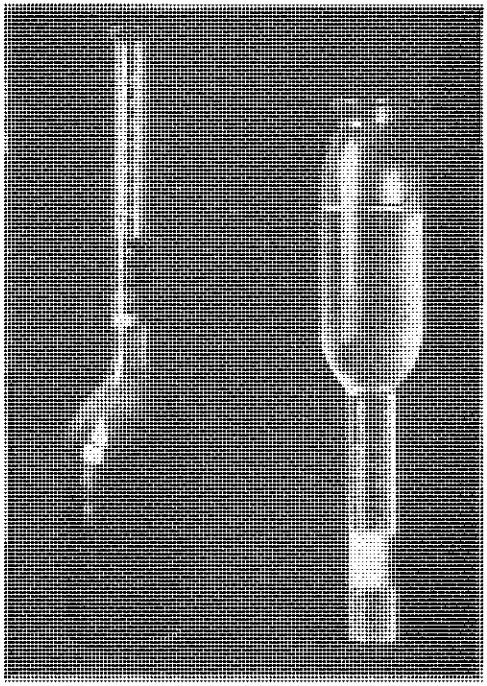
BULLETIN NO. 197 JULY, 1910

THE UNIVERSITY OF WISCONSIN
Agricultural Experiment Station



The true value of milk for cheese making can only be determined by testing for both fat and casein.

METHODS OF PAYING FOR MILK AT CHEESE FACTORIES

BY

S. M. BABCOCK, E. H. FARRINGTON AND E. B. HART.

MADISON, WISCONSIN

DIGEST

Payment for Milk at Cheese Factories previous to 1908 was based entirely upon the fat content of the milk as determined by the Babcock test. While experiments have proven that milk rich in fat does not yield as much cheese in proportion to the fat as does poor milk, cheesemakers have nevertheless attempted to base the capacity of milk for cheese production on its fat contents alone. This investigation was conducted to determine variation in casein in the milk of the same and of different herds with fluctuations and daily casein tests, and also to discover the relation of casein to fat and the effect of fat on the quality of cheese. Tests were made at nine cheese factories on the milk of 94 herds. Pages 3–5

The Variation of Casein in Milk from different sources ranges from 0.3 to 0.8 per cent for herd milk. Greater variations occurred between different herds, in some cases ranging from 1.8 to 2.8 per cent. The daily fluctuations in casein tests were gradual, amounting to as high as 0.7 per cent, a change from one day to another usually not exceeding 0.2 or 0.3 per cent. Pages 6–8

The Relation of Casein and Fat in herd milk was found quite variable. Of 495 samples tested, 70 per cent tested 2.3 to 2.6 per cent casein with fat varying from 3.2 to 4.7 per cent. When the fat varied, in most cases the casein varied in proportion, but in about 20 per cent of the tests made there was no close agreement.
Pages 8–10

The Relation of Fat to Quality of Cheese was shown by making cheese from milks containing varying amounts of fat and having these cheeses judged by *buyers for the market.* The results showed that cheese was made of slightly better quality when the milk contained a relatively high amount of fat. Other tests showed that under farm and factory conditions there is no indication that fat will be the controlling factor in the quality of cheese because of the non-uniform condition of the milk received, due to care in handling.
Pages 11–15

The Value of Milk for Cheese Making should be based upon the content of both fat and casein. For this reason both the Babcock fat test and the Hart casein test should be used in cheese factories. Upon the basis of these tests an allowance of equal values for fat and casein is a just method of payment. The use of the casein test is not necessarily expensive since in a factory having 30 patrons semi-monthly casein tests may be made at an annual cost, during a five-year period of not over $23 per year, including first cost of tester.
Pages 15–24

Methods of Paying for Milk at Cheese Factories

S. M. BABCOCK, E. H. FARRINGTON AND E. B. HART

It is important for the dairy interests of the state that there exist a proper understanding of the relation of milk composition to cheese production and the utility of methods for measuring the capacity of a milk for such production. Until 1908 the Babcock test was the only available method by which any specific constituents of milk could be measured rapidly and accurately. Coincident with the introduction of this test 20 years ago naturally came the attempt to base the capacity of milk for cheese production on its fat content alone.

Experiments by Babcock of this Station and Dean of the Guelph Station have conclusively demonstrated that rich milk at the same season of the year does not yield as much cheese in proportion to the fat it contains as does poor milk, and that rich milk towards the end of the season may do as well as a much poorer milk early in the season. It has been shown that there is no definite and fixed relation between the fat and casein content of the milk of individual cows. These results of Babcock and Dean would indicate that there is no constant and close agreement between the relative proportions of casein and fat in herd milks at different periods of lactation.

The work reported in this bulletin was undertaken for the express purpose of securing detailed information on the cheese producing capacity of milk produced in various localities in this state. It was believed that upon this information a fair and unprejudiced discussion of the adaptability of various methods to the payment for milk at cheese factories could be based.

COMMON METHODS OF PAYMENT.

Three methods for paying for milk at cheese factories have been used: (1) by weight, (2) by fat content, (3) by fat and casein content. The first method does not take into account the capacity of the milk for cheese production and is neither an intelligent nor progressive method. Payment on the fat basis alone has been extremely helpful to the dairy interests and today is the simplest method in general use, but the fat test alone is not a complete measure of the capacity of the milk for cheese production.

The investigations reported in the following pages were undertaken to determine and demonstrate the following things:

1. The variation in the casein content of milk of the same herd.
2. Variation in the casein content of milk in different herds.
3. Fluctuations in daily casein tests.
4. The relation of casein to fat in milk from a herd.
5. The effect of fat on the quality of cheese. After these points have been fully considered and are understood a just method of payment for milk delivered at cheese factories could be outlined.

