

THE VITAMIN CONTENT OF MARE'S MILK*

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According to Associates of Rogers (1), mare's milk is commonly used as a food in some sections of Western Asia. It is not used for human food in this country, but one may very properly consider the feasibility of using mare's milk for infant feeding, since its composition resembles that of human milk more nearly than cow's or goat's milk, which is commonly used for infant feeding. This is particularly true with respect to milk sugar. According to Gardner and Fox (6), and Brown and co-workers (3), human milk contains 7.38 per cent and 6.79 per cent of lactose, respectively, while Linton (18) and Hildebrandt (8), respectively, report mare's milk contains 6.14 per cent and 6.42 per cent. Furthermore, Turner (29) found that mare's milk is digested (in vitro) more readily than either cow's or goat's milk. However, at the moment far more interest is centered upon the nutritive value of mare's milk for raising foals. The observation at Massachusetts Agricultural Experiment Station that the body weight of Percheron foals when they are weaned varied from 685 to 830 pounds, naturally raised a question concerning whether the variability in weight results primarily from differences in the milk-producing capacity of the mares or in the quality of the milk. A review of the available literature produced relatively little information concerning the vitamin content of mare's milk. Furthermore, one should not attempt to estimate the vitamin content of mare's milk from data concerning cow's milk even when, as at Massachusetts Agricultural Experiment Station, the mares and cows feed in the same pasture and on hay grown in the same or similar fields, for cows are ruminants and mares are nonruminants. Wegner, Booth, Elvehjem, and Hart (31), Hunt, Kiek, Burroughs, Bethke, Schalk, and Gerlaugh (15) and others have shown that cattle can synthesize riboflavin in the rumen. Furthermore, Bechdel, Honeywell, Dutcher, and Knutsen (2) found that the microflora of the rumen enabled cows fed a vitamin B deficient ration to produce milk of normal vitamin B content. Also McElroy and Goss (19) found appreciable amounts of thiamine in the milk of a fistulated cow whose rumen contained no thiamine; but mares do not have a rumen in which to synthesize vitamins. In view of the paucity of data, this study was conducted to accumulate additional information regarding the vitamin content of mare's milk.

DESCRIPTION OF MARES

At the time the study was undertaken, only three Percheron brood mares,

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Bay State Laurette, Bay State Laura and Bay State Lady Lou were available as a source of milk.

Data concerning the age, weight, and breeding records of the mares in question are reported in table 1.

It will be noted that the body weight of Laura and Lady Lou are somewhat greater than that of Laurette, but this was to be anticipated since the latter worked regularly, often in the hot sunshine, sweating profusely while the other two were idle in a cool barn. The stage of lactation reported in table 1 pertains to the beginning of the experiment. When comparing the results of this study, it should be remembered that Laura is the mother of Laurette, and that Lady Lou and Laurette are half-sisters of the same age. During the period of this experiment, the mares and foals were main-

TABLE 1
Data concerning some of the physical and physiological aspects of the mares studied

Name	Breed	Age	Weight	No. of foal	Stage of lactation	Bred	Activity
Bay State Laurette	Percheron	<i>yrs.</i> 7	<i>lbs.</i> 1640	First	<i>mo.</i> 3	No	Works constantly
Bay State Laura	"	14	1800	Tenth	2	Yes*	Worked before foaling, idle since
Bay State Lady Lou	"	7	1900	Fourth	4	Yes*	Idle entire life
Dutchess	Saddle pony	9	1040	?	1.5	No	Ridden every day

* No recurrence of oestrus.

tained on a good pasture during the nights and were fed grain and hay in the barn during the day. Each mare received 3-4 quarts of crushed oats and 5 or 6 large ears of thoroughly matured, dry corn daily.

COLLECTION OF MILK

A pint or more of milk was required for the various assays. Hence it was necessary to separate the foals from the mares for an hour or more previous to collecting the sample. Since some of the assays were to be made by microbiological procedures, it seemed preferable to keep the bacterial content of the milk as low as possible. Accordingly, the milk was drawn directly into one-half-pint, sterilized milk bottles which were immediately capped.

It was of course recognized that the composition of the milk would not be truly typical for the animal in question unless the entire volume of milk was removed from the udder and thoroughly mixed before sampling, but since the foals were nursing, that procedure could not be followed, and only

enough milk was drawn for assay purposes. Thus all samples of milk from the Percheron mares represented the fore-milk. It was drawn just prior to or, in case the mare refused to "give down her milk," simultaneously with the foals nursing.

The freshly drawn mare's milk was very white with a slightly bluish tinge and thus its appearance was more like human milk or cow's skimmed milk than normal cow's or goat's milk. When the milk was drawn from the mare's udder or was subsequently poured from bottle to bottle, it foamed excessively due probably to a higher albumin content than is characteristic of cow's milk. The mare's milk had a sweetish taste, which perhaps might have been anticipated from its high lactose content.

