Effects of Feeding Calcium Salts of Conjugated Linoleic Acid (CLA) to Finishing Steers

A.S. Leaflet R1763

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Summary

Thirty crossbred steers were randomly assigned to three treatment groups and fed corn-based finishing diets (88% concentrate) containing 0, 1.0 or 2.5% conjugated linoleic acid (CLA) for an average of 130 days. Steers fed 2.5% CLA consumed less feed and had lower daily gains than control steers. Carcass weights tended to be reduced, and marbling scores were decreased by feeding 2.5% CLA. There were no significant effects of feeding CLA on dressing percentages, yield grades and backfat measurements. The rounds from each animal were physically separated into tissue components. Rounds from steers fed CLA contained a higher percentage of lean tissue and a lower percentage of fat. Feeding CLA increased concentrations of CLA in lipids from fat and lean in rib steaks and rounds. Increasing CLA in beef had no effects on shelf life, tenderness, juiciness, flavor or flavor intensity of rib steaks. Although results indicated that feeding calcium salts of CLA to beef steers decreased performance, concentrations of CLA in tissues could be increased offering the availability of a leaner, more healthful meat product.

Introduction

Conjugated linoleic acid (CLA) is a fatty acid present in lipids of animal origin. Concentrations of CLA are several fold greater in lipids of ruminant origin because of the biohydrogenation of unsaturated fatty acids in the rumen. CLA has been found to have several beneficial effects in laboratory animals, namely reduction in incidence of cancer in cancer induced experiments with mice, reduced atherosclerotic lesions in rabbits fed high cholesterol diets and increased growth of muscle in rats and pigs. It has been suggested that dietary CLA may have similar benefits in humans. This experiment was designed to measure the effects of feeding the calcium salts of CLA to finishing steers. The objectives were to measure the effects of feeding CLA on gain and performance of the steers, on carcass characteristics, on concentrations of CLA in lipids and on shelf life and quality attributes of steaks.

Materials and Methods

Thirty Continental-cross steers weighing approximately 790 lbs were randomly allotted to three dietary treatments. The steers were treated for internal and external parasites, implanted with Component TE-S and acclimated to the control finishing diet for 18 days prior to initiation of feeding CLA. Treatment groups consisted of two pens of five steers each of the following: control, 1.0% CLA, and 2.5% CLA. The composition of the diets is shown in Table 1. Calcium salts of CLA were prepared from a CLA-rich oil (CLA 60, ConLinco). The calcium salts (48% CLA isomers) were added to the diets replacing corn. The steers were fed twice per day according to appetite.

Initial plans were to harvest six steers per day for five different harvest dates. However due to failure of equipment in the packing plant, twelve steers were harvested in a different plant. The order of harvesting was determined by thickness of backfat and liveweight. The cattle were on trial an average of 124 days for the control and 133 days for those fed CLA. Hot carcass weights were measured following slaughter. Following a 48-hr chill thickness of backfat and ribeye area were measured and marbling and percentage of kidney, pelvic and heart fat (KPH) estimated by a USDA federal beef grader. The right hindquarter of each carcass was returned to the Iowa State University Meat Laboratory for physical separation of the round into tissue components and to obtain rib steaks for tenderness, shelf life and sensory studies. The round was dissected into lean, fat and bone for chemical analysis, and weights of each component were used to estimate separable lean in the carcass with the equation: separable lean per side = 137.62 + 2.94(separable lean in the round –37.44). The beef strip loins were trimmed to 0.5 in. of fat and stored for 17 days post harvest at 1^0 C. The subcutaneous and intermuscular fat were then removed and 1.0 in. and 0.5 in. steaks cut from the longissimus dorsi. These steaks were covered with polyvinyl chloride oxygen-permeable overwrap and aged an additional 1, 2, 3 and 7 days at 2^0 C in a self-serve cooler. The steaks were then vacuum packaged and stored at -30^0 C. Cores 0.5 in. in diameter were taken from 1.0 in. steaks cooked to 70^0 C and stored at 2^0 C for 24 hr for determination of tenderness by measuring force required to shear the cores in an Instron universal testing machine. Separate 1.0 in. steaks were selected at random, cooked to 70^0 C and cut into 0.5 in cubes, and served to a consumer sensory panel (15 to 17 persons per session) in eight sessions. An eight-point scale was used to measure each characteristic, eight being extremely tender, juicy, flavorful and intensely flavored and one being extremely tough, dry, off flavored and bland. Oxidative rancidity was measured in one 0.5 in. steak from each carcass by determination of malonaldehyde using tiobarbituric acid.

