NOTES ON MILK, CREAM, SKIM MILK, AND BUTTERMILK.

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THE following notes refer almost entirely to work done in the laboratory of the Aylesbury Dairy Company. As I have done in the previous two years, I should like, in the first place, to give you a summary of the work done, and the chief results arrived at, during the year 1883. No essential alterations have taken place, either in the controlling system carried out, or in the analytical methods employed, and as I have dwelt upon these points at some length in my former reports (*THE ANALYST*, April, 1882, and March, 1883), I shall speak rather briefly with regard to this part of my present paper.

I. The work done in the laboratory of the Aylesbury Dairy Company during the year 1883.

The total number of analyses made in 1883 is 15,005, against 8,817 in 1881, and 12,430 in 1882. This total comprises in round figures 14,000 milk samples, and 850 cream samples, the rest being made up by analyses of skim milk, buttermilk, butter, and some others.

Of all the milk samples analysed, 9,650 were taken on the arrival of the milk in the company's dairy, and before it was sent out. The monthly averages of these analyses are given in the following table:—

TABLE I.
Monthly Averages of Milk Analyses.

1883.		Spec. grav.	Total solids.	Fat.	Solids not fat.
January	..	1·0320	.. 12·94	.. 3·63	.. 9·31
February	..	1·0320	.. 12·89	.. 3·57	.. 9·32
March	..	1·0319	.. 12·83	.. 3·46	.. 9·37
April	..	1·0320	.. 12·69	.. 3·32	.. 9·37
May	..	1·0322	.. 12·74	.. 3·26	.. 9·48
June	..	1·0324	.. 12·67	.. 3·28	.. 9·39
July	..	1·0320	.. 12·77	.. 3·41	.. 9·36
August	..	1·0319	.. 12·91	.. 3·48	.. 9·43
September	..	1·0326	.. 13·19	.. 3·55	.. 9·64
October	..	1·0329	.. 13·34	.. 3·63	.. 9·71
November	..	1·0326	.. 13·41	.. 3·74	.. 9·67
December	..	1·0325	.. 13·20	.. 3·67	.. 9·53
Yearly average		1·0323	.. 12·97	.. 3·50	.. 9·47

The average composition of the milk received in 1883 was, practically speaking, the same as in the previous year, the corresponding figures for 1882 being :—Spec. grav., 1·0319; total solids, 13·03; fat, 3·52; solids not fat, 9·51.

The specific gravity falls almost without exception between 1·030 and 1·034; in proportionately very few instances the total solids were below 12 per cent., the fat below 3 per cent., and the solids not fat, below 9 per cent.

There were 4,130 milk samples analysed, which had been taken by the company's own inspectors from the men, when working their rounds. The result of these analyses in almost every instance closely resembled those obtained by analysing the samples previously mentioned, proving that the latter had been properly taken, and that there occur

in very exceptionable cases only noticeable changes during the distribution of the milk, a work occupying from three to four hours. I had the averages drawn, of all the analyses of samples taken by the inspectors for the months of January, February, and March. They were found to be as follows:—

	Total solids.	Fat.	Solids not fat.	Total solids.	Fat.	Solids not fat.
January	.. 12·84 ..	3·50 ..	9·34 against ..	12·94 ..	3·63 ..	9·31 as given
February	.. 12·79 ..	3·41 ..	9·38 ,, ..	12·89 ..	3·57 ..	9·32 in
March	.. 12·75 ..	3·31 ..	9·44 ,, ..	12·83 ..	3·46 ..	9·37 Table I.

There are, however, exceptions to this rule, and you will remember that I brought such an exceptional case under your notice some time ago (*THE ANALYST*, January, 1883). To-day I am in a position to record a similar case. The milk, from a certain farm, was sent out with the morning delivery, having been well mixed previously. Its composition was then:—Total solids, 12·4; fat, 3·8; solids not fat, 9·1. A sample taken in the street by one of the company's inspectors at 7·10 o'clock contained:—Total solids, 11·3; fat, 2·2; solids, n. f., 9·1. On the following day the milk from the same farm, before being sent out, was of the following composition:—Total solids, 12·2; fat, 3·2; sol. n. f., 9·0; and a sample taken on the round at 7·20 o'clock contained:—Total solids, 11·2; fat, 2·1; sol. n. f., 9·1. When put aside in a cremometer this milk threw up quite a distinct layer of cream within the unusually short time of half an hour. The milk was not sent out any longer, but used for the production of cream.

