Hydrated Lime Matrix Decreases Ruminal Biohydrogenation of Flaxseed Fatty Acids

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Introduction

Omega-3 fatty acids are essential nutrients for humans, but dietary intake of these nutrients by many Americans is inadequate due to low consumption of omega-3-rich foods such as fish, walnuts, and flaxseed. In contrast, per capita consumption of red meat is relatively high, but these products normally contain only small amounts of omega-3 fatty acids. Feeding cattle diets that contain omega-3 fatty acids has consistently increased the proportion of the desirable fats that accumulate in beef. Unfortunately, the proportion of dietary omega-3 fats that are deposited into beef tissues is relatively low, because microorganisms within the rumen biohydrogenate the unsaturated omega-3 fatty acids extensively to produce the saturated fats that are characteristic of beef fat. Encapsulation of fats has been proposed as a method for improving efficiency of transfer of omega-3 fats into beef. Encapsulation processes apply a protective barrier on the surface of fats or fat-containing feeds, which theoretically decreases fats' susceptibility to microbial biohydrogenation. Protective coatings must remain intact to retain their functionality, and physical damage to the coatings that occurs with normal handling can result in poor efficacy because the core material is exposed to microorganisms in the rumen. Embedding feed particles within a homogeneous protective matrix constitutes a potentially useful alternative to protective surface barriers. The matrix is created by mixing feed particles that are to be protected with a suitable matrix material that is resistant to microbial digestion and subsequently forming the mixture into pills. In cases where physical damage occurs, exposure of the core material is confined to the broken surface, and the remainder of the matrix retains its ruminal stability.

The objective of this study was to determine if embedding flaxseed within a matrix of hydrated dolomitic lime could be used as a method to decrease biohydrogenation of polyunsaturated omega-3 fatty acids, thus improving efficiency of omega-3 fatty acids absorption into the bloodstream.

Experimental Procedures

Forty-five steers (556.6 ± 40.2 lb) were blocked by weight and randomly assigned to individual pens, then pens were assigned to dietary treatments (15 replicates). Steers were fed for 14 days with a basal diet consisting of 50% forage and 50% concentrate (Control). In treatments 2 and 3, a portion of flaked corn was replaced with ground flaxseed (Flax) or ground flaxseed that had been embedded within a matrix of hydrated dolomitic lime (L-Flax) as shown in Table 1. Cattle were fed once daily, and weights of unconsumed feed were determined daily.

[1] Lhoist North America, Fort Worth, TX.

Animals were weighed and blood samples were taken from the jugular vein for analysis of long-chain fatty acid (LCFA) concentrations on day 0, 7, and 14 of the study. Heparinized vacuum tubes were used to collect whole blood. Blood samples were immediately placed on ice, then centrifuged at 1,200 x g for 20 minutes to recover blood plasma. Concentrations of major fatty acids in the blood plasma were determined by gas chromatography.

Data were analyzed using the MIXED model procedure of SAS (Version 9.0) with diet, sampling day, and the diet × sampling day interaction as fixed effects and with feeding location as a random effect. Animal was the experimental unit.

Results and Discussion

Table 2 summarizes the concentrations of major long-chain fatty acids in blood plasma on days 0, 7, and 14 after feeding the experimental diets. Day 0 values represent the baseline, and thus are similar for all treatment groups. We were unable to detect alpha-linolenic acid (C18:3n3), a key omega-3 fatty acid, in blood plasma on day 0. This result was expected, because the diet fed during the pre-trial period consisted of ingredients that normally contain relatively small amounts of omega-3 fatty acids. After 7 days of feeding the experimental diets, concentrations of alpha-linolenic acid remained relatively low in the Control group but increased markedly in blood plasma of cattle fed flaxseed. The increase in plasma concentrations of alpha-linolenic acid was even more dramatic in cattle fed the dolomitic hydrate-flaxseed mixture. Plasma concentrations of omega-3 fatty acids in cattle fed the embedded flaxseed were more than 4 times the level observed in cattle fed flaxseed, suggesting the dolomitic lime hydrate was effective as a protective matrix. The differences among treatments remained after 14 days, demonstrating that it is feasible to increase tissue concentrations of omega-3 fatty acids by incorporating omega-3-rich ingredients into the diet. Furthermore, embedding ground flaxseed into a matrix consisting of dolomitic lime hydrate constitutes an effective method for increasing the proportion of polyunsaturated omega-3 fatty acids absorbed from the gastrointestinal tract for deposition into tissues.

Implications

Embedding ground flaxseed within a protective matrix consisting of dolomitic lime hydrate is an effective method for delivery of omega-3 fatty acids to improve the efficiency of transfer from the diet into tissues of cattle.

Acknowledgements

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Table 1. Composition of diets fed during the pre-trial adaptation period and for experimental diets without flaxseed (Control), with ground flaxseed (Flax), or with ground flaxseed embedded within a protective matrix of dolomitic lime hydrate (L-Flax)

Ingredients, %	Pre-trial	Control	Flax	L-Flax
Wet corn gluten feed	30.00	30.00	30.00	30.00
Wheat straw	25.00	25.00	25.00	25.00
Prairie hay	25.00	25.00	25.00	25.00
Steam-flaked corn	10.36	12.78	12.86	8.50
Linseed meal	--	3.01	1.22	1.50
Corn oil	--	1.19	0.10	--
Ground flaxseed	--	--	2.79	--
Hydrate-encapsulated flaxseed	--	--	--	8.13
Glycerin	5.00	--	--	--
Supplement[1]	4.64	3.02	3.03	1.87

[1] Formulated to provide 300 mg/day Rumensin (Elanco Animal Health, Greenfield, IN), 1,000 IU/lb vitamin A, 0.3% salt, 0.7% calcium, 0.7% potassium, 0.1 ppm cobalt, 10 ppm copper, 0.6 ppm iodine, 60 ppm manganese, 0.25 ppm selenium, and 60 ppm zinc in the total diet on a 100% dry matter basis.

Table 2. Concentrations (μg/mL) of major long-chain fatty acids in blood plasma of cattle fed diets without flaxseed (Control), with ground flaxseed (Flax), or with ground flaxseed embedded within a protective matrix of dolomitic lime hydrate (L-Flax)

	Day 0			Day 7			Day 14				*P*-value		
Item[a]	Control	Flax	L-Flax	Control	Flax	L-Flax	Control	Flax	L-Flax	SEM	Day	Diet	Day × Diet
C16:0	73	77	75	79	79	84	77	75	89	3.2	0.02	0.01	0.08
C18:0	123	126	125	149	149	151	130	126	147	6.2	<0.01	0.16	0.32
C18:1	77	81	80	92	87	79	83	86	86	4.8	0.10	0.72	0.35
C18:2	300	277	293	288	266	303	311	261	337	13.2	0.18	<0.01	0.14
C18:3n3	0	0	0	0	19	78	0	30	87	2.7	<0.01	<0.01	<0.01

[a] Long-chain fatty acids are identified as follows: C16:0 is palmitic acid (saturated), C18:0 is stearic acid (saturated), C18:1 is oleic acid (monounsaturated), C18:2 is linolenic acid (a polyunsaturated omega-6 fatty acid), and C18:3n3 is alpha-linolenic acid (a polyunsaturated omega-3 fatty acid).