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COMPOSITION OF MARE'S MILK¹

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ALTHOUGH more than sixty references to mare's milk production and composition have been published, little work has been reported with the light horses commonly bred in the United States, and few workers have explored the changes that occur during the various stages of lactation. For these reasons the following study was initiated.

Experimental Procedure

Three Arabian and seven Quarter Horse mares in the Michigan State University band were used in this study. They ranged in age from 4 to 13 years with a mean and standard error of 7.5 ± 1.0 years. The number of previous lactations ranged from 0 to 8 with a mean of 2.4 ± 0.8 . The mares were kept outdoors until approximately 10 days before foaling, when they were housed in box stalls except for exercise periods. After foaling both mare and foal were put outdoors as soon as weather permitted. During the winter the mares were given free access to a high quality alfalfa-grass hay. Depending upon condition they were also given 4 to 6 ears of corn and 2 to 4 kg. of crushed oats each day. Dicalcium phosphate, trace mineral salt and water were available *ad libitum*. Alfalfa-grass pastures were used during the growing season plus supplemental grain as needed. The foals were born between March 23 and May 1.

Milk samples were obtained 15 to 30 min. after parturition (before first nursing of the foal) and at 12, 24 and 48 hr.; 5 and 8 days; 3 and 5 weeks; and 2, 3 and 4 months post-partum. The usual procedure was to encourage the foal to nurse one mammary gland, while all of the milk in the other gland was manually expressed into an acid-washed Pyrex beaker. The volume of milk obtained was measured, and the milk was then stored at -20°C . until analyzed.

Specific gravity was determined with a

pycnometer according to the A.O.A.C. (1960) procedure. Total solids were determined by preliminary drying of approximately 2 gm. of liquid milk on a steam bath and then drying this sample to a constant weight at 100°C . in a forced draft oven. Total nitrogen was determined by the semimicro-Kjeldahl procedure.

Total lipids were determined by a modification of the Roesse-Gottlieb method (A.O.A.C., 1960). Five gm. of milk were transferred to a narrow-mouthed, 50-ml. centrifuge tube. The following reagents were added individually with mixing after each addition: 1 ml. concentrated NH_4OH , 5 ml. absolute ethanol, 15 ml. diethyl ether and 15 ml. petroleum ether (boiling point range, 30° – 60°C .). The tube was then centrifuged at 2500 *g* for 1 min. The upper layer was removed and placed in a weighed, 8-cm. diameter, flat-bottomed evaporating dish. Fifteen ml. of diethyl ether and 15 ml. of petroleum ether were added individually to the tube followed by mixing and centrifuging as before. The upper layer was quantitatively removed and added to the previously removed material in the evaporating dish. The solvent was driven off on a steam bath, and the evaporating dish was placed in a convection oven at 135°C . under 250 mm. of vacuum for 10 min. The evaporating dish was then cooled in a desiccator and weighed.

Gross energy was determined (after drying approximately 5 gm. in a combustion cup) in a Parr⁴ adiabatic oxygen bomb calorimeter.

Ash was determined (after preliminary drying of 5 gm.) in a muffle furnace at 550°C . The ash was dissolved in 6 N HCl and diluted to an appropriate volume. Calcium, phosphorus and magnesium were determined by application of the methods of Mori (1959), Gomorri (1942) and Lindstrom and Diehl (1960), respectively. CDTA (1, 2-cyclohexylenedinitrilotetraacetic acid) served as the titrant in both the calcium and magnesium determinations. Sodium and potassium determinations were made with a Beck-

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⁴ Parr Instrument Co., Inc., Moline, Illinois.