The control over the cream, partly received from farmers, partly separated by centrifugal power in the company's own creameries, was much more extended during the last year. 530 samples of cream have been analysed after the same had been received in the dairy. The monthly averages of these analyses are given in Table II.

TABLE II.
Monthly Averages of Cream Analyses.

1883.	Tot. Solids	Fat.	Solids n. f.
January	39·8 ..	32·8 ..	7·0
February	41·6 ..	34·7 ..	6·9
March	39·8 ..	32·8 ..	7·0
April	41·7 ..	34·9 ..	6·8
May	44·6 ..	38·1 ..	6·5
June	46·8 ..	40·5 ..	6·3
July	44·2 ..	37·6 ..	6·6
August	47·4 ..	41·1 ..	
September	42·9 ..	36·2 ..	
October	40·4 ..		
November	39·2 ..		
December	38·9 ..		

Yearly Average

These figures include the analyses of containing less fat, than the cream samples were analysed, and the fat was found

So much about the general points.

II. MILK.

I have pointed out several times, that I think a great deal of taking the specific gravity of milk samples to be tested. In fact it is a test in itself, as it may be taken for granted that the specific gravity of dairy milk, *i.e.*, the mixed yield of not less than five cows in normal condition, always falls within the limits of 1.029 and 1.034. If ascertained by means of a lactometer, *i.e.*, a hydrometer with a short scale specially adapted to the purpose, the specific gravity of milk is found with the least possible amount of trouble and in the shortest time. It is true, that the specific gravity of milk is lowered down, not by the addition of water only, but that an abundance of cream has quite the same effect; but certainly very little experience is wanted, to distinguish between a super-rich and a watered milk. On the other hand, a normal specific gravity does not prove that the milk has not been tampered with; it may be, moreover, adulterated in two directions, skimmed and watered. That would be easily found out by knowing, besides the specific gravity, one item regarding the composition, the amount of total solids or of fat present. With regard to the latter, we have methods, which give very reliable results in the short time of fifteen or thirty minutes, and in fact this time suffices, to form a pretty correct opinion on any given sample of milk.

This is altered directly, when the milk has turned sour. Taking the specific gravity by means of the lactometer is rendered impossible, and the employment of the specific gravity bottle or the Sprengel's tube is, to say the least, in this case troublesome and time-taking. Again, taking proper samples for analytical determinations has become more difficult; in short, nobody would be prepared to pass an opinion on such a sample in so short a time as in the case of an undecomposed milk. As it is a very easy thing to separate the whey from sour milk, I thought it worth while to try, whether the whey, or more precisely speaking, the specific gravity of whey from sour milk, might be of some use in deciding the questions, whether the corresponding milk had been watered or not.

In the first place it was necessary to find out the normal specific gravity of whey obtained from sour milk. For that purpose one half pint of milk, contained in a tin can, was kept in the laboratory until it had become thick; this generally set in, after two days had elapsed. I may remark, that the experiments were carried out during the warmer time of the year. When the milk was coagulated, the tight fitting lid of the can was shut in hot water of about 150° F. until separation of the whey had taken place. The whey was then filtered off and its specific gravity ascertained.

Bringing the temperature to a certain point, four or five degrees below the normal, with a view to determine the influence of temperature on the specific gravity, it was found, that for every degree increase in temperature the specific gravity increases as much as 0.00017. A difference at least of 0.0005 is necessary. All the following statements refer

to samples of milk treated in the manner described before. The specific gravity varies from 1.0280 to 1.0302. Notwithstanding this variation, no error arises from a deficiency. All the milk

operated upon was rather rich, the total solids running up as high as 14·38 per cent, and in one single case only coming down below 12·5 per cent.; the specific gravity varied from 1·034 to 1·032.

I cannot say, that in every instance a variation in the specific gravity of the milk is reflected in the specific gravity of the corresponding whey; on the whole, however, it was found, that there exists some relation between the two specific gravities. Whenever the specific gravity of the milk is 1·033 or higher, the specific gravity of the whey is found to be on the average above 1·029, and a specific gravity of milk from 1·032 to 1·033 corresponds with a specific gravity of the whey of from 1·0285 to 1·0290. Continuing this, one may expect that in case the specific gravity of milk comes down to 1·030, that of the whey will be 1·028, but the latter will certainly not fall below 1·027.

Of course, the length of time the milk or whey has been kept, or more precisely the progress of the alcoholic fermentation, must influence the specific gravity as well. This influence was investigated into, side by side, with the influence of the addition of different quantities of water to the milk. Three series of experiments were carried out, all in the same manner, with the only exception that in two of them skim milk, in the third one whole milk, was employed. In each series the following six samples were operated upon :—

1. Milk, casein precipitated with acetic acid.
2. „ without any addition.
3. „ containing 5 per cent. of added water.
4. „ „ 10 „ „
5. „ „ 25 „ „
6. „ „ 25 „ „ casein precipitated with
acetic acid.

