# New York Agricultural Experiment Station.

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## MILK-FAT AND CHEESE YIELD.

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L. L. VAN SLYKE.

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GENEVA, N. Y.

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BULLETIN NO. 110.—NEW SERIES.

# MILK-FAT AND CHEESE YIELD.

BY L. L. VAN SLYKE.

## SUMMARY.

During the season of 1895 analysis was made of the milk of each of fifty herds of cows, whose milk was taken to a cheese factory. The immediate object was to learn the existing relation between milk-fat and casein, or milk-fat and cheese yield, with individual herds of cows; the further purpose being to ascertain whether milk-fat forms the fairest basis of paying for milk for cheese-making.

The data, thus obtained, when studied month by month and also for the entire season, lead to the following conclusions:

1. When fat in milk increases, the casein and cheese yield also increase in general, though in special cases the casein and cheese yield may increase while the fat remains unchanged, or the fat increase while the casein remains unchanged or even decreases. Different milks containing the same per cent. of fat may show considerable range in the per cent. of casein. However, the general tendency is for both fat and casein to increase at the same time.

2. Although casein and cheese yield generally increase when the milk-fat increases, the casein more often increases less rapidly in proportion than the fat. The general averages obtained from the season's results as between milk containing 3 and 4 per cent. of fat can be indicated as follows:

| Per cent. of fat in milk. | Per cent. of casein in milk. | Pounds of casein for one pound of fat in milk. | Pounds of cheese made from 100 pounds of milk. | Pounds of cheese made for one pound of fat in milk. |
|---|---|---|---|---|
| 3 | 2.10 | 0.70 | 8.55 | 2.85 |
| 4 | 2.40 | 0.60 | 10.40 | 2.60 |

The amount of casein for one pound of milk-fat decreases about one-tenth of a pound, from 0.70 to 0.60 pounds, when the fat in milk increases one pound.

3. As a rule, when milk-fat increases, the amount of cheese made for each pound of milk-fat decreases. In milk containing 3 per cent. of fat, 2.85 pounds of cheese are made for each pound of milk-fat; while in milk containing 4 per cent. of fat, 2.60 pounds of cheese are made for each pound of fat.

4. Why is the cheese-yield greater for a pound of fat in poor milk than in richer milk? What makes the cheese-yield for a pound of fat 2.85 pounds, or 0.25 pounds more in 3 per cent. fat milk than in 4 per cent. fat milk (yielding 2.60 pounds of cheese for each pound of milk-fat)? The increased yield of 0.25 pounds comes from casein and water.

5. Cheese made from milk poor in fat is not like, in composition, cheese made from milk rich in fat. The former contains more casein and water in 100 pounds. This increased cheese yield relative to fat, in case of poor milk, due to casein and water has a market value of only 2 cents a pound.

6. Milk rich in fat can be made to yield cheese of the same composition as milk poorer in fat in one of two ways: (1st.) By adding skim-milk to, or (2d) removing fat from, the richer milk. Then the cheese-yield for a pound of fat becomes the same.

7. The difference in the cheese-yield of milk-fat in the case of poor milk over richer milk is a skim-milk difference and the extra yield of cheese for fat from poor milk is the poorest kind of skim-milk cheese.

8. Payment for milk according to amount of cheese-yield gives unfair advantage to poor milk, since cheese made from rich milk is worth more, pound for pound, than cheese made from poorer milk.

9. Milk should in no case be paid for at cheese-factories by weight of milk alone, since different milks differ greatly in their cheese-making powers.

10. A critical comparison of all methods of paying for milk, suggested or in use, leads to the conclusion that milk-fat affords the fairest practicable basis to use in paying for milk for cheese-making.

## INTRODUCTION.

Until five years ago there was little evidence at hand to show whether there was any uniform relation between the amount of fat in milk and the yield of cheese made from milk. Up to this time it was almost universally held that, while fat in milk might have some definite relation to butter yield, there could be no similar relation between milk-fat and cheese, because casein played so important a part in cheese yield. As a result of work done at this Station, it has been established beyond question that there is within certain limits, a fairly definite and uniform relation between milk-fat and cheese yield, especially when we deal with large quantities of milk. Up to 1895, our work dealt largely with mixed factory milk, without extended study of detailed variations that might exist in the milk of different herds of cows. During the summer of 1895, we made a detailed study of the milk of each of fifty different herds of cows, whose milk was used in cheese-making at the factory of G. & F. H. Merry, of Verona, to whose co-operation we are indebted for securing for us the samples of milk examined.

The specific object of our investigation was to study the relation of fat to casein and to cheese yield in the milk of different herds, in order to ascertain whether this relation was uniform, or whether it varied and, if it varied, whether regularly or irregularly.

In order to insure a clear understanding of what our investigation involves and of what its bearing is upon the dairy industry in relation to cheese-making, we will present briefly some of the fundamental considerations relating to the question which forms the subject of this bulletin.

Formerly milk was universally paid for at cheese-factories according to weight alone, on the supposition that all kinds of normal milk were of equal value for cheese production. Investigation showed that the cheese-producing power of milk varied greatly, because the amount of cheese-making constituents in milk was very different in different milks. It was found that, of the several compounds contained in milk, only two are prominent

as cheese-producing materials or, stated differently, the cheese-producing power of milk is almost entirely measured by two of its solid constituents, so far as the composition of the milk is concerned. These two cheese-producing constituents are *fat* and *casein*. The other constituents of the milk, such as albumen, sugar, etc., pass into the whey for the most part and are lost. These two cheese-making constituents of milk vary much in different milks. If the amount of cheese made from milk depends upon the amount of fat and casein in milk, why would it not be well to use the fat and casein together as a basis in paying for milk? One serious objection lies in the fact that we have no simple method for determining the amount of casein in milk which is practicable in the hands of anyone but a trained chemist. Milk-fat, on the other hand, can be readily determined; but does it alone furnish a satisfactory guide as to the amount of cheese that can be made from milk? It was held that milk-fat cannot be an accurate guide in regard to cheese-yield, because, when fat increases in milk, the casein does not increase in anything like the same proportion, or, expressed in another way, milk poor in fat contains more casein for a pound of fat than does milk richer in fat and will therefore make more cheese for each pound of fat than will richer milk. The difference existing was asserted in a broad way but not in detail and no evidence was offered. Our former work showed conclusively that, while the fat and casein did not preserve an absolutely uniform relation, the relation varied within such limits as not to affect seriously the value of the method of paying for milk on the basis of its fat-content, especially when we take into consideration the influence of fat and casein on the quality of cheese produced, and also the relative market values of fat and casein.

In this bulletin we propose to consider more in detail than ever before just to what extent the relation of fat and casein in milk varies in the milk of different herds of factory cows.

We secured separate samples of milk from each of 50 herds every alternate week continuously for six months, obtaining in all 632 samples.

Our previous work has established fairly beyond question that the fat and casein in milk tend to preserve a quite uniform relation from month to month as the period of lactation advances,

provided abnormal conditions are absent, such as insufficient nutrition. We shall now study the relation of fat and casein in the milk of different herds, taking each month by itself, and also the season as a whole, thus eliminating any influence that might come from advance of lactation.

We shall present tabulated summaries of our detailed results, reserving a full publication of the data for our annual report. The tables will contain the following data :

1. The per cent. of fat in milk arranged in groups, each differing from the preceding and following by one-tenth of one per cent.

2. The average per cent. of casein corresponding to each group.

3. The amount of casein for each pound of milk-fat in each group.

4. The amount of cheese made from 100 pounds of milk in each group.

5. The amount of cheese made for each pound of milk-fat in each group.

The number of herds embraced in each group is also stated. A separate table is presented for each month of the season from May to October inclusive and also a table giving the herd averages for the entire season.

