Effect of Limestone on Digestibility of Feedlot Diets

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Story in Brief

Two levels of limestone (.7 and 2.0 percent) were fed with two levels of chopped alfalfa hay (10 and 50 percent) to 22 Hereford steers (517 lb). The diet also contained whole shelled corn and supplement. Animals were fed individually at a level equal to 2.5 percent of body weight daily in two equal meals. Organic matter, fiber and nitrogen digestibility were increased with added limestone. Fiber and nitrogen digestibility also increased as alfalfa was added to the diet. Beneficial effects of additional limestone involved increased fiber and nitrogen digestibility primarily, not increased starch digestibility. If increased fiber digestion speeds clearance from the rumen, limestone supplementation beyond nutritional requirements may increase feed intake as well as digestibility of higher roughage diets.

Introduction

Several researchers have reported that limestone supplementation increases energy availability of high concentrate diets. Increased starch digestion has been suggested as one explanation. Limestone has been suggested to increase starch digestion by preventing ruminal and intestinal pH from falling so low as to inhibit starch digestion. However, Zinn and Owens (1982) reported limestone altered ruminal and intestinal pH very little. Fiber digestion may be more susceptible than starch digestion to low ruminal pH.

The purpose of this study was to determine the influence of additional limestone on starch and fiber digestion.

Experimental Procedure

Twenty-two Hereford steers (517 lb) were fed one of two levels of alfalfa (10 and 50 percent) with two levels of limestone (.7 and 2.0 percent). Steers were fed 2.5 percent of their body weight as feed dry matter in two equal meals each day.

Table 1. Diet composition (% of dry matter)

	Diet	
	High roughage	Low roughage
Whole shelled corn	42	82
Alfalfa	50	10
Supplement	8	8
Analysis (%)		
Protein	13.6	12.4
Starch	31.57	58.54
ADF	24.63	6.70
Ca, (calculated)	.97-1.65	.44-.87

The diet included whole shelled corn (42 or 82 percent), alfalfa (10 or 50 percent) and 8 percent supplement (Table 1). Steers were fed each diet for 21 days. The limestone was incorporated into a pelleted supplement (Table 2). Chromic oxide was included in the supplement as an indigestible marker to calculate digestibility. Animals were housed in individual pens with concrete slatted floors. Samples of feces were collected the last 5 days of each period. Samples were analyzed for pH, dry matter, ash, nitrogen, starch, ADF (a fiber estimate) and chromium. Rumen samples were collected with a stomach tube the last day of each period. Rumen samples were analyzed for pH and volatile fatty acid concentrations.

Table 2. Supplement composition (% of dry matter)

	Diet	
	Low limestone	High limestone
Dry rolled corn	67.7	51.0
Urea	6.0	6.0
Potassium chloride	10.3	10.3
Calcium carbonate	9.1	25.8
Dicalcium phosphate	2.2	2.2
Salt	2.5	2.5
Chromic oxide	2.0	2.0
Trace mineral	.3	.3
Vitamin A	+	+

Results and Discussion

Limestone addition increased digestibility of organic matter, nitrogen and fiber (Table 3). Starch digestion tended to be greater with limestone addition, but effect was much less than for fiber. Limestone addition had little effect on rumen pH (Table 4). This suggests that the positive influence of additional limestone in this study probably was not due to a ruminal pH effect. Other possible benefits of added limestone include altered ruminal outflow rates, increased salivation and rumination or an effect of the calcium on enzyme action or stability. Calcium concentration of the low calcium-low roughage diet was .44 percent, which meets the NRC requirement, while the higher limestone diet contained .87 percent calcium. Limestone had similar effects on digestibility with both roughage levels (Table 5). The response in starch digestibility to addition of limestone tended to be greater with the lower roughage level (2.6 percentage units) than the higher roughage level (1.6 percentage units).

Table 3. Influence of limestone on diet digestibility

	Limestone level, %	
	.7	2.0
Digestibility (%)		
Organic matter	68.8^{a}	74.0^{b}
Starch	90.3	92.3
Fiber	27.9^{a}	35.6^{b}
Nitrogen	62.1^{a}	67.6^{b}

^{ab}Means in a row with different superscripts differ statistically ($P<.01$).

