Factors Affecting the Calcium, Magnesium and Phosphorus Content of Beef Cow Milk

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ABSTRACT

This paper reports the calcium, magnesium and phosphorus content of milk from Shorthorn cattle during the five month calf nursing period as well as the effect of prepartum administration of a single intramuscular dose of vitamin D_3 or of 25-hydroxyvitamin D_3 on the milk mineral constitutents. The colostrum of the group which received 25-hydroxyvitamin D_3 was found to contain a higher percentage of calcium on the second and third day than the colostrum of control cows or those receiving D_3. No differences occurred in colostrum magnesium or phosphorus contents due to prepartum treatment. Calcium, magnesium and phosphorus concentrations were all high in the first day of lactation, but declined until the third day after parturition. Milk calcium, magnesium and phosphorus content of individual cows was not uniform throughout the lactation and the variation was different for different cows.

RÉSUMÉ

Cette communication rapporte la teneur du lait de vaches Shorthorn en calcium, en magnésium et en phosphore, au cours d'une période d'allaitement qui dura cinq mois; elle mentionne aussi l'effet de l'administration, avant le vêlage, d'une injection intramusculaire de vitamine D_3 ou de 25-hydroxyvitamine D_3, sur les constituants minéraux de leur lait. Le colostrum des vaches qui avaient reçu la 25-hydroxyvitamine D_3 se révéla plus riche en calcium, aux deuxième et troisième jours après le vêlage, que celui des vaches témoins et de celles qui avaient reçu la vitamine D_3. Le traitement avant le vêlage ne provoqua pas de différences dans la teneur du colostrum en magnésium et en phosphore. Les concentrations en calcium, en magnésium et en phosphore, s'avérèrent toutes élevées, immédiatement après le vêlage; elles diminuèrent cependant jusqu'au troisième jour après la parturition. La teneur du lait en calcium, en magnésium et en phosphore, n'afficha pas d'uniformité, au cours de la lactation; elle varia, au contraire, d'une vache à l'autre.

Little information is available on the milk composition of beef cattle and on factors which influence its composition (6, 12). Knowledge of milk composition of beef cows is essential as it directly affects the growth performance of suckling calves. Most of the published data on mineral milk composition was related to dairy breed. It appears that bovine milk calcium and phosphorus concentrations are controlled by genetic factors (5). Gueguen and Journet (4) reported differences in the mineral concentrations of bovine milk between three French dairy breeds. In view of the scarcity of such information for beef breeds and since milk is an important source of calcium and phosphorus, a broader knowledge of the percentages present in beef cows' milk, of the variations and of the factors responsible for any variations is desirable. The role of vitamin D in calcium and phosphorus metabolism has been recognized for many years and was reported (13) that prepartum feeding of cows with solanum glaucophyllum, a plant rich in 1 α-25-hydroxyvitamin D, increased the calcium and phosphorus composition of colostrum. The purpose of the present work was to determine whether administration of a single massive dose of vitamin D or 25-hydroxyvitamin D a few days prior to parturition, would influence the calcium, phosphorus and magnesium composition of concentration of these minerals in the milk of beef cows was assessed.

A total of 27 gestating Shorthorn heifers two years of age were used; ten received intramuscularly (I.M.) 3×10^6 IU vitamin D_3 in 2 mL propylene glycol (Rogar/STB, Montreal, P.Q.); nine received I.M. 5 mg of 25-hydroxyvitamin D_3 (25-OHD_3) in aqueous ethanolic solution (The Upjohn Co., Kalamozoo, Michigan); and the remaining heifers served as controls.

The cows of all three groups shared the same barn and yard, and received the same management during the trial. They were fed grass-silage during the October

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1978 to September 1979 period. The silage was prepared from a mixed sward consisting mostly of timothy and fescue. This was ensiled at the boot stage using 0.2% formic acid as a preservative. During the experimental period, all animals had free access to water and mineral mixture containing 65% cobaltized-iodized salt and 35% dicalcium phosphate.

Milk samples from these cows were collected at fixed intervals after calving (Table I). The cows were milked by hand to give a sample of about 150 mL for laboratory analyses. Hand milkings were carried out in the morning and the calf was tied up near its dam before nursing to encourage milk let down and all the four quarters of the udders were milked to give a uniform sample of the milk.