In studying these results, it is well to keep in mind that the yield of cheese, relative to milk-fat, varies directly with the amount of casein relative to milk-fat. When the relative proportions of fat and casein in milk remain uniform, the amount of cheese produced for each pound of fat in milk remains the same. When the casein in milk increases relative to the fat, then the amount of cheese produced for each pound of fat increases. When the casein in milk decreases relative to the fat, then the amount of cheese produced for each pound of fat decreases.

TABLE SHOWING THE RELATION OF FAT IN MILK TO CASEIN AND TO YIELD OF CHEESE DURING **May.**

| No. of herds. | Pounds of fat in 100 pounds of milk. | Pounds of casein in 100 pounds of milk. | Pounds of casein for one pound of fat in milk. | Pounds of cheese made from 100 pounds of milk. | Pounds of cheese made for one pound of fat in milk. |
|---|---|---|---|---|---|
| 0 | 3 to 3.1 | —— | —— | —— | —— |
| 2 | 3.1 to 3.2 | 2.39 | 0.76 | 9.41 | 3.01 |
| 6 | 3.2 to 3.3 | 2.28 | 0.71 | 9.26 | 2.86 |
| 6 | 3.3 to 3.4 | 2.35 | 0.71 | 9.53 | 2.86 |
| 7 | 3.4 to 3.5 | 2.40 | 0.70 | 9.79 | 2.84 |
| 7 | 3.5 to 3 6 | 2.31 | 0.65 | 9.69 | 2.72 |
| 3 | 3.6 to 3.7 | 2.46 | 0.68 | 10.14 | 2.80 |
| 7 | 3.7 to 3.8 | 2.42 | 0.65 | 10.17 | 2.72 |
| 4 | 3.8 to 3.9 | 2.55 | 0.67 | 10.60 | 2.76 |
| 5 | 3.9 to 4 | 2.52 | 0.64 | 10.64 | 2.70 |
| 2 | 4. to 4.1 | 2.37 | 0.59 | 10.33 | 2 58 |
| 0 | 4.1 to 4.2 | —— | —— | —— | —— |
| 0 | 4.2 to 4.3 | —— | —— | —— | —— |
| 1 | 4.3 to 4.4 | 2.41 | 0.55 | 10.81 | 2.50 |

An examination of the preceding table enables us to make the following statements:

(1st.) In the milk of the 50 herds of cows the fat varied from 3.1 to 4.4 per cent. while the amount of casein for a pound of fat in milk varied from 0.76 to 0.55 pounds. If we take the variation of fat as one per cent. say from 3 to 4 or 3.1 to 4.1 per cent. etc., the decrease of casein relative to fat amounted to about 0.16 pounds.

(2d.) Excluding 5 extreme herds and using the results obtained from 45 herds, the decrease of casein for a pound of fat amounted to 0.07 pounds.

(3d.) Taking all the results, the relative average decrease of casein was 0.016 pounds for each tenth of a pound of fat in milk.

(4th.) Between the limits of 3.2 and 4 per cent. of fat, which include 45 herds, the relative average decrease was only 0.007 pounds of casein for each tenth of a pound of fat.

(5th.) Expressed in yield of cheese relative to milk-fat, there was in the extreme cases a decrease of 0.50 pounds of cheese for one pound of fat in milk; or, excluding 5 extreme herds, there was a decrease of 0.16 pounds of cheese for a pound of milk-fat.

(6th.) Between the limits of 3.2 and 4 per cent. of fat in milk,

the amount of cheese made for one pound of fat in milk varied between the limits of 2.86 and 2.70 pounds, equivalent to an average decrease of 0.016 pounds of cheese for one-tenth of a pound of milk-fat.

TABLE SHOWING RELATION OF FAT IN MILK TO CASEIN AND TO YIELD OF CHEESE DURING **June.**

| No. of herds. | Pounds of fat in 100 pounds of milk. | Pounds of casein in 100 pounds of milk. | Pounds of casein for one pound of fat in milk. | Pounds of cheese made from 100 pounds of milk. | Pounds of cheese made for one pound of fat in milk. |
|---|---|---|---|---|---|
| 4 | 3.1 to 3.2 | 2.30 | 0.73 | 9.21 | 2.92 |
| 1 | 3.2 to 3.3 | 2.32 | 0.71 | 9.40 | 2.87 |
| 6 | 3.3 to 3.4 | 2.20 | 0.66 | 9.17 | 2.75 |
| 10 | 3.4 to 3.5 | 2.30 | 0.67 | 9.52 | 2.78 |
| 8 | 3.5 to 3 6 | 2.37 | 0.67 | 9.79 | 2.78 |
| 4 | 3.6 to 3.7 | 2.36 | 0.65 | 9.88 | 2.73 |
| 4 | 3.7 to 3.8 | 2.34 | 0.63 | 9.92 | 2.68 |
| 2 | 3.8 to 3.9 | 2.34 | 0.61 | 10.07 | 2.62 |
| 4 | 3.9 to 4 | 2.40 | 0.61 | 10.32 | 2.62 |
| 4 | 4 to 4.1 | 2.39 | 0.60 | 10.40 | 2.59 |
| 1 | 4.1 to 4.2 | 2.38 | 0.58 | 10.52 | 2.53 |
| 2 | 4.2 to 4.3 | 2.38 | 0.57 | 10.59 | 2.51 |

In connection with the preceding table, containing data for the month of June, attention is called to the following facts:

(1st.) The fat in milk varied from 3.1 to 4.3 per cent., while the amount of casein present in milk for each pound of fat varied from 0.73 to 0.57 pounds; or, taking the variation of fat in milk as one per cent., from 3.1 to 4.1 per cent. etc., the decrease of casein relative to fat amounted to about 0.15 pounds.

(2d.) Excluding 5 extreme herds and using the results obtained from 45 herds, there was a decrease of 0.10 pounds of casein for a pound of fat in milk.

(3d.) Taking all the results, the relative decrease of casein was 0.013 pounds for each tenth of a pound of milk-fat.

(4th.) Between the limits of 3.3 and 4 per cent. of fat, the relative decrease was only 0.006 pounds of casein for each tenth of a pound of fat.

(5th.) Expressed in yield of cheese relative to milk-fat, there was in the extreme cases a decrease of 0.41 pounds of cheese for one pound of fat in milk.

(6th.) Between the limits of 3.3 and 4 per cent. of fat in milk, the amount of cheese made for one pound of fat in milk varied between the limits 2.75 and 2.62 pounds, equivalent to an average decrease of 0.013 pounds of cheese for one-tenth of a pound of milk-fat.

TABLE SHOWING RELATION OF FAT IN MILK TO CASEIN AND TO YIELD OF CHEESE DURING **July.**

| No. of herds. | Pounds of fat in 100 pounds of milk. | Pounds of casein in 100 pounds of milk. | Pounds of casein for one pound of fat in milk. | Pounds of cheese made from 100 pounds of milk. | Pounds of cheese made for one pound of fat in milk. |
|---|---|---|---|---|---|
| 2 | 3 to 3.1 | 2.10 | 0.69 | 8.58 | 2.83 |
| 0 | 3.1 to 3.2 | —— | —— | —— | —— |
| 1 | 3.2 to 3.3 | 2.11 | 0.65 | 8.85 | 2.72 |
| 3 | 3.3 to 3.4 | 2.13 | 0.64 | 9.00 | 2.70 |
| 7 | 3.4 to 3.5 | 2.10 | 0.61 | 9.01 | 2.63 |
| 3 | 3 5 to 3.6 | 2.29 | 0.65 | 9.63 | 2.72 |
| 5 | 3.6 to 3.7 | 2.19 | 0.60 | 9.49 | 2.60 |
| 6 | 3.7 to 3.8 | 2.19 | 0.59 | 9.58 | 2.57 |
| 8 | 3.8 to 3.9 | 2.24 | 0.59 | 9.82 | 2.56 |
| 7 | 3.9 to 4 | 2.21 | 0.56 | 9.87 | 2.50 |
| 5 | 4 to 4.1 | 2.33 | 0.57 | 10.26 | 2.53 |
| 2 | 4.1 to 4.2 | 2.36 | 0.58 | 10.40 | 2.54 |
| 0 | 4.2 to 4.3 | —— | —— | —— | —— |
| 1 | 4.3 to 4.4 | 2.32 | 0.54 | 10.53 | 2.45 |

From a study of the data for July we can summarize our results as follows:

(1st.) The fat in milk varied from 3 to 4.4 per cent., while the amount of casein in milk or each pound of fat varied from 0.69 to 0.54 pounds; or, taking the range of milk fat as one per cent. as from 3 to 4 or 3.4 to 4.4 per cent. etc., the decrease of casein relative to fat amounted to about 0.11 pounds.

