

A NEW METHOD OF ASCERTAINING THE AMOUNT OF FAT IN MILK.

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AN apparatus which would render possible an easy, quick and exact determination of the amount of butterfat in milk, has for many years been a desideratum, but all attempts to construct such an apparatus have till quite recently proved unsuccessful.

The simplest way of estimating the amount of fat, which nature itself seems to suggest, is to let the cream rise and notice its volume. This method, which is extensively used by practical men, is however very unreliable, as there is no constant relation between the volume of cream thrown and the percentage of pure fat. An attempt has been made to improve this method by dissolving the fat in ether, as in the Marchand's Lactobutyrometer, but sufficient accuracy can hardly be obtained in this way. The best apparatus, so far as accuracy is concerned, is undoubtedly Professor Soxhlet's aerometrical apparatus, by which the specific gravity of an ethereal solution of the fat is taken, the solution being made according to a given method and the gravity taken at a fixed temperature. A certain sp. gr. then corresponds to a certain amount of fat in the

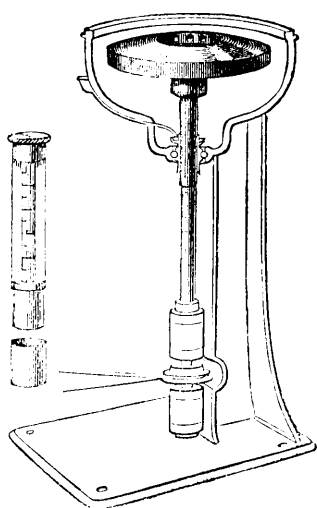
milk, but it may reasonably be objected to this method that it is rather costly, and that such a delicate instrument could not well be worked by a practical dairyman.

As far back as 1859, experiments were made by Professor C. J. Fuchs at Karlsruhe with the view of obtaining a more complete and uniform rising of the fat globules by employing centrifugal force instead of the force of gravitation, as in the ordinary creamometer; but he failed to produce a sufficiently strong and rapidly revolving machine. In 1881 Professor N. J. Fjord, of Copenhagen, constructed his "Control Centrifuge," especially intended for, and by him mostly used for examining separated milk, for which purpose it worked to great satisfaction. It was never intended to be used by others besides his staff, for which reason he never published any directions for its use; it was not intended for, nor did he claim that it could be used for analysing whole milk. Nevertheless it has been taken up, exhibited, and at many places used for analysing whole milk. On account of its favourable reception he has lately altered his apparatus, which is now intended for controlling the supply of milk and enabling dairy factories to pay for it according to the amount of butterfat it contains. The apparatus in its new shape contains fifty-four cylindrical tubes, to hold fifty-four samples of milk. The cream is made to rise in the tubes by making the apparatus revolve about 60,000 times in the Danish Centrifuge, which takes about three-quarters of an hour. The thickness of the cream is thus then measured.

There is one objection to be made to this apparatus, viz., that it indicates the *amount of cream* and not of *butterfat*, and although undoubtedly the completeness of the rising of the cream and its uniformity is much greater in this case than in the ordinary creamometer, still this app. must only be considered as one step further towards the ideal, which is to have the *pure butterfat* isolated by mechanical separation. This is the goal after which Dr. de Laval, of Stockholm, has been striving, and which he has at length attained in his new machine, the Lactocrite.

In order to get the fat globules in the milk to unite to one clear mass of fat, it is

necessary to render the casein more completely dissolved than it is in the milk in its natural state. There has been, and probably is still, a difference of opinion as to whether the fat globules are coated with a membrane or not, but all agree upon the fact that for some reason or other they do not unite as readily as might be expected. The truth seems to be that by a molecular attraction the casein forms a condensed layer, but not a real membrane, around the fat globules. To dissolve the casein Dr. de Laval at first tried an admixture of alkali, which proved of little avail. He therefore took the opposite course and succeeded in dissolving the casein completely by boiling the milk with acetic acid. As is well known, small quantities of free acetic acid will precipitate the casein while a large excess will redissolve it. By the proposed treatment the serum of the milk is transformed into a perfectly clear and thin fluid, and the fat is apparently not affected.