During the progress of the study, a privately owned saddle mare, Dutchess, lost her 6-week-old foal by tetanus (lockjaw). It was necessary to milk the mare while terminating lactation. Assays were made of her milk, which was always cream-colored, but the results should be considered as applying to abnormal milk, since the intervals between drawing the milk increased and the volume of milk decreased. Samples 2 and 3 were obtained from the same milking. Sample 2 is representative of one pint of fore-milk and sample 3 represents one and one-half quarts of the last milk drawn. Likewise sample 4 represents the fore-milk and sample 5 the last portion of the milk drawn 72 hours after samples 2 and 3. Sample 6 was drawn the following day (24 hours later) and was representative of all the milk obtained. Sample 7, which was drawn more than two days (52 hours) later, was deep cream color and was representative of the one pint of milk, which was the total quantity that could be obtained.

EXPERIMENTAL

The milk was taken directly to the laboratory and assayed for ascorbic, nicotinic and pantothenic acids, riboflavin, thiamine, bacteria, fat, size of fat globules, and total solids. The bacterial and ascorbic acid assays were started within approximately 15 minutes after the milk was drawn from the mares. The remaining assays were started within the next hour. The reduced ascorbic acid was assayed by Sharp's (26) rapid method. The microbiological method of Krehl, Strong, and Elvehjem (16) was employed for determining the amount of nicotinic acid. The Neal and Strong (21) microbiological method was used for pantothenic acid. Riboflavin was assayed by the Holmes and Jones (12) method and thiamine by a modification of the Hennessy and Cerecedo (7) procedure. The number of bacteria was estimated in accordance with "Standard Methods for the Examination of Dairy Products" (28), and fat was determined by the Babcock (17) method, modified to the extent that only 15 cc. of acid were used. The size of the fat globules was measured by an adaptation of the hanging drop procedure, and the Mojonnier and Troy (20) method was followed for determining the total solids.

RESULTS

Forty samples of milk from 3 Percheron mares and a saddle pony, were assayed for ascorbic acid, riboflavin, bacteria, fat, size of fat globules, and total solids. Nearly all the samples were assayed for nicotinic acid and thiamine, but only three samples were assayed for pantothenic acid. The results of these assays are reported in detail in table 2. For convenience, these results are discussed under the appropriate headings.

Ascorbic acid. The ascorbic acid content of the individual samples of milk from each mare varied. The average values were 13.7 for Laurette, 12.2 for Laura, and 12.7 mg. per liter for Lady Lou. Judged by these values, the milk of Percheron brood mares contained only about two-thirds as much reduced ascorbic acid as that previously reported (11) for cows which consumed forage produced on the same land and under essentially the same conditions as the hay and grass consumed by the mares. However, Sigrist (27) claims that the vitamin C content of mare's milk is not dependent upon the age or the type of ration but varies with individual animals.

Nicotinic acid. The nicotinic acid content of normal milk varied from 0.53 mg. for sample 7 from Laurette to 0.83 mg. per liter for sample 8 from Laura. The average values were 0.67 mg. for Laurette, 0.77 mg. for Laura and 0.72 mg. per liter for Lady Lou. The amount of nicotinic acid in the milk from Dutchess varied from 0.53 mg. to 0.94 mg. with an average of 0.72 mg. per liter, but, as mentioned before, this milk was obtained during the cessation of lactation. These values are somewhat lower than 1.1 mg. per liter obtained for milk (9) from the college herd of cows during the late summer.

Pantothenic acid. Due to unforeseen developments, it was possible to assay only three samples of mare's milk for pantothenic, namely sample 1 from each of the three Percheron mares. The values obtained were 3.47 mg. for Laurette, 2.55 mg. for Laura and 2.28 mg. per liter of milk from Lady Lou. These data are too meager to permit any general conclusions concerning the pantothenic acid content of mare's milk, but it is of interest to note that the average value, i.e., 2.77 mg. per liter, is somewhat lower than 3.66 mg. per liter previously reported (10) for the milk from the college herd of cows.

Riboflavin. The riboflavin content of the milk from the Percheron brood mares was quite variable. The average values obtained were 0.11 mg. for Laurette, 0.13 mg. for Laura, and 0.09 mg. per liter for Lady Lou. These values are less than one-tenth that obtained for cow's milk previously studied (13) in this laboratory. However, they are in agreement with the findings of Rasmussen, Bogart, and Maynard (24), who state that limited studies by the fluorometric method indicated that the lactoflavin content of mare's milk is very low. Later, Rasmussen (25) reported that the riboflavin content of mare's milk was about one-tenth the amount found in cow's milk.