(2d) Excluding 3 extreme herds and using the results obtained from 47 herds, there was a decrease of 0.09 pounds of casein for a pound of fat in milk.

(3d.) Taking all the results, the average relative decrease of casein was 0.011 pounds for each tenth of a pound of fat in milk.

(4th.) Between the limits of 3.2 and 4.2 per cent. of fat in milk, the relative average decrease was only 0.007 pounds of casein for each tenth of a pound of fat.

(5th.) Expressed in yield of cheese relative to fat in milk, there was in the extreme cases a decrease of 0.38 pounds of cheese for one pound of fat in milk.

(6th.) Between the limits of 3.2 and 4.2 per cent. of fat in milk, the amount of cheese made for one pound of fat in milk varied between the limits 2.72 and 2.50 pounds, which is equivalent to an average decrease of 0.022 pounds of cheese for one-tenth of a pound of milk-fat.

TABLE SHOWING RELATION OF FAT IN MILK TO CASEIN AND TO YIELD OF CHEESE DURING **August.**

| No. of herds. | Pounds of fat in 100 pounds of milk. | Pounds of casein in 100 pounds of milk. | Pounds of casein for one pound of fat in milk. | Pounds of cheese made from 100 pounds of milk. | Pounds of cheese made for one pound of fat in milk. |
|---|---|---|---|---|---|
| 0 | 3 to 3.5 | —— | —— | —— | —— |
| 3 | 3.5 to 3.6 | 2.10 | 0.60 | 9.13 | 2.59 |
| 4 | 3.6 to 3.7 | 2.18 | 0.60 | 9.46 | 2.59 |
| 5 | 3.7 to 3.8 | 2.22 | 0.60 | 9.63 | 2.59 |
| 7 | 3.8 to 3 9 | 2.28 | 0.60 | 9.92 | 2.59 |
| 5 | 3.9 to 4 | 2.21 | 0.56 | 9.83 | 2.50 |
| 7 | 4 to 4.1 | 2.26 | 0.56 | 10.09 | 2.50 |
| 3 | 4.1 to 4.2 | 2.21 | 0.53 | 10.07 | 2.44 |
| 6 | 4.2 to 4.3 | 2.32 | 0.55 | 10.46 | 2.47 |
| 5 | 4.3 to 4.4 | 2.28 | 0.53 | 10.47 | 2.42 |
| 0 | 4.4 to 4.5 | —— | —— | —— | —— |
| 2 | 4.5 to 4.6 | 2.48 | 0.55 | 11.20 | 2.47 |
| 1 | 4.6 to 4.7 | 2.33 | 0.51 | 10.90 | 2.37 |
| 1 | 4.7 to 4.8 | 2.37 | 0.50 | 11.18 | 2.35 |
| 0 | 4.8 to 4.9 | —— | —— | —— | —— |
| 1 | 4.9 to 5 | 2.43 | 0.50 | 11.50 | 2 35 |

The results secured in August can be summarized from the preceding table as follows:

(1st.) The fat in milk varied from 3.5 to 5 per cent., while the amount of casein in milk for each pound of fat ranged from 0.60 to 0.50 pounds; or, taking the variation of milk-fat as one per cent., as 3.6 to 4.6, 3.7 to 4.7 per cent. etc., the decrease of casein relative to fat amounted to about 0.07 pounds.

(2d.) Excluding three extreme herds and using the results secured with 47 herds, there was a decrease of 0.07 pounds of casein for a pound of fat in milk.

(3d.) Taking all the results, the average relative decrease of casein was 0.007 pounds for each tenth of a pound of fat in milk.

(4th.) Between the limits of 3.5 and 4.2 per cent. of fat in milk, the relative average decrease was only 0.007 pounds of casein for each tenth of a pound of fat.

(5th.) Expressed in yield of cheese relative to fat in milk, there was in extreme cases a decrease of 0.24 pounds of cheese for one pound of fat in milk.

(6th.) Between the limits of 3.5 and 4.5 per cent. of fat in milk, the amount of cheese made for one pound of fat in milk varied between the limits of 2.59 and 2.47 pounds, which is equivalent to an average decrease of 0.012 pounds of cheese for one tenth of a pound of milk-fat.

TABLE SHOWING RELATION OF FAT IN MILK TO CASEIN AND TO YIELD OF CHEESE DURING **September.**

| No of herds. | Pounds of fat in 100 pounds of milk. | Pounds of casein in 100 pounds of milk. | Pounds of casein for one pound of fat in milk. | Pounds of cheese made from 100 pounds of milk. | Pounds of cheese made for one pound of fat in milk. |
|---|---|---|---|---|---|
| 0 | 3 to 3.2 | —— | —— | —— | —— |
| 1 | 3.2 to 3.3 | 2.12 | 0.66 | 8.83 | 2.76 |
| 1 | 3.3 to 3.4 | 2.35 | 0.70 | 9.54 | 2.86 |
| 0 | 3.4 to 3.5 | —— | —— | —— | —— |
| 5 | 3.5 to 3.6 | 2.41 | 0.68 | 9.91 | 2.80 |
| 4 | 3.6 to 3.7 | 2 44 | 0.67 | 10.10 | 2.78 |
| 4 | 3.7 to 3.8 | 2.52 | 0.68 | 10.40 | 2.80 |
| 6 | 3.8 to 3.9 | 2.37 | 0.62 | 10.14 | 2.65 |
| 6 | 3.9 to 4 | 2.52 | 0.64 | 10.63 | 2.70 |
| 6 | 4 to 4.1 | 2.54 | 0.63 | 10.77 | 2.68 |
| 6 | 4.1 to 4.2 | 2.45 | 0.60 | 10.66 | 2.60 |
| 3 | 4.2 to 4.3 | 2.48 | 0.59 | 10.84 | 2.58 |
| 2 | 4.3 to 4.4 | 2.70 | 0.62 | 11.53 | 2.65 |
| 1 | 4.4 to 4.5 | 2.40 | 0.54 | 10.87 | 2.45 |
| 0 | 4.5 to 4.6 | —— | —— | —— | —— |
| 2 | 4.6 to 4.7 | 2.55 | 0.55 | 11.46 | 2.47 |
| 2 | 4.7 to 4.8 | 2.57 | 0.54 | 11.71 | 2.45 |
| 1 | 4.8 to 4.9 | 2.61 | 0.54 | 11.84 | 2.45 |

A study of the results for September, contained in the preceding table, can be summarized as follows:

(1st.) The fat in milk varied from 3.2 to 4.9 per cent., while the amount of casein in milk for each pound of fat varied from 0.70 to 0.54 pounds; or, taking the variation of fat in milk as one

per cent., as 3.2 to 4.2, 3.3 to 4.3 per cent. etc., the decrease of casein relative to fat amounted to about 0.10 pounds.

(2d.) Excluding 5 extreme herds and using the results given by the remaining 45 herds, there was a decrease of 0.13 pounds of casein for a pound of fat in milk.

(3d.) Taking all the results, the average relative decrease of casein was 0.01 pounds for each tenth of a pound of fat in milk.

(4th.) Between the limits of 3.4 and 4.4 per cent. of fat in milk, the relative average decrease was only 0.009 pounds of casein for each tenth of a pound of fat.

(5th.) Expressed in yield of cheese, relative to fat in milk, there was in extreme cases a decrease of 0.41 pounds of cheese for one pound of fat in milk.