After the milk had become sour and the casein coagulated, the whey was separated as described before, and the specific gravity of the whey thus obtained, determined several times during a fortnight's time. The following table contains the average figures of the three series :—

TABLE III.
Specific Gravity of Whey.

Sample	Determined on				
	1st Day	3rd Day	5th Day	8th Day	14th Day
1.	1·0305	1·0304	1·0301	1·0301	1·0261
2.	..	1·0295	1·0294	1·0291	1·0260
3.	..	1·0284	1·0283	1·0274	..
4.	..	1·0269	1·0265	1·0256	..
5.	..	1·0222	1·0219	1·0218	1·0181
6.	1·0230	1·0228	1·0226	1·0228	..

To point out the most important facts only, shown by these figures, we find that the alcoholic fermentation proceeds rather slowly during the first week, but influences the specific gravity of whey considerably after a second week has elapsed. The presence even of the very small quantity of acetic acid seems to have the effect of retarding alcoholic fermentation. The addition of water to the milk is shown distinctly by the specific gravity of the whey. It is true, that an addition of 5, and even of 10 per cent. of water does not in every case bring the specific gravity of whey down under the

supposed limit of 1.027. But this fact cannot surprise, for we all know very well, that employing even the most elaborate and exact process of analysis we may be unable to condemn a milk which has been watered to the same extent.

I believe, that taking the specific gravity of whey obtained from sour milk may be useful in some case or other, and permit us to form an opinion on the milk concerned, especially so, when particulars are known as to how and how long the milk had been kept.

III. CREAM.

Milk, if left standing quietly for some time, throws up a layer, which differs from the original milk chiefly by its richness in fat, and which is called cream. Everybody knows that, and we know very little more. I should be quite at a loss what to say if the simple question were put to me: "How much fat must be present in milk so as to say that a sample of milk is cream?" I have seen so-called cream containing scarcely more fat than a good rich milk, and on the other hand, products containing almost as much fat as butter.

The value of cream, as far as composition is concerned, depends chiefly, not to say entirely, upon the quantity of fat present. As with the increase of fat the specific gravity must decrease, it should be possible to make a rough estimation of the fat in cream by ascertaining the specific gravity. But cream gets with the increasing degree of concentration thicker and thicker, and taking the specific gravity becomes troublesome, and the use of an hydrometer impossible. If the cream is not sour, one may restore a higher degree of fluidity by heating it up, and I have made some experiments with a view to ascertain the influence of variations in the temperature and in the quantity of fat upon the specific gravity.

I found that pure sweet cream, containing 40 per cent. of fat shows at a temperature of 175° F., a specific gravity of 0.960, and that a difference in the temperature of 10° F causes a difference of 0.004 in the specific gravity, and further, that a difference of 10 per cent. in the amount of fat is equal to a difference of 0.015 in the specific gravity; thus, the specific gravity of cream is as follows:—

Cream with	30	40	50 per cent. of fat.
at 185° F.	0.971	0.956	0.941
„ 175 „	0.975	0.960	0.945
„ 165 „	0.979	0.964	0.949

I should like to be clearly understood that I bring these figures before you simply as a contribution to our knowledge of cream, and not as a general method for testing the same. It may be useful under certain circumstances to take the specific gravity in this manner, but certainly not in the chemical laboratory.

Of course, the most exact way to ascertain the fat is extracting it in Soxhlet's apparatus. It may, however, happen that an indirect estimation is preferred to the direct one. There is, for instance, no doubt that in a certain time one can make more determinations of total solids than of fat; the former are less troublesome, and besides, less costly.

We have said before, that cream differs from milk chiefly by the increased amount of fat present. That is true, but is not the whole truth. The fat globules of milk are floating in the serum, and the latter, where it envelopes the globules, is more concentrated; it contains the albuminoids in a higher proportion. Supposing a milk contains 3 per cent. of fat and 97 per cent. of serum, the latter consisting of 9 per cent. of non-fatty solids, and 88 per cent. of water; 100 parts of serum would contain then 9·28 parts of non-fatty solids. If cream, containing 50 per cent. of fat, would be separated from this milk, the 50 parts of serum would not contain one-half of 9·28, that is, 4·64 parts of non-fatty solids, but about 1 part more. Basing upon this speculation, I have drawn up a table for the calculation of fat in cream from the total solids, of which I give you here a limited number of figures:—

TABLE IV.
Calculation of Fat in Cream from Total Solids.

