

ON SOME POINTS CONNECTED WITH MILK ANALYSIS.

By A. DUPRE, PH.D., F.R.S.

THE recent Manchester milk case has shown in a striking manner the difficulties still surrounding the question of milk analysis, and will no doubt necessitate a careful reconsideration, by the Society of Public Analysts, of all points relating to it.

Before, however, entering on the consideration of any of the chemical questions involved, I wish shortly to comment on two statements, which have been advanced on behalf of Somerset House. Firstly, the statement that Somerset House "is perfectly neutral as between the parties," has been put forward in a manner to imply that Public Analysts are not neutral. Whether this was the meaning intended to be conveyed I know not, but it is the natural inference to be drawn from the statement as made. Be this as it may, I wish to enter my emphatic protest against such a statement, which in my opinion is one that ought not to have been made. Public Analysts have nothing to do with one party, or the other, and are absolutely neutral.

In the second place, the Somerset House Chemists seem to imagine that they only, in deciding on the genuineness, or otherwise, of any given sample of milk, take into consideration the whole of the constituents of the milk, by which statement, I presume, is really meant the fat, solids not fat, and ash. Now it has been stated over and over again at our meetings, that in order to come to a correct and just conclusion it is not enough to take into consideration the solids not fat only. Indeed the necessity of doing this is so plain that it seems incredible that anybody should think otherwise. The statement is entirely erroneous.

Method of Analysis to be adopted.—It appears to be imagined by some that that process for estimating the proportion of solids in milk which gives the lower result is necessarily the correct one. The fallacy of such reasoning is sufficiently obvious to an analytical chemist, but when made before non-scientific persons it is very apt to mislead them. It is probably impossible to estimate with any extreme degree of exactness, the amount of solids contained in a fluid of such complicated composition as milk, and all our processes will give approximations merely, that process being the best which gives the most constant or concordant results; whether the result is slightly higher or lower than that given by other processes is perfectly immaterial.

Drying to constant weight.—Some chemists profess to dry their milk residues to constant weight and apparently pride themselves on their superior accuracy. I never attempt to do this and I have no doubt that nobody else does it. What is really done probably is to dry the residue to such a degree that it shall not lose more than say one milligram, or 1/100th of a grain in an hour or so; this much can readily be accomplished and is all that is necessary. To attempt to dry to absolute constancy would not only require much time, even if it could be accomplished at all, but would be of very doubtful advantage. At any rate it would be well if every one who says that he dries his milk residues to constant weight were to give exact details as to what he really does, and the question of drying to constant weight or not could then be fairly discussed.

Influence on composition or specific gravity.—Hitherto it has been supposed that the specific gravity of milk was governed mainly by the percentage of fat and of solids not fat it contained. If, however, the tables in Dr. Bell's little work, *Analysis and Adulteration of Foods*, giving the composition of a number of samples of milk, are correct, a main cause of variation must be sought for in the varying composition of the solids not fat.

The chief non-fatty solids of milk are sugar, casein and albumen, and ash, and any variation in the influence exerted by equal percentages of these solids must obviously be brought about by a variation in the relative proportion of these main constituents. It

becomes therefore of importance to determine—firstly, the influence on gravity due to each of these constituents; and secondly, the extreme variation in the proportion of each found in genuine milk from healthy cows. In order to throw some light on the first point, I have had several samples of milk carefully examined in regard to the following points. Specific gravity of entire milk, total solids, fat, solids not fat, ash, specific gravity of the whey obtained by coagulating the milk at a boiling temperature after the addition of some acetic acid, the amount of solids contained in this whey, both organic and inorganic. I have taken all organic solids not fat coagulated by the above process as casein and albumen, and all the organic solids in the whey as sugar. This is no doubt not quite correct, as there are other substances present in small quantity, but the error, if any, thus introduced cannot be large, and in ordinary milk analysis no further separation into constituents would be attempted.

Taking then the influence on gravity of 1 per cent. of fat, according to O. Hehner, at -0.75 ,* I find the influence of 1 per cent. solids not fat to be $+ 3.624$ of 1 per cent. of sugar, $+ 3.70$ of 1 per cent. of casein and albumen $+ 2.55$. The factor for solids not fat is practically identical with that previously found by O. Hehner.