(6th.) Between the limits of 3.2 and 4.2 per cent. of fat in milk, the amount of cheese made for one pound of fat in milk varied between the limits of 2.86 and 2.58 pounds, which is equivalent to an average decrease of 0.028 pounds of cheese for one-tenth of a pound of milk-fat.

TABLE SHOWING RELATION OF FAT IN MILK TO CASEIN AND TO YIELD OF CHEESE DURING **October.**

| No. of herds. | Pounds of fat in 100 pounds of milk. | Pounds of casein in 100 pounds of milk. | Pounds of casein for one pound of fat in milk. | Pounds of cheese made from 100 pounds of milk. | Pounds of cheese made for one pound of fat in milk. |
|---|---|---|---|---|---|
| 0 | 3 to 3.6 | —— | —— | —— | —— |
| 1 | 3.6 to 3.7 | 2.56 | 0.71 | 10.36 | 2.88 |
| 1 | 3.7 to 3.8 | 2.45 | 0.66 | 10.33 | 2.75 |
| 4 | 3.8 to 3.9 | 2.60 | 0.68 | 10.70 | 2.80 |
| 3 | 3.9 to 4 | 2.62 | 0.67 | 10.87 | 2.77 |
| 7 | 4 to 4.1 | 2.64 | 0.65 | 11.05 | 2.73 |
| 7 | 4.1 to 4.2 | 2.72 | 0.66 | 11.36 | 2.75 |
| 10 | 4.2 to 4.3 | 2.77 | 0.66 | 11.59 | 2.74 |
| 6 | 4.3 to 4.4 | 2.72 | 0.63 | 11.55 | 2.68 |
| 3 | 4.4 to 4.5 | 2.77 | 0.62 | 11.84 | 2.64 |
| 2 | 4.5 to 4.6 | 2.75 | 0.60 | 11.87 | 2.61 |
| 2 | 4.6 to 4.7 | 2.90 | 0.63 | 12.34 | 2.67 |
| 2 | 4.7 to 4 8 | 2.84 | 0.59 | 12.35 | 2.59 |
| 0 | 4.8 to 4.9 | —— | —— | —— | —— |
| 0 | 4.9 to 5 | —— | —— | —— | —— |
| 2 | 5 to 5.1 | 2.77 | 0.55 | 12.44 | 2.48 |

The results obtained in October and presented in the preceding table can be summarized as follows:

(1st.) The fat in milk varied from 3.6 to 5 per cent., while the amount of casein in milk for each pound of fat varied from 0.71 to 0.55 pounds; or, taking the range of fat in milk within limits of one per cent., as 3.6 to 4.6, 3.7 to 4.7 per cent. etc., the decrease of casein relative to fat amounted to about 0.08 pounds.

(2d.) Excluding 3 extreme herds and using the results given by the remaining 47 herds, there was a decrease of 0.09 pounds of casein for a pound of fat in milk.

(3d.) Taking all the results, the average relative decrease of casein was 0.01 pounds for each tenth of a pound of fat in milk.

(4th.) Between the limits of 3.7 and 4.8 per cent. of fat in milk, the relative average decrease was only 0.009 pounds of casein for each tenth of a pound of fat.

(5th.) Expressed in yield of cheese relative to milk-fat, there was in extreme cases a decrease of 0.40 pounds of cheese for one pound of fat in milk.

(6th.) Between the limits of 3.7 and 4.8 per cent. of fat in milk, the amount of cheese made for one pound of fat in milk varied between the limits of 2.80 and 2.59 pounds, which is equivalent to an average decrease of 0.021 pounds of cheese for one-tenth of a pound of fat in milk.

TABLE SHOWING AVERAGE RELATION OF FAT IN MILK TO CASEIN AND TO YIELD OF CHEESE **during the Season of 1895 from May to October.**

| No. of herds. | Pounds of fat in 100 pounds of milk | Pounds of casein in 100 pounds of milk. | Pounds of casein for one pound of fat in milk. | Pounds of cheese made from 100 pounds of milk. | Pounds of cheese made for one pound of fat in milk. |
|---|---|---|---|---|---|
| 0 | 3 to 3.3 | —— | —— | —— | —— |
| 1 | 3.3 to 3.4 | 2.19 | 0.66 | 9.12 | 2.76 |
| 2 | 3.4 to 3.5 | 2.34 | 0.68 | 9.67 | 2.80 |
| 5 | 3.5 to 3.6 | 2.27 | 0.64 | 9.59 | 2.70 |
| 6 | 3.6 to 3.7 | 2.38 | 0.65 | 9.95 | 2.73 |
| 7 | 3.7 to 3.8 | 2.38 | 0.64 | 10.06 | 2.70 |
| 9 | 3.8 to 3.9 | 2.39 | 0.62 | 10.22 | 2.65 |
| 4 | 3.9 to 4 | 2.40 | 0.61 | 10.30 | 2.63 |
| 7 | 4 to 4.1 | 2.50 | 0.62 | 10.68 | 2.65 |
| 3 | 4.1 to 4.2 | 2.47 | 0.60 | 10.74 | 2.60 |
| 3 | 4.2 to 4.3 | 2.46 | 0.58 | 10.81 | 2.55 |
| 3 | 4.3 to 4.4 | 2.50 | 0.58 | 11.02 | 2.55 |

In the preceding table we have tabulated general averages for the entire season. We obtained season averages for each herd and then summarized the averages in this tabulated form. Attention is called to the following facts:

(1st.) The fat in milk varied from 3.3 to 4.4 per cent., and the amount of casein present in milk for each pound of fat varied from 0.68 to 0.58 pounds, a decrease of 0.10 pounds between the herds highest and lowest in fat.

(2d.) Excluding three herds, there was a decrease of 0.07 pounds of casein for a pound of fat in milk; or, using the results secured with 41 of the 50 herds, the decrease was reduced to 0.05 pounds of casein.

(3d.) Including all the results, the average relative decrease of casein was a little less than 0.01 pounds for each tenth of a pound of fat in milk.

(4th.) Between the limits of 3.3 and 4.2 per cent. of fat in milk, the relative average decrease was only 0.008 pounds of casein for each tenth of a pound of fat.

(5th.) Expressed in yield of cheese relative to milk-fat, there was in the extreme cases a decrease 0.25 pounds of cheese for one pound of fat in milk.

(6th.) Between the limits of 3.3 and 4.2 per cent. of fat in milk, the amount of cheese made for one pound of fat in milk varied between the limits of 2.80 and 2.60 pounds, which is equivalent to an average decrease of 0.02 pounds of cheese for one-tenth of a pound of fat in milk.

## Milk-Fat as a Basis for Measuring Cheese Production.

We have seen that, while milk-fat is not an absolutely strict measure of the cheese-producing value of milk, it is in reality a fair and practicable guide in enabling us to learn the relative values of different milks for cheese production. It is probably true more often than not that milk containing three per cent. of fat will make somewhat more cheese for a pound of fat than will milk containing four or more per cent. of fat. The practical phase of the question which at once presents itself is this: Is the difference in the cheese-producing value of milk poor in fat and milk richer in fat so great as to destroy the value of milk-fat as a basis for measuring cheese production? How great a difference can be expected to exist usually? The data secured with 50 separate

herds of cows during one factory season enable us to ascertain very closely what average variations exist in the cheese-producing power of milk-fat contained in milks of different composition.

We find, taking the average of our whole season's work, that, when two milks differ in fat by one per cent., the one containing the smaller amount of fat contains one-tenth more of a pound of casein for a pound of fat than does the richer milk. To illustrate, milk containing 3 per cent. of fat usually can be expected to contain 2.10 per cent. of casein or 0.70 pounds of casein for one pound of fat; while milk containing 4 per cent. of fat will rarely, under normal conditions, contain less than 2.40 per cent. of casein or 0.60 pounds of casein for one pound of fat. We shall, in our further discussion, use for convenience the limits 3 and 4 per cent. of milk-fat. It is important to bring out clearly what makes the difference in relative cheese yield between milk poor in fat and milk rich in fat.