The introduction by this Station of a simple casein test, in 1908, made it possible to inaugurate these studies on the casein content of the milk from herds and accumulate a considerable body of data on this subject. This work was conducted by Mr. W. H. Cooper, whose familiarity with both the fat and casein tests made his services especially valuable. During the summer and fall of 1909 tests were made on a large number of herds. In all 94 herds were involved in this work and both fat and casein were determined. The testing was done at cheese factories in this state in order that actual conditions might be known. Special care was taken to insure accuracy in the testing, but otherwise the conditions were the same as in any Wisconsin cheese factory. Factories were chosen in different sections of the state corresponding to the three principal cheddar cheese sections. Four factories were located in or near Sheboygan Falls, Sheboygan County; one each at Gotham and Twin Bluffs, Richland County, and three near Marshfield, Wood County. At Sheboygan Falls the tests extended through a

seven weeks' period in July and August; at Twin Bluffs and Gotham through six weeks in August and September; and at Marshfield during four weeks in October and November.

The tests were made on 7-day composite samples of herd milks. Potassium dichromate was used as a preservative, at the rate of about one-tenth of a gram per 100 cc. of milk. As the large potassium dichromate tablets, formerly on the market, contained four-tenths gram of preservative, one-half of a tablet was used for the entire week. The new tablets, now on the market, made expressly for the casein test, are one-fourth the size of the old ones, each containing one-tenth gram of dichromate. Half the amount of preservative was placed in the sample bottle at the beginning of the week and the remainder added after three days.

Brown or amber colored sample bottles were used, as such bottles have been found to retard greatly the action of light on the mixture of potassium dichromate and the proteins of the milk. They were kept as much as possible in a cool, dark place. The curing room was usually the best place for the bottles when not in use at the intake. The sampling was done at the intake of each factory by the maker, and the testing done by Mr. Cooper when the samples were completed. The same herds were tested from week to week at each factory.

In addition to the tests of the composite samples, daily tests of the *fresh* milk of these same herds were made at two of the factories throughout the entire period of testing. This not only furnished a check on the accuracy of the composite tests, but also data on the daily fluctuations in the casein content of the individual herd milks.

VARIATION IN CASEIN TESTS OF THE SAME HERDS

More or less variation in casein content was found. Of the 94 herds from which milk was tested, 35 showed a variation in casein content from one week to another of 0.3 to 0.5 per cent; seven showed from 0.6 to 0.8 per cent variation, while the remaining 52 herds showed less than 0.3 per cent variation.

The following table gives the range in casein tests of those herds which showed a variation of 0.3 per cent or more, the highest and lowest test for each herd being given. The tests were made on weekly composite samples.

TABLE I.—VARIATION IN THE CASEIN CONTENT OF MILK OF THE SAME HERD. WEEKLY COMPOSITE SAMPLES.

SHEBOYGAN COUNTY, JULY 1 TO AUGUST 15, 1909.

Herd No.	No. of cows in herd.	Casein Content.		Herd No.	No. of cows in herd.	Casein Content.	
		Lowest.	Highest.			Lowest	Highest.
1	22	2.2	2.6	14	12	2 1	2.4
2	22	2.3	2.6	15	9	2 2	2.5
4	30	1.8	2.4	21	5	2 5	2 8
5	11	2.2	2.5	22	9	2.3	2 6
6	10	2.2	2.5	28	10	2 4	2.8
9	27	1.8	2.4	29	20	2.3	2 6
11	12	2.2	2.5	35	14	2.2	2 5
13	35	1.9	2.6				

RICHLAND COUNTY, AUGUST 16 TO SEPTEMBER 30.

39	21	2.1	2.4	57	16	2 2	2.5
40	5	2.3	2.6	58	17	2.1	2.4
41	25	2.8	3.1	60	27	2 1	2.6
47	15	2.2	2.5	62	8	2.2	2.5
48	3	2.2	2.6	64	14	2.4	2.7
49	20	2.2	2.6	65	35	2.5	2.5
52	10	2.3	2.6	66	31	2 3	2.8

WOOD COUNTY, OCTOBER 1-31.

68	6	2.6	3.2	82	5	2.7	3.2
70	13	2.5	2.8	83	5	2 8	2.9
72	7	2.4	3.0	84	6	3 0	3.6
75	5	2.6	2.9	85	12	2.6	3 0
77	15	2.3	2.9	90	7	2 6	3 2
79	6	2.7	3.0	91	7	2.6	2.9
81	7	2.6	2.0				

21 herds tested in Sheboygan County varied less than 0.3 per cent.
16 herds tested in Richland County varied less than 0.3 per cent.
15 herds tested in Wood County varied less than 0.3 per cent.

VARIATION IN THE CASEIN CONTENT OF MILK FROM DIFFERENT HERDS

Between the different herd milks, variations were more noticeable. At Sheboygan Falls during July and August the tests ranged from 1.8 per cent to 2.8 per cent; at Gotham and Twin Bluffs during August and September, the range was from 2.1 per cent to 3.1 per cent, and at Marshfield, during October, a range of from 2.4 per cent to 3.6 per cent was found. The variations were about equal at the three places; the higher tests

at Twin Bluffs, Gotham, and Marshfield were probably partly due to the later season and consequent decrease in milk flow.

One might expect that the lower results were those secured in the first week of testing, while the higher ones represent those obtained in the later periods, in this way giving variations incident only to the advance in the lactation period. This, however, is not the case as some of the higher and lower tests appear in both the first and last weeks of testing.

TABLE II.—RANGE OF CASEIN TEST IN COMPOSITE SAMPLES OF HERD MILKS.

