

THE ESTIMATION OF MILK-SUGAR IN MILK.

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WE have been in the habit of estimating the milk-sugar in milk by the method described by Vieth (*ANALYST*, xiii. 63); this is a slight modification of that worked out by Wiley (*Amer. Chem. Jour.*, vi., 289), and the novelty in it consisted of the making of corrections for volume of fat, etc.

Vieth's method of calculation is founded on the following assumptions: (*a*) That the volume of proteids in 100 c.c. is 3.0 c.c.; (*b*) that the volume of fat in 100 c.c. is the percentage of fat divided by .93.

This last assumption is not strictly correct, the volume of fat being the percentage of fat multiplied by the specific gravity of the milk and divided by .93, but the error is very small. It is usually sufficient to multiply the percentage of fat by 1.11 to obtain the volume in 100 c.c. of milk.

Wiley and Ewell have recently published (*ANALYST*, xxi., 182) a method for the estimation of milk-sugar in milk by double dilution and polarization; they make up 65.82 grammes of milk to 100 c.c. and 200 c.c. respectively, precipitate with acid mercuric nitrate and polarize the filtrates.

If *a* equal the reading from the 100 c.c. solution, and *b* the reading from the 200 c.c. solution, the correct reading will be $\frac{ab}{a-b}$ and the volume of the precipitate $\frac{100(a-2b)}{a-b}$.

A series of thirteen experiments to prove the correctness of the method is given, and the volume of the precipitate is calculated in each case; from the series it is concluded that "this correction is less in quantity than the combined volume of the fat and albuminoids." It appears, however, on recalculation of their figures, that the volume of the precipitate is wrongly calculated, the formula $\frac{100(a-2b)}{b}$ having been apparently used instead of the correct one given in their paper, and reproduced above.

In the table opposite Wiley and Ewell's figures are reproduced, the volumes of the precipitate being calculated by the correct formula; the volume of the precipitate is also calculated by Vieth's method.

It is seen that, though the average of the two methods agrees well, there is a fairly wide divergence between individual results. A comparison of the polarimetric figures of Nos. 1 and 9 will demonstrate that this divergence is chiefly due to the large experimental error of Wiley and Ewell's method. In these two it happens that the polarization in the 100 c.c. flask is the same, while the polarization in the 200 c.c. flask differs only by .07, which is within the limits of reading; this difference of polarization makes 1.5 c.c. difference in the volume of proteids. It also makes a difference of .07 per cent. in the percentage of milk-sugar, while, had Vieth's method been used, a difference of .07° would make a difference of less than .02 per cent. To obtain the accuracy recorded, Wiley and Ewell found it necessary to use a very

No.	Per cent. Fat.	Polarization in 200 c.c. Flask.	Polarization in 100 c.c. Flask.	Calculated Volume of Precipitate.	Vieth's Method Volume of Precipitate.	Differ- ence.
1.	—	9.37	19.26	5.3	5.4	5.0*
2.	—	9.59	20.33	10.7		
3.	—	9.36	19.20	4.9	5.1	5.0*
4.	—	9.60	20.25	10.0		
5.	2.9	10.15	20.84	5.1	4.0	- 1.1
6.	4.8	10.31	21.21	5.4	5.3	- 0.1
7.	3.1	9.49	19.41	4.3	4.1	- 0.2
8.	4.0	10.01	20.45	4.1	4.7	+ 0.6
9.	1.4	9.44	19.26	3.9	2.9	- 1.0
10.	5.5	11.05	22.68	5.0	5.8	+ 0.8
11.	4.4	9.57	19.47	3.3	5.0	+ 1.7
12.	2.0	9.75	19.93	4.2	3.3	- 0.9
13.	17.6	8.72	19.13	16.2	14.4	- 1.8
Mean		...	...	...	5.7	5.5

delicate polariscope with tubes 400 m.m. long ; with a less delicate polariscope and shorter tubes, the experimental error would be correspondingly magnified.

