Effect of Flaxseed Inclusion on Ruminal Fermentation, Digestion and Microbial Protein Synthesis in Growing and Finishing Diets for Beef Cattle

T.C. Gilbery, G.P. Lardy, D.S. Hagberg and M.L. Bauer
NDSU Department of Animal Sciences

A metabolism trial evaluating the effects of flax inclusion in growing and finishing diets for beef cattle indicate crude protein (CP) and organic matter (OM) digestion were not altered when flax was fed at 8 percent of dietary dry matter (DM).

Abstract

Four Holstein steers (1649.06 ± 48.50 lbs.) initial body weight [BW]) fitted with ruminal and duodenal cannulae were used in a 4 x 4 Latin square design to evaluate the effects of flax inclusion in growing and finishing diets on intake, ruminal fermentation and site of digestion. Flax replaced linseed meal and part of corn at 8 percent of dietary DM in growing (40 percent concentrate) and finishing (80 percent concentrate) diets. All dietary treatments were fed in unlimited amounts (ad libitum) as a totally-mixed ration (TMR). There were no differences among treatments for dry matter intake (DMI; 22.5 pounds, 2.4 percent of body weight; P = 0.24). Flax decreased microbial OM flow at the duodenum (P = 0.02). Total tract OM digestion was greater for steers fed finishing diets (P = 0.02) and apparent ruminal OM digestibility tended to increase for steers fed finishing diets (P = 0.09). Steers consuming finishing diets had greater (P = 0.001) total tract CP digestion compared to steers fed the growing diets. Microbial efficiency was greater (P = 0.04) for steers on growing diets compared to finishing diets. Steers fed growing diets had increased ($P \leq 0.004$) ruminal neutral detergent fiber (NDF) and acid detergent fiber (ADF) digestion compared to steers fed finishing diets. Steers consuming flax had lower (P = 0.02) ruminal ammonia. There was no effect ($P \geq 0.19$) of flax on crude protein, NDF, ADF and OM ruminal and total tract digestion. Results indicate flax inclusion did not alter OM and CP digestion when replacing part of corn and linseed meal in growing and finishing diets for beef cattle.

Introduction

Flax (*Linum usitatissimum*) is an oilseed grown primarily for its oil-rich seed that contains 41 percent oil, 20% CP and 20% NDF (Canadian Grain Commission, 2001). North Dakota flaxseed production accounted for 90% of the U.S. flax crop in 2007 (National Agricultural Statistics Service, 2008). Flax in receiving diets has improved calf health, performance and, potentially, nutritional aspects of beef for consumers (Drouillard et al., 2001; Maddock et al., 2006). Average daily gain and the gain-to-feed ratio (G:F) were superior in diets containing flax, compared with tallow, and death loss was lowest for flax-fed calves (Drouillard et al., 2002; 2004). Beef from cattle fed flax contains greater levels of omega-3 fatty acids, potentially resulting in niche marketing opportunities for beef producers (Maddock et al., 2006). Drouillard et al. (2002) reported increased DMI with the inclusion of flax at 10% of diet DM in finishing diets for cattle. Furthermore, Maddock et al. (2006) reported increased hot carcass weight (HCW) and lower U.S. Department of Agriculture yield grades when measuring carcass composition of heifers fed finishing diets containing flax. Drouillard et al. (2002, 2004) observed an increase in the percentage of carcasses grading USDA Choice or greater following a finishing phase in which cattle consumed flax at 5% of dietary DM. Our objective was to evaluate the effects of flax inclusion in growing and finishing diets on intake, ruminal fermentation and site of digestion.

Procedures

Four ruminally- and duodenally-cannulated Holstein steers (1649.06 ± 48.50 lbs.) initial BW) were used in a 4 x 4 Latin square design to evaluate the effects of flax inclusion on ruminal fermentation and digestion. Steers consumed growing and finishing diets in which flax replaced linseed meal and a portion of the corn at 8 percent of dietary DM in growing (40 percent concentrate) and finishing (80 percent concentrate) diets.
Steers were housed in an enclosed barn in individual stanchions (4-foot by 7-foot). Steers were fed the diets in the form of a totally-mixed ration at 7 a.m. and 7 p.m. and were allowed free access to water. Diets were offered to ensure ad libitum intakes and 10 percent feed refusal daily.

Feed ingredients were alfalfa hay, corn silage, dry-rolled corn, linseed meal or rolled flax and supplement (Table 1). Treatments were arranged in a 2 x 2 factorial with the main effects being diet concentrate level (growing diet at 40 percent concentrate or finishing diet at 80 percent concentrate) and flax inclusion (0 percent vs. 8 percent flax). The resulting treatments included: 1) growing diet without flax**,** 2) growing diet with 8 percent flax, 3) finishing diet without flax and 4) finishing diet with 8 percent flax (Table 1). Diets were formulated to provide 13% and 15% CP (growing and finishing diets respectively; DM basis) and calcium-to-phosphorus (Ca: P) ratio of 2-to-1 (DM basis). Corn and flax were processed by dry rolling.