Lipids were extracted from samples of fat and lean from rib steaks and rounds from each animal using two parts chloroform and one part methanol. The extracted lipids were stored at -20^0 C until being methylated with sodium methoxide. The methyl esters of the fatty acids were separated by gas chromatography and identified by comparing their retention times with individual standard fatty acids.

The experimental model was a randomized design. Data were analyzed by GLM and ANOVA procedures of SAS. Pen of steers was used as the experimental unit for analysis of the feed intake and feed efficiency data, and individual animal was used as the experimental unit for all other measurements.

Results and Discussion

Steers fed CLA consumed less feed and gained less than control steers (Table 2); however, feed efficiency was not significantly different among the three groups. Compared with other studies done with other species, laboratory animals and pigs fed CLA tend to consume less feed but have similar gain so that feed efficiency is improved.

Marbling scores and thickness of backfat measurements indicated that steers fed CLA had reduced accretion of body fat (Table 3 and Figure 1). As a result the percentage of carcasses grading Choice was reduced, and the lean yield of the carcasses was improved when steers were fed CLA. Physical separation of the rounds into tissue components also indicated that steers fed CLA had less fat (Table 4). Though carcass weights tended to be reduced, weight of the rounds was not affected by dietary CLA. There was a numerical trend for lean in the round to be increased and for a significant decrease in the amount of fat in the rounds from steers fed CLA. The calculated lean mass in the carcass was similar for all three groups of steers even though those fed CLA had less total carcass weight. All the measurements related to body composition indicated that steers receiving CLA maintained muscle mass and decreased body fat suggesting that there may have been some repartitioning of energy away from adipose tissue.

Analyses of fatty acids in lipids extracted from fat and lean separated from the loins and rounds are summarized in Tables 5, 6, 7 and 8. Overall, feeding CLA increased the concentration of the saturated fatty acids in lipids extracted from fat and lean. The concentration of the monounsaturated fatty acid, oleic acid, was significantly decreased in lipids from steers fed CLA whereas the concentration of the polyunsaturated fatty acids, linoleic and linolenic acids, were either not changed or increased. The concentration of the sum of all isomers of CLA was linearly increased by feeding 1% and 2.5% CLA. The concentration of CLA was increased to a greater extent in fat than in muscle suggesting that the phospholipids in muscle membranes were less affected than the triglycerides in fat depots.

The physical force required to shear the cooked steaks indicated that all steaks were tender, and there were no consistent trends indicating that increasing the CLA content of beef muscle affected tenderness. Evaluation of the cooked steaks by a consumer sensory panel also indicated that increased CLA concentration in beef muscle did not affect tenderness, flavor or overall acceptability. Even though there were significant changes in the fatty acid composition of beef lipids by feeding CLA there were no consequences on shelf life as measured by color or rancidity.

Other research has shown that lipids from grazing cattle have greater concentrations of CLA than those from grain-fed cattle. Why grazing cattle consuming less fat have higher tissue CLA is not known. It is concluded from this study that feeding calcium salts of CLA to steers fed high-corn finishing diets can significantly increase the concentration of CLA in beef. In a related experiment with sheep we have observed that more than 85% of the calcium salts of CLA were hydrogenated in the rumen. There may be other approaches to increase CLA concentration in beef that would be more efficient than the approach used in this study. The observed decrease in performance of the CLA-fed steers in the feedlot limits the application of this approach. It is not clear from this study if the decrease in feed consumed resulted from a change in partitioning of energy in metabolism or the physical effects of the calcium salts in the feed. If a market develops for beef with greater concentrations of CLA, there will likely have to be other methods developed to protect the CLA from hydrogenation in the rumen. Other methods to increase CLA deposited in tissue lipids by increasing absorption of precursors of CLA from the digestive tract may be more practical. The results of this study show that increasing the CLA content of beef does not alter shelf life or consumer acceptability of the meat.

Table 1. Composition of the diets (% of dry matter).

Ingredient	Control	1.0% CLA	2.5% CLA
Cracked corn	78.93	77.23	74.72
Alfalfa pellets	11.94	11.92	11.89
Cane molasses	1.46	1.46	1.46
Soybean meal	4.99	5.25	5.63
Urea	0.69	0.69	0.69
Limestone	1.55	0.94	
NaCl	0.30	0.30	0.30
Trace minerals	0.024	0.024	0.024
Vitamin A premix[a]	0.08	0.08	0.08
Rumensin 80[b]	0.019	0.019	0.019
Elemental sulfur	0.022	0.022	0.022
Ca salts of fatty acids		2.07	5.17

[a]Provided 1,400 IU of vitamin A activity per pound of dry matter.
[b]Provided 15.6 mg of sodium monensin per pound of dry matter.

