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Effects of Franklin Feed-Grade Limestone vs. Aerion Industries Nutrion Limestone on performance and carcass characteristics of finishing beef steers

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Introduction

Because grains comprise the major portion of diets for finishing beef cattle, and grains contain little calcium, limestone is typically added to finishing diets at levels of .7 to more than 1% of the dry matter. Feed-grade limestone varies in quality and consistency, which could alter performance responses by finishing beef steers. Selection of superior sources of limestone and(or) treatment of selected limestones to increase their reactivity in the gastrointestinal tract, might alter the supply of available calcium. Our objective was to determine whether performance and carcass characteristics of finishing beef steers differed when a select source of treated limestone (Aerion Industries Nutrion limestone) was fed at two levels compared with a common feed-grade source of limestone.

Experimental Procedures

Cattle. One hundred ten Angus and Angus x Hereford steers were received at the Texas Tech University Burnett Center from Lexington Livestock in Lexington, NE on April 24, 1999. Steers were sorted to three dirt-floor pens at the Burnett Center and fed 10 lb per steer of a 60% concentrate starter diet. Two days after arrival, all steers were processed as follows: 1) individual ear tag in the left ear; 2) vaccination with Bovishield 4+Lepto (Pfizer Anim. Health); 3) vaccination with Fortress 7 (Pfizer Anim. Health); 4) treatment with Dectomax pour-on (Pfizer Anim. Health); and 5) measurement of individual body weight (BW). Steers were returned to the dirt-floor pens after processing, where they continued to receive a 60% concentrate diet.

Experimental Design. The BW data for the 110 steers were ranked from least to greatest. The four steers of lightest BW and the 16 steers of heaviest BW were designated as Extra cattle. The remaining 90 steers were assigned randomly within BW strata to one of three treatments, after which treatments were randomly assigned to pens (five steers per pen with six pens per treatment). Treatments were as follows:

- **F** – Dietary limestone supplied by Franklin High-Calcium limestone;
- **M** – Dietary limestone supplied by a 50:50 mixture of Franklin High-Calcium limestone and Nutrion limestone;
- **N** – Dietary limestone supplied by Nutrion limestone

The particle size of limestone from the three sources was similar, and one lot of each of the three limestone sources was delivered to the Burnett Center on the same day before the experiment began. Limestone from these three lots was used throughout the study to mix the treatment premixes.

The experiment was started on May 4, 1999, at which time steers were weighed individually, implanted with Ralgro (Schering-Plough Anim. Health), and sorted to the six concrete, slotted-floor pens previously assigned to each treatment. All cattle were switched from the 60% concentrate starter diet to a 70% concentrate diet that was fed at a rate of 16 lb per steer. Intermediate premixes containing the three limestone sources were included in the 70% concentrate diet.

Experimental Diets. Ingredient composition of the diets fed during the experiment is shown in Table 1. These data reflect adjustments for the average dry matter (DM) content of feed ingredients for the period during which a given diet was fed. As noted previously, each source of limestone was supplied in the form of an intermediate premix (Table 2). Premixes were mixed in 1,000-lb quantities in a stainless steel Hayes and Stolz horizontal ribbon mixer and stored in sealed poly bags. To avoid cross-contamination of limestone sources, the mixer was thoroughly cleaned between each batch of premix. Each premix had the same composition, except for the source of limestone, and supplied protein, various minerals and vitamins, Rumensin (30 g/ton, DM basis), and Tylan (8 g/ton, DM basis). Bags of each treatment premix were dumped, as needed, into one of three separate computer-controlled premix bins in the Burnett Center feed mill.

Management, Feeding, and Weighing Procedures. The three treatment diets were mixed in a 45-cubic foot capacity Marion paddle mixer. Once the total amount of feed for a given treatment was mixed, the mixed batch was released from the Marion paddle mixer and delivered by a drag-chain conveyer to a hopper mounted on load cells. The amount of feed allotted to each pen within treatment was then weighed to the nearest 1 lb by activating a drag-chain conveyor in the hopper and delivering the desired quantity of feed to individual 55-gal poly drums (one drum for each pen per treatment). Mixing and feeding order of treatment diets throughout the experiment was F, M, and N. To avoid cross-contamination of diets, at least one batch of a diet other than the three treatment diets was mixed between the treatment diets.