Date.	Factory.	Location.	No. of herds tested.	Lowest	Highest.
		County.		Percent.	Percent.
July 1-Aug. 15	A	Sheboygan	8	1.8	2.6
July 1-Aug. 15	B	Sheboygan	8	1.8	2.6
July 1-Aug. 15	C	Sheboygan	8	2.3	2.8
July 1-Aug. 15	D	Sheboygan	12	1.9	2.6
Aug. 16-Sept. 30	E	Richland	18	2.1	3.1
Aug. 16-Sept. 30	F	Richland	12	2.1	2.8
Oct. 1-30	G	Wood	12	2.4	3.2
Oct. 1-30	H	Wood	6	2.6	3.6
Oct. 1-30	I	Wood	10	2.6	3.2

The above Table II gives the highest and lowest casein tests of composite samples found at each factory. It shows very clearly the range in casein which may occur.

FLUCTUATION IN THE DAILY CASEIN TESTS. The daily casein tests of fresh milk showed more or less variation; these variations as a rule, were not sudden, but gradual in increase or

TABLE III.—RANGE IN DAILY CASEIN TESTS OF HERD MILKS.

Factory D.					Factory E.				
Herd No.	No. of cows.	Lowest.	Highest.	Variation.	Herd No.	No. of cows.	Lowest.	Highest.	Variation.
25	8	2.4	2.8	0.4	37	25	1.9	2.6	0.7
26	8	2.4	2.7	0.3	38	18	2.0	2.6	0.6
27	5	2.3	2.8	0.5	39	12	1.9	2.4	0.5
28	14	2.1	2.5	0.4	40	5	2.1	2.4	0.3
29	20	2.2	2.8	0.6	41	25	2.4	3.0	0.6
30	3	2.0	2.6	0.6	42	14	1.9	2.5	0.6
31	3	2.0	2.6	0.6	43	9	2.0	2.7	0.7
32	3	1.8	2.3	0.5	44	22	2.1	2.8	0.7
33	28	2.0	2.4	0.4	45	7	2.2	2.6	0.4
34	16	2.3	2.6	0.3	46	16	1.9	2.4	0.5
35	14	2.0	2.4	0.4	47	15	2.0	2.4	0.4
36	2	1.8	2.3	0.5	48	3	2.1	2.5	0.4

decrease from day to day. They do show, however, that in some cases a single one day test of a herd milk may not be a correct or fair test for that herd. During the period through which the tests were made, as high as seven-tenths per cent variation was found for some herds, but even in these cases the variation was gradual and not abrupt. The change from one day to another was usually not more than two or three tenths per cent. The following Table III gives the range of casein tests for each herd as shown by the daily tests. At factory D the tests were made daily for seven weeks in July and August, and at factory E for six weeks in August and September.

RELATION OF CASEIN AND FAT IN HERD MILKS

A study of the casein and fat tests, made on the composite samples of herd milks at the various cheese factories, shows that there was considerable variation in the relation of the fat and casein to each other. Although in a great many cases the ratio between fat and casein was quite constant, the exceptions and variations were so numerous as to make it plain that no fixed rule of general application could be used for the calculation of the casein content from the fat test.

TABLE IV.—RELATION OF FAT TO CASEIN IN HERD MILK.

No. of composite samples.	Casein.	Range in fat test.			Fat to 100 pounds casein.
		Lowest.	Fat to 100 pounds casein.	Highest.	
	Per cent.	Per cent.	Pounds.	Per cent.	Pounds.
3	1.8	3.2	177	3.5	194
3	1.9	3.1	163	3.4	173
6	2.0	2.8	140	3.5	175
10	2.1	2.8	133	4.0	190
36	2.2	3.0	136	4.0	182
84	2.3	3.2	139	4.3	187
104	2.4	3.2	133	4.2	175
73	2.5	3.3	132	4.3	172
86	2.6	3.3	127	4.7	181
30	2.7	3.4	123	4.6	170
33	2.8	3.6	128	5.2	185
9	2.9	4.2	145	5.2	179
9	3.0	4.3	143	6.0	200
3	3.1	4.6	148	5.2	167
4	3.2	4.6	143	5.2	162
1	3.5	.....	.....	5.6	160
1	3.6	.....	.....	5.4	150

Samples with the same percentage of casein had wide variations in their fat tests. Of 495 samples tested, 347, or 70 per cent tested from 2.3 per cent to 2.6 per cent casein, with fat tests varying from 3.2 per cent to 4.7 per cent. The other 30 per cent tested from 1.8 to 3.6 per cent of casein with 2.8 to 6.0 per cent fat; 84 samples tested 2.3 per cent of casein, with a fat content of 3.2 to 4.3 per cent; 104 samples had 2.4 per cent casein with from 3.2 to 4.2 per cent fat; and 86 samples tested 2.6 per cent casein with 3.3 to 4.7 per cent fat.

In Table IV is given the variation in the fat test for milks having the same casein test, as well as the number of samples tested.

With milk having the same fat test, the fluctuations in the casein tests were equally noticeable, the variations running as high as one per cent. A large number—56 per cent—of the fat tests were between 3.6 and 4.0 per cent, while the casein varied

TABLE V.—RELATION OF CASEIN TO FAT IN HERD MILKS.