TABLE 2
Results of assays of mare's milk

Sample No.	Ascorbic acid	Nicotinic acid	Riboflavin	Thiamine	Bacteria	Fat	Size of fat globules	Total solids
Bay State Laurette								
	<i>mg./l.</i>	<i>mg./l.</i>	<i>mg./l.</i>	<i>mg./l.</i>	<i>per cc.</i>	<i>%</i>	μ	<i>%</i>
1	14.5	.....	0.08	.....	150	0.6	3.0	9.73
2	6.5	.....	0.07	.....	420	0.7	3.0	9.87
3	13.5	0.75	0.09	0.45	1340	1.3	3.0	10.34
4	10.0	0.64	0.08	0.52	500	0.8	3.0	10.12
5	17.5	0.56	0.11	0.49	990	0.4	3.0	9.84
6	16.5	0.58	0.11	.....	880	1.8	4.0	10.80
7	14.5	0.53	0.14	.....	550	1.3	3.0	9.86
8	16.5	0.62	0.12	0.44	150	1.0	4.0	9.76
9	14.5	0.81	0.13	0.42	260	1.1	2.5	10.17
10	14.0	0.73	0.17	0.46	810	1.1	3.0	10.02
11	12.5	0.81	0.15	0.41	60	0.8	3.0	10.11
Average	13.7	0.67	0.11	0.46	555	1.0	3.1	10.06
Bay State Laura								
1	11.5	.....	0.05	.....	60	0.8	4.0	9.67
2	12.0	.....	0.11	.....	950	1.3	4.0	10.41
3	10.5	0.80	.....	0.32	630	0.7	4.0	9.63
4	11.0	0.81	0.07	0.46	130	1.5	4.0	10.40
5	15.0	0.81	0.15	0.46	170	0.8	4.0	10.08
6	17.0	0.75	0.09	.....	160	1.3	3.5	10.41
7	13.5	0.66	0.16	.....	410	1.5	3.0	10.25
8	10.5	0.83	0.20	0.42	190	1.8	3.0	10.57
9	10.0	0.77	0.15	0.38	340	0.8	3.0	9.88
10	12.0	0.80	0.15	0.42	140	1.1	3.0	10.13
11	11.5	0.72	0.19	0.38	130	1.0	3.0	10.22
Average	12.2	0.77	0.13	0.41	301	1.1	3.5	10.15
Bay State Lady Lou								
1	15.5	.....	0.06	.....	80	1.6	2.5	10.41
2	9.0	.....	0.07	.....	610	1.8	3.5	10.88
3	10.0	0.75	0.07	0.40	230	1.9	4.0	10.87
4	10.5	0.68	0.07	0.33	510	1.1	3.5	9.96
5	15.5	0.81	0.09	0.34	380	1.2	4.0	10.28
6	20.0	0.65	0.09	.....	310	2.5	4.0	11.21
7	13.0	0.68	0.12	.....	210	1.5	3.5	10.25
8	15.5	0.67	0.08	0.25	20	2.5	4.0	10.63
9	10.0	0.71	0.14	0.30	270	1.0	3.0	9.74
10	12.5	0.77	0.13	0.30	50	1.8	4.0	10.34
11	8.5	0.76	0.09	0.28	170	0.9	3.5	9.84
Average	12.7	0.72	0.09	0.31	258	1.6	3.6	10.40
Dutchess								
1	15.0*	0.65	0.15	.....	.....	6.5	5.0	13.74
2	16.5	0.53	0.22	.....	30	0.4	2.0	8.42
3	10.5	0.53	0.28	.....	.....	1.6	7.0	9.20
4	22.0	0.80	0.36	0.24	900	2.5	3.0	9.29
5	23.5	0.93	0.36	0.25	200	9.5	9.0	17.49
6	16.0	0.69	0.26	0.24	900	1.5	4.0	10.47
7	17.0	0.94	0.22	.....	190	7.1	5.0	16.33
Average	17.2	0.72	0.26	0.24	444	4.2	5.0	12.13

* For details regarding samples drawn during the rapid cessation of lactation see page 165.

Thiamine. The average values for seven samples of milk from each of the Percheron mares were: 0.46 mg. for Laurette, 0.41 mg. for Laura, and 0.31 mg. per liter for Lady Lou. Judged by these values for individual animals, mare's milk contained slightly more thiamine than 0.33 mg. per liter which was found in raw, mixed, herd milk (9) produced by Ayrshire, Holstein, Guernsey, and Jersey cows, and slightly less than 0.45 mg. per liter previously reported as an average value for goat's milk (14).