## Difference in Cheese-Producing Power of Milk-Fat in Different Milks.

From 100 pounds of milk containing 3 per cent. of fat, we have a yield of 8.55 pounds of cheese; from 100 pounds of milk containing 4 per cent. of fat, we have a yield of 10.40 pounds of cheese. The increased yield of cheese from 100 pounds of milk is due to the added amount of fat and casein contained in the richer milk. In the milk containing 3 per cent. of fat, there are made 2.85 pounds of cheese for each pound of milk-fat; in the milk containing 4 per cent. of fat, there are made 2.60 pounds of cheese for each pound of milk fat. The difference between 2.85 and 2 60 equals 0.25 pounds. Now, what makes this extra yield of 0.25 pounds of cheese for each pound of fat in the case of the milk containing 3 per cent. of fat? Is it due to fat? It cannot be, as the figures are based on one pound of fat in both cases. It must then be due to the fact that the milk poorer in fat contains more casein for a pound of fat than does the milk richer in fat. *This increased yield of 0.25 pounds of cheese for a pound of milk-fat comes from casein and the water which it absorbs.* Take out this casein and water and the yield for a pound of fat would be the same in rich and poor milk.

## Market Value of Casein and Water in Cheese.

In the table below we have indicated the amount of fat, casein and cheese obtained from 100 pounds of milk ranging from 3 to 4 per cent. of fat and varying by one-tenth of one per cent. of fat. In column 4 is given the amount of cheese made for each pound of fat in milk.

In column 5 we give the amount of cheese which would be made from 100 pounds of milk, if each milk contained for each pound of milk-fat the same amount of casein as is contained in the milk containing 4 per cent. of milk-fat. In other words, these figures represent cheese having the same identical composition as cheese made from the milk containing 4 per cent. of fat. We have simply removed the excess of casein in the poorer milks.

In column 6 is given the amount of casein removed from each milk in order to make the relation of fat and casein uniform with the fat and casein in the richest milk. In column 7 is given the amount of water which this removed casein would absorb in being made into cheese. By adding the figures in columns 6 and 7, we get the total amount of cheese yield due to casein contained in column 6. The sum of the figures contained in columns 5, 6 and 7 is equal to the figures contained in column 3. We assume that the cheese given in column 5 sells for 8½ cents a pound, the money derived from this sale is given in column 8. We assume that the mixture of casein and water, which is practically separator-skim-milk cheese, sells for 2 cents a pound. The money derived from this sale is given in column 9. In column 10 is given the total sum derived from adding the figures in columns 8 and 9. In column 11 we give the value of each pound of milk-fat as found for each milk from the values given in column 10.

TABLE SHOWING RESULTS OF CALCULATING CHEESE TO UNIFORM COMPOSITION AND ALLOWING MARKET VALUES FOR CONSTITUENTS.

| Pounds of fat in 100 pounds of milk. | Pounds of casein in 100 pounds of milk | Pounds of cheese made from 100 pounds of milk. | Pounds of cheese made for one pound of fat in milk. | Pounds of cheese made from 100 pounds of milk after removing excess of casein. | Decreased yield of cheese due to removal of | | Value of cheese in column 5 at 8½ cents a pound. | Value of casein and water in columns 6 and 7 at 2 cents a pound. | Total value of cheese, casein and water in columns 8 and 9. | Value of one pound of milk-fat. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Casein. | Water. | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| | | | | | Pounds | Pounds | Cents. | Cents. | Cents. | Cents. |
| **3.** | 2.10 | **8.55** | 2.85 | **7.80** | **0.30** | 0.45 | 66.30 | 1.50 | **67.8** | **22.60** |
| **3.1** | 2.14 | **8.76** | 2.82 | **8.06** | **0.28** | 0.42 | 68 50 | 1.40 | **69.9** | **22.55** |
| **3.2** | 2.18 | **8.97** | 2.80 | **8.32** | **0.26** | 0.39 | 70.70 | 1.30 | **72.0** | **22.50** |
| **3.3** | 2.21 | **9.16** | 2.78 | **8.58** | **0.23** | 0.35 | 72.93 | 1.16 | **74.1** | **22.45** |
| **3.4** | 2.24 | **9.34** | 2.75 | **8.84** | **0.20** | 0.30 | 75.14 | 1.00 | **76.1** | **22.40** |
| **3.5** | 2.27 | **9.53** | 2.72 | **9.10** | **0.17** | 0.26 | 77.35 | 0.86 | **78.2** | **22.35** |
| **3.6** | 2.30 | **9.71** | 2.70 | **9.36** | **0.14** | 0.21 | 79.56 | 0.70 | **80.3** | **22.30** |
| **3.7** | 2.33 | **9.90** | 2.68 | **9.62** | **0.11** | 0.17 | 81.77 | 0.56 | **82.3** | **22.25** |
| **3.8** | 2.36 | **10.08** | 2.65 | **9.88** | **0.08** | 0.12 | 83.98 | 0.40 | **84.4** | **22.20** |
| **3.9** | 2.38 | **10.24** | 2.62 | **10.14** | **0.04** | 0.06 | 86.19 | 0.20 | **86.4** | **22.15** |
| **4.** | 2.40 | **10.40** | 2.60 | **10.40** | **0** | 0 | 88.20 | 0 | **88.2** | **22.10** |

In the foregoing table we have reduced all the cheese to the same composition or proportion of fat and casein by removing from the figures contained in column 3 such amounts of casein and water as would make all the cheese obtained from the different milks have the same composition. *The sole difference in composition between cheese made from milks poor and rich in fat is the increased proportion of casein and water contained in the cheese made from the poorer milk.* In market value this increased casein and water is much inferior to cheese. In allowing an increased value for each pound of fat in poor milk, we cannot in justice give more than is called for by the market value of those constituents which the cheese from poorer milk contains in larger proportions, relative to fat. In other words, it is unjust to allow 8½ cents for extra casein and water which cheese from poor milk contains, as compared with cheese from richer milk. The market value of

casein and water, as represented by separator skim-milk cheese, is rarely over 2 cents a pound; and it is therefore not just to pay for casein and water the same as we pay for whole-milk cheese.

From column 11 we see that, on the basis used, each pound of fat in the poorest milk (3 per cent. of fat) brings one-half cent more than does each pound of fat in the richest milk (4 per cent. of fat). To make a greater difference than this is simply to cheat the producer of richer milk in behalf of the producer of poorer milk.

## The Effect of Adding Skim-milk to Different Milks to Make Cheese of Uniform Composition.

There is another and, perhaps, clearer way of presenting the differences to which attention has been called above. We can easily make the cheese-producing value of milk-fat in milk containing 4 per cent. of fat identical with that of milk-fat in milk containing 3 per cent. of fat. How this can be done, we readily see, when we consider that the cheese-making power of fat in poor milk is greater than that in richer milk solely because it contains more casein in proportion to the fat. From our season's general average, we find that in milk containing 3 per cent. of fat, there is 2.10 per cent. of casein, while in milk containing 4 per cent. of fat there is 2.40 per cent. of casein. Now, if the richer milk contained as much casein for its fat as does the poorer milk, the milk containing 4 per cent. of fat would contain 2.80 per cent. of casein instead of 2.40 per cent. Now, is there any practicable way by means of which we can add casein to the richer milk, so that it will contain 2.80 pounds of casein for 4 pounds of fat? We need only to add a certain amount of separator-skim-milk according to the amount of casein contained. In the table below we have indicated in column 4 how much casein it is necessary to add to 100 pounds of each milk in order to make the cheese-producing power of each pound of milk-fat the same in all milks. In column 5 we state the number of pounds of separator-skim-milk, containing 2.25 per cent. of casein, that should be added to 100 pounds of milk to furnish the increased amount of casein given in column 4. The yield of cheese from 100 pounds of these casein-fortified milks is given in column 7; and in column 8, the increased yield of cheese due to the casein

added. Allowing 8½ cents a pound for the cheese and deducting the cost of the skim-milk added, at the rate of 12 cents for 100 pounds, we obtain in column 11 the money values received from the cheese produced. In column 12 the value is given for each pound of milk-fat.

