

The Composition of Cows' Milk in the Sudan.

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THE observations recorded in this paper embody the results of the analyses of samples of cows' milk examined in the Wellcome Tropical Research Laboratories, Khartoum, during the last 10 or 15 years. A considerable number of samples are taken by the Public Health Inspectors as a check on the ordinary milk supply of Khartoum, and others have been obtained from animals kept under supervision; the latter are of course undoubtedly genuine, and give an idea of the "normal" composition of milk in this country, enabling a comparison to be made with similar results obtained in other parts of the tropics.

All the samples have been obtained from the Khartoum district, of which the following climatological notes may be given:—(a) *Position*.—Lat. $15^{\circ}36'N$ long. $32^{\circ}32'E.$, about 1300 miles south of Cairo. Height above sea level 1200 feet. (b) *Temperature*.—Average for the year $95^{\circ}F.$ Mean maximum in May, $107.5^{\circ}F.$, mean minimum in January, $58.5^{\circ}F.$ (c) *Moisture*.—Mean annual rainfall 4", all in July and August. Humidity varies from 15 per cent. in April to 48 per cent. in August.

Animals kept by native farmers are called "Beladi" cattle, and those of the Khartoum district are shorthorned and humped. The bulls are used for draught purposes. At the Government Dairy, selection and crossing has resulted in animals having apparently a much higher order of milk-producing power; at present, however, it is exceedingly difficult to separate the combined effects of selection, careful feeding and good housing.

RELATION BETWEEN MORNING AND EVENING MILK.—Our arrangements did not always allow of effective supervision in taking samples in the afternoon; the principal series of observations are therefore confined to those on morning

milk, a special series of 80 samples being taken from five selected animals both in the morning and afternoon to determine the relative composition. The result of this test was as follows:

TABLE I.

	Morning	Evening
Time of milking	4.45 a.m.	3.30 p.m.
Mean percentage of fat	4.04	4.80
„ Solids-not-fat	9.53	9.54
„ Quantity of milk (lbs.)	15.86	13.50
„ Quantity of fat (lbs.)	0.641	0.648

The equality of the total amount of fat in the morning and evening milk is consistent with the results reported from similar observations in England; thus from the examination of over 2400 samples, Monier Williams (*ANALYST*, 1920, 45, 204) calculates the mean fat production as 0.44 lb. in the morning and 0.38 lb. in the evening. Similar results may be calculated from data given by Ingle (*Manual of Agricultural Chemistry*, 1920, p. 355) as follows:

TABLE II.

	Series I		Series II		Series III	
	Morning	Evening	Morning	Evening	Morning	Evening
Time of milking	6	3	6	5.30	6	3
Percentage of fat	2.94	4.50	3.20	3.63	2.90	4.48
Mean quantity of fat in lbs.	0.570	0.576	0.500	0.484	0.446	0.484

AVERAGE COMPOSITION OF GENUINE MILK.—The mean composition of 284 genuine samples, collected between 1906 and 1921, is given below, together with figures obtained by workers in Egypt, British East Africa and India.

TABLE III.

	Egypt ¹	British East Africa ²	India ³	Sudan (Morning milk)
Fat	5.4	5.25	5.9	4.74
Solids-not-fat	9.2	9.25	—	9.56

If the percentage of fat in the Sudan morning milk be multiplied by the ratio of fat in morning milk to fat in total milk (from Table I.), the average percentage of fat becomes 5.15 instead of 4.74.

The point noteworthy in all these results is the high percentage both of fat and solids-not-fat in tropical milk; in consequence, the use of English legal standards is entirely inapplicable in these countries.

The 284 samples referred to above were obtained in the course of four series of tests, of which the following are the separate results:

TABLE IV.

Series	Origin	No. of samples	Fat	Solids-not-fat
1	Government herd, 1906	18	5.43	9.27
2	Private herd, 1915-1916	23	4.96	9.24
3	The same herd, 1920	87	5.05	9.41
4	Government herd, 1920-1921	156	4.46	9.74

(1) *Reports of the Dept. of Pub. Health*, Cairo, 1919. (2) *THE ANALYST*, 1920, page 301. (3) *Mem. Dept. Agr. India, Chem. Ser. 2* (1911), No. 1 (abstracted in *Expt. Sta. Record*, 25, 1911, p. 778).

SEASONAL VARIATIONS.—The first of the above series was carried out by the late Dr. Beam, and the details published in Report of the Wellcome Tropical Research Laboratories for 1908 (p. 396). The samples were collected during February, March and April, and from the general constancy of the composition it was concluded that the pronounced seasonal variations present in other countries were not pronounced in the Sudan. An examination, however, of the detailed results of the second series shows a maximum fat content in the rainy months of the year, July and August, when green forage material is at its best, and a minimum in November, for which no explanation suggests itself.

The results were obtained by the examination of the mixed milk of 10 animals taken twice a month.

TABLE V.

