Effects of Timing of Flax Feeding on Feedlot Performance, Carcass Traits, and Fatty Acid Profile in Beef Muscle

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Abstract

Flax was added to the diet of feeder steers at different times between weaning and marketing to ascertain the impact on feedlot performance, carcass traits, and fatty acid content in beef muscle. Weaned steer calves (n = 167, initial weight 603.27 ± 37.04 lbs.) were fed the following treatments: 1) control (CON) no flax in the diet, 2) flax fed only during a 56-day receiving (REC) period, 3) flax fed only during finishing (FIN), and 4) flax fed continually (CNT) from arrival until market. No overall differences in feed intake, gain, or feed efficiency were observed. A tendency for increased Yield Grade ($P = 0.13$) and fat thickness ($P = 0.13$) was observed for CNT feeding over CON and FIN treatments with REC intermediate. Percent KPH was less ($P = 0.06$) for REC (2.33) than the other three treatments: CON (2.44), FIN (2.45), and CNT (2.49). N-3 fatty acids increased ($P < 0.01$) linearly with flax feeding time as did n:3-n:6 ratio. While flax may be a useful feed ingredient for feedlot cattle, in this study, there were no performance advantages. N-3 fatty acids in beef increased above the control at 35% for REC, 111% for FIN, and 144% for CNT. The biological implications of this level of the various n-3 fatty acids in beef needs to be defined.

Introduction

Feeding flax to cattle is not a new practice. Morrison's Feeds and Feeding (1946) reports flax seed is superior to most other feeds for cattle due to its high oil content (36+%). North Dakota leads the nation in flax production accounting for up to 95 percent of U.S. production (Berglund and Zollinger, 2002). Flax or flax screenings are often considered as feeds that contain significant amounts of energy and protein (Lardy and Anderson, 2003). Recent interest in flax feeding has developed to explore effects on animal health, feedlot performance, and impact on fatty acid content of beef. Flax in feedlot receiving diets improved calf health, feedlot performance, and potentially nutritional aspects of beef (Drouillard et al., 2004) in a study conducted using feeder heifers from the mid-South region of the U.S. In this study, gains and feed efficiency were superior in diets containing flax compared to full fat soybeans or tallow. Death loss was lower for the flax-fed heifers in the Kansas State University study. Meat from cattle fed flax has been reported to contain significantly higher levels of omega-3 fatty acids (Drouillard et al., 2004) which are of interest for human health. However, feeding flax at 8 percent of the finishing diet did not improve the fatty acid profile in North Dakota beef steers, (Maddock et al., 2004) but performance was enhanced with rolled flax compared to ground or whole flax. With mixed results from past studies, it is important to conduct a definitive study on the optimum timing of flax feeding and the effects on animal health, feedlot performance, carcass traits, and fatty acid profile. Recent escalation in the flax prices and demand for human consumption has decreased interest in feeding flax to livestock.

Materials and methods

Steers and Rations. Weaned steer calves (n = 167, initial weight 603.27 ± 37.04 lbs.) consigned to the Central Dakota Feeder Calf Club producer feedout program were shipped 110 miles to the NDSU Carrington Research Extension Center (CREC) feedyard from Turtle Lake, ND. The spring-born steers had been assembled from 42 different ranches across North Dakota and represent a wide variety of breeds and management . After arrival at CREC and a day of rest, all steers were individually weighed, blocked by weight, and allotted within weight block to one of four treatments. Treatment groups within each block were assigned to one of 16 identical pens with 10 to 11 head/pen. Treatments were: 1) control (CON) no flax in the diet, 2) flax fed only in the receiving ration (REC), 3) flax fed only during finishing ration (FIN), and 4) flax fed continually (CNT) from arrival until market. Ration composition for the corn-based receiving and finishing diets with and without flaxseed is provided in Table 1. Receiving diets were formulated with 60% concentrate and contained a minimum of 56 Mcal/lb. The receiving diets were fed for 56 days. The finishing diets were formulated with 85 percent concentrate and contained 61 Mcal/lb NEg or more. The FIN diet was offered at day 84 and fed for three 28-day weigh periods. Diets met or exceeded NRC recommendations for finishing steers (NRC, 1996). Figure 1 illustrates the timing of when flax was fed in the respective diet treatments. Flaxseed was ground through a hammer mill to approximately 700 microns to increase digestibility as described by Maddock et al. (2003). Supplemental calcium carbonate was added to balance the Ca:P ratio and the ionophore supplement provided 280 mg monensin sodium (Rumensin®, Elanco Animal Health, Indianapolis, IN) per head daily. The totally-mixed diets were fed once daily in fenceline bunks to appetite after morning bunk readings were taken. Steers had continual access to water from fenceline automatic fountains. Bedding was provided in equal amounts to each pen during the winter at approximately weekly intervals.

