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Encapsulation of flaxseed in a dolomitic lime matrix: effects on feedlot performance and carcass characteristics of steers vs. heifers

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Encapsulation of Flaxseed in a Dolomitic Lime Matrix: Effects on Feedlot Performance and Carcass Characteristics of Steers vs. Heifers

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Introduction

Polyunsaturated fatty acids, when fed to cattle, are subject to extensive alteration by ruminal microbes, effectively converting the polyunsaturated fats into saturated fats. The oil of flaxseed is rich in alpha linolenic acid (~55% of the oil), which is an essential polyunsaturated, omega-3 fatty acid. Enrichment of feedlot cattle diets with flaxseed has been used effectively as a means of increasing the proportions of omega-3 fatty acids incorporated into beef, but efficiency of transfer from the animal's diet to beef is relatively low. Encapsulating the flaxseed or flaxseed oil in a matrix that is resistant to the actions of ruminal microbes could provide a mechanism for increasing the efficiency with which polyunsaturated fats are absorbed and deposited into tissues.

We have investigated the potential for using hydrated lime to form protective matrices with oil-rich feeds, such as flaxseed, to increase the incorporation of omega-3 fatty acids into meat. Dolomitic lime is mixed with ground flaxseed, water is added, the mixture is blended in a high-speed turbulizer, and the resulting material is then dried to form a granular matrix. During the manufacturing process, a portion of the hydrated lime becomes recarbonated. This recarbonated matrix is ruminally stable, which prevents rumen microbes from converting polyunsaturated oils to saturated fats. Additional recarbonation occurs in the rumen due to exposure to high concentrations of carbon dioxide produced by rumen microbes, further stabilizing the matrix. The objective of this study was to compare feedlot performance and carcass characteristics of heifers and steers fed traditional finishing diets to those of cattle supplemented with encapsulated blends of ground flaxseed and dolomitic lime hydrate.

Experimental Procedures

Forty crossbred steers with an average initial body weight of 921 ± 57 lb and 40 crossbred heifers with an average initial body weight of 814 ± 62 lb were used in a randomized complete block design with a 2 × 4 factorial arrangement of treatments to test interactions between gender (steers and heifer) and diet. Finishing diets consisted of: (1) Control (no flaxseed); (2) 4% of a 50:50 mixture of dolomitic lime and flaxseed; (3) 6% of a dolomitic hydrate flaxseed mixture containing 67% lime and 33% flaxseed; and (4) 6% of a 33:67 dolomitic hydrate:flax blend for the latter half of the finishing period. Composition of experimental diets is summarized in Table 1. Diets were mixed immediately before feeding and delivered to each pen once daily at 11:30 a.m. Ten steers and 10 heifers were assigned to each dietary treatment. Cattle were divided equally into heavy and light groups; the heavies half were marketed after 116 days on feed, and the lighter group was marketed after 144 days of feedlot finishing. Cattle were harvested at a commercial abattoir in Holcomb, KS. On the day of harvest, incidence of liver abscesses was recorded as well as hot carcass weight. Carcasses were chilled for 24

hours, then graded. Carcass measurements included 12th-rib subcutaneous fat thickness; ribeye area; percentage of kidney, pelvic, and heart fat; marbling score; and USDA quality and yield grade. Data were analyzed using the MIXED model procedure of SAS (Version 9.0; SAS Institute, Cary, NC) with gender, diet, and the gender × diet interaction as fixed effects and weight group as a random effect. Animal was the experimental unit. Frequency data (liver abscesses and USDA yield and quality grades) were analyzed as binomial proportions with the GLIMMIX procedure of SAS using the same model as described previously.

Results and Discussion

Feedlot performance is summarized in Table 2. There were no interactions between diet and gender. Regardless of diet, steers consumed more feed and had more rapid rates of gain than heifers ($P < 0.01$). Efficiency tended to be better for steers than for heifers, but these differences were not statistically different. Feeding lime-encapsulated flaxseed decreased intake markedly ($P < 0.01$), but gains and efficiencies were not statistically different from controls. The 4% and 6% lime treatments yielded similar gain and efficiency, however. The substantial decrease in feed intake associated with addition of lime-encapsulated flaxseed (12% decrease for heifers and 10% decrease for steers) was not expected. No such observations were made in previous studies with growing cattle fed forage-based diets. The hydrate matrix is very alkaline, which may have affected palatability, but the absence of this effect in forage-based diets suggests that poor palatability may not be the cause of this change. It is conceivable that we altered cation-anion balance sufficiently to disrupt normal feeding behavior. Future studies are being planned to examine this effect in greater detail.

As expected, steer carcasses were heavier than those of heifers (722 vs. 619 lb, respectively; $P < 0.01$; Table 3). Steers also had greater ribeye areas than heifers ($P < 0.01$), and steer carcasses generally were leaner and graded more poorly than those of the heifers. Feeding lime-encapsulated flaxseed generally decreased carcass weight ($P = 0.03$), which we attribute to the rather dramatic decrease in feed intake for these treatments. Carcass characteristics other than carcass weight were unaffected by treatment.