No. of composite samples.	Fat.	Range in casein test.			
		Lowest.	Casein to 100 pounds fat.	Highest.	Casein to 100 pounds fat.
	Per cent.	Per cent.	Pounds.	Per cent.	Pounds.
2	2.8	2.0	71	3.1	75
4	3.0	2.0	67	2.2	73
3	3.1	1.9	61	2.1	67
10	3.2	1.8	56	2.8	87
17	3.3	1.8	54	2.6	79
30	3.4	1.9	56	2.7	79
19	3.5	1.8	51	2.6	74
60	3.6	2.1	58	2.8	77
36	3.7	2.2	59	2.8	75
74	3.8	2.1	55	2.7	71
26	3.9	2.1	54	2.7	69
64	4.0	2.1	52	2.8	70
19	4.1	2.4	59	2.7	65
27	4.2	2.3	55	2.9	69
11	4.3	2.3	53	3.0	70
19	4.4	2.6	59	2.9	66
7	4.5	2.7	60	2.9	64
12	4.6	2.7	58	3.2	69
4	4.7	2.6	55	3.2	68
4	4.8	2.8	58	3.0	62
3	5.0	2.8	56	3.0	60
4	5.1	2.8	55	3.0	59
5	5.2	2.8	54	3.2	61
1	5.4	.....	.....	3.6	66
1	5.6	.....	.....	3.5	62
1	6.0	.....	.....	3.0	50

from 2.1 to 2.8 per cent. In 60 samples, testing 3.6 per cent of fat, the casein test was from 2.1 to 2.8 per cent; in 74 tests of 3.8 per cent of fat, the casein was 2.1 to 2.7 per cent; and with 64 samples, testing 4.0 per cent fat, the casein test ranged from 2.1 to 2.8 per cent.

The above Table gives the variations in the percentage of casein in herd milks having the same fat tests. The number of samples tested in each case is also given.

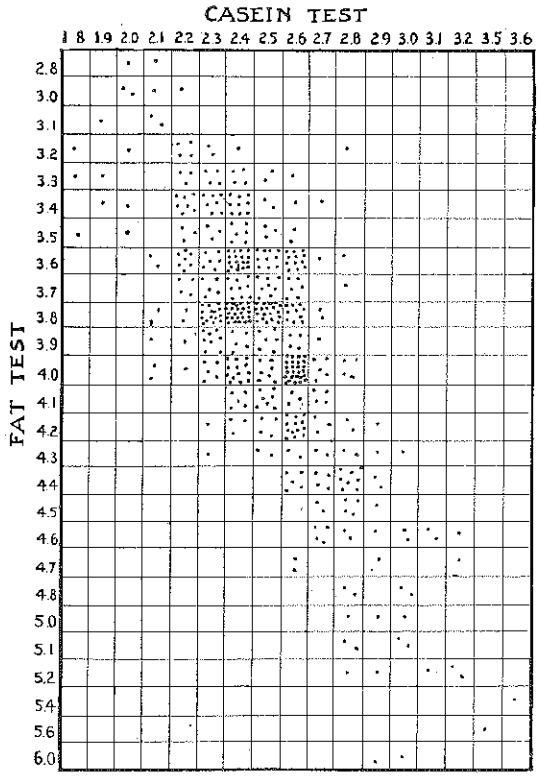


Figure 1. Relation of casein and fat tests of the same sample of milk. Note that the increase in casein content is uniform with the increase in fat content.

Figure 1 illustrates graphically the variation in the relation of fat to casein in herd milks. Each dot represents a single composite test. It can be seen at a glance that the majority of tests fall within certain limited areas, but that there is con-

siderable variation from any set rule. The chart also emphasizes in a general way the truth of the statement that an increase of fat is accompanied by an increase of casein. This is not an absolute and constant condition, but only general and may not always occur.

EFFECT OF FAT ON THE QUALITY OF CHEESE

This question has been much discussed and at some of the Experiment Stations experimentally investigated. None of the work, however, has been designed so as to give a conclusive answer to the problem. The experimenters have either made cheddar cheese from different milks with different fat content, or from the same milk, but to which so much cream had been added as to make it an entirely abnormal milk. The sanitary condition of the milk is such an important factor in determining the quality of the cheese that selection of milks of varying fat content, but from different sources, cannot give positive and conclusive data. It is equally a questionable procedure, for securing definite data for *normal* milks, to vary excessively the fat content of the milk by removing or adding cream, thus modifying the milk considerably from that of a *normal product*. It is perfectly plain that skim milk cheese is not a normal cheddar cheese and would never be so judged. While it is also equally plain that excess of fat will offend in the other direction when *judged by buyers for the market* for this class of cheese.

To secure data on this point cheese was made from the same milk, but with a variable fat content in most cases within the range of normal milks. This reduced the experiment to one variable factor and eradicated the other equally important factor, the sanitary condition of the milk. This was usually done by taking about 800 pounds of mixed whole milk and skimming a part of it in the separator. The milk used was that delivered by the University creamery patrons. It was planned to make four cheeses of variable fat content in four separate vats from the 800 pounds of milk. In vat I, 150 pounds of whole milk and 50 pounds of the skim milk were placed; in vat II, 175 pounds of whole milk and 25 pounds of skim milk; in vat III, 200 pounds of whole milk; in vat IV 197¾ pounds of whole

milk and 2¼ pounds of separated cream. In some of the cases 1,000 pounds of mixed milk were allowed to stand over night and a division made by drawing off 200 pound portions from the bottom of the vat after a partial mixing. This gave us, from the same mixture, milks of different fat content. So far as possible identical procedure of manufacture was followed. The cheeses were always made under the supervision of Mr. F. W. Laabs, late of the dairy department. They were cured at 55 degrees F. for two months. About 6,000 pounds of milk were used in the experiment and represents seven different days of making. At the end of two months the cheeses were scored by three judges, Mr. Marty and Mr. F. W. Laabs of the dairy department and Mr. Baer of the State Dairy and Food Commission. One set of cheese, made somewhat earlier than the others, was also scored by Mr. H. J. Noyes of Muscoda, a cheese buyer. The scores and fat content of the milks are given in the following Table VI:

TABLE VI.—FAT CONTENT OF MILKS AND SCORES OF CHEESE.

