GESTATION VERSUS STAGE OF LACTATION AS FACTORS CAUSING ABNORMAL COMPOSITION OF COW'S MILK *

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All regulations¹ standardizing cow's milk for human consumption exclude its use for a period of time before parturition, the period varying from fifteen to sixty days. Standards of this character are based on the supposition that pregnancy influences the normal composition of milk; in other words, that the milk no longer has a normal composition after gestation has reached a certain stage. The evidence on which this supposition is based is, however, extremely difficult to find, although the literature is extensive with regard to variations in the composition of milk.

The question of the factors influencing the normal composition of cow's milk has for several years been the object of critical study by the Missouri Agricultural Experiment Station. Certain portions of data, which were obtained for another purpose,² give a clearer insight into the importance of gestation as a factor causing milk of abnormal composition than any data yet published on this question. It is the purpose of this paper to present those data, together with some additional data, which have a bearing on the question of whether it is the stage of the gestation period or the stage of the lactation period which is the important factor causing milk of abnormal composition as the cow approaches parturition.

SOURCE AND CHARACTER OF DATA

The data presented represent the analyses of the milk and milk fat during the last days of the lactation period of twelve cows, representing four breeds, namely, Jersey, Holstein, Ayrshire and Shorthorn. The analyses for each sample of milk are more complete than any so far

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1. For example, the standards adopted for "Certified Milk" by the American Association of Medical Milk Commissions (Proc. Sixth Ann. Conference, Am. Assn. Med. Milk Comm., 1912, p. 124) exclude the milk for a period of forty-five days before parturition.

2. Eckles, C. H., and Shaw, R. H.: Influence of the Stage of Lactation on the Composition and Properties of Milk. U. S. Department of Agriculture, Bureau of Animal Industry, Bull. 155, January, 1913.

reported bearing on this question. All the cows were pure-bred dairy animals. All except one, Cow 22, received the same uniform ration for the entire lactation period from which the data are taken. The ration consisted of choice alfalfa hay and a grain mixture of corn 8 parts, bran 1 part and oats 1 part. Cow 22 was on pasture with additional grain at the time the data were taken. All the cows were pregnant with the exception of Cow 118. Complete analyses are reported for both the milk and milk fat. For the milk the data include the specific gravity and the percentage of total solids, fat, lactose, total protein and casein. The data in regard to the milk fat include the following physical and chemical constants: saponification value, Reichert-Meissl number, iodine-absorption value, and melting point. The methods of analyses used were those of the Association of Agricultural Chemists.³

DESCRIPTION OF TABLES

In Table 1 is presented the composition of the milk and milk fat for a seven-day composite at the close of the lactation period of each of the cows, in comparison with the true average composition for the entire lactation period. The latter values for each cow follow the letter (a), while the values for the seven-day composite at the last of the lactation period follow the letter (b). For several of the cows the last day of the seven-day composite was the last day of the lactation period. Some of the others were milked for a few days longer, this amounting to seventeen days in the case of Cows 300, 301 and 118. Two of the animals, namely, Cows 4 and 403, were milked for several weeks after the last sample was taken, Cow 4 being milked for four weeks, in fact up to the next parturition, and Cow 403 for five weeks. The data from the several cows are arranged in the order of the number of days before parturition when the last samples of milk and butter were taken for analysis. This varied in the different cows from thirteen to ninety-three days.

The figures following the letter (c) for certain of the animals are data similar to those following (b), the difference being that they represent a seven-day composite ending forty-five days before parturition. These data are given for purposes of comparison with the regulations of the American Association of Medical Milk Commissions.

Some additional data are given in the table, such as, (1) the stage of the lactation period when the samples were taken, (2) daily milk flow of each cow at the beginning of lactation and at the time the samples were taken, with the percentage drop, and (3) the length of time each cow was dry before the next parturition.

