

THE COMPOSITION OF MILK, AND THE CONDITIONS AFFECTING IT,
AS SHOWN BY BELL'S ANALYSES.

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DR. BELL'S analyses of milk, dated August 15, 1893, have several times been quoted in police-court proceedings, and it seemed worth while to examine them in detail, to ascertain how far they can be quoted in opposition to this society's standard, particularly as the report accompanying them is so meagre.

The average composition is shown by the following table :

Averages.	Sp. Gr.	Solids per Cent. (Bell).			Calculated.	
		Not-Fat.	Fat.	Total.	S.-n.-F.	Fat.
273 Cows	1032.3	8.908	3.991	12.899	8.86	4.03
55 Dairies	1031.9	8.96	4.00	12.96	8.80	4.16
Dr. Vieth	—	—	—	12.90	8.8	4.1

The solids-not-fat and fat have been calculated from Hehner and Richmond's table, so that the results could be compared with Vieth's average of 120,540 samples. It will be seen that these averages are practically identical, though it is somewhat remarkable that in the dairies the calculated fat exceeds the found by .16 per cent., while in the single cows the excess is only .04 per cent.

The range in quality is shown by the following table. I have also calculated all the low figures of the single cows for comparison with the Society's standard.

	55 DAIRIES.		273 Cows.	
Total Solids.				
Under 11.5 %	0 Milks = 0 %		7 Milks = 3 %	
11.5 to 11.99	4	7	37	14
12.0 „ 12.49	6	11	69	25
12.5 „ 12.99	19	35	44	16
13 „ 13.99	23	42	82	30
14 „ 14.99	3	5	22	8
15 and over	0	0	12	4
	55	100	273	100

Fat.	Bell.		Bell.	Calculated.
Under 2.75 %	0 Milks = 0 %		6 Milks = 2 %	3 Milks = 1 %
2.76 to 2.99	1	2	12	5
3.0 „ 3.19	1	2	21	8
3.2 „ 3.49	8	15	37	14
3.5 „ 3.99	18	32	75	27
4 „ 4.99	26	47	95	34
5 and over	1	2	27	10
	55	100	273	100

Solids-not-Fat.	Bell.		Bell.	Calculated.
Under 8 %	0 Milks = 0 %		5 Milks = 2 %	7 Milks = 3 %
8.0 to 8.29	0	0	10	4
8.3 „ 8.49	2	4	31	11
8.5 „ 8.69	6	11	33	12
8.7 „ 8.99	21	38	95	35
9.0 „ 9.49	25	45	71	26
9.5 and over	1	2	28	10
	55	100	273	100

It will be seen that no dairy gave less than 11·5 per cent. of total solids, the lowest being 11·68 per cent. and 11·80 per cent., while the lowest single cows were 10·33 per cent., 11·19 per cent., 11·21 per cent., and 11·35 per cent., the other three being more than 11·4 per cent.

Among the dairies, the only one below 3 per cent. of fat is 2·89 per cent., which when calculated, gives 2·99 per cent. The two lowest single cows give 2·43 per cent., and calculate to 2·6 per cent. and 2·67 per cent. The seven milks with total solids under 11·5 per cent. have all less than 3 per cent. of fat.

Two of the dairy milks give solids-not-fat under 8·5 per cent., viz., 8·4 per cent. and 8·48 per cent.; but four of the calculated figures are below the standard, viz., 8·28 per cent., 8·33 per cent., 8·35 per cent., and 8·42 per cent. The two lowest single cows are 7·52 per cent. and 7·79 per cent., and the two lowest calculated are 7·52 per cent. and 7·66 per cent.

In all, 74 milks from single cows are below the Society's limits—10 being low in fat only, 61 in solids-not-fat only, and 3 in both; but in 37 cases there is a compensation in the other constituents, so that the total solids are 12 per cent. or over, while 26 more are within 0·2 per cent. of the standard, leaving only 11 milks, or 4 per cent., that are much below the standard.

It has been stated that the coil process gives "an increase of what is called butter-fat of perhaps 0·2 per cent." over the Bell process, but it is worth while noting that sometimes the calculated fat exceeds the figures given by 0·4 per cent.; in other cases the calculated fat is lower—in one case as much as 0·26 per cent.

As in each milk, the age, food, hour of milking, and time from calving are given, as well as the breed of the cows, and the quantity of milk yielded, I tried to find if, from these analyses, any general conclusion as to the effect of these factors on the quantity of the milk could be arrived at. It might be thought that these things do not concern the members of the Society, but as the public analyst may any time be cross-examined as to the effect of food, etc., I do not think any apology is needed.

The following table gives the average composition and quantity of milk yielded by the cows of the various breeds, but it should be noticed that the number of samples in some cases is too small to be of much use.