Table 4. Effect of limestone level on ruminal parameters

	Limestone (%)	
	.7	2.0
Rumen:		
pH	6.57	6.57
Volatile fatty acids[d]		
Total μmoles/ml	90.1	90.4
Acetate	56.9	56.2
Propionate	22.0	23.3
Butyrate	9.5	9.5
Isobutyrate	6.6	6.6
Valerate	2.1	1.9
Isovalerate	2.2	2.1
Caproate	0.7	0.5
C_2/C_3	3.1[b]	2.7[a]
NGR[c]	3.9[b]	3.4[a]

[ab]Means with different superscripts differ statistically ($P<.05$).
[c]Non-glucogenic ratio.
[d]Individual VFA in moles/100 moles.
Total VFA in μmoles/ML.

Table 5. Effect of limestone addition within two roughage levels

Roughage level	10		50	
Limestone level	.7	2.0	.7	2.0
Digestibility (%)				
Organic matter	72.4	77.4	65.7	71.2
Starch	88.8	91.4	91.5	93.1
Fiber	16.3	23.0	37.6	46.1
Nitrogen	60.9	68.9	63.2	68.2

Fiber digestion was significantly increased with added alfalfa (Table 5). Starch and nitrogen digestibility tended to increase with added roughage while organic matter digestibility was reduced. Since much of the protein in alfalfa is associated with fiber, increased fiber digestion should increase nitrogen digestibility. Though roughages in some trials have reduced starch digestibility, roughage addition to the diet also may increase rumination and digestion of the whole shelled corn. Studies with intestinally cannulated cattle and pigs suggests that with whole corn, the kernel surface limits digestion. With ground or processed corn, other factors may limit digestion.

Volatile fatty acid concentrations (Table 4) were similar; however, the ratio of acetate to propionate (C_2/C_3) was less with added calcium. This could decrease methane loss and increase energetic efficiency. Efficiency of energy utilization also has been related to the ratio of non-glucogenic to glucogenic fatty acids (NGR). Ratios from 2 to 3.5 appear to be utilized efficiently for growth while ratios above or below this range may be used less efficiently for growth. Limestone decreased the NGR from 3.9 to 3.4. Forage addition to the diet decreased concentrations of total volatile fatty acid, propionate, valerate, isovalerate and caproate (Table 7). Acetate levels increased greatly with additional roughage.

Table 6. Roughage level effect on diet digestibility

	Roughage level (%)	
	10	50
Digestibility (%)		
Organic matter	74.9[b]	68.4[a]
Starch	90.1	92.3
Fiber	19.7[a]	41.9[b]
Nitrogen	63.9	65.7

[ab]Means in a row with different superscripts differ statistically ($P<.01$).

Table 7. Effects of roughage level on ruminal parameters

	Roughage level (%)	
	10	50
Rumen:		
pH	6.35	6.77
Volatile fatty acids		
Total	94.3[f]	87.0[e]
Acetate	48.4[a]	63.0[b]
Propionate	29.0[b]	17.6[a]
Butyrate	9.8	9.2
Isobutyrate	6.8	6.4
Valerate	2.8[b]	1.4[a]
Isovalerate	2.5[b]	1.9[a]
Caproate	0.8[d]	0.4[c]
C_2C_3	1.9[a]	3.7[b]
NGR	2.5[a]	4.5[b]

[ab]Means in a row with different superscripts differ statistically ($P<.01$).
[cd]Means in a row with different superscripts differ statistically ($P<.05$).
[ef]Means in a row with different superscripts differ statistically ($P<.10$).
[g]Non-glucogenic ratio.

In summary, limestone addition to increase dietary calcium from .44 to .87 percent of diet dry matter increased digestibility of organic matter, nitrogen and fiber. With high roughage diets, the increased fiber digestibility due to added limestone may increase clearance of fiber from the rumen and thereby permit feed intake and gain to increase. Added calcium might be beneficial in a similar manner for stressed cattle. Benefits from added limestone in this trial were related primarily to increased fiber and nitrogen digestion rather than increased starch digestibility. Results would support feedlot trial findings elsewhere in this report that when added calcium increases feed intake, it will improve animal performance.

Literature Cited

Zinn, R.A. and F.N. Owens. 1982. Okla. Agr. Exp. Sta. Res. Rep. MP-112.