The specific gravity of an average sample of milk will therefore be made up as follows:

Constituents.	Influence of these on gravity.
Fat.....3.5 per cent.	— 2.54
Sugar.....5.0 ,,	+18.50
Casein, &c. 3.3 ,,	+ 8.42
Ash.....0.72 ,,	+ 5.40
<hr/>	
Specific gravity of milk	1029.78
Specific gravity without the fat	1032.32

Supposing in this milk the organic solids not fat to be either all sugar or all casein and albumen, the alteration in gravity thereby produced would be the maximum possible which could be produced by any variation in the relative proportion of these constituents. The proportion of ash varies so slightly in all genuine milks that its influence on gravity may be taken as an almost constant quantity.

Well then, the specific gravity of the above milk with all sugar would be 1038.50
with all casein and albumen 1023.95

difference 9.55

Such milks are, of course, never found; nevertheless, the figures show that no considerable variation in the gravity of milks, with the same percentages of solids not fat, might be found, particularly when dealing with milks from single cows. In mixed milks from a number of cows variations in gravity due to this cause will probably always be small.

A variation for example from 2.5 per cent. casein and albumen, and 5.8 per cent. of sugar, to 4.3 per cent. of casein and albumen, and 4.0 per cent. of sugar, would produce a difference in gravity of 2.07 only. In Dr. Bell's tables, variations amounting to 8.77, after allowance for fat and ash has been made, will be found.

It is obvious that when these specific gravity factors have once been accurately fixed—and I bring forward my factors as first approximations only, we should be able to calculate

* According to my experiments 1 per cent. of tribasic phosphate of calcium has an influence on gravity of 7.6; the other ash constituents have slightly less.

the composition of a milk in considerable detail from the figures usually obtained in any ordinary milk analysis, viz. : the specific gravity of the milk, fat, solids not fat, and ash.

Thus we get the specific gravity due to the sugar, and casein, and albumen, by adding to the specific gravity of the milk the loss in gravity due to the fat, and subtracting that due to the ash from the remainder, and from the above specific gravity factors, we may calculate the amounts of sugar, and casein, and albumen, as follows. Let x represent the amount of sugar ; y , that of casein, &c. ; a , the total amount of sugar and casein, &c. (solids not fat minus the ash) ; and b , the gravity due to these calculated as above. Then

$$\begin{array}{rcl} x + y & = & a \\ 3\cdot7\ x + 2\cdot55\ y & = & b \\ x = \frac{b - 2\cdot55\ a}{1\cdot15} \\ y & = & a - x \end{array}$$

To give an example. I found the specific gravity of a milk to be 1030·5, and this milk contained fat 3·51, solids not fat 9·19, ash 0·72. We have therefore, $a = 8\cdot47$ and $b =$

$$\begin{array}{rcl} & & 30\cdot50 \\ +\ 3\cdot51 \times \cdot725 & = & 2\cdot53 \\ -\ \cdot72 \times 7\cdot5 & = & 5\cdot40 \\ \hline & & 27\cdot64 \end{array}$$

From which we calculate, $x = 5\cdot25$, and $y = 3\cdot22$. The proportion of sugar and casein, &c., found by actual analysis having been 5·38 and 3·09 respectively. I believe it will be found that such a calculation will give a useful check as to the accuracy or otherwise of the results obtained in milk analysis.

As above stated, I bring forward these specific gravity factors as first approximations only, my object in this paper being mainly to illustrate to what extent the specific gravity of a milk may reasonably be expected to vary, owing to varying proportion of sugar and casein, &c. ; and secondly, to point out the value of some factors, when once carefully ascertained, in general milk analysis.

I have indeed found that my factors are totally inapplicable to the analysis of cows' milk, given on page 3, part II., of Dr. Bell's little work. Nor have I been able to calculate any factors embracing all five analyses given. Factors however can be calculated which will give, with a fair degree of accuracy, the composition of milks, No. 1, No. 2, No. 3 and No. 5. These are—factor for 1 per cent. of sugar 4 ; for 1 per cent. of casein, &c., 2·7. Applying these to milk No. 1, for example, we get

	Found.		Calculated.
Sugar.....	4·91	4·95
Casein, &c.	3·05	3·01

Applying these latter factors, in conjunction with those for fat and ash previously given, to Dr. Bell's larger tables of milk analyses, some strange results are obtained. I will give four only, which, however, it is only fair to add, represent, I believe, the extreme cases.