Table 2. Performance of steers during the feeding period.

	Diet				
	Control	1.0%	2.5%	SEM[c]	LSD[d]
No. Steers	10	10	10		
Starting weight, lbs	944	937	942		
Ending Weight, lb	1355	1287	1287		
Average days fed	124	133	133		
Daily gain, lb	3.30[a]	2.64[b]	2.64[b]	0.18	0.51
Feed intake, lbs DM/d	24.6[a]	21.8[a,b]	19.8[b]	0.68	3.04
Feed/gain	7.4[a]	8.6[a]	7.6[a]	0.27	1.22

[a,b]Means within a row with different superscripts differ (P < .05).
[c]Standard error of the mean.
[d]Least significant difference (P < .05).

Table 3. Carcass measurements.

		Diet			
Item	Control	1.0%	2.5%	SEM[c]	LSD[d]
Carcass weight, lbs	825	779	766	20.9	60.6
Dressing %	60.8	60.5	59.4	0.79	2.28
Marbling score[e]	424a	391[a,b]	368[b]	17.6	51.0
Percent USDA Choice[f]	60	50	20	15.5	45.0
Backfat, in	0.43	0.34	0.31	0.05	0.14
Ribeye area, sq. in.	13.1	13.1	11.9	0.15	1.30
Yield grade	2.2	2.1	1.9	0.20	0.60

[a,b]Means within a row with different superscripts differ (P < .05).
[c]Standard error of the mean.
[d]Least significant difference (P < .05).
[e]Slight^0 = 300, Small^0 = 400.
[f]Percent of carcasses with Small^0 or greater marbling.

Table 4. Measurements of the round and estimated carcass lean.

	Diet				
Item	Control	1.0%	2.5%	SEM[c]	LSD[d]
Physical separation of tissues					
Round weight, lbs	93.8	93.3	92.8	2.60	6.60
Separated lean, lbs	61.3	62.5	62.4	2.13	6.18
Separated lean, % of round	65.2	66.9	67.3	0.75	2.17
Separated fat, lbs	15.1[a]	14.2[a,b]	12.3[b]	0.68	2.00
Separated fat, % of round	16.2[a]	15.3[a]	13.3[b]	0.68	1.99
Bone, lbs	16.8	16.2	17.5	0.51	1.47
Bone, % of round	17.9[a,b]	17.4[a]	18.9[b]	0.46	1.33
Calculated carcass lean					
Lean in carcass, lbs	606.6	603.8	600.9	15.33	44.44

[a,b]Means within a row with different superscripts differ (P < .05).
[c]Standard error of the mean.
[d]Least significant difference (P < .05).

Table 5. Fatty acids in lipids extracted from fat separated from loins.

	Diet				
Fatty acid, mg/g fat	Control	1.0%	2.5%	SEM[d]	LSD[e]
Myristic	23.1[a]	28.2[a]	36.3[b]	2.03	5.87
Palmitic	170.4	179.2	194.5	9.77	28.35
Stearic	76.0	88.9	97.3	8.43	24.44
Oleic	268.2[a]	240.4[a,b]	230.2[b]	11.8	34.20
Linoleic	15.6[a]	20.0[b]	17.2[a,b]	1.36	3.94
Linolenic	1.5	1.6	1.4	0.10	0.28
Conjugated linoleic	5.5[a]	12.8[b]	20.4	1.91	5.53
Arachidonic	0.7	0.7	0.7	0.05	0.15

[a,b,c]Means within a row with different superscripts differ (P < .05).
[d]Standard error of the mean.
[e]Least significant difference (P < .05).

Table 6. Fatty acids in lipids extracted from lean separated from loins.

	Diet				
Fatty acid, mg/g fat	Control	1.0%	2.5%	SEM[d]	LSD[e]
Myristic	21.6[a]	22.5[a,b]	24.8[b]	1.09	3.17
Palmitic	163.1	156.4	158.8	5.94	17.23
Stearic	84.1	89.6	91.1	4.13	11.96
Oleic	257.7[a]	218.8[b]	218.2[b]	9.16	27.85
Linoleic	28.4[a]	34.7[b]	31.4[a,b]	2.03	5.89
Linolenic	4.6	5.0	4.7	0.26	0.75
Conjugated linoleic	5.2[a]	8.2[b]	12.4[c]	0.91	2.64
Arachidonic	9.1	9.3	10.4	0.76	2.21

[a,b,c]Means within a row with different superscripts differ (P < .05).
[d]Standard error of the mean.
[e]Least significant difference (P < .05).

