five months, or $5.00.

If a cow is pastured five months there remains 215 days, including the dry period, during which this ration of an average cost of 11 cents a day must be fed.

215 days at 11 cents = $23.65 + $1.00 per month for pasture, or $5.00 = $28.65 which is the total cost of feed.

Other expenses for keeping cow for one year are as follows:

Feed cost	$28 65
Labor for one man to attend cow	12.50
Cow worth $50.00 at 6 per cent interest on investment	3.00
Deterioration by age, if bought at 5 years, average period of unprofitableness at 13 years	2.50
Death of cow by disease or accident, death of calves, average shrinkage	2.00
Failure to breed, including maintenance of dry cows	2.50
Cow barn for 20 cows costing $600, well, tank, wind-mill and piping at $300, at 6 per cent interest on investment	2.75
General maintenance expense, which includes taxes, fire and storm insurance, ordinary repairs, such as pasture fences, water fixtures, paint, roof, etc	2.50
Hauling 1200 pounds of cream at 10 cents per cwt	1.20
Total expenditure for one cow for one year	$57.60

The income for an average cow, such as is estimated from the records of the scrub cows tested at the Kansas State Experiment Station, is as follows:

6000 pounds of milk which contains on an average 4.2 per cent of butter fat.

$6000 \times .042 = 252$ pounds of butter fat, which will make with an increase of $\frac{1}{6}$.

$\frac{1}{6}$ of $252 = 42$.

42 + 252 = 294 pounds of butter.

294 pounds of butter sold at 22 cents = $64.62.

If 20 per cent cream is made from these 6000 pounds of milk there would be $\frac{6000 \times .042}{.20} = \frac{252}{.20} = 1210$ pounds of cream.

1210 pounds of cream, or 145 gallons, sold at 50 cents per gallon = $72.50.

6000 — 1210 = 4790 lbs. of skim-milk at 20 cents per cwt. = $9.58.

1210 pounds of cream — 294 pounds of butter = 916 pounds of butter-milk, at 10 cents per cwt. = $0.916.

The average value of the manure of a cow compared with the constituents in fertilizers is $29.50 per year. If we assume that through the waste and other causes, on the average farm, the manure has only one-third this value, the approximate value of the manure of a cow would be worth about $10.00.

The calf is another source of profit. At birth a calf is generally worth from $2.00 to $3.00, depending somewhat on the breed of the individual cow or sire.

SUMMARY SHOWING PROFIT OF COW FOR ONE YEAR FROM BUTTER.

Value of butter	$64.62
Value of skim-milk	9.58
Value of butter-milk	.92
Value of manure	10.00
Value of calf	2.00
Total value of product	$87.12
Total cost of cow for one year	57.60
Total profit	$29.52

SUMMARY SHOWING PROFIT OF COW FOR ONE YEAR FROM CREAM.

Value of cream	$72.50
Value of skim-milk	9.58
Value of manure	10.00
Value of calf	2.00
Total value of product	$94.08
Total cost of cow for one year	57.60
Total profit for one year	$36.48

STANDARD DAIRY PRODUCTS.

The United States Department of Agriculture has established standards of purity for different dairy-food products by which all dairy products can be graded. The standards of these dairy products are as follows:

Milk (whole milk) is the lacteal secretion obtained by the complete milking of one or more healthy cows, properly fed and kept, excluding that obtained within fifteen days before and five days after calving.

Standard milk is milk containing not less than three and one quarter (3.25) per cent of milk fat and eight and one-quarter (8.25) per cent of solids not fat, and which has an acidity equivalent to not more than two tenths (0.2) per cent of lactic acid.

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.

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

Pasteurized milk is milk that has been heated sufficiently to kill most of the active organisms present and to retard the development of their spores without changing the taste or flavor of the milk.

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 is milk from which a considerable portion of water has been evaporated with or without the addition of sugar (sucrose).

Standard condensed milk is condensed milk containing at least thirty-six (36) per cent of milk solids, of which not less than one-fourth is milk fat and not more than fifty (50) per cent of the total solids is added sugar (sucrose).

Cream is that portion of milk, rich in butter fat, which rises to the surface of milk on standing, or is separated from it by centrifugal force.

Standard cream is cream containing not less than eighteen (18) per cent of milk fat.

Butter is the product of 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.

Standard butter is butter containing not less than eighty-two and five-tenths (82.5) per cent of butter fat.

Renovated or process butter is the product obtained by melting butter and reworking, without the addition or use of chemicals or any substances except milk, cream, or salt.

Standard renovated or process butter is renovated or process butter containing not more than sixteen (16) per cent of water and at least eighty-two and five-tenths (82.5) per cent of butter fat.

Cheese is the solid product obtained by coagulating the casein of milk by means of rennet or acids with or without the addition of ripening ferments and seasoning.

Whole milk or full-cream cheese is cheese made from milk from which no portion of the fat has been removed.

Cream cheese is cheese made from whole milk to which cream has been added.

Standard whole-milk cheese, full-cream cheese, or cream cheese is cheese containing, in the water-free substance, not less than forty-eight (48) per cent of butter fat.

Ice-cream is a product made from cream or milk and cream, with or without eggs, fruits, nuts, and harmless flavoring and coloring matters, sweetened with sugar (sucrose) and frozen into a mass of fine, granular texture.