Milk from single cows :—

No. 83, page 20, Sugar	6·53	} 8·92
Casein, &c.	2·34	
No. 9, page 25, Sugar	0·91	} 10·40
Casein, &c.	9·49	

Similar differences, though not quite so striking, are found even among the Dairy samples.

No. 5, page 26, Sugar	5·34	} 7·98
Caseine, &c.	2·64	
No. 16, page 26, Sugar	2·22	} 9·15
Caseine, &c.	6·93	

I cannot help thinking that there is something wrong in these analyses.

I have, I trust, said sufficient to show the value of the factors proposed when once fairly established, and also to induce others to take up this inquiry, which is one of very considerable interest in relation to milk analysis, and which, at the present time, urgently requires examination.

Loss of Solids on Keeping.—This question has been repeatedly investigated by members of the Society of Public Analysts; first, I believe, by Dr. Stevenson, in a paper read before the Society, February 5th, 1875. The general conclusion arrived at was that when once the milk had suffered changes other than merely turning sour, correct analysis was no longer possible. At Somerset House they seem, however, to have arrived at a different conclusion, and a correction for “natural loss” figures in all certificates issued from Somerset House relating to the analysis for old milk, as if this loss was a regular, and naturally regular, thing which could be calculated with nicety. I have, therefore, once more undertaken some experiments on this question—which is one of very considerable importance, and trust that others will also give their more recent experience; we may then hope to dispose once for all of this imaginary regular natural loss.

No. 1 was a sample of milk which came to me for analysis, and had accidentally been left standing in the laboratory in the half empty bottle; no care whatever had been taken for its preservation.

Nos. 2 and 3 was a sample of milk purchased by myself, the only difference between them being that in the case of No. 2 the bottle had been filled completely, while in the case of No. 3 the bottle was only three-fourths filled. Great care had been taken to clean the bottles. These three samples were analysed the second time twenty days after the analysis of the fresh milk. The remaining four samples were samples retained by the Inspector, and would have been forwarded to Somerset House for analysis had there been occasion for it. The bottles were nearly full, and the second analyses were made twenty-five days after the first.

Number of solids not fat:—

Sample.	Originally.	After keeping.	Calculated by Dr. Bell's figures.	Difference.	Acid as lactic acid.
1	8·27	8·21	8·60	+·33	1·05%
2	9·21	8·70	9·09	—·12	1·18%
3	9·21	8·42	8·81	—·40	1·06%
4	8·08	7·84	8·29	+·21	1·12%
5	8·83	8·30	8·75	—·08	1·06%
6	8·66	8·20	8·65	—·01	1·19%
7	7·68	7·20	7·65	—·03	1·12%

Every figure given is the mean of two concordant analyses, and all samples, except No. 1, which stood during September, were examined twice during the month of October.

It will be seen that in two cases the calculated result agrees closely with the original analyses, in two more the agreement is moderately close, while in the remaining three it is

very wide of the mark. It is to be noted, more especially, that in two cases, the calculated result is considerably higher than the original analysis, these milks most unnaturally not having suffered their fair share of "natural" loss, whereas in the one remaining case, No. 3, the actual loss far exceeded the "natural" loss. The difference between Nos. 2 and 3, the same sample bottled at the same time, is also very striking. The last column of this table gives the percentage of acid, calculated as lactic acid contained in the milk at the time of the second analysis. As was to be anticipated, there is no connection between actual loss and degree of acidity, notwithstanding the statement to the contrary advanced by Dr. Bell.

These results, confirming as they do results previously obtained by other observers, are, I think, sufficient to prove that no allowance for so called "natural" loss can be made after a milk has been kept for some time. The only safe and true course for an analyst to pursue when he is asked to analyse an old sample is to declare his inability to give an opinion as to its purity or otherwise, except in cases in which the watering has been so considerable that no observed variation in the rate of loss could account for the results found, or in cases in which the ash is lowered sufficiently to afford a safe ground to form an opinion.

In conclusion, I would express a hope that Dr. Bell has been incorrectly reported, when he is made to say at Manchester that the method on which the so-called natural loss for milk is calculated is perfectly scientific, and similar to that on the strength of which his Board pays a drawback of over half a million a year in the case of beer. The method is not scientific, and there is no analogy whatever between the two cases mentioned.