Dry matter determinations on ingredients used in the experimental diets were made every 2 wk throughout the experiment. These ingredient DM values were used to calculate the DM percentage of each dietary ingredient during the experiment. In addition, samples of mixed feed delivered to feed bunks were taken weekly throughout the experiment. These bunk sample DM values (adjusted for feed refusals) were used to compute average DM intake (DMI) by the cattle in each pen. Samples of feed taken from the bunk were composited for each 28-d period of the experiment and further composited across the entire experimental period. Samples were ground to pass a 2-mm screen in a Wiley mill, and overall composites were analyzed for DM, ash, CP, ADF, Ca, and P (AOAC, 1990; Table 3).

Each feed bunk of the 18 pens was evaluated visually at approximately 0700 to 0730 daily. The quantity of feed remaining in each bunk was estimated, and the suggested daily allotment of feed for each pen was recorded. This bunk-reading process was designed to allow for little or no accumulation of unconsumed feed (0 to 1 lb per pen). Pens of cattle that maintained a given level of feed intake for a 3-d period were challenged to consume a higher level (.4 lb/steer challenge). Feed bunks were cleaned, and unconsumed feed was weighed at 28-d intervals (corresponding to intermediate weigh dates) throughout the trial. Dry matter content of feed bunk weighback samples was determined in a forced-air oven by drying for approximately 20 h at 100^{o}C.

After 28, 56, 84, and 112 d on feed, steers in all pens were weighed before the morning feeding. All BW measurements were obtained using a single-animal scale (C & S Single-Animal Squeeze Chute set on four load cells). The scale was calibrated with 1,000 lb of certified weights (Texas Dept. of Agriculture) on the day before each scheduled weigh day. On d 56, at the time of a regularly scheduled BW measurement, each steer was implanted with Revalor S (Hoechst Roussel Vet). After the 112-d BW measurement, it was estimated that the cattle would have sufficient finish to grade USDA Choice within 3 to 4 wk. Hence, steers were weighed at approximately 0500 on September 21, 1999 and shipped to the Excel Corp. slaughter facility in Plainview, TX. Of the original 90 steers that started the experiment, three steers were removed from the experiment for reasons unrelated to treatment, resulting in a total of 87 steers being sent to the Excel Corp. facility.

Carcass Evaluation. Personnel of the West Texas A&M University Beef Carcass Research Center obtained all carcass measurements. Measurements included hot carcass weight, longissimus muscle area, marbling score, percentage of kidney, pelvic, and heart (KPH) fat, fat thickness measured between the 12th and 13th ribs, yield grade, and liver abscess score. Liver abscess scores were recorded on a scale of 1 to 7, with 1 = no abscesses, 2 = A-, 3 = A, 4 = A+, 5 = telangiectasis, 6 = distoma (fluke damage), and 7 = fecal contamination that occurred at slaughter. Of the 87 steers sent to the slaughter plant, complete data were obtained for hot carcass weight, longissiums muscle area, marbling score, KPH, and quality grade, whereas 86 observations were available for fat thickness, yield grade, and liver score.

Statistical Analyses. All data were analyzed with pen as the experimental unit. A completely random design was employed, and computations were made with the GLM procedure of SAS (1987). Pen means for daily gain and average daily DMI were included in the data file, and feed:gain ratio was computed as the quotient of daily DMI divided by daily gain. The effect of treatment was included in the model for pen-based data. Carcass data were entered on an individual animal basis and analyzed with a model that included effects for treatment and pen within treatment. Pen within treatment was specified as the error term for testing treatment effects. Residual mean square in this model for carcass data (not used for testing) would include individual animal variation. The following orthogonal contrasts were used to evaluate treatment differences: 1) F vs the average of M and N limestone and 2) M vs N limestone. Carcass quality grade and liver abscess score data were analyzed by Chi-square procedures (SAS, 1987) using individual animal data.