Found Total solids.			Fat. Calculated			Solids not fat.
60·0	..	..	55·0	..	..	5·0
55·0	..	..	49·5	..	..	5·5
50·0	..	..	44·0	..	..	6·0
45·0	..	..	38·5	..	..	6·5
40·0	..	..	33·0	..	..	7·0
35·0	..	..	27·5	..	..	7·5
30·0	..	..	22·0	..	..	8·0
25·0	..	..	16·5	..	..	8·5
20·0	..	..	11·0	..	..	9·0

In order to ascertain how far this table agrees with actual facts, a series of cream samples—22 altogether—were analysed, and the results obtained compared with the figures of the table. The total solids were determined by keeping about 3 grams of cream in a platinum capsule for six hours on a steam bath, and for other six hours in a hot air bath, at a temperature of from 205 to 215° F. To determine the fat, about 5 grams of cream were mixed with plaster of Paris, brought to dryness, the dry powder put in a paper capsule and exhausted in Soxhlet's apparatus. The results are given in the following table:—

TABLE V.
Analyses of Cream.

No	Total solids.	Found.	Fat.	Calculated.	Difference.
1	.. 40·9	..	34·1	.. 34·0	.. — 0·1
2	.. 48·0	..	41·0	.. 41·8	.. + 0·8
3	.. 59·9	..	55·2	.. 54·9	.. — 0·3
4	.. 33·8	..	25·5	.. 26·2	.. + 0·7
5	.. 31·4	..	24·0	.. 23·5	.. — 0·5
6	.. 60·6	..	56·8	.. 55·7	.. — 1·1
7	.. 47·1	..	40·4	.. 40·8	.. + 0·4
8	.. 63·4	..	58·8	.. 58·7	.. — 0·1
9	.. 26·1	..	18·1	.. 17·7	.. — 0·4
10	.. 42·9	..	35·9	.. 36·2	.. + 0·3
11	.. 65·5	..	60·9	.. 61·1	.. + 0·2
12	.. 47·1	..	40·4	.. 40·8	.. + 0·4
13	.. 63·4	..	58·8	.. 58·7	.. — 0·1
14	.. 30·7	..	22·8	.. 22·8	.. 0·0
15	.. 36·6	..	29·5	.. 29·3	.. — 0·2
16	.. 45·7	..	37·5	.. 39·3	.. + 1·8
17	.. 38·6	..	31·2	.. 31·5	.. + 0·3
18	.. 57·8	..	52·3	.. 52·6	.. + 0·3
19	.. 39·0	..	32·2	.. 31·9	.. — 0·3
20	.. 46·7	..	40·1	.. 40·4	.. + 0·3
21	.. 37·2	..	29·9	.. 29·9	.. 0·0
22	.. 46·8	..	40·0	.. 40·5	.. + 0·5
Average	45·87	..	39·34	.. 39·47	.. + 0·13

With the two exceptions—No. 6 and 16—in which the difference amounts to -1.1 and $+1.8$, the figures for fat found and calculated agree fairly well, certainly well enough to permit the application of this method, whenever not the exact analysis, but the control of cream, is the object. As there was no time to make the analyses in duplicate, I am unable to say what errors were made in the cases of No. 6 and 16. That the large differences in these cases are due to errors, I am fully convinced, but in spite of this I did not like to omit the figures from the table. The average will scarcely be altered.

IV. SKIM MILK.

The cream having been removed from milk, the remaining skim milk still contains some fat besides the greater part of all the other constituents of milk. As the nutritious value of the albuminoids and carbohydrates in milk in connection with the mineral salts present is very great, pure skim milk is to be considered a very good and wholesome food or addition to food for man and beast.

The quantity of fat left in the skim milk chiefly depends upon the method employed for separating the cream. This used to be done until eight years ago exclusively by leaving the milk standing quietly in vessels of different shape, size and material, and under different conditions according to the special requirements of the different setting systems for raising cream. One can bring these systems under two heads, viz., the shallow setting system with the application of a mean temperature of 55°F. , and the deep setting system with the application of a temperature as near as possible to freezing point.

Eight years ago a new method of separating cream from milk was brought out, and has developed itself rapidly, and during the short time of a few years superseded and replaced already the old setting system in very many instances. I refer to the method of extracting cream by centrifugal power in machines commonly called cream separators.

