Title: Feeding CLA to Improve the Production and Quality Characteristics of Pork – **NPB #98-136**

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Abstract

Two experiments were conducted to assess the efficacy of feeding conjugated linoleic acid (CLA) to market pigs. Characteristics of growth, efficiency, carcass traits and meat quality were measured. In experiment 1, (n=92) pigs were fed 0.75% CLA in the diet at varying starting points in the growing phase (28 kg, 57 kg and 86 kg) until slaughter at 115 kg of body weight. Feed intake and average daily gain were not affected by CLA supplementation, but feed efficiency increased quadratically with increased time on CLA. Additionally, backfat thickness decreased linearly and loineye area increased linearly with increasing time on CLA. Subjective quality scores for marbling and firmness increased linearly in response to CLA feeding. Objective color measures of loin chops for yellowness increased (p<.05) with CLA and redness scores tended to increase with CLA. No differences were observed for water holding capacity, but CLA chops exhibited lower lipid oxidation values at 1 day of retail shelf storage. Addititionally, bellies tended to be firmer with CLA supplementation compared with control bellies. Sensory characteristics for loin chops were not affected by CLA supplementation.

Experiment 2, (n=64) consisted of three genotypes, stress gene free (normal), heterozygous stress (carrier) and homozygous stress (stress) fed 0.75% CLA or a control diet. Normal pigs on CLA had significantly greater gain to feed and average daily gain compared with normal pigs on the control diet. Carrier and stress pigs did not exhibit the same response. Tenth rib fat was not affected by CLA supplementation, but last rib fat was higher for normal pigs on CLA compared to normal pigs on the control diet. No differences were observed with CLA supplementation for color, marbling, firmness or sensory characteristics for any genotype.

Introduction

Production of more efficient pigs which also have carcasses that excel in meat quality characteristics (color, marbling and firmness) is critical to the profitability of today's pork producer. Many of today's pigs are either fast growing or have high meat quality, but it seems difficult to produce pigs which will combine these to attributes. Recent research has focused on adding different compounds to diets of fast growing, lean producing pigs in order to maintain their genetic potential while trying to add quality needed to meet consumer demand both domestically and internationally. Supplementation of conjugated linoleic acid (CLA) has been reported as an effective method to decrease fat in pigs and increase growth and performance. Additionally, CLA has been the subject of much research as an anticarcinogenic, antiatherogenic and immune function improving compound in rats and rabbits. Not only does this research have implications in animal health, but possibly in the future it will positively influence human health by consumption of CLA supplemented pork products.

Objectives

Determine length of time necessary to feed CLA to optimize:

a. production efficiencies
b. the effects of CLA on body and carcass composition
c. loin, ham and belly quality characteristics

Procedures

The first experiment consisted of 92 crossbred barrows, which were allotted to control or CLA diets (0.75%) at varying body weights. Treatment groups included a control at a starting weight of 28 kg (T1), CLA at 28 kg(T4), CLA at 57 kg(T3) and CLA at 86 kg(T2) of body weight. All pigs were slaughtered and growth efficiency, carcass, loin quality and ham quality data were collected. The measurements from both experiments are complete for parameters of growth and performance include; gain-to-feed ratio, average daily gain, loineye area, fat thickness, loin color, loin marbling, loin firmness, lipid oxidation, loin proximate analysis, loin water holding capacity, ham composition, and loin and ham sensory panel attributes. Due to circumstances beyond our control, one half of the bellies from experiment one were lost in the Hormel plant in Austin, MN. Because of small numbers this did not allow for a sample size, which could be statistically analyzed.

Experiment two included different genotypes of stress pigs (n=64). These pigs were also fed CLA at 0.75% in the diet. Data collected and analyzed for experiment two included the same growth, carcass and meat quality characteristics collected for those animals/products in experiment one.

CLA was in an oil form and replaced soy oil in the treated diets. Treated diets contained 0.75% of the source of CLA. The CLA source was a 60% mixture of CLA isomers. Average daily gain and feed efficiency were calculated at the conclusion of the feeding trial. All pigs remained on their respective diet until 115 kg of body weight at which time they were humanely slaughtered at Hormel, Inc. in Austin, MN. Carcasses were chilled 24hr postmortem before carcass measurements were taken. The left side of each carcass was ribbed between the 10th and 11th rib, and loineye area, 10th rib, 1st rib and last lumbar fat were measured.