The milk from the North Devon cows is highest in solids-not-fat and lowest in fat. The Dutch cows give lowest total solids and solids-not-fat, while the Jersey milks are highest both in total solids and in fat. The cross-breeds give the greatest, and the Kerries the least yield of milk :

Breed.	Number of Cows.	Solids-not-Fat.	Fat.	Total Solids.	Average Yield. Quarts.
Sussex	2	8·92	3·39	12·31	7·5
Welsh	2	9·15	4·40	13·55	4·2
Guernsey	4	9·30	5·16	14·46	4·1
Jersey	6	9·22	5·43	14·65	3·7
Kerry	5	8·87	4·67	13·54	2·7
North Devon	6	9·68	3·43	13·11	3·8
Dutch	13	8·65	3·75	12·40	5·3
Ayrshire	15	9·22	4·24	13·46	4·6
Cross-breeds	17	9·01	3·99	13·00	5·6
Shorthorns	203	8·86	3·92	12·78	5·3
General Average	273	8·908	3·991	12·899	

As there was such a difference in the various breeds, it was deemed advisable to eliminate this factor and investigate the shorthorns only. It is well known that morning milk is poorer than evening, and it has been suggested that this is due to the difference of time elapsing between milking. To test this, the facts with regard to each cow were copied on a strip of cardboard, and the strips sorted. For solids-not-fat they were divided into three classes—under 8·5 per cent., 8·5 per cent. to 9 per cent., and 9 per cent. and over—and each class subdivided into first meal and second meal, and the numbers in each class counted and calculated to percentages. Thus, 23 per cent. of the milks under 8·5 were first meal, and 77 per cent. second meal. The fats were similarly classified, and then both were arranged with regard to hours from last milking.

Figures on the same horizontal line may be compared, but vertically each class adds up to 100 :

	Solids-not-Fat.			Fat.			Average Quantity. Quarts.
	Under 8·5.	8·5 to 8·99.	9·0 & over.	Under 3·5.	3·5 to 4·49.	4·5 & over.	
First meal ...	23	29	29	55	21	5*	
Second meal ...	77	71	71	45	79	95	
Hours between milking :							
8 to 9 hours	30	29	30	11	28	60	4·4
10 „ 11 „	48	41	37	29	50	36	5·1
12 „ 13 „	17	16	16	24	17	2*	6·4
14 „ 16 „	5*	14	17	36	5	2*	5·9

This table shows that while 55 per cent. of the milks low in fat were first meal, only 5 per cent. of those rich in fat belong to this meal. Also that, while 11 per cent. of poor milk were 8 to 9 hours between milking, 60 per cent. of the milks high in fat were in this class, showing that the longer the time between milking, the larger will be the proportion of milks low in fat, a conclusion which is supported by the other figures. If, however, the solids-not-fat be examined, it will be seen that time makes practically no difference, but a longer interval has a slight tendency to decrease the proportion of poor milks.

This shows that for the study of the effect of food on the amount of fat, etc., it is necessary to select either first or second meal cows, or the differences due to the meal would mask the smaller variations ; the second-meal class, being the larger (147 cows), was selected, but all shorthorns were taken for the solids-not-fat :

* Number of cows small.

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		Solids-not-Fat.			Fat.		
		Under 8.5.	8.5 to 8.99.	9.0 & over.	Under 3.5.	3.5 to 4.49.	4.5 & over.
Age	2 to 4½ years	11*	34	32	31	33	24
	5 „ 6 „	62	36	46	54	39	65
	7 „ 8 „	16	24	22	11*	19	11
	9 „ 12 „	11	6	0	4*	9	0
Yield	1 to 3½ quarts	25	23	28	19	22	37
	4 „ 5 „	45	27	31	39	41	30
	6 „ 7 „	17	37	27	23	30	30
	8 „ 10 „	13	13	14	19	7	3
Time from Calving	1 to 6 weeks	18	28	30	15*	28	27
	7 „ 12 „	37	36	16	38	33	25
	3½ „ 6 months	27	23	30	31	28	18
	7 „ 9 „	10*	8	16	8*	6	27
	10 months & over	8*	5	8	8*	5*	3*
Percentage of cows fed on							
	Hay	20	48	32	17	55	28
	Mangolds or Swedes ...	22	47	31	16	55	29
	Brewers' or distillers' grains	21	43	36	14	50	36
	Linseed or cotton-seed cake	25	45	30	16	62	22
	Chaff or straw	25	49	26	17	64	19
	Meals (oat, pea, barley, etc.)	18	53	29	19	62	19
	Grass	15	56	29	19	56	25

With regard to age, it may be noted that cows five and six years old give a large proportion of the milks, and that no milks high in fat or solids-not-fat occur in milk from cows over eight years old.

When the quantity of milk is under one gallon, the proportion of milks high in fat is increased, and when two gallons and over is yielded at a milking, there is a small proportion of rich milks. The milks given by cows for periods of less than seven weeks after calving have a small proportion poor both in fat and solids-not-fat, and those seven to nine months after calving are of a better quality, particularly in fat.

With regard to the effects of food, the problem is very complicated, as the majority of cows are fed on from three to six different kinds. The figures given are the percentage of rich, medium, and poor milks yielded by cows fed on each food considered by itself—thus, out of 100 cows fed on hay, 20 gave milk that was low, 48 medium milk, and 32 milk high in solids-not-fat. Some of the cows were fed on grass only, and with regard to part of them it is remarked that the grass was very scarce. The very small variations appear to show that food by itself has not much effect on the composition of the milk if the cows are fairly fed, as these are supposed to be. The large proportion of good milks from cows fed on grains is notable.

* Number of cows small.

The one respect in which the information given about these milks is deficient, is that no date is stated, and as the time of the year exercises a marked effect on the composition of the milk, one feels that, as this could not be allowed for, the influence of season may have introduced some errors into the above results. To summarize what has been said, these analyses show

(1) That, with four very slight exceptions, all the mixed milks are up to the Society's standard.

(2) That only 4 per cent. of the milks from the single cows would show signs of much adulteration, as judged by the Society's standard, if allowance is made for excess of the other constituents.

(3) That analyses by the Bell method may give from 0·40 less to 0·26 per cent. more than the calculated figures.

(4) That the longer the time between milking, the lower will be the fat in milk.

(5) That, with the exception of breed, the other conditions have much less effect on the proportion of poor milks.