Table 1. Formulation of dietary treatments (% of DM).

	Treatment			
	No Flax		With Flax	
Item	Growing	Finishing	Growing	Finishing
Corn silage	40.00	10.00	40.00	10.00
Corn	26.09	66.11	23.88	63.11
Alfalfa	20.00	10.00	20.00	10.00
Flax	-	-	8.00	8.00
Concentrated separator byproduct[1]	5.00	5.00	5.00	5.00
Linseed meal	5.80	5.00	-	-
SBM	1.00	1.00	1.00	1.00
Trace mineral premix[2]	0.60	0.60	0.60	0.60
Limestone	0.90	1.40	0.80	1.40
Dicalcium phosphate	0.10	-	0.10	-
Chromic oxide	0.25	0.25	0.25	0.25
Urea	0.22	0.60	0.38	0.60
Monensin premix[3]	0.02	0.02	0.02	0.02
Vitamin A and D premix[4]	0.02	0.02	0.02	0.02

[1]De-sugared beet molasses.

[2]Contained (per kg) a minimum of 32.9 g Ca, 25.6 g Cu, 160 g Zn, 65.0 g Fe, 40.0 g Mn, 1.05 g

[3]Contained 176 g/kg of monensin; formulated to contain 200 mg of monensin/kg of diet.

[4] Contained vitamin A and D concentrations of 22,000 and 2,100 IU/kg, respectively.

Each experimental period was 14 days in length, allowing nine days for adaptation to diet and five days for sample collection. Feed refusal samples were measured to determine DMI. Total fecal output was measured to determine total tract digestion. Intestinal samples were taken during a three-day period to estimate nutrient flow. Ruminal fluid samples were collected and analyzed for ammonia (NH_3) volatile fatty acid concentrations and pH.

Table 2. Analyzed nutrient composition of feed ingredients in growing and finishing diets (% of DM).

Item	OM	NDF	ADF	CP	Fat
Corn silage	93.20	50.30	27.20	7.60	2.80
Alfalfa	89.40	57.00	41.80	16.50	0.70
Corn	98.20	18.70	3.80	10.20	5.30
Flax	95.70	37.00	23.80	23.40	24.40
Linseed meal	93.20	26.10	14.60	40.40	4.80
Growing					
No flax	89.40	37.40	20.20	13.60	2.60
With flax	89.90	38.80	21.70	13.40	5.00
Finishing					
No flax	90.50	30.00	12.90	15.00	4.00
With flax	90.90	30.30	13.00	14.50	7.30

Results

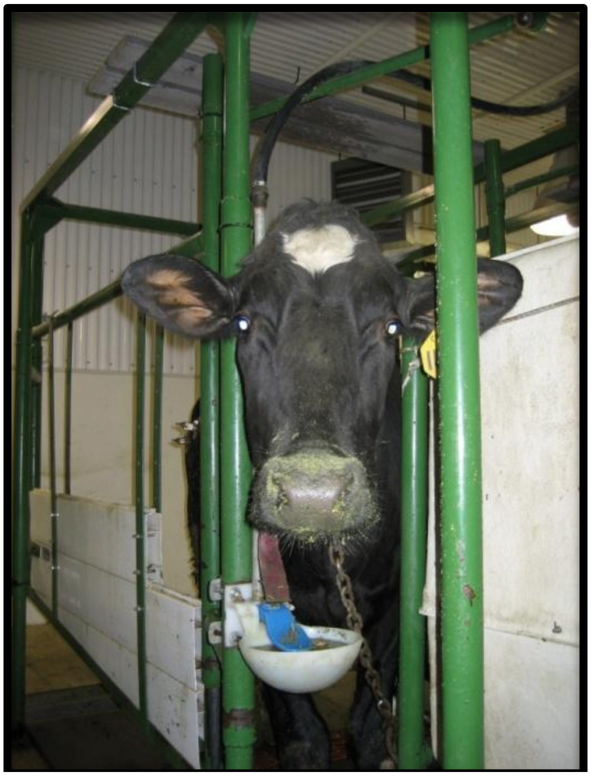
Dry-matter intake was not affected (P = 0.24; 22.5 ± 1.2 lbs./day) by flax inclusion or ration type (growing vs. finishing). Steers fed finishing diets had increased (P = 0.02) OM digestion, compared with the growing ration-fed steers. Dietary flax inclusion did not alter (P = 0.66) total tract OM digestion. Apparent ruminal and total tract CP digestion was greater ($P \leq 0.03$) and true ruminal CP tended to be greater (P = 0.08) for steers fed finishing diets that reflect the more readily digestible nutrient sources available in the high-concentrate diets. Growing ration-fed steers had greater (P = 0.04) microbial efficiency, which followed the same trends as microbial CP. The higher levels of digestion observed for the finishing diets were not unexpected as roughage was replaced by the more readily digestible corn grain in the finishing diet, compared with growing diets.