At 24hr postmortem, whole bone-in loins were removed from the left side of each carcass. Loins were weighed, boxed and shipped under refrigerated conditions to the Iowa State University meat laboratory. At 48 hr postmortem, whole loins were subjectively evaluated for color, marbling and firmness at the 10th and 11th rib face according to a five-point scale (NPPC, 1992). Chops were deboned and trimmed to 0.01 cm of subcutaneous fat. Chops were paired at random and placed in Viskase® vacuum bags. The vacuum packages were assigned to 1, 14 or 28 days of retail storage. Each package was stored for its respective time at 2° C under lighting conditions similar to retail storage. Three 1.27cm chops were also cut from each loin for measurement of pH, water holding capacity, lipid oxidation and proximate analysis. These chops were stored under vacuum in accordance with the 2.54cm chops. Proximate analysis, including fat and moisture was performed by the following methods. Fat was determined by hexane extraction using a Soxhlet method (AOAC, 1990). Moisture was determined as a difference between wet and dried samples from the fat determination. Proximate analysis was used to verify the subjective marbling scores. At the appropriate day of storage, chops were removed from vacuum and placed on styrofoam trays with oxygen permeable polyvinyl chloride overwrap. Chops were placed in the retail cooler for 24 hr after being repackaged. After the 24 hr period, objective colors were measured with the Hunter Lab Color system (Hunter Associates Laboratory, Inc. Reston, VA) with a 2.54 cm objective. L*, a* and b* values were evaluated. Sensory characteristics were evaluated on chops cooked in a broiler set at 176^{o} C to 71º C Each chop was cut into 2.54 cm cubes for sensory evaluation. A panel consisting of 10 subjects evaluated day 28 chops for tenderness, flavor, juiciness, off flavor and overall acceptability according to an 8-point scale (AMSA, 1992).

Results

Experiment 1

Data for growth efficiency and carcass characteristics are presented in Table 1. Average daily gain and feed intake were not affected by CLA supplementation, but gain to feed ratio increased quadratically in response to length of feeding. Pigs started on CLA from 29 to 58 kg of body weight had the highest gain to feed ratios. Additionally, there was a linear decrease in backfat thickness and a linear increase in loin muscle area in response to increasing days of feeding CLA. Carcass weight was not affected by CLA supplementation.

Subjective quality scores for color marbling and firmness of loins at the 10th and 11th rib interface, using NPPC standards, are shown in Table 2. A linear increase ($p<.05$) was observed for degree of marbling and a linear trend ($p<.07$) for firmness score was also noted. These subjective scores for both marbling and firmness increased with increasing time on a CLA diet. Marbling and loin muscle firmness scores were highly correlated (.93) suggesting that CLA fat is firmer than control fat. This increased firmness of the loin face increased as marbling increased. No differences were observed for subjective color scores between control and CLA chops.

An objective color score was determined by using the Hunter color system (Table 3). This system evaluated lightness (L*), redness (a*) and yellowness (b*) of loin chops. CLA chops tended to have a higher a* value indicating a trend toward a redder color. CLA chops also were significantly ($p<.05$) higher for b* values compared with control chops indicating a more yellow color.

Additional quality values for loins included pH, water holding capacity (WHC) and lipid oxidation (TBA) as reported in table 4. These measures were taken at 1, 14 and 28 days of storage time at 2^{o} C. TBA values, a measure of lipid oxidation, were lower ($p<.05$) for CLA chops at day 1 compared with control chops. However, these significant differences were not observed by days 14 and 28. Values for pH and WHC were very acceptable and did not differ between CLA and control chops. However, WHC values tended to improve over time for all chops.

Sensory characteristics (Fig. 1) of loin chops were evaluated by a 10-member panel. Each panelist evaluated samples of pork chops broiled to 71^{o} C for tenderness, juiciness, flavor intensity and overall flavor based on an 8-point descriptive scale. No significant differences were observed for the sensory characteristics when CLA and control chops were compared. Moreover, all sensory attributes of samples were acceptable.

In addition, fresh and processed hams were evaluated for various quality characteristics and improvements in fresh ham color, color uniformity, and marbling were observed (Please see ISU Swine Research Report 1998).

In experiment 2, growth data for average daily gain and gain to feed ratio are summarized in Tables 5 and 6, respectively. In both characteristics, the effect of CLA was dependent on the stress factor of the pig. For gain-to-feed ratio, normal pigs fed CLA exhibited higher ($p<.05$) feed efficiency and higher ($p<.05$) average daily gain when compared with normal pigs on the control diet. Stress gene carrier and positive pigs did not exhibit the same response when they were compared with CLA and control diets. However, some of these results may be explained by small numbers of pigs in the CLA carrier and CLA positive groups due to death loss and carcass losses in the packing plant.