Results and Discussion

Performance Data. Body weight, daily gain, DMI, and feed:gain ratio data are shown in Table 4. Neither initial (average = 757.6 lb) nor final (average = 1,222.4 lb) BW differed among treatments. As expected from the similar initial and final BW, daily gain did not differ ($P > .10$) among treatments for the overall 140-d study or for any of the cumulative intervals throughout the study. Daily DMI was less for the average of the cattle fed the M and N treatments than for those fed the F treatment for d 0 to 28 of the study; however, despite a consistent numerical trend for lower DMI with the M and N treatments compared with the F treatment, no other differences ($P > .10$) in DMI were noted during the study. As a result of lower DMI and equal or greater daily gain, feed:gain was improved ($P < .05$) 14.2% from d 0 to 28 for the average of M and N vs F, and improved ($P < .10$) 4.6% for the average of M and N vs F from d 0 to 56. As with DMI, feed:gain was numerically superior for the average of M and N vs F for the remaining cumulative periods, but differences were not significant ($P > .10$). For the 140-d study, a non-significant improvement in feed:gain of 2.4 and 3.6% was noted for M and N, respectively, relative to F.

Differences among treatments in gastrointestinal fill at the conclusion of an experiment might affect treatment differences in performance based on live BW measurements. Hence, when hot carcass weight is known, it is common to divide hot carcass weight by a standard dressing percent to calculate a carcass adjusted final BW. This carcass-adjusted final BW can then be used to calculate a carcass-adjusted daily gain for the entire study period. As with unadjusted gain, carcass-adjusted daily gain (Table 4) did not differ ($P < .10$) among the three treatments. However, calculation of carcass-adjusted feed:gain (d 0 to 140 daily DMI divided by carcass-adjusted daily gain) magnified differences among treatments such that the difference in feed:gain between the average of M and N vs F approached significance ($P < .12$). Carcass-adjusted feed:gain was improved 3.8 and 3.9% for M and N, respectively, compared with F.

Dietary NEm and NEg concentrations were calculated (NRC, 1996) from performance data for the three treatments groups. Calculated values for NEm were 2.07, 2.11, 2.13 Mcal/kg of DM for the F, M, and N treatment groups, respectively. Corresponding NEg values were 1.41, 1.44, and 1.46 Mcal/kg of DM, respectively. Values for NEm and NEg based on dietary ingredient composition (NRC, 1996) were 2.15 and 1.47 Mcal/kg, respectively. The slight increases in NE values calculated from performance data for the M and N treatments relative to the F treatment reflect the slight improvements in feed:gain observed with these two treatments.

Carcass Data. Carcass measurements are shown in Table 5. None of the carcass measurements collected differed ($P > .10$) among the three treatments. On average, 66.56% of the cattle graded USDA choice, with an average fat thickness of .47 inches, indicating that the cattle had reached the desired degree of finish by the conclusion of the 140-d study.

Liver score data are shown in Table 6. Although these data were analyzed statistically, the number of observations in each subclass was too small for a reliable analysis. No obvious differences in distributions of liver scores were evident among the three treatment groups, with 90% or more of the livers evaluated being free of abscesses or other factors that might result in condemnation.

Summary and Conclusions

Under the conditions of the present experiment, feeding limestone from different sources did not have large effects on cattle performance. However, daily DMI was consistently lower with the Mix and Nutrion sources of limestone than with Franklin High-Calcium limestone. Typically, DMI by cattle fed the Mix limestone was intermediate to DMI by cattle fed Franklin High-Calcium and Nutrion limestones, with the least intake by cattle fed the Nutrion limestone. Equal gain among treatments resulted in numerical improvements in feed:gain for the Mix and Nutrition limestones compared with the Franklin High-Calcium limestone treatment. Carcass-adjusted feed:gain tended ($P < .12$) to be improved by approximately 3.8% to 3.9% for the Mix and Nutrion limestones compared with Franklin High-Calcium limestone.