Bacteria. The average number of bacteria in the mare's milk was 550 for Laurette, 300 for Laura and 260 per cc. for Lady Lou. These relatively small numbers of bacteria in freshly drawn mare's milk indicate that it, like cow's milk, is probably sterile or nearly so when drawn by the foal directly from the udder. If this assumption is tenable, one must naturally conclude that if foals synthesize vitamins in the intestinal tract, such synthesis is not initiated by the bacteria present in the mare's milk supplied to the foal.

Fat. The fat content of all the samples of milk from the Percheron mares was extremely low as compared with values reported by Overman, Sanmann, and Wright (22) which ranged from 3.55 per cent for Holstein to 5.19 per cent for Guernsey milk. The average values were 1.0 for Laurette, 1.1 for Laura and 1.6 per cent for Lady Lou. Possibly the low fat content may have been a cause for the very white appearance of the milk. However, it should be noted that the mare's milk used in this study was the fore-milk and Van Slyke (30) and others have shown that during milking the percentage of fat increases and unless the udder is carefully stripped and the total milk thoroughly mixed, the sample will not be truly representative with respect to the fat. In fact, in one instance the fore-milk contained less than one-tenth as much fat as the last portion (stripping). Linton (18) found that the fat content of mare's milk increased with the length of time the foal was separated from the mare. In fact, he claims that if the foal is kept from the mare for several hours, the fat content of the milk will increase to a level higher than is well tolerated by foals and he points out that the empirical procedure of milking out a mare that has been working or otherwise separated for several hours from her foal, has a sound scientific basis.

Size of fat globules. The size of fat globules (table 2) represents the average obtained for each sample. While the variation in size is not as large as that reported for cow's milk fat globules (1), i.e., 0.10 μ to 22.0 μ , the average values 3.1 μ for Laurette, 3.5 μ for Laura and 3.6 μ for Lady Lou are essentially the same as the average size of fat globules in cow's milk; namely, 3.0 μ . They are larger than 2.0 μ reported (1) for goat's fat globules.

Total solids. The total solids in the milk varied somewhat for each animal. The average values were 10.06 for Laurette, 10.15 for Laura and 10.40

per cent for Lady Lou. These values are definitely lower than the value of 12.57 per cent reported by Eckles and Shaw (5) for Shorthorn cow's milk and 12.00 per cent, 12.72 per cent, 14.49 per cent, and 14.70 per cent for milk (22) from Holstein, Ayrshire, Guernsey, and Jersey cows respectively.

Hydrogen ion concentration. The pH values obtained for the forty samples of mare's milk varied for the different animals and also varied from day to day for the same animal. The range was from pH 6.66 to 6.98 with an average of 6.81 for normal milk from the Percheron mares. The milk obtained from the saddle mare during the cessation of lactation had a higher pH reading. The value 6.81 is definitely higher than pH 6.37 previously reported (14) for goat's milk, slightly higher than pH 6.6 computed (1) for cow's milk, but less than 6.97 found by Davidsohn (4) for human milk.

Mare's milk during cessation of lactation. The seven samples of milk obtained from Dutchess during the cessation of lactation differed from the milk produced by the Percheron mares. The average values were ascorbic acid, 17.2; nicotinic acid, 0.72; riboflavin, 0.26; and thiamine, 0.24 mg. per liter, fat, 4.2 per cent; size of fat globules, 5.0 μ and total solids, 12.13 per cent. Of these values, the ascorbic acid, riboflavin, fat, size of fat globules, and total solids were greater than for the milk from the Percheron mares; the nicotinic acid was about the same; but the thiamine content was less than that of the other mares. To what extent these differences were brought about by differences in size, breed, and stage of lactation is not known. The very rapid cessation of lactation may have been a major cause of some of the differences in the composition of the milk, for Palmer and Eckles (23) and others have found that as cows and women approach the end of lactation, the protein and fat content of their milk increases.

SUMMARY

Forty samples of milk were obtained from three Percheron mares during the normal lactation and from a saddle pony during very rapid cessation of lactation. The milk was very white with a bluish tinge, foamed excessively and had a sweetish taste. The average values for mare's milk during normal lactation were as follows: ascorbic acid, 12.9 mg.; nicotinic acid, 0.72 mg.; pantothenic acid (three samples), 2.77 mg.; riboflavin, 0.11 mg.; thiamine, 0.39 mg. per liter; fat, 1.2 per cent; fat globule size, 3.4 μ ; total solids, 10.20 per cent. Of these values ascorbic and nicotinic acid, riboflavin, fat, and total solids were lower than the corresponding values for cow's milk, but the thiamine values were higher.

The milk obtained from the saddle pony during the period of rapid cessation of lactation contained more ascorbic acid, riboflavin, fat, and total solids, and had larger fat globules than was found for the other three mares experiencing normal lactation; the amount of thiamine was much less.

The greatest difference in vitamin content between mare's and cow's milk was in riboflavin; the former having only about one-tenth of the latter.

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