In the case of each milk, after receiving the added casein in the form of skim-milk, there are 0.70 pounds of casein for each pound of milk-fat, and 2.85 pounds of cheese are made for each pound of fat.

TABLE SHOWING RESULTS OF ADDING SKIM-MILK TO DIFFERENT MILKS IN ORDER TO MAKE CHEESE OF UNIFORM COMPOSITION.

| Pounds of fat in 100 pounds of milk. | Pounds of casein in 100 pounds of milk. | Pounds of casein required to make proportion of fat and casein uniform. | Pounds of casein to be added to 100 pounds of milk to make fat and casein uniform. | Pounds of skim-milk to add to 100 pounds of milk to furnish required casein. | Cost of skim-milk added. | Cheese-yield from milk to which skim-milk is added. | Increased cheese-yield caused by adding skim-milk. | Value of increased cheese-yield at 8½ cents a pound. | Profit derived from adding skim-milk to 100 pounds of whole milk. | Value of total cheese yield, less cost of skim-milk. | Value of one pound of milk-fat. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| | | | | | Cents. | Pounds. | Pounds. | Cents. | Cents. | Cents. | Cents. |
| 3 | 2.10 | 2.10 | 0 | 0 | 0 | 8.55 | 0 | 0 | 0 | 72.68 | 24.23 |
| 3.1 | 2.14 | 2.17 | 0.03 | 1.3 | 0.16 | 8.84 | 0.08 | 0.68 | 0.52 | 74.98 | 24.20 |
| 3.2 | 2.18 | 2.24 | 0.06 | 2.5 | 0.30 | 9.12 | 0.15 | 1.28 | 0.98 | 77.23 | 24.13 |
| 3.3 | 2.21 | 2.31 | 0.10 | 4.2 | 0.50 | 9.41 | 0.25 | 2.13 | 1.63 | 79.49 | 24.10 |
| 3.4 | 2.24 | 2.38 | 0.14 | 6.0 | 0.72 | 9.69 | 0.35 | 2.98 | 2.26 | 81.65 | 24.02 |
| 3.5 | 2.27 | 2.45 | 0.18 | 7.5 | 0.90 | 9.98 | 0.45 | 3.83 | 2.93 | 83.93 | 23.97 |
| 3.6 | 2.30 | 2.52 | 0.22 | 9.2 | 1.10 | 10.26 | 0.55 | 4.68 | 3.58 | 86.12 | 23.92 |
| 3.7 | 2.33 | 2.59 | 0.26 | 10.8 | 1.30 | 10.55 | 0.65 | 5.53 | 4.23 | 88.38 | 23.89 |
| 3.8 | 2.36 | 2.66 | 0.30 | 12.5 | 1.50 | 10.83 | 0.75 | 6.38 | 4.88 | 90.56 | 23.83 |
| 3.9 | 2.38 | 2.73 | 0.35 | 14.6 | 1.75 | 11.12 | 0.88 | 7.48 | 5.73 | 92.77 | 23.80 |
| 4 | 2.40 | 2.80 | 0.40 | 16.7 | 2 | 11.40 | 1.00 | 8.50 | 6.50 | 94.90 | 23.73 |

The facts which are embodied in the foregoing table indicate the same difference of actual money value between the richest and poorest milks that we observed before. The value of one pound of milk-fat is one-half of one cent more in the poorest than in the richest milk.

## The Effect of Removing Fat from Different Milks to make Cheese of Uniform Composition.

There is still another way in which these milks can have the cheese-making power of their fat made uniform. As milk grows richer in fat, there is more fat in proportion to casein. Instead of adding casein to make up the deficiency, we can remove fat and thus make the relation of fat and casein uniform. By separating a certain amount of milk and returning the skim-milk to the unseparated portion, we can easily remove the excess of fat relative to casein in any rich milk. The milk thus treated will make cheese of exactly the same composition as the poorer milk and the fat removed can be made into butter. In the following table, we give in column 2 the amounts of fat remaining in the milks, after enough fat has been removed to make the amount of casein equal 0.70 pounds for each pound of milk-fat. In column 3 we state the amounts of fat to be removed and in column 4 the approximate amount of milk to be separated in 100 pounds in order to remove the fat desired. We state also the amounts of butter made from the fat removed, the value of such butter at 18 cents a pound. In column 7 we give the amounts of cheese made from the milks after the desired amounts of fat have been removed. In column 8 is stated the value of the cheese at 8½ cents a pound and in column 9 the total value of cheese and butter. In column 10 we give the value of each pound of milk-fat, corresponding to the values given in column 9.

TABLE SHOWING RESULTS OF REMOVING FAT FROM DIFFERENT MILKS IN ORDER TO MAKE CHEESE OF UNIFORM COMPOSITION.

| Pounds of fat in 100 pounds of milk. | Fat left in milk after removing fat to make relation of fat and casein uniform. | Pounds of fat removed from 100 pounds of milk. | Pounds of milk to be separated to remove fat. | Pounds of butter made from fat removed from 100 pounds of milk. | Value of butter in column 5 at 18 cents a pound. | Pounds of cheese made from milk after removing fat. | Value of cheese in column 7 at 8½ cents a pound. | Value of cheese and butter made from 100 pounds of milk. | Value of one pound of milk-fat. |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | | | | | Cents. | | Cents. | Cents. | Cents. |
| **3.** | **0** | 0 | **0** | **0** | 0 | **8.55** | 72.68 | **72.68** | **24.23** |
| **3.1** | **3.06** | 0.04 | **1.3** | **0.05** | 0.90 | **8.72** | 74.12 | **75.02** | **24.20** |
| **3.2** | **3.11** | 0.09 | **3** | **0.10** | 1.80 | **8.87** | 75.40 | **77.20** | **24.12** |
| **3.3** | **3.16** | 0.14 | **4.2** | **0.16** | 2.88 | **9.00** | 76.50 | **79.38** | **24.06** |
| **3.4** | **3.20** | 0.20 | **6** | **0.23** | 4.14 | **9.12** | 77.52 | **81.66** | **24.02** |
| **3.5** | **3.24** | 0.26 | **7.4** | **0.30** | 5.40 | **9.24** | 78.54 | **83.94** | **23.98** |
| **3.6** | **3.29** | 0.31 | **8.6** | **0.36** | 6.48 | **9.37** | 79.65 | **86.13** | **23.93** |
| **3.7** | **3.33** | 0.37 | **10** | **0.43** | 7.74 | **9.49** | 80.67 | **88.41** | **23.89** |
| **3.8** | **3.37** | 0.43 | **11.3** | **0.50** | 9 | **9.61** | 81.68 | **90.68** | **23.86** |
| **3.9** | **3.40** | 0.50 | **13** | **0.58** | 10.44 | **9.69** | 82.36 | **92.80** | **23.80** |
| **4.** | **3.43** | 0.57 | **14.3** | **0.66** | 11.88 | **9.77** | 83.05 | **94.93** | **23.73** |

An examination of the figures in column 10 leads to the same result reached in the previous conclusions, viz.: that the actual value of one pound of milk-fat in milk containing 3 per cent. of fat does not exceed the value of one pound of milk-fat in milk containing 4 per cent. of fat by more than one-half of one cent.

## Milk-Fat as a Basis of Paying for Milk for Cheese-making.

Dairymen who produce milk for cheese-making hold one of three opinions in regard to the use of milk-fat as a basis to use in paying for milk. Some strongly object to its use on the ground that all normal milks have an equal value for cheese production; but this objection is founded on the densest ignorance of the composition of milk and its relation to cheese production. Others fully accept the use of the milk-fat basis as representing what is fair and desirable. Others accept the use of the milk-fat basis in a modified form, claiming that fat in poorer milk corresponds relatively to more cheese than does fat in richer milk and that the actual cheese production should, as nearly as possible, serve

as the basis of payment, on the ground that the constituents in 100 pounds of cheese made from poor milk have just as great a market value as do the constituents in 100 pounds of cheese made from richer milk.