The consistently lower DMI and trend for improved feed:gain by cattle fed the Mix and Nutrion limestones deserves further study. Efforts to determine the biological basis for these trends should prove useful in determining how to best choose limestone sources for use in the diets of finishing beef cattle.

Literature Cited

AOAC. 1990. Official Methods of Analysis (15th Ed.). Association of Official Analytical Chemists. Washington, DC.

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Table 1. Ingredient composition (%, DM basis) of the experimental diets

	Percentage of dietary concentrate								
	70			80			90		
Ingredient	F[a]	M[a]	N[a]	F	M	N	F	M	N
Cottonseed hulls	15.17	15.16	15.16	10.03	10.03	10.03	5.02	5.02	5.02
Ground alfalfa hay	15.18	15.18	15.18	10.26	10.26	10.26	4.97	4.97	4.97
Steam-flaked corn	54.85	54.85	54.84	64.87	64.87	64.87	75.53	75.53	75.52
Cottonseed meal	4.04	4.04	4.04	4.14	4.14	4.14	4.00	4.00	4.00
Molasses	4.22	4.22	4.22	4.15	4.15	4.15	4.15	4.15	4.15
Fat (yellow grease)	3.08	3.08	3.08	3.10	3.10	3.10	2.93	2.93	2.93
Urea	.95	.95	.95	.92	.92	.92	.90	.90	.90
TTU premix[b]	2.51	2.52	2.53	2.53	2.53	2.53	2.50	2.50	2.50

[a] F = Franklin High-Calcium limestone; M = 50:50 mixture of Franklin High-Calcium limestone and Nutrion limestone; and N = Nutrion limestone.

[b] Premix composition, which included the three limestone sources, is shown in Table 2.

Table 2. Composition of the TTU premix used in experimental diets

Ingredient	%, DM basis
Cottonseed meal	23.9733
Limestone[a]	42.1053
Dicalcium phosphate	1.0363
Potassium chloride	8.0000
Magnesium oxide	3.5587
Ammonium sulfate	6.6667
Salt	12.0000
Cobalt carbonate	.0017
Copper sulfate	.1572
Iron sulfate	.1333
EDDI	.0025
Manganese oxide	.2667
Selenium premix, .2% Se	.1000
Zinc sulfate	.8251
Vitamin A, 650,000 IU/g[b]	.0122
Vitamin E, 275 IU/g[b]	.1260
Rumensin, 80 mg/lb[b]	.6750
Tylan, 40 mg/lb[b]	.3600

[a] Limestone supplied by either Franklin High-Calcium limestone, a 50:50 mixture of Franklin High-Calcium limestone and Nutrion limestone, or Nutrion limestone.

[b] Concentrations noted by the ingredient are on a 90% DM basis.

Table 3. Chemical composition of the experimental diets

	Percentage of dietary concentrate								
	70			80			90		
Ingredient	F[a]	M[a]	N[a]	F	M	N	F	M	N
Dry matter, %[b]	83.28	79.67	77.17	82.72	78.50	81.93	82.28	81.64	81.40
Ash, %	5.14	5.66	5.30	4.22	5.19	4.52	4.54	4.36	4.48
Crude protein, %	13.21	13.46	13.77	12.57	13.54	12.45	14.11	14.02	14.46
ADF, %[c]	18.12	18.11	18.11	13.31	13.31	13.31	6.30	7.61	6.79
Calcium, %	.68	.68	.60	.52	.53	.52	.49	.46	.52
Phosphorus, %	.23	.26	.27	.22	.28	.25	.35	.34	.34

[a] F = Franklin High-Calcium limestone; M = 50:50 mixture of Franklin High-Calcium limestone and Nutrion limestone; and N = Nutrion limestone.

[b] All values except Dry matter, % are expressed on a DM basis. Values represent analyses conducted on a sample of each diet composited across the experiment.

[c] ADF = Acid detergent fiber. Values for the 70 and 80% concentrate diets were calculated from NRC (1996) feed composition tables, whereas values for the 90% concentrate diet were analyzed.