Implications

Feeding ground flaxseed embedded within a protective matrix consisting of dolomitic lime hydrate decreased feed intake and carcass weight of feedlot steers and heifers. Average daily gain and most other carcass attributes were unaffected by diet, although the measures generally followed patterns that were consistent with reduced feed intake.

Acknowledgements

The hydrated lime embedding process is the subject of a U.S. patent application jointly submitted by Kansas State University and Lhoist North America (Fort Worth, TX).

Table 1. Composition of experimental diets on a 100% dry matter basis

	Diets		
Item	Control	4% 50:50	6% 67:33
Steam-flaked corn	56.36	54.48	52.97
Wet corn gluten feed	30.00	30.00	30.00
Corn silage	5.00	5.00	5.00
Wheat straw	3.00	3.00	3.00
50:50 lime:flax	-	4.00	-
67:33 lime:flax	-	-	6.00
Supplement[1]	3.48	1.35	0.87
Feed additive premix[2]	2.16	2.16	2.16

[1] Formulated to provide 0.3% salt, 0.1 ppm cobalt, 10 ppm copper, 0.6 ppm iodine, 60 ppm manganese, 0.25 ppm selenium, 60 ppm zinc, 1,000 IU/lb vitamin A, and 20 IU/lb vitamin E on a dry matter basis.
[2] Formulated to provide the following: 300 mg/d of Rumensin and 90 mg/day Tylan (Elanco Animal Health, Indianapolis, IN). Heifers also received 0.4 mg/day of Heifermaxx (Elanco Animal Health).

Table 2. Feedlot performance of heifers and steers fed finishing diets with or without lime-encapsulated flaxseed[1]

	Diets					*P*-value	
Item	Control	4% 50:50	6% 67:33	6% 67:33 Late	SEM	Gender	Diet
Dry matter intake, lb/day							
Heifers	16.75[a]	14.90[b]	14.71[b]	14.77[b]	0.329	<0.01	<0.01
Steers	18.96[a]	17.02[b]	16.67[b]	17.57[c]	0.329		
Average daily gain, lb							
Heifers	2.60	2.45	2.49	2.36	0.121	0.03	0.18
Steers	3.31	3.06	2.98	3.00	0.121		
Feed:gain							
Heifers	6.44	6.08	5.90	6.25	0.008	0.16	0.28
Steers	5.72	5.56	5.59	5.86	0.008		

[1] Cattle were fed diets containing (dry basis) no flaxseed (Control); 4% of an encapsulated 50:50 blend of dolomitic hydrate and flaxseed for the entire finishing period; 6% of an encapsulated 67:33 blend of dolomitic hydrate and ground flaxseed for the entire finishing period; or 6% of an encapsulated 67:33 blend of dolomitic hydrate and ground flaxseed for the final half of feedlot finishing (Late).
[a–c] Means in a row without a common superscript are different, $P < 0.05$.

Table 3. Carcass characteristics of heifers and steers fed finishing diets with or without lime-encapsulated flaxseed[1]

	Diets					*P*-value	
Item	Control	4% 50:50	6% 67:33	6% 67:33 Late	SEM	Gender	Diet
Hot carcass weight, lb							
Heifers	639[a]	611[b]	619[b]	608[b]	7.8	<0.01	0.03
Steers	747[a]	723[b]	710[b]	706[b]			
Ribeye area, sq. in.							
Heifers	14.0	13.2	13.6	13.2	2.7	<0.01	0.26
Steers	14.8	15.1	14.9	14.0			
Kidney, pelvic, and heart fat, %							
Heifers	2.4	2.2	2.6	2.3	0.12	0.25	0.08
Steers	2.6	2.1	2.2	2.3			
12th-rib fat, in.							
Heifers	0.61	0.56	0.57	0.51	0.162	0.07	0.22
Steers	0.56	0.41	0.40	0.46			
Liver abscess, %							
Heifers	0	20	10	20	9.9	0.53	0.15
Steers	0	20	0	10			
USDA yield grade							
Heifers	2.4	2.7	2.6	2.3	0.33	0.47	0.91
Steers	2.6	2.1	2.1	2.3			
Marbling score[2]							
Heifers	486	432	491	417	40	0.10	0.22
Steers	398	375	386	368			
USDA Prime, %							
Heifers	10	0	10	0	6	0.57	0.31
Steers	0	0	10	0			
Premium Choice, %							
Heifers	20	10	30	20	11	0.09	0.70
Steers	0	0	0	10			
Choice, %							
Heifers	80	50	70	70	18	0.03	0.55
Steers	40	30	20	20			
Select, %							
Heifers	10	40	20	20	21	0.07	0.64
Steers	60	60	70	80			

[1] Cattle were fed diets containing (dry basis) no flaxseed (Control); 4% of an encapsulated 50:50 blend of dolomitic hydrate and flaxseed for the entire finishing period; 6% of an encapsulated 67:33 blend of dolomitic hydrate and ground flaxseed for the entire finishing period; or 6% of an encapsulated 67:33 blend of dolomitic hydrate and ground flaxseed for the final half of feedlot finishing (Late).

[2] Marbling scores determined by USDA graders; Slight = 300 to 399, Small = 400 to 499, and Modest = 500 to 599.

[a,b] Means in a row without a common superscript are different, $P < 0.05$.