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Combining ruminally protected choline and flaxseed in cattle diets to increase the assimilation of omega-3 fatty acids from the diet

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Abstract

Omega-3 fatty acids are an essential part of a healthy human diet. If consumed regularly, these fatty acids attenuate inflammation and lower risk of inflammatory diseases, such as heart disease and rheumatoid arthritis. The human body cannot synthesize adequate amounts of omega-3 fatty acids; they must be obtained by consuming foods that are rich in omega-3s. Omega-3 fatty acids can be found in foods like fish, some oilseeds, and some nut oils. Overall consumption of these foods is relatively low compared with the consumption of red meat such as beef, which typically contains relatively small amounts of omega-3 fatty acids. Flaxseed contains high levels of omega-3 fatty acids, and when fed to cattle, these fats are absorbed and deposited into beef tissues. The transfer of omega-3 fatty acids from the diet to tissues is very poor, however, due to extensive alteration of fats by microbes in the rumen. If transfer efficiency from diet to tissues could be improved, beef could become a viable source of omega-3 fatty acids for consumers. Choline plays an important role in the metabolism of fats, and deficiencies of dietary choline could limit the absorption and tissue deposition of polyunsaturated fatty acids, including omega-3 fatty acids. Our objective was to evaluate the effects of combining ruminally protected choline and flaxseed on changes in plasma concentrations of long-chain fatty acids.

Keywords

Cattlemen's Day, 2014; Kansas Agricultural Experiment Station contribution; no. 14-262-S; Report of progress (Kansas State University. Agricultural Experiment Station and Cooperative Extension Service); 1101; Beef Cattle Research, 2014 is known as Cattlemen's Day, 2014; Beef; Omega-3 fatty acids; Choline; Flaxseed; Diet

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Combining Ruminally Protected Choline and Flaxseed in Cattle Diets to Increase the Assimilation of Omega-3 Fatty Acids from the Diet

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Introduction

Omega-3 fatty acids are an essential part of a healthy human diet. If consumed regularly, these fatty acids attenuate inflammation and lower risk of inflammatory diseases, such as heart disease and rheumatoid arthritis. The human body cannot synthesize adequate amounts of omega-3 fatty acids; they must be obtained by consuming foods that are rich in omega-3s. Omega-3 fatty acids can be found in foods like fish, some oilseeds, and some nut oils. Overall consumption of these foods is relatively low compared with the consumption of red meat such as beef, which typically contains relatively small amounts of omega-3 fatty acids. Flaxseed contains high levels of omega-3 fatty acids, and when fed to cattle, these fats are absorbed and deposited into beef tissues. The transfer of omega-3 fatty acids from the diet to tissues is very poor, however, due to extensive alteration of fats by microbes in the rumen. If transfer efficiency from diet to tissues could be improved, beef could become a viable source of omega-3 fatty acids for consumers. Choline plays an important role in the metabolism of fats, and deficiencies of dietary choline could limit the absorption and tissue deposition of polyunsaturated fatty acids, including omega-3 fatty acids. Our objective was to evaluate the effects of combining ruminally protected choline and flaxseed on changes in plasma concentrations of long-chain fatty acids.

Experimental Procedures

Crossbred heifers (108 heifers; 628 ± 30 lb) were stratified by initial body weight and allocated randomly, within strata, to 36 concrete-surfaced pens (3 heifers/pen). Heifers were fed diets with: (1) no flaxseed/no choline; (2) flaxseed/no choline; (3) choline/no flaxseed; and (4) flaxseed and choline. Diets (Table 1) were fed *ad libitum* once daily for 14 days. At the end of the 14-day feeding period, cattle were weighed and blood was sampled by jugular puncture. Average daily gain, dry matter feed consumption, and feed conversion efficiency were calculated for each pen of animals. Blood samples were chilled and centrifuged to recover blood plasma. Fatty acid methyl esters were measured in blood plasma by gas chromatography. Data were analyzed using the mixed model procedure of SAS (SAS Institute, Cary, NC) with fixed effects of flaxseed, choline, and flaxseed × choline. The random effect was weight block, and the experimental unit was the feedlot pen.