TABLE 1. MAJOR CONSTITUENTS OF MARE'S MILK

Stage of lactation	No. of samples	Specific gravity	Total solids	Crude protein (N×6.38)	Lipids	Lactose ^a	Gross energy
			gm./100gm.	gm./100gm.	gm./100gm.	gm./100gm.	kcal./100gm.
Partum	8	1.076±0.004 ^b	25.2±1.3	19.1±1.5	0.7±0.1	4.6±0.7	135±10
12 hr.	10	1.036±0.001	11.5±0.6	3.8±0.4	2.4±0.2	4.8±0.5	64± 4
24 hr.	10	1.035±0.001	11.4±0.3	3.3±0.2	2.5±0.3	5.2±0.3	62± 3
48 hr.	9	1.035±0.001	12.0±0.3	3.3±0.1	2.5±0.3	5.8±0.2	62± 4
5 days	10	1.035±0.000	11.6±0.2	3.1±0.1	2.1±0.2	5.9±0.2	59± 1
8 days	10	1.034±0.001	11.5±0.3	3.1±0.1	2.0±0.1	5.9±0.2	59± 2
3 weeks	10	1.035±0.000	11.3±0.2	2.7±0.1	2.0±0.1	6.1±0.1	56± 2
5 weeks	10	1.034±0.001	11.2±0.3	2.7±0.1	2.3±0.2	5.7±0.2	59± 2
2 months	10	1.033±0.001	10.3±0.1	2.2±0.1	1.6±0.2	6.1±0.2	52± 2
3 months	10	1.034±0.000	10.4±0.2	2.0±0.0	1.4±0.2	6.6±0.1	52± 2
4 months	10	1.034±0.000	10.0±0.6	2.0±0.1	1.3±0.1	6.5±0.1	49± 2

^a Determined by difference [total solids—(crude protein+lipids+ash)].
^b Mean and standard error.

man DU spectrophotometer equipped with a flame attachment using an oxygen-acetylene burner. The 590-mμ emission line was used for sodium and the 770-mμ emission line was used for potassium.

Results and Discussion

The mean volume and standard error of milk obtained at each sampling (contents of one mammary gland) was 107±1.7 ml. with a range of 76 to 162 ml. Neseni *et al.* (1958) reported that light-breed foals obtained 221 gm. of milk at each nursing. The means and

standard errors for determinations of specific gravity, gross energy, total solids, crude protein, lipids and lactose are shown in table 1 and are illustrated in figures 1 and 2. All means, except lipid and lactose concentration, were highest at parturition before the foals had nursed and then tended to decline throughout lactation. Lipid concentration was lowest at parturition, increased to a peak at 24 to 48 hr. and then declined. Lactose concentration tended to rise from parturition to a high point at 3 months. Linton (1937), working with data from Shetland ponies, calculated regression equations relating the con-

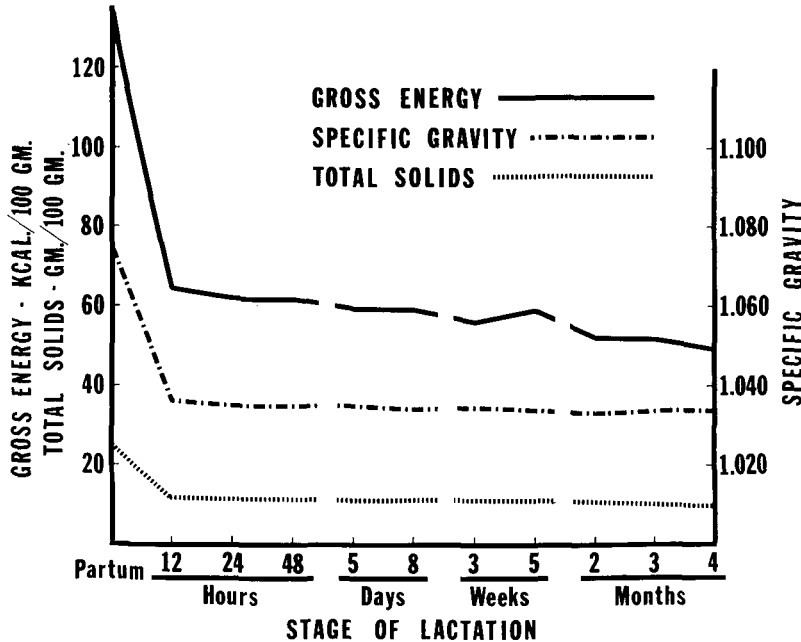


Figure 1. Changes in the specific gravity and concentration of gross energy and total solids in mare's milk at various stages of lactation.