Let us now briefly make some comparisons between different methods of paying for milk for cheese-making, in order to test the question of fairness, expressed in money value. For the sake of simplicity we will compare the milks of two men, when there is a difference of one per cent. of milk-fat, for example, 3 and 4 per cent. We will assume that the cheese produced nets ten cents a pound. We will make our comparison on the basis of 100 pounds of milk, allowing that the cheese yield from 100 pounds of milk containing 3 per cent. of fat is 8.55 pounds, and from milk containing 4 per cent. of fat, 10.40 pounds.

As a standard of comparison, we will use the values which are found by taking the market value of the fat and solids-not-fat separately. To explain more fully, when cheese sells at ten cents a pound, this makes each pound of fat in the cheese worth about 25.9 cents and each pound of solids-not-fat (casein, ash, etc.) worth about 3.9 cents. Applying these values to the cheese made from the two milks under consideration or *determining the value of the cheese according to its composition*, we find that the cheese made from 100 pounds of milk containing 3 per cent. of fat has a market value of 82.1 cents, while the cheese made from 100 pounds of milk containing 4 per cent. of fat has a market value of 107.4 cents. This may be called the exact or standard method of ascertaining the value of milk for cheese-making. This method recognizes the real values of all the constituents of the milk which are concerned in cheese-making. This method does the greatest possible justice to all kinds of milk, and therefore we will use the results given by this method as a basis for comparison with other methods.

The methods to be compared are the following :

1. Standard method based on yield and composition of cheese.
2. Method based on weight of milk.
3. Method based on weight of cheese produced.
4. Modified method based on milk-fat.
5. Method based on milk-fat.

## 1. Comparison of Standard Method and Weight-of-Milk Method.

When milk is paid for by weight alone, each patron receives the same amount of money for 100 pounds of milk, without any regard whatever for the composition of the milk or the amount of cheese it will make. The amount of cheese made from 100 pounds of each kind of milk specified above is the sum of 8.55 pounds and 10.40 pounds, or a total of 18.95 pounds, which, at 10 cents a pound, brings 189.5 cents. This is divided equally between the two patrons, because each furnishes the same amount of milk. Hence each receives 94.75 cents for the cheese made from his milk.

| Patrons. | Pounds of fat in 100 pounds of milk. | Pounds of cheese made from 100 pounds of milk. | Standard Method. Amount of money received when divided according to yield and composition of cheese. | Weight of Milk Method. Amount of money received when divided according to weight of milk furnished. |
|---|---|---|---|---|
| | | | Cents. | Cents. |
| A | 3 | 8.55 | **82.1** | **94.75** |
| B | 4 | 10.40 | **107.4** | **94.75** |

When payment is made by the weight-of-milk method, A receives the same amount of money for 8.55 pounds of cheese that B receives for 10.40 pounds; A receives over 11 cents for each pound of the cheese made from his milk, while B receives only 9.1 cents a pound for the cheese made from his milk. A receives 31.6 cents for each pound of his milk-fat, while B receives only 23.7 cents for each pound of his. A receives for 100 pounds of milk 12.65 cents which belongs entirely to B, because this extra money comes solely from the additional amount of more valuable cheese produced by the milk of B. One method makes no difference in the value of the milk furnished, while there actually exists a difference of 25.3 cents for 100 pounds of milk in favor of B. Estimated for a season, the difference between the dividends of A and B should be not less than $7.50 for each cow. That gross injustice is inevitably done, when milk is paid for by the weight-of-milk method, must become too obvious to require further discussion.

## 2. Comparison of Standard Method and the Yield-of-Cheese Method.

The proposition that yield-of-cheese furnishes the only just basis upon which to pay for milk is very plausible ; but it is seen not to be fair when we consider the difference existing in the composition of the cheese produced from milks containing different amounts of fat. We have only to consider that all the difference that may exist in favor of poorer milk is entirely eliminated by adding skim-milk to, or removing fat from, the richer milk, so far as relates to the composition of the cheese produced or the relation of milk-fat to cheese yield. The difference in the relation of milk-fat to cheese yield in favor of poor milk as compared with richer milk is simply a *skim-milk difference and therefore a skim-milk-cheese difference.* This difference, as it affects paying for milk, is indicated in the following table :

| Patrons. | Pounds of fat in 100 pounds of milk. | Pounds of cheese made from 100 pounds of milk. | Standard Method Amount of money received when divided according to yield and composition of cheese. | Yield of Cheese Method. Amount of money received when divided according to yield of cheese. |
|---|---|---|---|---|
| | | | Cents. | Cents. |
| A | 3 | 8.55 | **82.1** | **85.5** |
| B | 4 | 10.40 | **107.4** | **104.0** |

When payment is made by the yield-of-cheese method, A receives for 100 pounds of milk 3.4 cents more, and B, 3.4 cents less, than each should when the payment is made in the most equitable manner. While there is a much closer approximation to fairness, we see that there is still a marked advantage in favor of the poorer milk; since A's milk-fat brings him 28.5 cents a pound and B's milk-fat brings him only 26 cents a pound, whereas there should, at most, be an average difference of not more than one-half cent. Estimated for a season, B receives for each cow about two dollars less than he should receive, and A receives that much more, when each is paid according to the amount of cheese made from milk, without reference to the composition of the cheese made.

## 3. Comparison of Standard Method and the Modified Milk-fat Method.

A method of paying for milk at cheese factories has been proposed and used to a very limited extent in Canada, which is intended to take into consideration the casein of milk as well as the fat. The effort is made to accomplish this by adding two to the per cent. of milk. For example, in the case of A and B, whose milks contain 3 and 4 per cent. of fat, we add two to each and the figures become 5 and 6. If the total cheese sells for 189.5 cents, then A will receive five-elevenths of this or 86.1 cents, while B will receive six-elevenths or 103.4 cents. The addition of this fixed number is supposed to make allowance for the casein in the different milks. In the tabulated statement below, we give the results of this method of dividing the money received from cheese, compared with the results of dividing according to the yield and composition of cheese.

| Patrons. | Pounds of fat in 100 pounds of milk. | Pounds of cheese made from 100 pounds of milk. | Standard Method. Amount of money received when divided according to yield and composition of cheese. | Modified Milk-Fat Method. Amount of money received when divided according to modified milk-fat method. |
|---|---|---|---|---|
| | | | Cents. | Cents. |
| A | 3 | 8.55 | **82.1** | **86.1** |
| B | 4 | 10.40 | **107.4** | **103.4** |

When payment for milk is made by the modified milk-fat method, A receives for 100 pounds of milk 4 cents more, and B, 4 cents less, than each should, when the payment is made in the fairest manner. A's milk-fat will yield him 28.7 cents a pound and B's will bring him only 25.85 cents a pound. This is a marked advantage in favor of the poorer milk, nearly six times as great a difference as there should justly be. Estimated for a season, B receives for each cow $2.40 less than he should receive, and A receives that much more, when paid according to the modified milk-fat method as described above, without reference to the composition of the cheese made.

The fairness of this modified milk-fat method is based upon two erroneous assumptions. First, it assumes that cheese made from

poor milk has the same composition and its constituents the same market value as cheese made from richer milk. Second, it assumes that by adding 2 we make proper allowance for the casein in all milks, or, in other words, that A's milk contains as much casein as B's. It ignores the general rule that casein increases when the fat increases, even though the increase may not be proportional to the increase of fat. It allows payment for all the casein in poor milk, but only for a part of the casein in richer milk. The advantage is in favor of poor milk, and is as before a skim-milk advantage.