Of course the quantity of fat left in skim milk depends, not entirely upon the system in use, but upon numerous other conditions as well. One may, however, safely say that skim milk, if one of the setting systems is employed, contains on an average from 0.8 to 1.0 per cent. of fat, in very many instances more and in very exceptional cases less than 0.5 per cent., and that if a cream separator is used, the skim milk should never contain more than 0.5 per cent. of fat. According to reliable analyses the fat has been extracted from milk by centrifugal power to such an extent, that less than 0.1 per cent. was left in the skim milk, but to extract even the last trace of fat by these means has been impossible up to the present and will always be an impossibility. The separation of cream is based in every instance on the difference in the specific gravity between fat globules and milk serum in which they are floating. This difference becomes less and less with the decrease in the size of the globules, and at last is counterbalanced by the adhering envelope of condensed serum, of which we have spoken in another place.

As the alteration caused by separating the cream chiefly concerns the fat, *i.e.*, the lightest constituent, we must expect the specific gravity of skim milk to be higher than that of whole milk. This is confirmed by the fact that the specific gravity of skim milk varies from 1.033 to 1.037, or in other words, the specific gravity of skim milk is 0.003 higher in average than that of whole milk.

As to the determination of fat in skim milk Soxhlet's areometric method should be employed, or the fat extracted in the well-known apparatus brought out by the same chemist. For the use of the said apparatus Soxhlet gives the following directions:— 10 grams of milk mixed in a porcelain dish with 20 grams of plaster of Paris are to be dried on the steam bath. The dry powder is filled into a paper capsule and extracted. After the apparatus has been filled and emptied itself ten times the extraction of the fat is completed. If whole milk or relatively rich skim milk is analysed, sea sand or glass powder may be used instead of plaster of Paris. But whenever the fat present amounts to less than 1·5 per cent., one should stick to the original directions and use plaster of Paris, if possible, not double but three or four times the quantity of milk taken, as in this way only a speedy and complete exhaustion can be secured.

The following table contains some analyses of skim milk:—

TABLE VI.

Analyses of Skim Milk.

No.	Spec. Grav.	Tot. Solids.	Fat.	Sol. n. fat.	Remarks.
1	1·0350	9·75	0·55	9·20	Shallow setting system.
2	1·0355	9·90	0·54	9·36	
3	1·0340	10·10	1·00	9·10	
4	1·0355	10·43	0·98	9·45	
5	1·0335	9·68	1·05	8·63	Deep setting system.
6	1·0345	9·70	0·60	9·10	
7	1·0355	9·81	0·43	9·38	
8	1·0350	10·26	0·88	9·38	
9	1·0365	9·96	0·46	9·50	Centrifugal system.
10	1·0350	9·28	0·34	8·94	
11	1·0370	9·94	0·34	9·60	
12	1·0370	9·80	0·35	9·45	

V. BUTTERMILK.

Buttermilk is extensively used as food for domestic animals, and in some rural districts also as diet for the population. As it is not an article of trade it will in very exceptional cases only form the object of chemical analysis in the laboratory of the public analyst. The money value of buttermilk is, in spite of its highly nutritious qualities, too low to tempt adulteration. Being a sort of bye-product in making butter, one must not expect much fat in buttermilk. The quantity of fat is generally above 0·5 per cent., but does not rise above 1·0 per cent., unless the operation of churning is not properly executed. Whenever it has been tried to churn sweet milk very unsatisfactory results were obtained, about half of the fat being left in the buttermilk; sour milk, as well as sweet or sour cream, form the right material for making butter. Of course the differences in the material influence the composition of the buttermilk to some extent, but other conditions have a far greater influence. During the warm season very often some salt is added to the cream in order to preserve it, and this appears again in the buttermilk. Again, when the butter has been collected it is washed with cold water. This water is generally mixed with the buttermilk, diluting the latter more or less. Some analyses of buttermilk will illustrate these few remarks.

TABLE VII.

Analyses of Buttermilk.

No.	Total Solids.		Fat.	Solids not fat.		Ash.
1	..	9.77	..	1.09	..	8.68
2	..	9.03	..	0.63	..	8.40
3	..	10.39	..	0.78	..	9.61
4	..	8.02	..	0.65	..	7.37
5	..	9.64	..	2.51	..	7.13
6	..	8.13	..	0.82	..	7.31
7	..	10.14	..	0.92	..	9.22
8	..	8.91	..	0.50	..	8.41
9	..	8.98	..	0.49	..	8.49
10	..	10.70	..	0.54	..	10.16
11	..	9.80	..	0.76	..	9.04
12	..	9.72	..	0.80	..	8.92