3. U. S. Department of Agriculture, Bureau of Chemistry, Bull. 107 (Revised), 1908.

TABLE 1.—RELATION OF STAGE OF LACTATION AND GESTATION TO THE COMPOSITION AND PROPERTIES OF MILK AND MILK FAT

Cow	Time Before Parturi- tion of Sample, Days	Milk Flow per Day			Time Dry, Days	Composition of Milk				Rela- tion of Casein to Total P., per Cent.	Composition of Milk Fat				
		Milk Flow per Day				Total Solids, per Cent.	Lac- tose, per Cent.	Fat, per Cent.	Total Protein, per Cent.		Casein, per Cent.	Saponi- fication Value	Reichert- Meissl No.	Iodin Value, Hübl	Melting Point, C.
		At First, Lbs.	At End, Lbs.	Drop, per Cent.											
209 (a)	13-20	34.2	6.9	79.9	13	11.35	4.25	3.10	3.21	2.49	77.5	229.1	24.44	35.48	32.0
209 (b)	351	34.2	10.6	71.1	..	13.43	4.52	4.01	4.66	3.64	79.1	215.8	20.93	39.06	37.8
209 (c)	45-52	34.2	10.6	71.1	..	13.70	4.57	3.75	4.66	3.77	80.8	221.4	22.28	36.63	34.4
205 (a)	19-26	26.3	4.8	81.7	12	12.12	5.05	3.23	3.00	2.49	83.0	228.2	25.81	34.46	33.8
205 (c)	45-52	26.3	9.4	64.2	..	13.54	5.10	3.61	3.96	3.51	88.7	200.1	7.63	44.96	52.9
22 (a)	354	11.4	3.1	73.7	20	15.35	5.26	5.18	4.03	3.16	78.5	232.4	28.85	28.62	33.2
22 (c)	394	11.4	9.3	18.4	..	14.84	5.25	4.98	5.30	4.06	77.0	224.4	12.05	41.53	31.9
99 (a)	334	23.6	4.5	80.9	21	13.24	4.95	4.64	3.27	2.65	81.0	228.6	28.69	28.87	33.0
99 (b)	25-32	23.6	7.9	66.5	..	16.24	6.20	6.07	4.34	3.45	79.5	217.7	14.64	31.12	34.6
99 (c)	45-52	23.6	7.9	66.5	..	14.85	4.78	5.42	3.89	3.19	82.0	224.0	23.60	30.45	35.0
4 (a)	296	25.7	12.6	50.9	0	14.09	4.85	4.87	3.70	2.93	79.2	227.3	23.17	29.99	32.9
4 (b)	282	25.7	11.4	55.6	..	14.80	4.42	5.63	4.27	3.38	79.0	227.6	25.87	32.19	33.0
4 (c)	45-52	25.7	11.4	55.6	..	14.55	4.44	4.82	4.46	3.38	75.8	227.2	26.50	32.62	33.2
403 (a)	312	30.3	4.1	86.5	19	12.17	3.98	3.37	3.28	2.62	79.8	227.9	26.29	34.72	32.9
403 (b)	53-60	30.3	4.1	86.5	19	13.31	4.40	4.10	4.08	3.13	76.7	224.9	23.03	35.98	33.3
300 (a)	75-82	27.9	3.1	88.6	58	12.08	4.85	3.51	3.11	2.62	84.2	228.4	26.34	31.14	33.8
300 (b)	79-86	27.9	3.1	88.6	58	14.14	3.74	4.65	4.60	3.90	84.8	216.7	17.43	39.64	33.3
402 (a)	308	21.6	3.2	85.2	70	13.01	4.91	4.13	3.49	2.87	82.2	226.9	25.55	34.09	33.4
402 (b)	308	21.6	3.2	85.2	70	13.37	4.14	4.50	4.53	4.15	91.6	210.4	14.98	41.33	37.1
400 (a)	310	22.7	4.3	81.0	83	13.08	5.04	3.89	3.40	2.74	80.6	227.6	26.89	34.08	33.6
400 (b)	310	22.7	4.3	81.0	83	12.79	4.29	4.20	3.70	3.45	93.3	216.5	22.41	38.77	36.6
206 (a)	359	45.4	4.5	90.1	73	10.73	4.26	2.93	2.70	2.11	78.1	230.1	26.13	32.63	32.9
206 (b)	359	45.4	4.5	90.1	73	13.95	4.48	3.73	4.91	3.89	92.8	215.4	15.27	37.62	35.2
301 (a)	394	20.4	4.6	77.5	76	12.71	4.96	3.85	3.33	2.81	84.5	227.9	25.52	32.06	33.2
301 (b)	394	20.4	4.6	77.5	76	13.02	4.90	3.48	4.41	3.83	87.1	219.5	18.58	36.35	33.7
118 (a)	Farrow	14.3	6.6	53.8	..	15.02	4.80	5.36	3.97	3.13	78.9	227.2	23.28	32.79	33.0
118 (b)	Farrow	14.3	6.6	53.8	..	17.97	5.11	7.30	4.85	3.64	75.0	216.5	11.70	32.41	37.4