We can only conclude that this method is practically useless, on account of the large experimental error, the waste of time, and large amount of sample required.

The only objection to Vieth's method is that it is necessary to make a calculation for each sample, which, when several determinations are made at once, is apt to become tedious. To dispense with the calculation, we propose to add to each 100 c.c. of milk :

(a) Three c.c. of acid mercuric nitrate to compensate for the volume of the proteids.

(b) (Fat + 1.11) c.c. to compensate for the volume of the fat.

(c) One-tenth of the degrees of specific gravity.

(d) A sufficient volume to reduce scale readings to percentages of milk-sugar.

With the instrument we use [the Mitscherlich half-shadow polariscope, described by Vieth (*ANALYST*, xi. 141)], d is 10.0 c.c. to 100 c.c. of milk ; it may be calculated for other instruments by the formula $\left(\frac{55.3 K \times l}{100} - 100\right) \times S$ where K = factor necessary to convert angular degrees into scale readings, l = length of tube used, and S = specific gravity of the milk (which may be taken as 1.032 without appreciable error).

If the fat was 3.7, and the specific gravity was 1.0325, then $3 + 4.1 + 3.25 + 10 = 20.35$ c.c. must be added to 100 c.c. of milk, or 10.17 c.c. to 50 c.c.

We have noticed the fact pointed out by Wiley and Ewell, that the stronger mercuric nitrate solution prescribed by Wiley is liable to discolour the proteids, but we cannot agree with them that it is the xantho-protein reaction ; it is more properly described as Millon's reaction. We find it advantageous, however, to use their weaker solution, and add 15 c.c. of this to 100 c.c. of milk, making up the bulk with water.

* These figures are volumes of sand actually added.

A few test analyses are appended to show that accurate results can be obtained by dilution to obtain direct readings.

Obs.	Sp. Gr.	Fat.	Dilution.	Direct	Dilute	Milk Sugar.		Volume of Precipitate.	
				Polarimetric	Reading.	Veith.	Wiley and Ewell.*	Veith.	Wiley and Ewell.*
R.	1.0305	4.50	121.0	4.93	4.17	4.15	3.94	8.0	2.9
B.	"	"	"	4.95	4.21	4.16	3.79	8.0	—9
R.	1.0340	3.60	120.4	5.85	4.93	4.92	5.07	7.0	9.7
B.	"	"	"	5.88	4.89	4.95	5.48	7.0	16.0
R.	1.0300	4.60	121.1	4.82	4.06	4.05	4.21	8.1	11.6
B.	"	"	"	4.80	4.08	4.04	3.73	8.1	4
Average				5.205	4.39	4.38	4.37	7.7	6.6

We have also experimented with the action of various preservatives added to milk in the proportion of 1 gramme per 100 c.c. (except in the case of formalin where 2 c.c. were accidentally added); the samples were allowed to stand a week in an incubator at 25°.

				Polarization.
Original milk	...	...	...	5.63°
1 c.c. Chloroform per 100 c.c.	...	...	...	5.61°
1 gr. Borax per 100 c.c.	...	...	...	5.50°
2 c.c. Formalin per 100 c.c.	...	...	...	5.62° (corrected for dilution).
1 gr. Salicylic acid per 100 c.c.	...	...	...	5.61°
1 gr. Mercuric chloride per 100 c.c.	...	...	...	5.59°

With the exception of borax, it is seen that all the preservatives prevented any change.

DISCUSSION.

The PRESIDENT (Dr. Dyer) said that among the many valuable papers in the old volumes of THE ANALYST a very prominent place must be given to those which emanated from the laboratory of the Aylesbury Dairy Company in the days of their old friend Dr. Vieth, and it was very pleasurable year by year to find Mr. Richmond carrying on this work, and bringing before the Society the results of his very large experience.

One little point which he noticed in the first paper was the high proportion of ash in two of the abnormal samples of milk. His own experience, and probably that of many others, showed that, when milk gave an abnormally low percentage of total solids, the ash was usually high, at once pointing out the abnormality of the samples, so that they were not easily confused with watered samples.