Table 1. Diets with and without flax fed from weaning to market weight.

	Receiving		Finishing	
Ingredient	No Flax	Flax	No Flax	Flax
	------------Percent, Dry matter basis-------------			
Corn, dry-rolled	38.60	33.94	60.49	57.41
Flax, ground	-	10.00	-	8.33
Field peas, dry-rolled	14.15	12.22	11.96	5.04
Wet dist. grains	14.30	12.45	10.46	11.19
Barley hay, chopped	30.38	28.85	-	-
Straw, chopped	-	-	14.45	15.22
Ionophore supplement	1.70	1.68	1.88	2.01
Calcium carbonate	0.87	0.87	0.75	0.81
Calculated Nutrients				
Dry matter, %	73.50	75.38	77.02	76.83
NEg, Mcal/lb	55.95	59.16	61.05	62.73
Crude protein, %	14.97	15.27	11.99	12.14
Calcium, %	0.66	0.65	0.51	0.54
Phosphorous, %	0.29	0.32	0.31	0.32
Potassium, %	0.95	0.92	0.63	0.61

Figure 1. Timeline for inclusion of flax in feedlot rations.

	Treatment Diets			
	Control	Receiving	Finishing	Continual
Period 1	No flax	Flax	No flax	Flax
Period 2	No flax	Flax	No flax	Flax
Period 3	No flax	No flax	No flax	Flax
Period 4	No flax	No flax	Flax	Flax
Period 5	No flax	No flax	Flax	Flax
Period 6	No flax	No flax	Flax	Flax

Feedlot Performance. Feedlot performance was compared by measuring feed intake, gain, and feed efficiency. Steers were weighed individually every 28 days and daily feed intake was averaged for each pen during each weigh period, with feed efficiency also calculated on a pen basis for each weigh period. All animal care and use procedures were approved by North Dakota State University's Institutional Animal Care and Use Committee prior to initiation of the study.

Carcass Traits. Once steers within a block were visually appraised to have approximately an average of 0.4 in. of subcutaneous fat at the 12th rib, they were transported to Tyson Fresh Meats, Dakota City, NE (approximately 465 miles), harvested and hot carcass weights were collected. Two blocks were harvested after 190 days on feed and two blocks were harvested after 208 days on feed. Carcasses were chilled for 24 hours, after which 12th rib fat thickness and 12th rib longissimus area were measured and recorded. Marbling score, kidney, pelvic, and heart fat percent, (KPH), and USDA quality grade were determined by trained North Dakota State University personnel and recorded.

Fatty Acid Profiles. Longissimus muscle sections, caudal to the 12th rib and approximately 2-3 in. thick, were removed from the left side of each carcass in the abattoir, tagged to preserve individual animal identity, and immediately transported in coolers (< 39° F) to the meats laboratory at North Dakota State University where they were trimmed, vacuum packaged and aged at 39° F for 14 days. Following aging, muscle samples were frozen -68° F for determination of fatty acid composition and transported to the laboratory at the School of Medicine and Human Nutrition Center, at the University of North Dakota in Grand Forks. Frozen muscle samples were pulverized under liquid nitrogen. Lipids from the tissue powder were extracted using a single-phase extraction with n-hexane/2-propanol (3:2 vol/vol; Hara and Radin, 1978). After centrifugation at 2,500 rpm to pellet debris, the lipid containing liquid phase was decanted and stored at -176° F until analysis.

Statistical Design and Analysis. Data were analyzed as a randomized complete block design using the MIXED procedures of SAS (Cary, NC). Pen served as experimental unit (n = 16) for all dependent variables. Block was considered a random effect for all statistical analysis. Treatment was the main effect in the model for feedlot performance, carcass data, and fatty acid analysis.

Results

Average steer weight (P > 0.51) and DMI (P > 0.29) were not different due to treatments (Table 2) during any of the 28-day weigh periods, the 56-day receiving time, the finishing component or overall. However, ADG (Table 2) during period three was significantly different (P = 0.02) when

CNT steers gained the most (3.94 ± 0.12 lbs.) and REC steers gained the least (3.29 ± 0.12), CON and FIN were intermediate. The decrease in relative energy level for steers transitioned from a flax to a no-flax diet in the REC treatment may have negatively affected gain in this situation. That is the only period with any statistical difference observed for ADG. Feed efficiency (Table 3), expressed as gain per unit feed, appears to be affected ($P < 0.04$) at the same time with the REC treatment calves showing less efficient conversion. Again, this is the only instance of an observed statistical difference in feed efficiency and may be the result of reduced energy density. Carcass traits (Table 4) were not different ($P > 0.13$) except for KPH which appears to be lower ($P < 0.06$) for REC (2.33) compared with the other three treatments at 2.44 for CON, 2.45 for FIN and 2.49 for CNT. Yield Grade and fat thickness show a tendency ($P > 0.13$) to be greater for the CNT treatment (3.30 and .58 in., respectively) with CON and FIN observed at 3.03 and 0.50 and 3.00 and 0.48, respectively. REC was 3.16 and 0.54.