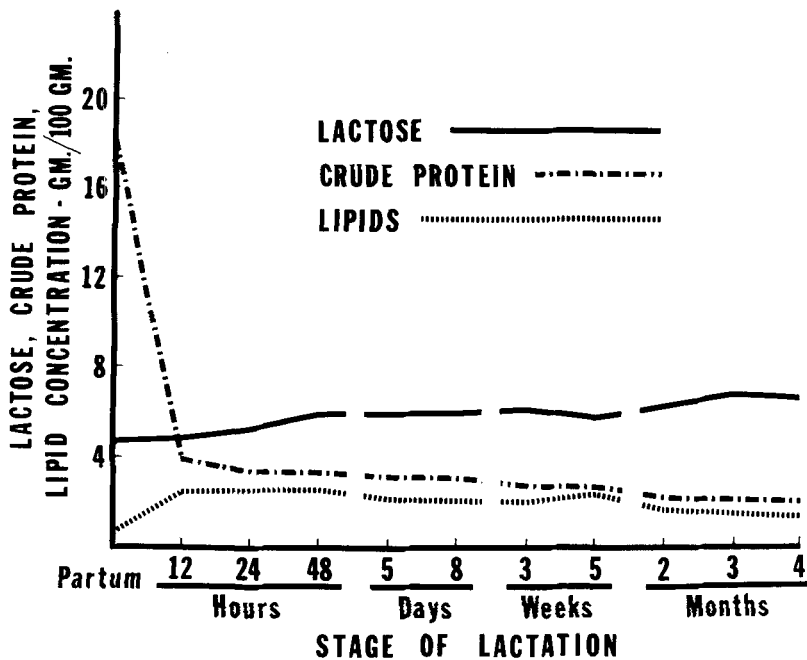


Figure 2. Changes in the concentration of lactose, crude protein and lipids in mare's milk at various stages of lactation.

centration of several milk constituents to the stage of lactation and found that lactose concentration increased as lactation progressed. In contrast to the observations reported here, he also found that the concentration of solids and fat increased throughout lactation. Neseni *et al.* (1958) reported, in a study of heavy and light mares and Shetland ponies, that mean values for colostrum and milk, respectively, were: dry matter, 17.01 and 11.23%; fat, 2.28 and 1.90%; total protein, 8.03 and 2.63%; and energy, 66.1 and 47.05 kcal./100 ml.

The means and standard errors of ash, cal-

cium, phosphorus, magnesium, sodium and potassium concentrations are presented in table 2 and are illustrated in figures 3 and 4. Ash concentration was highest at parturition, dropped abruptly by 12 hr., rose to a second peak at 8 days and then declined. Calcium concentration followed the same trend, although the highest value was observed at 8 days. Phosphorus concentration rose from parturition to a peak at 48 hr. and then declined. Magnesium, sodium and potassium concentrations were highest at parturition and then generally declined throughout lactation. Linton (1937) reported that ash, calcium and