Cheese No.	Fat in Milk.	Scores.			Cheese No.	Fat in Milk.	Scores.			
		Baer.	Laabs.	Marty.			Baer.	Laabs.	Marty.	Noyes.
1.....	3.6	94	93½	94	14.....	3.5	87	88	90	.....
2.....	3.9	95	94½	93	15.....	4.0	90	91	94	.....
3.....	4.1	95½	96	92	16.....	5.7	94	95	95	.....
4.....	4.4	95½	96	94½	17.....	3.3	89	89	89	.....
5.....	2.9	92½	92½	92	18.....	4.2	93	93	90	.....
6.....	3.6	93	93½	93	19.....	4.6	95	95½	95	.....
7.....	4.0	93½	94½	91	20.....	3.1	92½	89	92	.....
8.....	4.4	94	95	95	21.....	3.6	92	90	90	.....
9.....	2.0	83	85	83	22.....	4.5	94	93½	93½	.....
10.....	2.7	86	91	90	23.....	3.0	90	94½	94	96
11.....	3.9	91	92	95	24.....	3.4	95	95	96	96
12.....	5.5	96	95½	96	25.....	3.8	93	96	96	97
13.....	2.5	85	84	90	26.....	4.4	91	96	94	95½

If we condense the above table and average the scores an interesting result is developed:—

Percent of fat in the milk.	Score of cheese.
2.0 - 2.5	85
2.6 - 3.0	91.8
3.1 - 3.5	91.3
3.6 - 4.0	93.3
4.1 - 4.5	94.2
Above 4.5	95.2

This table shows that where the average of all the scores was taken there was a slight but distinctively progressive increase in the quality of the cheese with increase of fat in the milk. While it was not large within the range of normal factory milks—those testing from 3 to 4.5 per cent—nevertheless it was apparent to these judges.

Examination of the complete table given above will show that in certain sets there was not, with increase of fat, a continued increase in quality as judged by these scores. Cheeses 23 to 26 are a clear illustration of this fact. Fat and casein determinations in these cheeses gave the results shown in Table VII:—

TABLE VII.—RATIO OF CASEIN TO FAT AND THE AVERAGE SCORES.

Cheese No.	Fat.	Casein.	Ratio of Casein to Fat.	Average Score.
	Percent.	Percent.		
23	32.6	26.0	1:1.25	93.6
24	33.6	24.2	1:1.38	95.5
25	35.5	22.6	1:1.57	95.5
26	36.4	20.3	1:1.79	94.1

In this particular set, where, for every pound of casein there was a variation of from 1.25 to 1.79 pounds of fat, the quality had not progressively increased. But in nearly every other case the quality improved with the increase of fat and where the fat content of the milk dropped near or below 3 per cent, the quality was considerably impaired and lowered. These data, it should be remembered, were secured on cheeses made from milks with only one variable factor and that was the fat content of the milk. The bacterial flora for each set must have been much alike and consequently no disturbing factors were introduced in the curing process, tending to make the cheeses unlike.

SCORES OF FACTORY CHEESE FROM MILKS OF UNLIKE FAT CONTENT

The cheese scoring exhibitions of the Dairy Department, in progress in this state, afforded excellent opportunity for securing data on whether the cheese made from high fat milks were those scoring highest in the contest. To secure these data the

factories entering the Exhibitions were asked to file a statement of the fat content of the milk from which the cheese was made. The fat content of the milk and scores of the cheese are given in Table VIII :—

TABLE VIII.—SCORES OF CHEESE MADE FROM MILK OF VARYING FAT CONTENT.

Cheese No.	Fat in milk.	Score.	Cheese No.	Fat in milk.	Score.
	Per cent.			Per cent.	
1	4.9	86.6	13	3.9	92.8
2	4.3	95.6	14	3.8	92.0
3	4.3	94.2	15	3.8	93.8
4	4.2	94.6	16	3.8	88.0
5	4.2	94.3	17	3.7	91.0
6	4.2	97.0	18	3.7	95.5
7	4.2	90.0	19	3.7	91.0
8	4.1	97.5	20	3.6	94.0
9	4.1	92.5	21	3.6	96.5
10	4.0	94.8	22	3.5	92.9
11	4.0	90.5	23	3.5	94.6
12	3.9	94.8	24	3.4	89.8

BUTTER FAT IN MILK NO DEFINITE INDICATOR OF CHEESE VALUE

Under factory and farm conditions, existing at present, there is absolutely no indication that the fat content of normal milk will be the controlling factor in the quality of the cheese. This is due to the dirty condition of the milk delivered. A cheese made from a 3.4 per cent milk scored 89.9, while one made from a 4.9 per cent milk scored 86.6 per cent. Two others made from 3.5 and 4.3 per cent milk scored 94.6 and 94.2 respectively. This is not surprising. There appears to be an impression that because a normal milk is low in fat the cheese made from it will be low in fat, or approach a skim cheese. This is not true. It should be remembered that the casein content of normal milk is always lower than the fat content and consequently a cheese made from normal 3 per cent herd milk will always have in it a higher per cent of fat than casein. While a cheese made from a 4.5 per cent milk may have a relatively higher fat content than that made from a 3 per cent milk, nevertheless under factory conditions, it may not score higher. This, as above stated, is due to the fact that the sanitary condition of the milk is a very important factor in controlling the quality of cheese and that fat alone has only slight influence, even in nor-

mal milks of like quality, when judged for cheddar cheese by the *buyers for the market.*

METHODS OF PAYMENT FOR MILK

The methods that are at all worth considering, for paying for milk at cheese factories, are either those based on the fat content of the milk alone or upon the total capacity of the milk for cheese production, as measured by both the fat and casein content. Payment by weight alone is neither an intelligent nor progressive method since it ignores absolutely the milk's capacity for cheese production.