	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.
Fat	4.62	4.90	5.02	5.11	5.11	6.05	5.72	5.10	4.60	3.88	4.55	4.92
Solids-not-fat	9.56	9.43	8.98	9.05	9.25	9.38	9.19	9.53	8.89	9.12	9.25	9.45

DAILY VARIATIONS IN COMPOSITION.—The variations in composition in the individual samples from Series 3 and 4 of Table IV. are shown in Tables VI. and VII., from which it will be seen that the percentage of fat of a single animal in this country may vary to an astonishingly high degree; and although part of the variation in fat content is due to the period of lactation (the percentage of fat steadily increasing), yet the milk from successive samplings also shows a very wide variation, this feature being more marked in the case of the privately-owned pure Beladi herd.

TABLE VI.

VARIATIONS IN PERCENTAGE OF FAT IN MILK OF PRIVATE HERD (SERIES 3).

Mark of Cow	No. of samples	Per Cent.			Percentage of samples falling within the range given below						
		Mean	Max.	Min.	below	3.5	4 to	4.5 to	5 to	5.5 to	above
					3.5	to 4	4.5	5	5.5	6	
S	16	4.60	6.3	3.3	6	31	25	12	6	6	12
B	18	5.37	8.3	2.7	6	6	0	28	17	28	17
C	17	4.95	8.1	3.3	11	11	6	30	18	11	12
Ar.	18	4.47	6.5	3.1	29	11	0	39	17	0	6
Al.	18	5.88	7.6	2.8	6	0	17	6	6	17	50
For all samples	87	5.05	8.3	2.7	11	12	10	23	13	12	18

TABLE VII.

VARIATIONS IN PERCENTAGE OF FAT IN MILK OF GOVERNMENT HERD (SERIES 4.)

No. and Breed of Cow	No. of samples	Per Cent.			Percentage of samples falling within the range given below						
		Mean	Max.	Min.	below	3.5	4 to	4.5 to	5 to	5.5 to	above
					3.5	to 4	4.5	5 to 5	5.5 to 6	6	
8. Sudan	25	4.57	7.0	3.3	8	24	32	20	4	4	8
11. Do.	28	4.61	6.1	3.2	4	7	36	39	7	4	4
18. Egyptian & Shorthorn	34	4.25	6.3	3.6	3	41	32	18	0	3	3
21. Sudan	35	4.50	6.5	3.1	6	26	29	14	6	17	3
37. $\frac{1}{4}$ Shorthorn & $\frac{3}{4}$ Sudan	8	5.55	7.1	3.9	0	13	13	25	13	0	37
40. Do.	26	4.09	5.0	3.1	8	31	46	15	0	0	0
For all samples	156	4.46	7.0	3.1	5	24	31	22	5	5	9

The greater uniformity in quality of the milk from the Government herd as compared with that from the privately-owned herd can be seen by plotting the usual distribution curves from Tables VI. and VII., or, more conveniently, by

calculating the "probable variation" from the results of all the analyses from each animal. This has been done by a simplified Peter's formula $\frac{0.845 \sum (v)}{n - \frac{1}{2}}$, where n is the number of analyses, and $\sum (v)$ the sum of all the variations of the fat percentages from the mean fat percentage for the animal. The figures are given in the next table:

TABLE VIII.
PROBABLE VARIATIONS IN FAT PERCENTAGE.

Government Herd			Private Herd (all Beladi)	
No. of Cow	Breed	Probable Variation	Letter of Cow	Probable Variation
8	Beladi	0.57	S	0.69
11	Beladi	0.35	B	0.68
18	$\frac{1}{2}$ Shorthorn	0.38	C	0.71
21	Beladi	0.64	Ar.	0.61
40	$\frac{1}{4}$ Shorthorn	0.31	Al.	0.97
Mean		0.45	Mean	0.73

Whilst the greater uniformity of the milk of the Government herd is probably partly due to better care, housing and feeding, it is apparently also due, at least in part, to the breed. It will be seen from the above table that, whilst the mean of the probable variations of the three Beladi animals is 0.52, that of the two with shorthorn blood is 0.35, a fact strongly suggesting that the introduction of shorthorn blood has resulted in greater uniformity of milk.

COMPOSITION OF SAMPLES TAKEN FROM MILK-SELLERS IN KHARTOUM AND OMDURMAN.—In conclusion, the figures may be given for the average composition of all samples submitted by the Medical Officer of Health for analysis, of which the stated origin was the cow. They include, of course, a number of obviously adulterated samples, but the mean composition is, on the whole, satisfactory. The number of samples is not large, as most of the milk sold in the streets is from goats or sheep, or is stated to be mixed. Of the 290 samples examined during the past two years only 37 were stated to be cows' milk. The average composition was: Fat 4.24 per cent., solids-not-fat 9.26 per cent.

SUMMARY.—(a) Cows' milk in the Sudan resembles that in other tropical countries in being rich both in fat and other solids.

(b) The total fat production is approximately the same in the morning and evening.

(c) There is a distinct seasonal variation in composition, the fat percentage being highest in the rainy months of July and August, and lowest in November.

(d) Wide variations in the composition of milk of individual animals occur in both herds, but are more marked in the case of the privately owned herd. Detailed examination of the results of the analyses suggest that these variations are due partly to the breed and partly to conditions of housing and feeding.

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