He was much interested in Mr. Richmond's remarks with regard to the nitrogen in decomposed samples, because he had lately heard from another member of the Society (Mr. Smetham, of Liverpool) that that gentleman had been making a somewhat extensive series of experiments on the value of the nitrogen factor in dealing with decomposed milks. He had not seen all Mr. Smetham's figures, but as far as

* We have, by calculating from our own figures, exaggerated the errors of Wiley and Ewell's method; roughly speaking, we have about doubled the experimental error.

the results had gone some time ago, Mr. Smetham had found that the nitrogen remained remarkably constant. It might be converted into different nitrogenous compounds, but it stayed in the milk, and did not seem to be lost in the form of free nitrogen. He thought that Mr. Smetham would have some results shortly to bring before the Society on this subject.

With regard to sterilized milk, he did not know whether it was suggested by Mr. Richmond that the presence of sterilized milk in ordinary milk was a thing to be deprecated, or regarded as an adulteration. Sterilized milk was generally considered to be a valuable article. It would probably be more interesting to the public to be able to detect the presence of unsterilized milk in milk that was supposed to be sterilized, but to this one would take a shorter cut by making a bacteriological examination.

Mr. ALLEN observed that the multitude of figures which had been placed upon the blackboard, and which, after all, only represented a fraction of the results actually obtained, was a sufficient indication of the vast amount of work the authors of these papers had got through; and as a Society, they were very much indebted to Mr. Richmond and Mr. Boseley for laying before them these results, which had now become a very welcome annual institution, the absence of which would be greatly missed. It was interesting to learn that Dr. Vieth's method for the determination of milk-sugar was able to hold its own with more recent modifications of the process. He had a high opinion of Wiley and Ewell's method; but if the use of a specially delicate polarimeter was essential, it militated greatly against the employment of the method in practice.

Dr. EDMUNDS raised the question whether sterilized milk, and, in fact, all sterilized foods, did not lose some of their vitalizing properties, especially for young children.

Dr. RIDEAL said that he was about to make a similar remark to that made by Dr. Edmunds. He usually lived in the country, but for the last two or three months he had resided in town. It was hardly a chemical matter, but in the country they were in the habit of keeping the milk overnight for the cream to rise. On coming up to London, however, the milk was supplied by a dairy company, and it was found that the cream of this London milk would not rise on standing, which seemed to point to the fact that the mixed milk had not the property of rising as pointed out in the paper. He thought that a consumer buying milk should reasonably expect it to throw the normal amount of cream on standing.

He did not think that either sterilized milk or humanized sterilized milk had the same value as unsterilized milk, which was probably due to the fact that the ferments present had lost their activity. He had been trying humanized milk from the same firm for a week or two, with results that were not satisfactory, but which were improved by the addition of a small quantity of unsterilized cow's milk, which probably supplied the missing ferment, if such were necessary, without materially altering the composition.

With regard to sour milks, he thought that the points referred to by Mr. Richmond ought to be made widely known, as they indicated an easy method of

ascertaining with certainty the composition of sour-milk samples. If a Lister-Babcock machine was used for determining the fat, a Kjeldahl determination could possibly be made on a fair average sample taken from the comparatively large quantity in the machine.

Mr. HEHNER said that the remarks of Dr. Edmunds and Dr. Rideal, which raised some doubt as to the food value of sterilized milk, had a serious aspect in view of sanitary considerations. If there were not any very strong evidence that by sterilization some material damage was done to milk, such statements might do unintentional harm. There was no chemical or physiological evidence whatever, as far as he was aware, that milk did contain any ferment necessary to digestion.