TABLE 2. MINERAL CONSTITUENTS OF MARE'S MILK

Stage of lactation	No. of samples	Ash	Calcium	Phosphorus	Magnesium	Sodium	Potassium
		gm./100gm.	mcg./gm.	mcg./gm.	mcg./gm.	mcg./gm.	mcg./gm.
Partum	8	0.72±0.02 ^a	847±40	389±16	473±69	524±82	1143±66
12 hr.	10	0.50±0.02	782±42	399±21	138±9	364±11	965±46
24 hr.	10	0.53±0.02	973±56	442±19	110±6	337±18	841±41
48 hr.	9	0.54±0.02	1110±52	457±17	92±5	296±9	861±41
5 days	10	0.54±0.01	1199±39	444±11	101±6	265±10	846±28
8 days	10	0.55±0.01	1278±52	441±10	94±6	238±13	780±36
3 weeks	10	0.50±0.01	1261±35	391±7	68±11	185±6	606±15
5 weeks	10	0.43±0.01	1110±29	325±13	63±4	188±8	555±24
2 months	10	0.37±0.01	905±35	285±11	49±3	203±15	456±21
3 months	10	0.32±0.01	708±18	243±6	40±3	174±6	405±15
4 months	10	0.27±0.01	614±28	216±7	43±2	161±3	370±15

^a Mean and standard error.

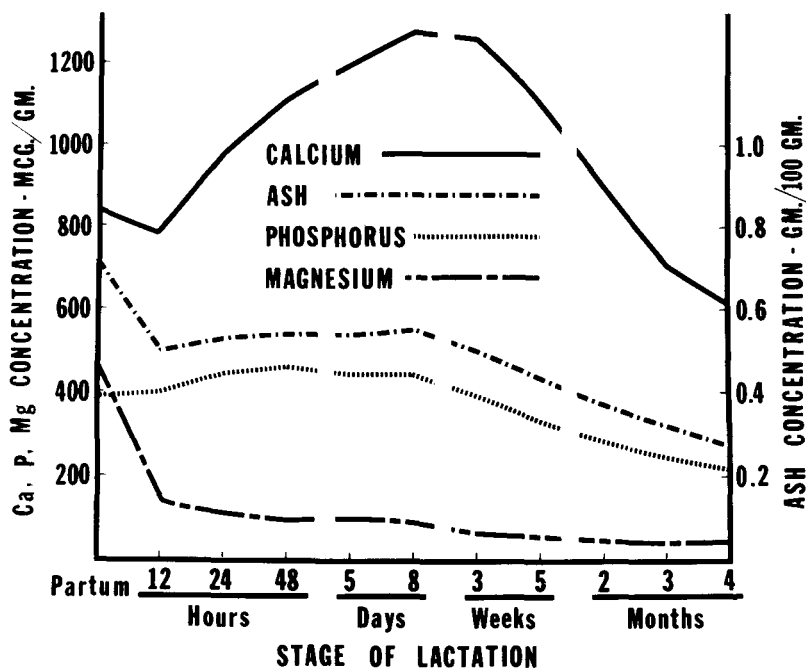


Figure 3. Changes in the concentration of ash, calcium, phosphorus and magnesium in mare's milk at various stages of lactation.

phosphorus concentration declined during lactation in Shetland ponies. Holmes *et al.* (1947), in comparison with the data pre-

sented here, reported appreciably higher phosphorus concentrations in the milk of Percheron mares. The overall mean was 630