1. Cow in milk 411 days. 2. Cow not in milk again.

In Table 2 is shown the relation of the time before parturition to certain abnormalities in the composition of the milk and milk fat of each animal. The characteristics of the milk considered in this table are the percentage of total protein and fat, and the Reichert-Meissl number of the milk fat. The standards chosen as the limits of normality are 4.5 per cent. fat and 4 per cent. protein,⁴ and a minimum Reichert-Meissl number of 24.00⁵ for butter fat. The time given in the table is the number of days before parturition when the three characteristics passed beyond these limits of normality.

TABLE 2.—RELATION OF TIME BEFORE PARTURITION TO ABNORMAL MILK

Cow	Protein, per Cent.	Time, Days	Fat, per Cent.	Time, Days	Reichert- Meissl Number	Time, Days
209	4.15	62	6.54	23	20.31	107
205	4.02	29	 ¹	...	21.88	99
99	4.08	55	 ²	...	23.60	62
4	4.21	49	 ²	...	 ³	...
403	4.08	60	 ¹	...	23.03	49
300	4.08	92	 ¹	...	23.25	113
402	4.08	110	4.71	110	22.38	145
400	 ⁴	...	 ¹	...	23.33	128
206	4.15	107	 ¹	...	23.08	135
301	4.15	103	 ¹	...	22.26	110

1. Did not exceed 4.5 per cent.

2. Animal normally tested over 4.5 per cent.

3. Did not go lower than 24.00.

4. Did not exceed 4.0 per cent.

DISCUSSION OF DATA

An examination of Table 1 with the above standards in view shows at once that the stage of the gestation period bore no relation to the time the milk and milk fat passed the limits of normality chosen for comparison. Only a few specific citations are necessary to establish this fact. For example, both the milk and milk fat showed greater abnormalities in composition in the case of Cow 206 when she was three months from parturition than in the case of Cow 209 when she was only two weeks removed from parturition. Again, no greater abnormalities in composition of milk and milk fat are shown in the

4. These are the standards for certified milk of the American Association of Medical Milk Commissions, adopted as those best suited for purposes of diet and nutrition.

5. The minimum legal standard for butter fat of the United States Pure Food Laws.

entire table than by Cow 118, which was farrow. Finally, the samples which show the least abnormality are those from Cows 4 and 403, particularly with respect to the composition of the milk fat. It was these animals whose milking period was continued the longest after the last sample was taken for analysis, this being four weeks in the case of Cow 4, and five weeks in the case of Cow 403. It is clear that when the last sample was taken for analysis in the case of these animals neither of them had reached a stage in their lactation period which corresponded with that of the other animals from which data are presented.

An interesting feature of the table is the relation between the casein and total protein of the milk at the time the last sample was taken, in comparison with the relation which prevailed throughout the entire lactation period. The data show that in most cases the same relation existed at the close of lactation as throughout the lactation period, indicating that the protein increase in milk, which is characteristic of advancing lactation, is more or less of a concentration of protein constituents and not essentially an increase in the output of casein.