Payment on the fat basis alone has been extremely helpful and decidedly progressive for the dairy interests and today is the simplest method in use, but it is not a complete measure of the capacity of the milk for cheese production as is shown by the investigations reported in this bulletin.

The variation in the casein content of herd milks and the absence of a constant and definite relation between the casein and fat content, make it clear, that fat alone cannot accurately determine the cheese producing capacity of the milk. This has long been recognized, but to counterbalance this defect in the method it has been stated that the fat controls the quality and consequently high fat milk, while not having the relative cheese producing capacity of lower fat milk, nevertheless improved the quality so as to offset this defect in the method of payment.

If all milks commercially produced were alike in their sanitary condition we believe that this would still be true and it is unfortunate that such conditions do not exist; but the fact remains that milks are not alike in this respect and it is not probable that such conditions, whereby all milks will be brought to uniform quality, will be realized for some time.

A rich but dirty milk may spoil an entire vat. There is no method available, capable of scoring the purity of milks close enough for grading the quality of the cheese which they will produce. The subtle fermentations carried on in the curing process and dependent in part upon the organisms of the milk are responsible for these differences.

The method proposed by Dean, of adding 2 to the fat test, has found some application; but the fact that the casein content of milks is a variable quantity and that the method does not

prevent the fraudulent dilution of milk with water, obviously renders it incomplete. But aside from these objections, it recognized in principle the advantages of a method resting upon the measurement of the capacity of milk to produce cheese.

For these reasons it appears to us that the most equitable basis for the payment of milk delivered at cheese factories is by the combined fat and casein tests. This measures the capacity of the milk to produce cheese. It pays the patron for the cheese solids delivered. It acts as an incentive for greater production just as the fat test has already done. In addition it will detect any large modication of the milk by watering.

The suggestion sometimes heard, that the casein test will induce the patron partially to skim his milk, make butter from the cream and take the partially skimmed milk to the cheese factory, thereby lowering the quality of the cheese, is not at all probable for two reasons, first, he will find that it does not pay to do this and, second, the State law, as well as the National Pure Food Act, requires 50 per cent of the cheese solids to be fat. As a matter of fact the casein test will tend to prevent the fraudulent practice of adding cream to the milk, thereby raising the fat test and increasing the patrons' dividends at the factory without materially increasing the cheese producing capacity of his milk.

COMPARISON OF DIVIDENDS CALCULATED ON THE FAT BASIS AND FAT PLUS CASEIN BASIS

To show the distribution of dividends[1] at cheese factories, proportioned on the fat basis and fat-plus-casein basis a number of calculations have been made.

In order to make comparisons, it was necessary to assume that the same amount of milk was delivered by each patron. The yield of green cheese was calculated according to the following formula: Yield of green cheese = (Casein $\times$ 2.5) + (Fat $\times$ 1.1). It was assumed that the cheese was sold at 14 cents per pound, aud the whole amount returned to the patrons, making no deductions for the usual expenses of manufacture. On

[1] The term "dividends" which is in common use among cheesemakers and as here used refers to the total receipts from sale of milk and has no relation to the meaning of the term used in financial operations.

the fat basis, the price to be paid per pound of fat was determined by dividing the amount resulting from the sale of the cheese, by the number of pounds of fat delivered; on the fat plus casein basis, equal values were assigned to fat and casein, and the price per pound determined from the amounts of these delivered.

Several dividends were first calculated in which the fat and casein tests of the milks selected were representative of 75 to 80 per cent of the milks tested—in which the relation of fat to casein was comparatively constant. Those *selected* were *actual cases* which were found during the summer's work, only the weights of milk being changed to make comparisons possible. They were selected in order to show that with the average patron the difference in dividends by the two methods is not very large for the amount of milk used in the calculation, but which would be but one-tenth or one-twentieth part of the amount delivered by many patrons in a year. However, the amount for a year is too large to be neglected. A wide variation was not to be expected, as payment for milk on the fat basis is based upon the assumption that the relation of fat and casein is always comparatively constant.

In Table IX are recorded some of these dividends based upon 6000 pounds of milk. This amount represents a fair average

TABLE IX.—CALCULATION OF DIVIDENDS ON THE FAT BASIS AND ON FAT PLUS CASEIN BASIS.

Patron.	A.	B.	C.	D.	E.	F.
Pounds milk	6000	6000	6000	6000	6000	6000
Fat test	3.7	3.5	4.6	3.9	4.4	5.1
Casein test	2.3	2.2	2.9	2.5	2.6	3.0
Pounds fat	222	210	276	234	264	306
Pounds casein	138	132	174	150	156	180
Pounds fat + casein	360	342	450	384	420	486
Pounds cheese	589	561	738	632	680	787
Fat at 37.03c per lb.						
Dividend on fat basis	$82.36	77.90	102.39	86.81	97.94	113.52
Fat + casein at 22.89c per lb.						
Dividend on fat plus casein basis	$82.44	$78.31	$103.05	$87.93	$96.18	$111.29
Difference	+.08	+.41	+.66	+1.12	—1.76	—2.33
Difference for 75,000 pounds	+1.00	+5.12	+8.25	+14.00	—22.00	—27.87

of what many of the patrons delivered in from one to two weeks; for 75,000 pounds, however, which may be expected for the year, the differences are proportionately greater.

While the results in Table IX do not show a very great injustice and represent the condition in a large number of cases, nevertheless there are many exceptions and these exceptions should be included in any method of payment that can in every way be considered equitable. For the purpose of illustrating this point more clearly dividends are calculated on several milks actually found during the summer's testing, and brought together in Table X.

TABLE X.—CALCULATION OF DIVIDENDS ON FAT BASIS AND ON FAT PLUS CASEIN BASIS.