The apparatus itself consists of a strong round steel disc on a spindle, like that of the separator bowl, and test-boxes of platina-plated brass with graduated glass tubes. The *modus operandi* is as follows:—10 c.c. of the sample of milk to be tested are run into a small test-glass, afterwards 10 c.c. of glacial acetic acid, containing five per cent. by volume of concentrated sulphuric acid are run into the same glass, which is then closed with a perforated cork-stopper, in which is inserted a piece of glass tube; this serves to prevent a concentration of the contents of the test-glass during the boiling. In a water-bath, arranged to hold twelve test-glasses, these are heated by steam or gas for seven or eight minutes, after which time the casein has been completely dissolved, while the liquid has acquired a slight violet tinge. The next step is to charge the test-boxes. These consist of a cup in which a perforated stopper fits tightly. The stopper holds the graduated glass tube, as the fat in the milk after boiling with acid has a great tendency to rise, the test-glass must be well shaken before its contents are poured into the cup, and when this is filled the stopper must be immediately pressed down in it, whereby any excess of the mixture will escape through the glass tube, and the test box is then filled completely. After the test-boxes have been charged in this way, they are ready to be placed in the disc, which will hold twelve at a time. The disc, which before use must be heated to about 110° F. by being placed in warm water of this temperature, has twelve cylindrical holes bored from a cavity on the top, radiating and a little sloping. In these the test-boxes are placed (if less than twelve test-boxes are used, there should always be an even number placed so as not to disturb the equilibrium) and the cavity is filled with water, which will keep the liquid in the test-boxes from being pressed out by the centrifugal force. The disc, which fits any stand of a Laval separator, is now made to revolve for three or four minutes at ordinary speed (6000 revolutions in the minute). When it is again at rest the test-boxes are drawn out, and the column of fat in the graduated tube is read off, the divisions indicating immediately tenths per cent of butter-fat by weight.

Before entering into the question of comparative analytical results it will be necessary to say a few words of explanation. It has been stated that any method of determining the amount of fat will give corresponding results in the hands of persons working in the same way and in the same laboratory, and that no method will give the same results on the same sample of milk in the hands of different analysts at different places. The first statement may be right, but is of very little interest; the second would be very serious indeed, if true. Any method which will extract all the fat and nothing else, will give very nearly the same results in the hands of any careful analyst, but it is an essential condition of a good method, that it shall extract *all the fat and nothing else*. All methods possessing these two qualities will give the same results on the same sample of milk carefully worked. To obtain a complete extraction of the fat, the milk must be given a very large surface, but this must not be done on paper containing resinous matter, as something will then be extracted besides the fat. For the same reason the ether used must be redistilled. When using Adams' method it is indispensable that all the resinous matter shall be extracted beforehand, which does not seem very easy. [I have found in one case that 5 siphonings extracted 0.023 gramme of a coil, but still left 0.010 gramme behind, which were extracted by 8 more siphonings.] With well-washed

paper coils I have found that Adams' method will give results corresponding very closely with those obtained by the method I generally use, which was first described by Dr. V. Storch, in 1883, but had then been in use for several years. According to this method about 10 grammes of milk are dried on about 10 grammes of pumice stone, ground to the size of lentils, sifted to remove the dust, and heated to a red heat. The dry mass is finely ground in a porcelain mortar and extracted in a very simple extracting tube. 50 c.c. of redistilled ether may be forced to percolate through the finely pulverized milk any number of times so as to remove all fat, and nothing but the fat can possibly be extracted. In analysing a sample of skim-milk twice by each of these methods I found :—

By Adams' method	0.70	0.68 per cent. of fat.
By Storch's do	0.65	0.64 ditto

Below I give some examples showing how far I have found the results obtained by the Lactocrite to compare with chemical analysis.

Chemical analysis.		Lactocrite.			
3.73	3.74	3.7	3.75	3.75	
		3.8	3.8	3.85	
		3.8	3.8	3.82	
4.08	4.07	4.1	4.2	4.2	
3.86		3.8	4.0	3.9	3.9

At least equally good results have been obtained by Mr. John Sebelien, lecturer to the Agricultural College, Ultuna, Sweden, and superintendent of the Dairy Laboratory of the same place. From his report I quote :—

Chemical analysis.		Lactocrite.			
3.68		3.65	3.65	3.70	
		3.70	3.70	3.67	
		3.67	3.70	3.70	
2.76		2.77	2.80	2.77	
		2.80	2.80	2.75	
2.70		2.65	2.70	2.65	2.70

These samples, which are by no means picked, will show that the Lactocrite is able to give a very close estimation of the amount of fat in milk. I think it may fairly be claimed for the Lactocrite that it will give an estimation within 0.1 of the amount of fat in whole milk.