Results and Discussion

The levels of alpha-linolenic acid, the principal omega-3 fatty acid found in flaxseed, were relatively low on day 0 of the trial (data not shown). This was expected because the cattle were fed diets that contained no appreciable quantities of omega-3 fatty acids prior to starting the experiment. Concentrations of long-chain fatty acids in blood plasma collected after 14 days of consuming the experimental diets are represented in Table 2. Plasma concentrations of alpha-linolenic acid increased dramatically ($P < 0.05$) for cattle fed diets containing flaxseed, whereas concentrations of omega-3 fatty acids remained relatively low in plasma of cattle fed diets without flaxseed. Feeding ruminally protected choline had no appreciable impact on blood concentrations of omega-3 fatty acids, regardless of whether or not flaxseed was fed. We had hypothesized that feeding ruminally protected choline would enhance absorption of omega-3 fatty acids due to choline's important role in transport of lipids, but our hypothesis is refuted by the results of this experiment. Figures 1 and 2 illustrate the effects of our experimental diets on average daily gain and feed efficiency. Feeding flaxseed had no notable impact on performance; however, cattle fed ruminally protected choline tended to gain more ($P = 0.11$) and were more efficient ($P = 0.06$) compared with their counterparts fed diets without supplemental choline.

Implications

Ruminally protected choline improved gain efficiency by approximately 10%, which is consistent with our observations in previous studies. The extruded flaxseed product increased plasma concentrations of omega-3 fatty acids, but including ruminally protected choline resulted in no further improvement in assimilation of dietary fats.

Table 1. Composition of experimental diets[1]

	Without ruminally protected choline		With ruminally protected choline	
Ingredients, %	Without flaxseed	With flaxseed	Without flaxseed	With flaxseed
Corn silage	25.00	25.00	25.00	25.00
Wet corn gluten feed	25.00	25.00	25.00	25.00
Steam-flaked corn	27.01	19.58	25.51	18.04
Ground alfalfa hay	15.00	15.00	15.00	15.00
Corn steep liquor	1.86	1.86	1.86	1.86
Feed additive premix[2]	1.80	1.80	1.80	1.80
Supplement[3]	4.33	1.76	4.60	2.08
Extruded flaxseed product[4]	-	10.00	-	10.00
Ruminally protected choline	-	-	1.23	1.23

[1] Treatments were: 0% flaxseed and 0 g/day ruminally protected choline, 10% flaxseed and 0 g/day ruminally protected choline, 0% flaxseed and 113 g/day ruminally protected choline, and 10% flaxseed and 113 g/day ruminally protected choline.

[2] Provided 300 mg/animal daily of Rumensin (Elanco Animal Health, Greenfield, IN).

[3] Formulated to provide 1,000 IU/lb vitamin A, 0.3% salt, 0.8% calcium, 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.

[4] Product contains 50% flaxseed.

Table 2. Effects of flaxseed and ruminally protected choline on plasma concentrations of long-chain fatty acids in growing heifers

	Without ruminally protected choline		With ruminally protected choline			Treatment effect		
Item, g/mL[1]	Without flaxseed	With flaxseed	Without flaxseed	With flaxseed	SEM	Flax	Chol	F×C
C14:0	12.3	10.9	11.4	12.8	0.86	No	No	No
C16:0	176.6	184.9	196.1	203.3	8.4	No	No	No
C18:0	276.0	356.4	326.3	359.8	14.9	Yes	No	No
C18:3n3	33.3	132.5	42.9	131.0	4.9	Yes	No	No

[1] Long-chain fatty acids are identified as follows: C14:0, myristic acid (saturated); C16:0, palmitic acid (saturated); C18:0, stearic acid (saturated); C18:3n3, alpha-linolenic acid (polyunsaturated omega-3 fatty acid).
[2] Effects of flaxseed, choline, and the interaction between flaxseed and choline. "Yes" indicates a significant effect of treatment (P < 0.05).