Table 2. Performance of steers fed flaxseed during different periods of production.

	Treatment					
Weight, lb.	Control	Receiving	Finishing	Continual	St. Error	*P* Value
Initial wt.						
17-Oct-05	604.91	602.56	604.05	600.65	37.04	0.93
Period 1						
14-Nov-05	730.91	729.82	727.02	723.79	36.62	0.86
Period 2						
12-Dec-05	830.86	837.62	834.59	822	36.46	0.51
Period 3						
9-Jan-06	932.59	929.65	936.65	932.3	38.58	0.96
Period 4						
6-Feb-06	1041.81	1038.57	1042.28	1043.39	41.14	0.99
Period 5						
5-Mar-06	1153.18	1156.68	1154.44	1161.03	39.82	0.96
Final wt.						
26-Apr or 14 May 06	1249.52	1260.64	1256.53	1261.59	41.03	0.87
Dry matter intake, lb./hd/day						
Period 1	16.88	16.83	16.71	16.67	0.84	1.00
Period 2	22.68	22.7	22.89	19.84	1.24	0.29
Period 3	22.65	23.18	23.17	23.79	1.18	0.92
Period 4	24.11	24.68	23.52	25.29	1.14	0.73
Period 5	25.72	26.16	25.75	26.57	0.89	0.89
Period 6	25.85	25.73	26.15	27.02	0.96	0.78
Receiving (P1-2)	19.78	19.77	19.80	18.26	1.02	0.65
Finishing (P4-6)	24.59	24.94	24.65	25.67	0.94	0.84
Overall (P1-6)	22.98	23.21	23.03	23.20	0.94	1.00
Average daily gain, lb./hd/day						
Period 1	4.47	4.54	4.40	4.40	0.16	0.91
Period 2	3.58	3.88	3.84	3.51	0.16	0.33
Period 3	3.63^{ab}	3.29^{b}	3.64^{ab}	3.94^{a}	0.12	0.02
Period 4	3.90	3.89	3.77	3.96	0.13	0.78
Period 5	3.02	3.19	3.03	3.18	0.13	0.66
Period 6	2.61	2.80	2.76	2.72	0.18	0.89
Receiving (P1-2)	3.89	4.07	3.97	3.82	0.10	0.38
Finishing (P4-6)	3.22	3.25	3.24	3.38	0.06	0.30
Overall (P1-6)	3.43	3.50	3.47	3.52	0.03	0.28

^{ab} Values with different superscripts are significantly different ($P < .10$)

Table 3. Feed efficiency of steers fed flax during various stages of production.

	Treatment					
Gain per Feed	Control	Receiving	Finishing	Continual	St. Error	*P* Value
Period 1	0.27	0.27	0.27	0.27	0.02	1.00
Period 2	0.16	0.17	0.17	0.18	0.01	0.57
Period 3	0.16[ab]	0.14[a]	0.16[ab]	0.17[b]	0.01	0.04
Period 4	0.16	0.16	0.16	0.16	0.01	0.98
Period 5	0.12	0.12	0.12	0.12	0.01	0.89
Period 6	0.10	0.11	0.11	0.10	0.01	0.74
Growing (P1-2)	0.20	0.21	0.20	0.21	0.01	0.78
Finishing (P4-6)	0.13	0.13	0.13	0.14	0.00	0.87
Overall (P1-6)	0.15	0.15	0.15	0.15	0.01	0.93

[ab] Values with different superscripts are significantly different (P< .10)

Table 4. Carcass quality of steers fed flaxseed during various stages of production.

	Treatment					
Item	Control	Receiving	Finishing	Continual	St. Error	*P* Value
Final wt, lb.	1295.20	1297.61	1294.40	1302.48	12.98	0.991
Hot carcass wt., lb.	783.79	785.62	784.83	798.02	8.28	0.584
Marbling score*	416.19	445.00	429.76	406.90	13.74	0.228
Dressing percent	0.63	0.62	0.63	0.63	0.00	0.384
Ribeye area, sq. in.	12.89	12.95	13.06	12.89	0.15	0.825
Yield Grade**	3.03	3.16	3.00	3.36	0.12	0.138
Fat thickness, in.	0.50	0.54	0.48	0.58	0.03	0.132
KPH, %	2.44[a]	2.33[b]	2.45[a]	2.49[a]	0.42	0.061

* Marbling score is a numeric value based on dispersion of fat inside ribeye muscle, 300-399 = select, 400-499 = low choice. Higher scores = more marbling and higher carcass value.