When skim-milk is treated in the Lactocrite the results will fall somewhat below those of the analysis, as seen in the following examples :

Chemical analysis.		Lactocrite.			
1.14	1.17	1.05	1.0		
		1.07	1.05		
0.87	0.90	0.75	0.8	0.75	0.8
		0.8	0.75	0.8	0.65
		0.82	0.75	0.8	0.8

Separated milk, from the cream separator, having but very little fat left in it, cannot be tested by the Lactocrite in the usual way, as many trials have shown the results to be about 0.2 per cent. too low, which difference in analysing separated milk of course cannot be allowed. Equally low results have been obtained from buttermilk

Sour milk, even curdled, may be treated in the Lactocrite just as well as sweet milk, as the strong acetic acid will dissolve the casein of sour milk as easily as that of sweet milk. The only difficulty lays in the measuring off the 10 c.c. of a true average quality.

One great advantage of the Lactocrite is the very simple way in which it is worked, so that no skill is necessary, but any dairyman may obtain as good results as the apparatus is able to yield. In order to illustrate this I give below the results obtained by two persons at their first attempts; the first person is a dairyman used to heavy work. By way of a check I myself made some tests of the same milks:—

By myself.	Dairyman.		
3.1	3.1	3.2	3.2
3.2	Failed	3.2	3.2
3.2	3.1	3.3	3.2
2.65	2.65	2.6	2.6
2.65	2.65	2.6	2.65

These very favourable results are of importance as showing that in the Lactocrite is at last found the long wished-for apparatus, possessing the two qualities not hitherto combined—simplicity of construction and working and sufficient correctness for all practical purposes.

The Lactocrite will, no doubt, be found invaluable for butter dairies, or dairy factories buying milk from different farmers, by enabling them to carry out the system of paying for the milk according to the amount of butterfat which is the only fair system. At present, both in England and in other countries, the farmer whose milk will make butter at a rate of 3 lbs. per 100 lbs. of milk gets the same price as the farmers whose milk is so rich as to give 5 lbs. of butter per 100 lbs. of milk, which of course is most unfair. When milk is paid for according to the fat contained in it, the temptation to skim it is done away with, and besides, a great encouragement is given to the production of rich milk.

The Lactocrite will also prove of use for analysts who have access to a separator stand, as it will give in a short time a more exact determination of the amount of fat than any other apparatus. In this connection it will be of interest to know that a special construction of it has been adapted to fit Dr. de Laval's small Hand Separator, worked by hand and requiring no foundation.

DISCUSSION.

Dr. VIETH said he had listened with great interest to the papers, and he thought himself that instruments and methods for determining the most valuable constituent of milk—fat—which can be worked outside the chemical laboratory, and yet give correct results in the hands of non-chemists were of the utmost importance to dairy-farming and dairy-industry. From what he had heard that night, and learned previously, he had no doubt that the Lactocrite was a very useful apparatus, and that the results obtained were highly satisfactory. He was astonished to see so close an agreement with results relating to skim milk, because the inventor distinctly states that if skim milk is examined with the apparatus .2 per cent. must be added to the result in order to bring up the fat to the percentage actually present. With regard to the cooling down of the

test-tubes, while reading off the results, he did not think that a matter of great consequence, as the tubes were made of pretty thick glass. He might mention that the Lactocrite was not the only apparatus of its kind, but that there also exists a centrifugal control-apparatus in connection with the Danish cream separator. Each apparatus appears to have some merits of its own; but there was scarcely any occasion for a close comparison of the two, as they would never compete with each other. The Lactocrite cannot be used where the Danish separator is being worked, nor can the Danish control apparatus be employed in connection with the Swedish separator.

Mr. ADAMS was highly gratified to see the remarkable corroboration the Lactocrite afforded to his own method of analysis. He had been favoured by Mr. H. Faber with some particulars respecting the other mode of analysis employed by him, and referred to in his paper, also with specimens of the apparatus which Mr. Faber makes use of, consisting of a conical tube some 6 or 8 inches long, plugged at the bottom or smaller end with wool, through which a small glass tube passes, the space between it and the conical tube being filled with pumice stone broken to a coarse powder—which pumice takes the place of the sand, powdered glass, or plaster of Paris of other methods. The pumice is first, ignited, then placed in a porcelain capsule, charged with the milk, which, when dried, is transferred to the tube to be extracted by ether under an upright condenser.

The speaker's experience of the process, as compared with his own, was that the yield of fat is 29 per cent. below truth, and besides its failure to extract the whole of the fat, he finds the pumice an unwieldy, disagreeable material to use as an absorbent, it being, in his opinion, much inferior to sand, glass or plaster, not only by reason of its ineffectiveness, but also because of its bulk and the difficulty of detachment from the porcelain capsule without loss of substance, and the destructive action it has on the capsule by scratching of the enamel.