Total milk ash was the residue obtained after a weighed sample was evaporated to dryness and burned in a muffle furnace at 550°C for two hours. Calcium and magnesium in the ash were determined by atomic absorption after the ash was dissolved in an acidic aqueous solution of 1% lanthanum chloride and 5% HCl (2). Phosphorus was estimated colorimetrically (1).

Silage samples were obtained weekly and composited for analyses of calcium, magnesium and phosphorus content as previously indicated for milk after nitric-perchloric acid digestion (7). The data were analysed statistically by the use of the general linear procedure in SAS package, which permit a balanced or unbalanced analyses of variance. The model used was Yi = treatment j + eij. Yi is time (i observation). Treatment j = 3 treatments levels. eij = error. Time can be day 1, 2, 3 week 1, week 2, month 1, month 2 . . .

The silage mineral content on a dry matter basis (%) of silage was: calcium: 0.82 ± 0.21 (S.D.), phosphorus: 0.21 ± 0.03 and magnesium: 0.24 ± 0.07, giving a calcium: phosphorus ratio of 4:1 much greater than the assumed optimum of 2:1. This is not, however, of particular importance to cattle, for which dietary ratios of calcium to phosphorus ranging from 1:1 to 7:1 give satisfactory and similar results (16). The mean time between injection and calving was 7.4 ± 1.2 (S.D.) day, for the vitamin D_3 group and 4.8 ± 0.6 S.D. for the 25-OH D_3 group.

In agreement with the results of Senft and Rappen (15) the highest calcium content during the entire lactation was observed in the first day colostrum after which there was a sharp decrease (Table I). Colostrum calcium (%) was higher on the second and third day

TABLE I. Calcium, Magnesium and Phosphorus Content of Milk (%) at Various Stages of Lactation of Beef Cows

Specified Times after Parturition	Control	Vitamin D Treated	25-hydroxyvitamin D_3	All Treatments Combined
		Calcium %		
Day 1	0.197 ± 0.0113	0.181 ± 0.0104	0.187 ± 0.0099	0.188 ± 0.0060
Day 2	0.126 ± 0.0087	0.129 ± 0.0032	0.158 ± 0.0226	0.138 ± 0.0082
Day 3	0.118 ± 0.0044	0.122 ± 0.0056	0.138 ± 0.0046	0.126 ± 0.0032
Week 1	0.128 ± 0.0040	0.127 ± 0.0123	0.128 ± 0.0037	0.127 ± 0.0045
Week 2	0.125 ± 0.0041	0.125 ± 0.0082	0.125 ± 0.0033	0.125 ± 0.0032
1st Month	0.131 ± 0.0016	0.136 ± 0.0055	0.132 ± 0.0027	0.133 ± 0.0021
2nd Month	0.132 ± 0.0029	0.136 ± 0.0051	0.129 ± 0.0033	0.133 ± 0.0023
3rd Month	0.129 ± 0.0027	0.134 ± 0.0046	0.134 ± 0.0010	0.132 ± 0.0018
4th Month	0.131 ± 0.0057	0.148 ± 0.0136	0.141 ± 0.0034	0.140 ± 0.0054
5th Month	0.144 ± 0.0140	0.142 ± 0.0045	0.133 ± 0.0034	0.140 ± 0.0051
		Magnesium %		
Day 1	0.0285 ± 0.0027	0.0251 ± 0.0014	0.0234 ± 0.0012	0.0255 ± 0.0011
Day 2	0.0124 ± 0.0012	0.0119 ± 0.0009	0.0128 ± 0.0011	0.0123 ± 0.0006
Day 3	0.0100 ± 0.0006	0.0099 ± 0.0003	0.0116 ± 0.0009	0.0105 ± 0.0003
Week 1	0.0204 ± 0.0100	0.0097 ± 0.0009	0.0098 ± 0.0002	0.0132 ± 0.0032
Week 2	0.0096 ± 0.0002	0.0098 ± 0.0003	0.0095 ± 0.0001	0.0096 ± 0.0001
1st Month	0.0096 ± 0.0001	0.0094 ± 0.0016	0.0082 ± 0.0010	0.0091 ± 0.0003
2nd Month	0.0092 ± 0.0002	0.0194 ± 0.0102	0.0092 ± 0.0002	0.0130 ± 0.0038
3rd Month	0.0097 ± 0.0001	0.0095 ± 0.0001	0.0100 ± 0.0002	0.0097 ± 0.0001
4th Month	0.0097 ± 0.0002	0.0178 ± 0.0090	0.0099 ± 0.0001	0.0127 ± 0.0033
5th Month	0.0116 ± 0.0008	0.0105 ± 0.0002	0.0104 ± 0.0004	0.0109 ± 0.0003
		Phosphorus %		
Day 1	0.181 ± 0.0094	0.171 ± 0.0090	0.174 ± 0.0073	0.175 ± 0.0049
Day 2	0.125 ± 0.0085	0.138 ± 0.0063	0.144 ± 0.0119	0.136 ± 0.0052
Day 3	0.119 ± 0.0035	0.120 ± 0.0048	0.128 ± 0.0041	0.122 ± 0.0025
Week 1	0.118 ± 0.0061	0.110 ± 0.0112	0.125 ± 0.0084	0.117 ± 0.0051
Week 2	0.103 ± 0.0058	0.106 ± 0.0055	0.105 ± 0.0037	0.105 ± 0.0028
1st Month	0.112 ± 0.0023	0.111 ± 0.0028	0.114 ± 0.0031	0.112 ± 0.0015
2nd Month	0.107 ± 0.0021	0.104 ± 0.0059	0.107 ± 0.0038	0.106 ± 0.0024
3rd Month	0.106 ± 0.0020	0.107 ± 0.0023	0.107 ± 0.0036	0.107 ± 0.0014
4th Month	0.106 ± 0.0041	0.117 ± 0.0059	0.113 ± 0.0026	0.112 ± 0.0027
5th Month	0.091 ± 0.0083	0.106 ± 0.0055	0.100 ± 0.0098	0.009 ± 0.0044