If any fixed factor is to be added, the figure which will give results in closest agreement with the yield and composition of cheese is 0.3. To illustrate, in case of A and B, adding 0.3 to 3 and 4, we have 3.3 and 4.3. Dividing 189.5 cents between these in proportion we have

A's receipts, 82.28 cents (Standard method = 82.1 cents.)
B's receipts, 107.22 cents (Standard method = 107.4 cents.)

### 4. Comparison of Standard Method and Milk-Fat Method.

In the milk-fat method the receipts from cheese are divided in proportion to the amount of fat furnished. A and B furnish respectively 3 and 4 pounds of milk-fat. The receipts from cheese are 189.5 cents, of which A receives three-sevenths, 81.2 cents, and B four-sevenths, 108.3 cents.

| Patrons. | Pounds of fat in 100 pounds of milk. | Pounds of cheese made from 100 pounds of milk. | Standard Method. Amount of money received when divided according to yield and composition of cheese. | Milk-Fat Method. Amount of money received when divided according to amount of milk-fat furnished. |
|---|---|---|---|---|
| | | | Cents. | Cents. |
| A | 3 | 8.55 | **82.1** | **81.2** |
| B | 4 | 10.40 | **107.4** | **108.3** |

When payment for milk is made according to the amount of milk-fat furnished, A receives nine-tenths of one cent less, and B receives nine-tenths of one cent more, than each does, when the payment is made in the fairest manner. A pound of milk-fat brings each 27.07 cents. Estimated for a season, A

receives for each cow 54 cents less, and B 54 cents more, than each would receive, if paid according to the standard method.

Now that we have compared each of the different methods with what we have called a standard method, it will be well to bring all the methods together for a general comparison.

AMOUNT OF MONEY RECEIVED FOR 100 POUNDS OF MILK BY DIFFERENT METHODS OF DIVISION.

| Patron. | Pounds of fat in 100 pounds of milk. | Pounds of cheese made from 100 pounds of milk. | STANDARD METHOD. On basis of yield and composition of cheese. | MILK-FAT METHOD. On basis of amount of milk-fat furnished. | YIELD-OF-CHEESE METHOD. On basis of weight of cheese produced. | MODIFIED MILK-FAT METHOD. On basis of milk-fat with 2 added for casein. | WEIGHT-OF-MILK METHOD. On basis of amount of milk furnished. |
|---|---|---|---|---|---|---|---|
| | | | Cents. | Cents. | Cents. | Cents. | Cents. |
| A | 3 | 8.55 | **82.1** | **81.2** | **85.5** | **86.1** | **94.75** |
| B | 4 | 10.40 | **107.4** | **108.3** | **104.0** | **103.4** | **94.75** |

We indicate below the amount received for each pound of fat in milk by A and B according to the different methods of division.

AMOUNT OF MONEY RECEIVED FOR ONE POUND OF MILK-FAT BY DIFFERENT METHODS OF DIVISION.

| Patrons. | STANDARD METHOD. | MILK-FAT METHOD. | YIELD-OF CHEESE METHOD. | MODIFIED MILK-FAT METHOD. | WEIGHT OF MILK METHOD |
|---|---|---|---|---|---|
| | Cents. | Cents. | Cents. | Cents. | Cents. |
| A | **27.37** | **27.07** | **28.50** | **28.70** | **31.58** |
| B | **26.85** | **27.07** | **26.00** | **25.85** | **23.69** |

In the tabulated statement below we give the amount of money each patron receives above or below the amount each would receive, when division is made by the standard method.

| Patron. | Milk-fat method. | | Yield-of-cheese method. | | Modified milk-fat method. | | Weight-of-milk method. | |
|---|---|---|---|---|---|---|---|---|
| | Above. | Below. | Above. | Below. | Above. | Below. | Above. | Below. |
| A | — | **0.9** | **3.4** | — | **4** | — | **12.65** | — |
| B | **0.9** | — | — | **3.4** | — | **4** | — | **12.65** |

From the last table preceding it will be noticed that of the different methods every one except the milk-fat method gives to the poorer milk more than belongs to it, while the milk-fat method alone gives to the richer milk more than strictly belongs to it. But while the extra amount given to the richer milk by the milk-fat method is only nine-tenths of one cent for 100 pounds of milk, the extra amount given to the poorer milk is in no case less than 3.4 cents for 100 pounds of milk and varies from this to 12.65 cents. It will thus be seen that the milk-fat method comes nearer to doing absolute justice than any other method in use.

By way of review, it is desirable to emphasize statements of certain important facts.

1st. Milk varies greatly in its composition. In paying for milk for cheese-making, absolute fairness can be realized in every individual case only by a careful direct determination of both fat and casein. But this is not practicable.

2d. Cheese made from milk rich in fat is greater in yield, and its constituents, pound for pound of cheese, possess a higher value than cheese made from milk poorer in fat.

3d. When a pound of fat in poor milk is equivalent to more cheese than is a pound of fat in richer milk, the difference can be wholly removed by adding skim-milk to, or removing fat from, the richer milk. The difference in composition between cheese made from poor and rich milk is a skim-milk difference and a skim-milk cheese difference.

4th. Of all practicable methods suggested, the use of milk-fat as a basis in paying for milk for cheese-making gives the nearest approach to absolute fairness.

5th. All proposed modifications of the milk-fat method are in the interest of the producer of poor milk as against the interest of the producer of richer milk.

## Reasons for Discarding the Weight-of-Milk Method.

*1st. Because it is based upon the false assumption, that all kinds of milk have the same cheese-producing value.* It fails to recognize the fundamental fact that milks differ in regard to the amount of cheese they can produce.

*2d. Because the method, being founded upon a false basis, is unjust and is, therefore, not business-like.* By this system, money

which belongs solely to the producer of the better milk is taken from his pocket and transferred to that of his neighbor, who produces poorer milk.

*3d. Because the old system discourages the production of better milk and is a positive barrier to improvement.* When milk is paid for by weight alone, then more money can be gained by increasing the amount of milk produced, without regard to its composition. It is a well-known fact that under this system the composition of milk has deteriorated in the last generation, and, so long as a premium was offered for increasing the amount of milk produced, there was no inducement to pay any attention to the composition of the milk, if only it met the legal requirements.

*4th. Because the old system encourages the addition of water, removal of cream and all similar forms of dishonesty.* When quantity and not quality is paid for, some will be found who will try dishonestly to take advantage of the system; and this can hardly be surprising, when the system itself is founded upon an untruth, and is itself dishonest.

## Reasons for Using the Milk-Fat Basis in Paying for Milk at Cheese Factories.

*1st. Because the amount of fat in milk offers the most accurate, practicable and just basis we have for determining the cheese-producing value of milk.*

*2d. Because this method recognizes the fundamental truth that different milks possess different values for cheese-making.*

*3d. Because this method, being based upon the truth, is just to all and is, therefore, in the highest sense, business-like.* It guarantees pay for what is in the milk that makes cheese.

*4th. Because the adoption of this method will result in an improvement in the character of the milk production.* Why? Because it offers an inducement to each dairyman to improve the composition of his milk. It puts more money into the pocket of the man who produces the better milk. This improvement will be realized as a result of more careful selection of dairy animals, more attention to breeding, more intelligent and economical feeding, more humane treatment of dairy animals and better care of milk.

*5th. Because all temptation to adulterate milk by watering or*

*skimming is removed*, since a man receives pay for just what he furnishes that is of most value for cheese production.

*6th. Because the adoption of this system lies at the very foundation of the future improvement of the dairy industry.* Nothing will so quickly open the eyes of dairymen and show them the need of improvement in milk production as the application of this system to their herds and individual animals.

*7th. Because improvement in the character of dairy animals and in the consequent yield and composition of milk means economy of production and increased profit.* Our investigation with different breeds of dairy animals has emphasized the fact that a pound of fat in rich milk is produced at a lower cost than in poorer milk. It would not be difficult to show that it would be easily possible within a few years to increase the yield of our annual cheese-product by an amount equal in value to one million dollars, with fewer animals and at an actually less cost than at present.