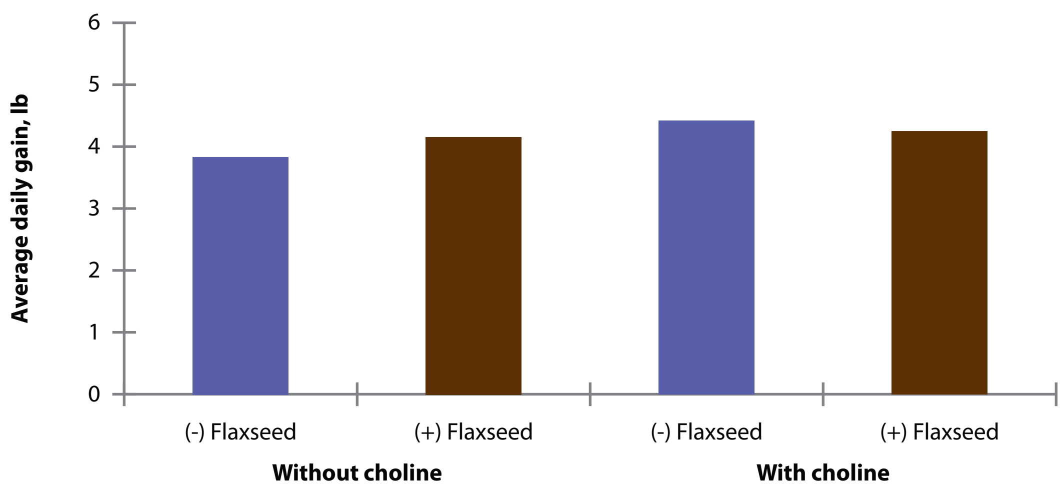

Figure 1. Average daily gain of cattle for the 14-day feeding period.
SEM: 0.125; effect of flaxseed, $P = 0.76$; effect of choline, $P = 0.11$; flaxseed × choline, $P = 0.26$.

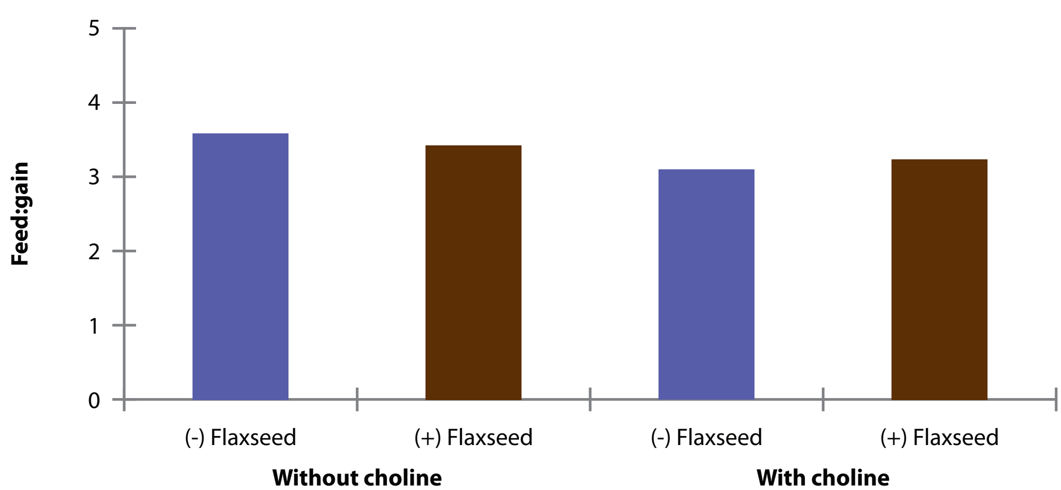

Figure 2. Feed efficiency for the 14-day feeding period, shown as feed:gain ratio.
SEM: 0.21; effect of flaxseed, $P = 0.93$; effect of choline, $P = 0.06$; flaxseed × choline, $P = 0.33$.