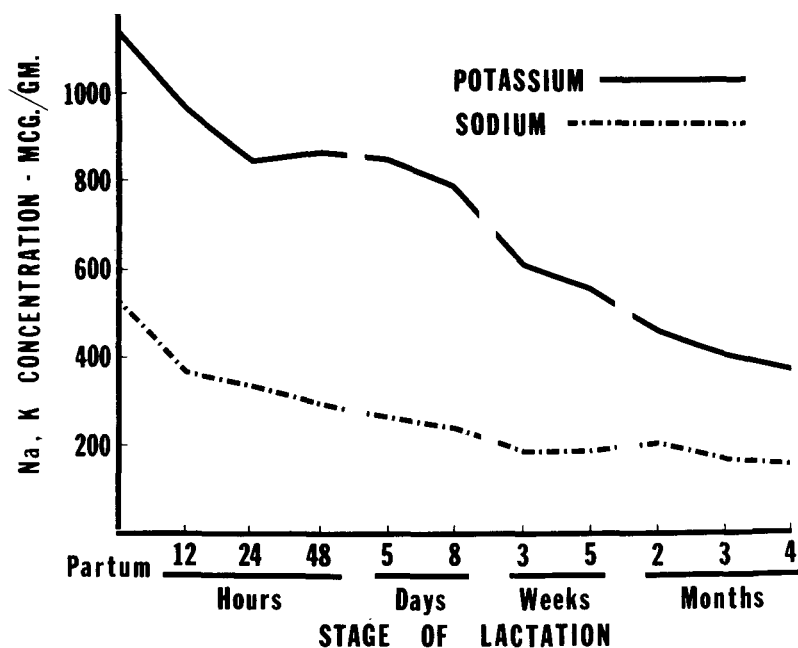


Figure 4. Changes in the concentration of potassium and sodium in mare's milk at various stages of lactation.

mcg./gm., which was higher than any of the individual values found in the present study at any stage of lactation. The calcium, magnesium and potassium values reported by this group were within the range of the present observations. The milk phosphorus concentrations reported by Linton (1937) were intermediate between those reported by Holmes *et al.* (1947) and the data from the present study.

Ling *et al.* (1961) have summarized data from unidentified sources representing the composition of mare's colostrum and milk. Milk concentrations of gross energy, total solids, crude protein, lipids, lactose, ash and calcium reported by these workers agreed closely with values found at 2 months postpartum in the present study. The concentrations of total solids and crude protein in colostrum collected during the first 24 hr. as reported by Ling *et al.* (1961) were intermediate between the parturition and 12-hr. values found in this study. These differences can be explained on the basis of differences in sampling time. However, many other factors have been shown to affect the composition of cow's milk. The fat content of cow's milk rises during milking, and the work of Gardner *et al.* (1956) suggests that the concentration of nonfat solids is similarly affected. Since the samples analyzed in the present study represented the complete milking of one mammary gland, this should not have introduced an error. Apparently there are species differences in this respect, since Whittlestone (1952) found no increase in the fat content of sow's milk during milking.

Reinart and Nesbit (1956a, b) have demonstrated that there are significant differences between breeds of cattle in the concentration of milk fat and nonfat solids, and Waite *et al.* (1956) have noted that age or the number of previous lactations significantly affects the concentration of nonfat solids in cow's milk. While two breeds were included in the present study and the mares' ages and number of previous lactations were known, the numbers of mares in each class were not large enough to provide a basis for conclusions regarding effects of these factors on milk composition. No obvious differences which might be ascribed to breed, age or number of prior lactations were evident.

Summary

Milk samples from three Arabian and seven Quarter Horse mares were obtained at par-

turition (before first nursing of the foal) and at 12, 24 and 48 hr.; 5 and 8 days; 3 and 5 weeks; and 2, 3 and 4 months postpartum. Determinations of specific gravity, gross energy, total solids, crude protein, lipids, ash, calcium, phosphorus, magnesium, sodium and potassium were made on each sample. Lactose concentration was estimated by difference. Values for gross energy, specific gravity, total solids, crude protein, ash, magnesium, sodium and potassium dropped abruptly from parturition to 12 hr. postpartum and then tended to decline slowly thereafter. Lactose concentration tended to rise slowly throughout lactation. Lipid and phosphorus concentration rose from parturition to 24 to 48 hr. postpartum and then tended to decline. Calcium concentration dropped from parturition to 12 hr., rose to a peak at 8 days and then declined. The following values were obtained at parturition and at 2 months postpartum, respectively: specific gravity, 1.076 and 1.033; gross energy, 135 and 52 kcal./100 gm.; total solids, 25 and 10 gm./100 gm.; crude protein, 19 and 2 gm./100 gm.; lipids, 0.7 and 1.6 gm./100 gm.; lactose, 5 and 6 gm./100 gm.; ash, 0.7 and 0.4 gm./100 gm.; calcium, 847 and 905 mcg./gm.; phosphorus, 389 and 285 mcg./gm.; magnesium, 473 and 49 mcg./gm.; sodium, 524 and 203 mcg./gm.; and potassium, 1143 and 456 mcg./gm.

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