	Milks of equal fat tests.			
Patron	A	B	A	B
Pounds milk	6000	6000	6000	6000
Fat test	3.2		4.3	
Casein test	2.8	1.8	2.9	2.3
Pounds fat	192	192	258	258
Pounds casein	168	108	174	138
Pounds fat + casein	360	300	432	396
Pounds cheese	631	481	719	629
Sold at 14 cents per pound	$155.68		$188.72	
Price per pound fat	40.5 cents		36.5 cents	
Dividend on fat basis	$77.84	$77.84	$94.36	$94.36
Price per pound fat + casein	23.5 cents		32.7 cents	
Dividend on fat + casein basis	$84.92	$70.76	$98.46	$90.26
Difference	+7.08	—7.08	+4.10	—4.10
Difference for 75'000 pounds	+88.50	—88.50	+51.25	—51.25

These results show that on the fat basis both patrons would receive the same amount of money irrespective of the cheese making capacity of their milk; on the combined fat and casein basis there would be a considerable difference in the amount each would receive. By the latter method the patron would be paid for the actual cheese making value of the milk. On the fat basis, two patrons having the same fat test, would receive the same price per pound for their milk, while on the other basis the patron with the higher casein test would receive the better price

for his milk instead of being compelled to share his profits with the producer of a milk of lower power for cheese production.

The dividends given are calculated on 6000 pounds of milk. The difference found in any case would he much greater, as the amount of milk delivered at the factory in a year by most patrons tested was from 75,000 to 150,000 pounds. The calculation based on 75,000 pounds is also given in the table. While it is fair to state that such wide variations may not have continued throughout the year, nevertheless the fact remains that they did exist during the period of testing and emphasize in no uncertain way the large variation that may occur. In such cases the difference in cash receipts for one patron will pay the cost of installing and running a casein tester.

COST OF OPERATING THE CASEIN TEST

One of the chief arguments against the introduction of the casein test into cheese factories has been that the cost of operating the test was excessively high. This, however, is not the case. The machine itself is the largest item of expense. A 6-bottle machine at the present time costs $30 and a 12-bottle tester $40. But the tester should be regarded as part of the factory equipment, and not as part of the operating expenses. The testers are well built and durable, and as there are no corrosive acids to injure the bearings and other metal work the life of a casein tester would probably be as long as that of a Babcock tester, in spite of its high speed.

The reagents used are not expensive. Chloroform can be purchased for 50 cents a pound, or even less in larger quantities. One pound is sufficient for 150 tests. A quart of 10 per cent acetic acid costs 25 cents, and will make 40 quarts of 0.25 per cent acid, which is enough for nearly 1,900 tests. This makes the cost of reagents 0.35 cents for a single test.

In a factory having 30 patrons, and making casein tests twice a month, there would be 720 tests to make in a year. The cost of reagents for these tests would be $2.52. Adding the price of the tester, the total cost for the first year would be $42.59, but as a pound of chloroform and a quart of 10 per cent acetic acid are furnished with the tester, the cost for the first year would be less than $42, including the tester. This would make the cost of operation for each succeeding year about $2.50.

For a five year period, the cost of tester and chemicals would be $10.52 per year, including the first cost of the tester.

Labor, and breakage of glassware, should also be considered, as for any test. At Sheboygan Falls, during July and August, only one bottle was broken in making over 1000 tests, so that, barring carelessness, the cost for breakage would be almost nothing.

To run 30 tests it will take a cheesemaker from 1½ hours to 3 hours, depending upon the skill of the maker, and local conditions. More time might be required if the composite samples had to be warmed or cooled, but if properly cared for, very much of this extra labor would be unnecessary. Two hours would be a fair average of the time required to test the 30 samples. At $2 per day, the cost of labor would be less than $1 per month, or $12 per year. Counting reagents and labor, the cost of operating the test would be about $15 per year. Adding the initial cost of the machine, $40, the total annual cost for the five year period would be about $23 per year.

CARE OF COMPOSITE SAMPLES

Some operators have experienced difficulty in getting satisfactory Babcock tests from composite samples preserved with potassium dichromate. The fat column was either cloudy or full of black specks. This was caused either by impure sulphuric acid, or improper care of the composite samples. Cheese makers have suggested that it would be better to run two sets of composites, using dichromate for the casein tests and corrosive sublimate for the fat tests. This, however, is not necessary.

Where the composite samples are kept in plain glass bottles and allowed to stand in the sunlight, a tough leathery cream layer is formed, due to the action of light on the mixture of dichromate and milk. It is almost impossible to remix this cream with the lower layers of the milk; it is also very resistant to the action of the sulphuric acid, and this causes the black specks. Too much dichomate makes the milk hard to dissolve in the acid, but does not otherwise affect the test.

By the use of brown, or amber-colored, sample bottles, which can be obtained from the dairy supply houses, these difficulties are largely obviated. They prevent, or greatly retard, the action of the sunlight. The cream layer does not become hardened

or toughened, and consequently is easily remixed with the milk. Less preservative is also required.

The dichromate should be added in two portions, half at the beginning of the week and half after three days, thus avoiding too great a concentration at the start. An ounce (30 cc.) of milk should be taken daily. To preserve this amount, one small dichromate tablet, made expressly for the casein test, should be used at the beginning, and a second small tablet added three days later. If less milk is used, the amount of dichromate should be reduced proportionately.

Each time a portion of milk is added the bottle should be rotated to thoroughly mix its contents; this prevents the formation of a thick cream layer, and secures an equal distribution of the preservative. The bottles should never be allowed to stand in direct sunlight. If possible, they should be set in a cool place such as the curing room when not in use at the intake. If this is not practicable, they should at least be kept in a dark cupboard, or box, away from strong light.

By observing these precautions, both casein and fat tests can be made upon the same composite sample.

