Calcium: Ruminal Concentrations and Digestibility of Feedstuffs by Lambs

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Story in Brief

Adding available calcium (calcium chloride) to a low calcium lamb diet sequentially increased calcium concentration in ruminal fluid and tended to depress ruminal pH. It would appear feasible to estimate calcium availability in the rumen from limestone and other feedstuffs based on calcium content of rumen fluid samples. Added calcium chloride did not alter digestibility but increased dry matter and ash content of feces. In vitro digestion of prairie hay was not altered by dietary calcium level or addition of calcium to ruminal fluid. But digestion of corn grain tended to increase with calcium added to rumen fluid from calcium deficient lambs. Digestion of corn grain also tended to be depressed with addition of calcium to rumen fluid from lambs fed an adequate level of calcium. These results suggest that there may be an optimal ruminal calcium level for starch digestion and excesses can be deleterious.

Introduction

Calcium supplementation of feedlot diets is widely discussed, but the site of action of limestone remains undecided despite many studies. Bryant (1973) indicated that cellulose digesting microbes require 50 ppm calcium but 350 ppm proved toxic to the bacteria. Hubbert (1958) found additions up to 300 ppm increased cellulose digestion by ruminal microbes while 450 ppm inhibited digestion. In contrast, Bales (1978) found that 10 ppm was adequate for digestion of milo stalks. Saliva, containing 16 to 30 ppm, therefore seems marginal in calcium so dietary supplementation is useful. Ruminal concentration has been estimated by various workers at level from 50 to 360 ppm, although these measurements may include suspended as well as soluble calcium. Levels of calcium in the rumen appear to be dependent on the diet, so possibly ruminal concentration could be used as an index of ruminal availability. The objectives of this experiment were to examine the influence of dietary calcium on 1) concentration of calcium in ruminal fluid and 2) digestion by growing lambs.

Materials and Methods

Twelve growing lambs (42 kg) housed in metabolism stalls were subdivded into 4 groups and fed one pound of feed twice daily of a basal diet for a total of 2 pounds per day (67.5 percent cracked corn, 20 percent cottonseed hulls, 12.5 percent soybean meal) or this diet with supplemental calcium chloride to form diets containing .18, .28 and .38 percent calcium. Calcium chloride

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was used instead of calcium carbonate due to its greater solubility and lack of buffering action which could alter fermentation. After 10 days, ruminal samples were obtained by stomach tube, centrifuged (10,000 g) and the supernatant fluid analyzed for pH and soluble calcium.

In a second study, six of the lambs above were fed the basal diet and six were fed the .38 percent calcium diet for 14 days. Feces were collected the final 5 days of the trial and digestibilities of dry matter, organic matter and starch were determined. On the last day of the study, ruminal fluid was obtained by stomach tube from 10 of these lambs (5 deficient and 5 adequately fed) and incubated with or without added calcium (to provide 280 ppm calcium during incubation) with either ground corn grain (12 hours) or prairie hay (18 hours).

Results and Discussion

Ruminal pH was decreased with addition of calcium to the diet (Table 1). Although calcium chloride is acid, it was surprising that addition of 1.4% calcium chloride to the diet would reduce ruminal pH unless it was increasing production of fermentation acids in the rumen. Calcium concentration in ruminal fluid increased linearly with intake of calcium. This suggests that availability of calcium from limestone and feedstuffs might be determined from a standard curve and ruminal concentrations.

Added calcium did not statistically alter digestibility of dry matter, organic matter or starch (Table 2). Starch digestibility was very high. This is probably

Table 1. Ruminal fluid concentrations of calcium.

Dietary Calcium, %	Ruminal Measurements	
	pH units	Soluble Ca ppm
.08	6.38[ab]	11.0[a]
.18	6.71[a]	19.6[ab]
.28	6.31[ab]	31.1[bc]
.38	5.93[b]	37.0[c]

[a,b,c]Means in a column with different superscripts differ ($P < .05$).

Table 2. Digestibility and feces composition.

	Dietary Ca, %	
	.08	.38
Digestibility, %		
Dry matter	83.2	84.3
Organic matter	83.7	84.8
Starch	99.5	99.7
Feces composition		
Dry matter, %	41.1[a]	49.8[b]
Ash, % of DM	7.7[a]	10.6[b]

[a,b]Means in a row with different superscripts differ ($P < .05$).

because lambs chew their food much more thoroughly during eating than cattle. Feces of lambs fed the higher calcium level contained more ash and dry matter than feces of lambs fed the low calcium diet.

Extent of digestion of corn grain and hay were not significantly altered either by dietary calcium level or by addition of calcium at the start of the incubation period (Table 3). Supplementing the diet with calcium did not influence digestion. However, the interaction between the dietary calcium level and the addition of calcium at the start of fermentation approached significance, with addition increasing digestion with rumen fluid from deficent lambs, and decreasing digestion with rumen fluid from adequately supplemented lambs. This would suggest that there may be a critical range of calcium for maximizing starch digestion. Further study of ruminal calcium concentrations and rate of starch digestion are needed since both deficient and excessive levels appeared to reduce digestion of corn grain (primarily starch) in a fashion similar to the effect of calcium on cellulose digestion. Variable digestion and efficiency responses to calcium supplementation may be due to different ruminal calcium concentrations from various supplemental and feed sources of calcium.

Table 3. In vitro digestion.

Dietary Ca, %	Ca Added at incubation	Feedstuff Corn Grain Digested, %	Prairie Hay
.08	None	41.8[ab]	24.5
.08	Yes	43.4[a]	24.6
.38	None	41.9[ab]	25.4
.38	Yes	36.8[b]	25.6

[a,b]Means in a column with different superscripts differ ($P < .05$).

Literature Cited

Bales, G. L., et al. 1978. J. Anim. Sci. 47:561.
Bryant, M. P. 1973. Federation Proceedings 32:1809.
Hubbert, F. Jr., et al. 1958. J. Anim. Sci. 17:559.