Cannulated steers feeding at individual stanchions.

Ruminal and post-ruminal flow (1.6 ± 0.1 lb./day) and digestion (72.4 ± 3.4 percent) of NDF in growing and finishing diets were not altered ($P \geq 0.13$) by flax inclusion. Total tract NDF digestion tended to increase ($P = 0.10$) for steers fed finishing diets, compared with growing diets (74 percent vs. 67 percent, respectively). The observed increase ($P \leq 0.03$) in NDF and ADF intake and increased intestinal flow of NDF and ADF for steers fed the growing diets reflect the higher level of forage present in the growing diet.

Ruminal data for pH, NH_3 and volatile fatty acid (VFA) are mean values reported for samples taken during 24 hours post-feeding. Ruminal pH and total VFA were not different ($P \geq 0.29$) for diet type or flax inclusion, with pH averaging 6.40 ± 0.12 for all treatments. There were no time x diet type x flax interactions ($P \geq 0.29$) for pH, NH_3-nitrogen (N) and VFA. Flax-fed steers had reduced ($P = 0.02$; 4.60 vs. 6.40 milliMolar [m*M*]) ruminal ammonia; no differences were observed in ruminal NH_3-N for diet type ($P = 0.43$).

Flax inclusion in growing and finishing diets fed to steers did not affect ($P \geq 0.13$) total VFA concentration. Steers consuming growing diets had greater ($P = 0.003$) ruminal acetate concentrations, compared with steers fed finishing diets. Conversely, molar proportion of propionate increased ($P = 0.04$) for steers fed the finishing diet.



Cannulated steer in individual stanchion.
Photo by Penny Nester

Table 3. Effect of flax inclusion on DMI, OM digestion and CP digestion in steers consuming growing and finishing diets.

	No Flax		With Flax			Contrast[a]		
Item	Grower	Finisher	Grower	Finisher	SEM[b]	Ration	Flax	Ration x Flax
DMI								
lb./d	22.1	24.3	22.4	21.4	1.19	0.53	0.24	0.14
% of BW	2.4	2.6	2.4	2.3	0.09	0.64	0.26	0.08
OMI, lb./d	19.7	22.0	20.1	19.5	1.04	0.33	0.24	0.12
Duodenal OM flow								
Microbial, lb./d	2.9	2.2	2.6	1.6	0.15	0.00	0.02	0.46
Digestion, % of intake								
Apparent ruminal	53.3	61.6	55.9	61.3	4.40	0.09	0.74	0.68
True ruminal	68.1	71. 8	68.7	69.9	4.10	0.46	0.83	0.69
Small intestine	14.3	14. 5	15.6	15.8	3.10	0.95	0.62	0.98
Large intestine	5.6	3.2	1.8	0.4	1.80	0.19	0.04	0.70
Total tract	73.3	79.3	73.4	77.6	1.80	0.02	0.66	0.64
CP Intake lb./d	3.0	3.6	3.0	3.1	0.17	0.09	0.16	0.14
Duodenal CP flow								
Microbial, lb./d	1.6	1.3	1.3	1.0	0.11	0.02	0.02	0.82
CP digestion, % of intake								
Apparent ruminal	-6.1	20.8	11.6	23.8	8.60	0.03	0.19	0.34
True ruminal	46.2	57.1	50.0	57.5	6.30	0.08	0.64	0.71
Small intestine	67.2	54.4	54.4	53.0	7.50	0.29	0.29	0.39
Large intestine	2.4	-0.5	-0.1	-3.1	2.10	0.18	0.25	0.96
Total tract	63.6	74.8	65.9	73.6	2.10	0.00	0.78	0.42
Microbial efficiency[c]	18.8	13.4	17.1	12.0	2.30	0.04	0.45	0.93

[a]Probabilities for contrast *F*-test.

[b]n = 4.

[c]Grams duodenal microbial N per kg ruminal OM truly fermented.

Implications

The results from this experiment indicate feeding flax at 8 percent of dietary DM in either growing or finishing diets did not change ruminal fermentation characteristics. In addition, flax inclusion did not alter OM and CP digestion when replacing part of corn and linseed meal in growing and finishing diets for beef cattle.

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