** Yield grade is a measure of fat to lean ratio, 1 = lean, 5 = fat.

[ab] Values with different superscripts are significantly different (P < 0.10)

There appear to be a number of differences in the fatty acid profile (Table 5) based on timing of flax feeding. Feeding flax during FIN and CNT generally increased n-3 fatty acids (P < 0.01) and also increased 18:2 n-6 (P < 0.04) resulting in an increase in total n-6 even though 20:3, 20:4, and 22:5 n-6 were greater for CON. The ratio of n-3:n-6 was greater (P < 0.01) for CNT and FIN as well.

Table 5. Fatty acid profile of steers fed flaxseed.

	Treatment						Contrasts
Item	Control	Receiving	Finishing	Continual	St. Error	*P* Value	Flax vs. No Flax
16:00	2527.81	2569.15	2667.45	2508.29	79.43	0.51	0.56
16:01	152.86	155.00	167.65	153.57	6.83	0.40	0.46
18:00	1568.76^{a}	1696.80^{ab}	1883.60^{b}	1734.86^{ab}	52.67	0.00	0.00
18:1n-9	2016.71	2086.45	2160.9	2143.81	101.94	0.75	0.34
18:1n-7	570.19^{ab}	612.55^{bc}	638.15^{c}	523.24^{a}	27.83	0.03	0.52
18:2n-6	3874.38^{a}	4201.55^{ab}	4427.60^{b}	3901.86^{a}	150.3	0.04	0.09
18:3n-3	107.00 ^{a}	156.15 ^{a}	425.55 ^{b}	465.33^{b}	16.77	<0.001	<0.001
20:3n-6	352.42^{a}	340.85^{ab}	314.55^{b}	263.62^{c}	11.65	<0.001	0.00
20:4n-6	1669.38^{ab}	1562.40^{b}	1704.00^{a}	1359.76^{c}	53.25	<0.001	0.05
20:5n-3	135.71^{a}	155.70^{a}	197.10 ^{b}	261.67 ^{c}	11.94	<0.001	<0.001
22:4n-6	148.76^{a}	132.85^{a}	129.60^{a}	94.05^{b}	6.53	<0.001	<0.001
22: 5n-6	33.29^{a}	29.10^{a}	26.50^{a}	13.57^{b}	1.49	<0.001	<0.001
22:5n-3	261.19^{a}	314.55^{ab}	340.55^{b}	387.00^{b}	13.35	<0.001	<0.001
22:6n-3	34.43^{a}	39.00^{ab}	43.00^{bc}	47.19^{c}	2.35	0.00	0.00
Sat	3580.33^{a}	4144.55^{ab}	4551.03^{b}	4243.03^{b}	221.03	0.03	0.01
UnSat	8186.69^{a}	9500.15^{ab}	10575.47^{b}	9614.87^{ab}	504.22	0.02	0.01
MUFA	2383.00^{a}	2776.71^{b}	2966.72^{b}	2820.74^{b}	165.46	0.09	0.02
PUFA	5803.68^{a}	6723.43^{ab}	7608.77^{b}	6794.12^{ab}	372.76	0.01	0.01
n-3	476.88^{a}	645.78^{b}	1006.38^{c}	1161.22^{c}	44.28	<0.001	<0.001
n-6	5326.80^{a}	6077.67^{ab}	6602.37^{b}	5632.9^{a}	344.61	0.06	0.05
n-3:n6	0.09^{a}	0.11^{a}	0.15^{ab}	0.21^{b}	0.004	<0.001	<0.001
UnSat:Sat	2.29	2.3	2.32	2.26	0.019	0.17	0.96
PUFA:MUFA	2.5	2.45	2.66	2.46	0.114	0.54	0.86
MUFA:Sat	0.66	0.67	0.65	0.67	0.02	0.90	0.96
PUFA:Sat	1.63	1.63	1.67	1.6	0.028	0.32	0.91

^{ab} Values with different superscripts are significantly different (P< .10)

Discussion and Implications

In this study, no consistent advantage in animal performance or carcass traits were observed for feeding flax to feedlot cattle. Flax, or possibly flax screenings, may be nutrient dense feeds that can be used for feedlot cattle but economics suggest competitive pricing with other feeds may dictate when and if flax is used as a feed ingredient.

While the statistics are much more convincing for positive effects of flax feeding on fatty acid content in beef, the biological implications need further exploration. To be effective as a reasonable source of n-3 fatty acids, beef consumption may need to be much more than current

USDA dietary recommendations. Other biological sources for humans, such as direct consumption of flax seed or flax oil, or capsular intake of fish oil, may be a more economical and volume appropriate as a neutraceutical for human consumption.

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