Table 4. Effects of limestone source on performance by finishing beef steers

	Limestone source[a]				
Item	F	M	N	SE[b]	Contrast[c]
Initial BW, lb	762.0	755.3	755.5	5.37	NS
Final BW, lb	1,229.1	1,218.9	1,219.3	18.58	NS
Daily gain, lb					
d 0 to 28	2.52	2.88	2.78	.163	NS
d 0 to 56	3.67	3.75	3.81	.099	NS
d 0 to 84	3.62	3.62	3.65	.128	NS
d 0 to 112	3.31	3.35	3.29	.123	NS
d 0 to 140	3.32	3.33	3.31	.130	NS
Carcass adjusted[d]	3.30	3.34	3.31	.120	NS
Daily DMI, lb/steer					
d 0 to 28	15.31	14.82	14.78	.125	1*
d 0 to 56	17.89	17.65	17.50	.223	NS
d 0 to 84	19.09	18.53	18.56	.296	NS
d 0 to 112	18.98	18.58	18.44	.328	NS
d 0 to 140	19.23	18.72	18.54	.403	NS
Feed:gain					
d 0 to 28	6.18	5.28	5.33	.311	1*
d 0 to 56	4.89	4.72	4.61	.093	1†
d 0 to 84	5.29	5.17	5.10	.160	NS
d 0 to 112	5.77	5.58	5.62	.147	NS
d 0 to 140	5.81	5.67	5.60	.141	NS
Carcass adjusted[d]	5.84	5.62	5.61	.108	NS

[a] F = Franklin High-Calcium limestone; M = 50:50 mixture of Franklin High-Calcium limestone and Nutrion limestone; and N = Nutrion limestone.

[b] Pooled standard error of treatment means, n = six pens/treatment.

[c] Orthogonal contrast of treatment means; 1 = F vs the average of M and N; 2 = M vs N. * = $P < .05$; † = $P < .10$; NS = not significant ($P > .10$).

[d] Carcass-adjusted gain was calculated from a standardized final BW, where the standardized final BW equaled the hot carcass weight divided by the average dressing percent (61.57%). Carcass-adjusted feed:gain was calculated as the ratio of d 0 to 140 DMI to carcass-adjusted gain.

Table 5. Effects of limestone source on carcass characteristics of finishing beef steers

	Limestone source[a]				
Item	F	M	N	SE[b]	Contrast[c]
Hot carcass wt, lb	755.1	751.9	750.9	10.57	NS
Dressing percent	61.45	61.70	61.57	.293	NS
LM area, sq. in.[d]	12.89	12.59	12.79	.204	NS
Fat thickness, in.	.47	.44	.49	.020	NS
KPH, %[e]	2.14	2.13	2.17	.069	NS
Yield grade	2.84	2.86	2.91	.069	NS
Marbling score[f]	425.5	408.3	432.7	13.66	NS
Choice, %	68.97	60.71	70.00	-	NS
Select, %	31.03	39.29	30.00	-	NS

[a] F = Franklin High-Calcium limestone; M = 50:50 mixture of Franklin High-Calcium limestone and Nutrion limestone; and N = Nutrion limestone.

[b] Pooled standard error of treatment means, n = six pens/treatment.

[c] Orthogonal contrast of treatment means; 1 = F vs the average of M and N; 2 = M vs N; NS = not significant (P > .10).

[d] LM = longissimus muscle.

[e] KPH = kidney, pelvic, and heart fat.

[f] 300 = Slight^0; 400 = Small^0; 500 = Modest^0.

Table 6. Distribution of liver scores (% of total) in finishing beef steers fed three different limestone sources

	Limestone source[a]		
Item	F	M	N
Not condemned	92.86	92.86	90.00
A-	3.57	7.14	3.33
A	0.00	0.00	0.00
A+	0.00	0.00	3.33
Distoma (fluke)	3.57	0.00	3.34

[a] F = Franklin High-Calcium limestone; M = 50:50 mixture of Franklin High-Calcium limestone and Nutrion limestone; and N = Nutrion limestone.