Mr. Richmond had omitted to mention the fact that calcium citrate was deposited from milk on boiling. In condensed unsweetened milks, a notable sediment of citrate existed; and this deposition might perhaps be another means of distinguishing boiled from raw milk. The change in the rate at which the cream rose was a very interesting fact. Whatever the explanation might be, it seemed to him that the viscosity of the milk had become altered. He had thought of using the viscosity of the milk as a rapid means of dairy analysis; but Mr. Richmond's results seemed to show that this would not be possible, except, perhaps, in the case of milks which it was certain had not been boiled. There were, other things being equal, two factors influencing the viscosity of milk—namely, the amount and size of the fat globules, and the amount of solids-not-fat. If the specific gravity and the viscosity, as measured by the rapidity of the flow through a narrow orifice, were determined, which could be done in a minute or two, some useful data might probably be obtained.

Mr. C. G. MOOR, with reference to the question of the adulteration of ordinary milk with unsweetened condensed milk, remarked that there was only one brand of unsweetened condensed milk sold in London to any extent, which was of Italian manufacture, and contained much less fat than it should if made from whole milk, and it contained a large addition of borax or boric acid.

Mr. BEVAN remarked that Mr. Richmond had mentioned only three abnormal samples, and desired to know whether they were the only ones he had met with during the year. He was interested in the President's remarks as to the ash, which showed the very great importance of always determining this, and being guided by it in forming an opinion. With regard to the nitrate test, he had been under the impression that Mr. Richmond had some time ago made experiments in this connection, and had found that nitrates might find their way through the medium of food into the milk in a perfectly normal manner.

Mr. RICHMOND said that the detection of diluted condensed milk in ordinary milk had been considered of such importance by the British Dairy Farmers' Association, that some years ago that Association had offered a gold medal for the publication of a method. Within the time during which the offer held good no method was discovered, but Mr. Faber had since brought out an excellent, and perhaps the best, method. He (Mr. Richmond) and his colleague had also studied the subject, and they thought it might still have sufficient importance to be worthy of consideration. Some years ago he (Mr. Richmond) had read a paper on the discrimination between abnormal and adulterated milks, in which he pointed out that a high ash was charac-

teristic of abnormal milks, and it afforded him much gratification that this was confirmed, as it had been, by the President and by Mr. Bevan. He might say that these three abnormal samples were the only ones that had come under his notice during the year. The question raised by Dr. Edmunds of the physiological effect which sterilization had upon milk was one of extreme importance, and one upon which it was hard to get reliable evidence. The opinions held and positive evidence adduced by medical men on this question were often absolutely contradictory; it was not one, however, which fell within the province of analysts. With regard to Dr. Rideal's remarks on the difference between country and London milk in the matter of the rising of the cream, it certainly was a widely-known fact that milk taken warm from the cow, and set immediately, gave more cream than if it were cooled down to a sufficiently low temperature to keep it for some hours, and not only was the quantity of cream larger, but the cream itself was much thicker. There had been one ferment described as present in milk, namely, the galactozymose of Béchamp, but this observer was the only person who had met with it, and his observations had not yet received confirmation. They had purposely omitted any mention of calcium citrate. They had thought of making some remarks on this subject, but on considering the matter, and making experiments in connection with the estimation of citrates, they found that it was not an easy thing to do, and were unable to get any results of real value, so they thought it best not to fill the paper with points that could only be just touched upon. With regard to the viscosity of milk, he did not think that this factor was likely to be of much use for analytical purposes, as it involved calculations of an extremely complicated character. The viscosity of milk was due to, first, the internal friction of the molecules of the aqueous portion, and, second, to the friction between the fat globules and the serum, and very small variations of conditions might and did affect the ratio of the separate effects of friction.

The PRESIDENT said that the Society's thanks were due to Mr. Richmond and Mr. Boseley for these papers. Even if there did not appear to be any immediate practical object in detecting the presence of sterilized milk, the results obtained were none the less interesting and valuable. The Society was a technical, but not altogether a utilitarian, Society, and always valued facts. Besides, even though the practical application of such facts might not be immediately apparent, there was always the possibility that they might ultimately prove useful.