Table 7. Fatty acids in lipids extracted from fat separated from rounds.

	Diet				
Fatty acid, mg/g fat	Control	1.0%	2.5%	SEM[d]	LSD[e]
Myristic	19.8[a]	23.8[a,b]	26.7[b]	1.62	4.70
Palmitic	142.5	160.3	162.0	8.95	25.96
Stearic	69.5	90.0	77.5	7.87	22.82
Oleic	235.0	240.3	231.2	12.54	36.35
Linoleic	13.3[a]	17.6[b]	14.5[a,b]	1.10	3.17
Linolenic	1.5[a]	1.8[b]	1.6[a,b]	0.11	0.32
Conjugated linoleic	5.4[a]	10.8[b]	16.5[c]	1.39	4.02
Arachidonic	0.8	0.8	0.8		

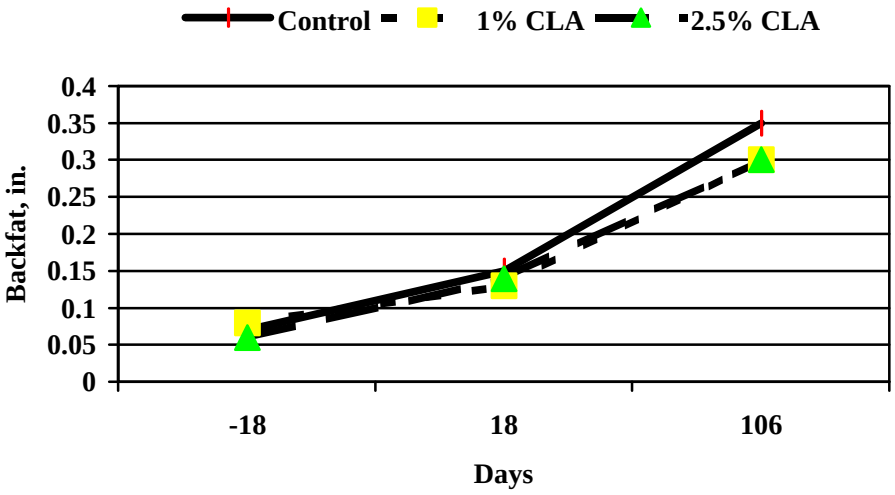
[a,b,c]Means within a row with different superscripts differ (P < .05).
[d]Standard error of the mean.
[e]Least significant difference (P < .05).

Table 8. Fatty acids in lipids extracted from lean separated from rounds.

	Diet				
Fatty acid, mg/g fat	Control	1.0%	2.5%	SEM[c]	LSD[d]
Myristic	18.7	19.4	21.0	0.93	2.68
Palmitic	143.9	138.5	141.6	5.45	15.80
Stearic	72.1	80.1	81.3	4.48	13.00
Oleic	262.5[a]	227.7[b]	214.5[b]	8.32	24.11
Linoleic	30.1	33.3	30.3	1.95	5.64
Linolenic	4.6	5.2	4.7	0.26	0.75
Conjugated linoleic	6.3[a]	10.2[b]	12.6[b]	0.89	2.58
Arachidonic	10.5	10.3	9.5	0.61	

[a,b]Means within a row with different superscripts differ (P < .05).
[c]Standard error of the mean.
[d]Least significant difference (P < .05).

Figure 1. Accretion of backfat as measured by usltrasound.



Implications

Supplementing high-corn diets with calcium salts of CLA increased concentration of CLA in lipids extracted from muscle and fat tissues. CLA enriched beef had similar tenderness, sensory and shelf-life properties. Enriching beef with CLA has the potential to greatly improve the nutritional quality of beef for human consumption.

Acknowledgments

This experiment was partially funded by a grant from the National Cattlemen's Beef Association. The CLA-rich oil was provided by ConLinco, Detroit Lakes, Min. The calcium salts of CLA were prepared by Bioproducts, Inc., Las Vegas, Nev. Materials were supplied as follows: Rumensin, Elanco Products, Indianapolis, Ind.; vitamin A, Roche Animal Nutrition and Health, Paramus, N.J.; and Component implants, VetLife, West Des Moines, Ia. The assistance of Rod Berryman, research farm superintendent; Jim O'Brian, meat processing specialist; Deborah Patton, laboratory technician; Julie Roberts, Beef Center secretary; and the animal caretakers at the ISU Beef Nutrition and Management Research Center is appreciated.