It is also clear from Table 1 that for seven of the twelve animals the milk passed the limits of normality chosen for comparison long before they had reached that stage of gestation, that is, forty-five days before parturition, which is most commonly recommended as that beyond which cows no longer give normal milk. The data in Table 1 following the letter (c) are accordingly given to see whether the forty-five day standard sufficed for the remaining five animals. An examination of these data shows that the milk of Cow 209 would have been excluded with fairness on account of the high protein content and the abnormal composition of the milk fat. The exclusion of the milk of Cows 205, 22 and 99 would not have been fair, however, on the basis of percentage of protein, which was in each case within the limits of normality chosen. An exclusion of the milk of these cows on the fat percentage basis would also have been unfair although the fat exceeded 4.5 per cent. in the case of Cows 22 and 99. These two animals were Jerseys, and their milk normally tested in excess of the 4.5 per cent. standard. It is worthy of note, however, that the milk fat of all three animals was abnormal in composition, particularly Cow 205. In the case of Cow 4 the exclusion of the milk at this time with fairness would also have been very questionable inasmuch as the milk was still following closely the average composition of the lactation period in all respects with the exception of a slightly increased total protein. It may be pointed out in connection with the data considered under (c) that each cow was still giving a gallon or more of milk a day. Dairy

cows giving this quantity of milk are found in the herds of most dairy-men, for it is the usual practice to continue the milking period as long as possible.

While considering the question of the standard of forty-five days before parturition, it is of interest to ascertain the length of time before parturition when the milk of the animals under discussion passed the limits of normal composition with which our data have been compared. This point is considered for certain of the animals in Table 2. The wide variation between the individual animals, and also from the forty-five day standard, is very striking.

DISCUSSION OF RESULTS

It is important to state that the data and discussion presented in this paper are not offered in any sense in criticism of the standards of normality with which the data have been compared. These standards have been used for comparison because they were adopted with the problem of infant feeding especially in view, and because we believe our data have particular bearing on that problem. We believe, however, that the standards might well be extended to include the composition of the milk fat as indicated by some one or more of the chemical or physical constants. Unfortunately, no information is at present available in regard to the relation of the composition of the fat of cow's milk to its suitability as food for infants, or as a matter of fact, for human food in general. It is clear, however, to any one who studies the question with an open mind, that it is easy for the dietitian to remedy an abnormal percentage of the milk constituents by the usual methods of modifying milk for infant feeding. An abnormal composition of the milk fat, however, cannot be corrected by these means.

The question on which our data have particular bearing is whether any milk standards are justified in excluding milk for use on the basis of the stage of the gestation period. Our data seem to us to show clearly that this is not the correct basis. The abnormalities to which cow's milk is subject when parturition is approaching are due largely, if not entirely, to the stage of the lactation period. The data here presented indicate clearly that cow's milk becomes abnormal in composition as soon as the lactation stimulus becomes an artificial one on the part of the dairyman, and that this result bears no relation to the stage of the gestation period. Many cows show these abnormalities several months before the next parturition, while very heavy producing cows with periods of parturition the usual interval of twelve to thirteen months apart, may continue to produce perfectly normal milk up to the very hour of the next parturition. The latter are the exception, however, rather than the rule. The great majority of dairy cows in

this country are relatively small producers. In these cases the high protein and fat content, and abnormal composition of the milk fat characteristic of the end of the lactation period may become important questions in connection with infant feeding long before the forty-five day limit is reached. Where mixed milk of a large herd is used the danger of wide variations due to the end of the lactation period would naturally be less likely to occur. The great danger lies in the small herd of cows which are likely to freshen about the same time of the year, and especially in the case of the family cow, in both of which cases the common practice is to continue milking the animals as long as possible.

To those who may desire to make use of the facts here presented, one very practical question arises in this connection, namely, what criterion is available by which the end of the lactation period can be judged? The percentage decrease in the milk flow from that when the cow was fresh is some indication of the stage of the lactation period. This information was given in connection with the data in Table 1 with this point in view. The relations are not definite enough, however, for the establishment of any safe rule that can be followed. Moreover, this information would usually be difficult to secure with accuracy. The milk from cows giving as low as a half-gallon a day should certainly be regarded with suspicion, and should be subjected to critical analysis, especially where the feeding of infants and children is concerned.

Dairy Building.