HOW OFTEN TO TEST.

The results of the testing carried on the past year show that where composite samples are used it will not be absolutely necessary to test every week. This would make additional labor for the cheese maker without deriving any great advantage. By running two 7-day composites a month during the first and third or second and fourth weeks very good results can be obtained. This is the method recommended. At one factory where work was conducted and where the casein test was used in paying for the milk, composite samples were collected for 14 days, in this way making two tests per month. While the results obtained by this method checked fairly well with those secured from four composites a month, there was more or less difficulty in preserving the samples for the long period, especially in the hot weather. In order to hold the samples it was frequently necessary to add so much potassium dichromate that it interfered with the accuracy of the test. This method of preserving composites is not to be recommended.

At another factory where the casein test was used, one week composite samples were collected, these being taken the first

and third weeks of the month. The average of the two monthly tests by this method checked closely with the average of the four weekly composites for the same period run by Mr. Cooper. At the same time the samples were preserved in excellent condition.

Fairly good results can be secured from one 7-day composite a month, but this method should not be used, unless it is absolutely impossible to make more than one test a month. Of course the very best way is to make a composite test every week, but this cannot always be done on account of lack of time. The frequency of testing beyond two composites per month must be left to the judgment of the cheese maker. Composite samples should never extend over more than seven days under the usual conditions. Two 7-day composites made during alternate weeks is the better arrangement. This gives an accurate test and at the same time is convenient for the cheese maker.

METHOD OF PAYMENT

In paying for milk where the casein test is operated, the plan in general use is to assign equal values to the fat and casein. Instead of making the price per pound of butter fat, as determined from the sale of cheese, the basis of payment, the price per pound of fat and casein is used. For example, with a 100 pounds of milk, testing 3.9 per cent fat and 2.5 per cent casein, the patron would be paid for 6.4 pounds of fat and casein, and not 3.9 pounds of fat. Or if the tests were 3.8 per cent fat and 2.2 per cent casein, he would be paid for 6.0 pounds of fat and casein, instead of 3.8 pounds of fat In this way each patron is paid for the cheese-making, and not butter-making value of his milk. Otherwise the method of payment is the same as on the fat basis. We do not know of any other method in vogue where the casein test is used. A relative value plan whereby the market price of the casein and butter fat would be considered in the distribution of dividends has suggested itself; where, instead of adding the full casein test to the fat test, thereby giving them equal values, only that fraction of the casein test equal to the market price of casein divided by the market price of fat would be added; for example, if butter fat is worth 21 cents and casein 7 cents per pound, then seven-twenty-firsts or one-third of the casein test would

be added to the fat test. Such a method would give the fat the advantage usually claimed for it in its influence on quality.

We doubt the feasibility of such a process for the reason that there is no evidence that the fat in normal milk controls the quality of cheese under commercial conditions. In addition it complicates matters. The method of payment adopted should be simple and easily applied. For the Cheddar cheese market, at least from the buyer's point of view, it is as objectionable to have too high fat as too low a fat content in the cheese. The one extreme makes the product pasty, while the other renders it corky. Because of this fact it is reasonable to consider the casein as important in controlling quality as the fat. As a matter of fact both bodies in a proportion defined within certain limits are necessary for the trade's standard of Cheddar cheese.

One often hears the objection raised to the equal value plan that the patron receives less per pound of fat than he would if it had been taken to a creamery. He must remember that his dividend in any case must be based on the sale of the cheese and whether he receives more cash for his milk when taken to the creamery or the cheese factory, will depend entirely upon the market price of these two products—butter and cheese. What the calculated price of butter fat will be, when it alone is figured from the cheese sales, is of no significance. It will, of course, be high when the casein is left out of the calculation, but in such a case the patron must remember that he has virtually given his casein away, for he has failed to consider it in the calculation.

From a consideration of all the facts it appears that the simplest method is to add both the fat and casein percentages together. From this figure, which represents pounds per hundred and from the price per pound of cheese solids determined from the sale of the cheese, the patron's dividend can be readily calculated.

CONCLUSIONS FROM STUDY OF TESTS

The data resulting from the testing of milk from many herds show that there is a variable content of casein in herd milks.

2. These data show that that there is no constant and close agreement in the proportional relation of the fat and casein

content of all herd milks. Consequently milks of the same fat content may not produce the same quantity of cheese.

3. In approximately 80 per cent of the 495 tests made for both fat and casein the proportional relation of the one constituent to the other was fairly constant. When the fat varied the casein varied in a proportional amount. In about 20 per cent there was no close agreement.

4. The quality of cheese made from milks of like sanitary condition and judged *by buyers for the market* was slightly but favorably influenced by increase of fat in the milk.

5. The quality of cheese made from milks produced under farm conditions and entered in competition in the Dairy Department Scoring Exhibitions stood in no direct relation to the quantity of fat in the milk from which they were manufactured.

6. For the above reasons the capacity of milks to produce cheese based on their content of both fat and casein appears to be the most equitable basis on which dividends to patrons should be distributed.

7. For approximately measuring the capacity of milk to produce cheese the Babcock fat test should be in use in every factory in the state. Although not a complete measure it is the simplest method now available.

8. For more complete measurement of the milk's capacity for cheese production the fat test should be supplemented by the Hart casein test.

9. An allowance of equal values for the pounds of fat and casein delivered by the patron, is a simple and equitable method for distributing dividends.

10. The expense of operating the casein test, details of collecting composite samples and frequency of testing are not serious difficulties to the cheesemaker if properly understood.

THE UNIVERSITY OF WISCONSIN

Agricultural Experiment Station

STATION STAFF

FARMERS' INSTITUTES

The bulletins of this Station are sent free to residents of the State. Names will be entered on the regular mailing list upon request.