Mean ± standard error
Treatment means were different for calcium on the 3rd day ($P < 0.05$)
Sampling time were all significantly different ($P < 0.01$) for all elements

($P < 0.05$) in the 25-OHD_3 treated cows than in the vitamin D_3 treated cows or controls (Table I). The reported difference between the 25-OHD_3 and vitamin D_3 could be attributed to the fact that 25-OHD_3 was administered 2.6 days closer to calving than vitamin D_3. However, this is unlikely because according to Hollis *et al* (8) there is about one week lag required for the full conversion to vitamin D_3 to 25-OHD_3 in cattle following administration of a massive dose of vitamin D_3. This reduced rate of decrease in calcium in the second and third day colostrum from the 25-OHD_3 prepartum treated cows could be related to increased intestinal calcium absorption (3) followed probably by higher transmammary calcium transfer than in the two other groups. No further effect of treatment ($P > 0.05$) was noted on milk composition during the remaining lactation. The effect of stage of lactation on the variation in milk calcium is shown in Table I. A relatively small variation in calcium milk composition was observed during the first three months of lactation, followed by an increase in the fourth and fifth months of lactation. As previously reported (11) it was noted that the calcium content of milk of individual dairy cows would not be uniform throughout lactation and the variation was different for different cows. Kirchgessner *et al* (9), noted that the calcium content of dairy cow milk (0.12%) remained constant in the individual animal for the greater part of lactation, whereas considerable differences were encountered between animals.

Milk phosphorus and magnesium levels were unaffected by prepartum vitamin D_3 or 25-OHD_3 treatment (Table I). In agreement with data (14) for dairy cattle the phosphorus content in the colostrum was highest on the first day after calving. It decreased sharply on the second day and then dropped gradually up to the end of the second week. During the remainder of the lactation, the phosphorus content fluctuated slightly and the lowest value was observed at the end of the fifth month. In agreement with the data of Lenkeit *et al* (10), in dairy cattle individual animals exhibited distinct individual differences in their milk phosphorus content.

Colostrum magnesium was the highest on the first day and then dropped rapidly the second day (Table I). As observed in dairy cattle by Cerbulis and Farrell (2), a wide variation was evident in magnesium levels between milk samples taken at different stages in lactation.

It can be concluded from this experiment that in addition to the effect of 25-OHD_3 on calcium content of the colostrum of the second and third days, a number of other factors such as individual animal and stage of lactation in this experiment also affected the milk mineral composition of Shorthorn cattle.

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