Carcass data, loineye area, 10^{th} rib fat and last rib fat depth, are included in Table 7. No significant differences were observed for loineye area. All pigs in the experimental group were heavily muscled as indicated by an overall average of 7.30 in.^{2}. Tenth rib fat values (fat over the longissimus) were not effected by CLA within a genotype class. However, the stress positive pigs exhibited lower 10^{th} rib fat, but this difference was not significant due to extreme variation within each genotype of pigs. Last rib fat measurements were negatively affected within normal pigs with CLA pigs averaging 1.51 inches compared with 1.07 inches in the control group. CLA did not affect last rib fat within the carrier and positive groups.

Subjective quality scores for lean color, marbling and firmness were not significantly changed by CLA within the three genotypes (Table 8). All pigs were acceptable for these quality attributes except the stress positive pigs, which were unacceptable for marbling regardless of diet, but did not differ statistically from control chops.

Subjective marbling scores were further analyzed by using proximate analysis (Table 9). Fat percentage within the loin chop tended to be higher for all genotypes on CLA diets, relative to controls. However, these differences were not significant due to rather high variation within each treatment group. Whole loins were stored in vacuum packaging for 21d prior to being cut into chops and placed in a self-service case on styrofoam trays with oxygen permeable overwrap. Differences were observed over three days of retail case storage for L*, a* and b* values. All chops tended to decrease in a* values over the three days of storage with the control and CLA chops exhibiting equivalent decreases in a* over this time period.

Summary

In normal, stress free genotype pigs, CLA supplementation improves feed efficiency and in some cases average daily gain. A decrease in 10^{th} rib fat for experiment one pigs was observed, but this same decrease in fatness was not observed in experiment two. Additionally, significant improvements can be noted for marbling and firmness characteristics in the loin muscle from experiment one. A trend for red color increases was exhibited in experiment one. CLA chops tended to have higher b* values in both experiments, but the practical significance of this increase may be inconsequential to consumer acceptability. Decreases in lipid oxidation (possibly related to flavor or increased shelf life) were observed early in retail storage for CLA loin chops in experiment one, but this difference was not carried into longer storage times of 7 and 14 days, respectively. Other values, pH and water holding capacity, were not affected by CLA supplementation. Sensory characteristics for experiment one chops were not affected by CLA supplementation, and all chops were acceptable for juiciness, tenderness, flavor intensity and overall acceptability traits.

Due to pig and carcass losses in the second experiment, the total number of pigs in each treatment group was adversely affected. It would seem prudent to repeat the second experiment with another replication with pigs of like genetics to get a more accurate account of the effect of CLA on pigs with a propensity for pork quality problems.

Table 1. Effect of conjugated linoleic acid on growing-finishing pig performance and carcass traits (n=92).

		Treatment group				P values	
Item	Bodyweight	1	2	3	4	Linear	Quadratic
ADG, g							
	28 to 57 kg	855	834	869	828	.60	.61
	57 to 86 kg	942	958	1,002	968	.30	.32
	86 to 115kg	980	1,003	966	950	.45	.61
	28 to 86kg	894	890	929	890	.71	.36
	28 to 115 kg	924	929	942	912	.77	.33
ADFI, g							
	28 to 57 kg	2,126	2,024	2,117	2,055	.46	.57
	57 to 86 kg	3,007	2,967	2,917	2,876	.06	.98
	86 to 115kg	3,306	3,287	3,297	3,292	.95	.95
	28 to 86kg	2,521	2,447	2,476	2,424	.08	.73
	28 to 115 kg	2,791	2,737	2,759	2,724	.47	.86
G/F, g/kg							
	28 to 57 kg	402	413	411	404	.92	.30
	57 to 86 kg	314	323	345	336	.05	.30
	86 to 115kg	296	306	293	288	.20	.29
	28 to 86kg	355	364	376	367	.20	.55
	28 to 115 kg	331	340	342	335	.44	.05
Carcass weight, kg		84.4	84.4	85.3	83.5	.93	.95
Backfat, mm							
	10^{th} rib	26.2	22.4	22.4	20.8	.01	.15
	1^{st} rib	47.0	43.2	42.9	41.7	.05	.28
	Last lumbar	24.6	22.1	21.6	21.6	.02	.08
Loin muscle area, cm^2		39.1	41.7	43.4	42.7	.01	.17

Table 2. Least squares means and standard errors for subjective measures of color, marbling and firmness of loin chops (n=92).

Trt[a]	Color	SE	Marb	SE	Firm	SE
1	2.43	.10	2.04b	.10	2.36	.06
2	2.31	.11	2.18c	.10	2.27	.07
3	2.47	.10	2.35d	.10	2.45	.06
4	2.38	.10	2.31d	.10	2.49	.06

[a] 1= control 28kg; 2= 86kg body weight; 3 = 57kg body weight; 4= 28kg body weight.
Values within a column with different letters are significant at P<.05.

Table 3. Least squares means for Hunter L*, a*, and b* values of fresh overwrap chops at 24 hr of retail storage independent of day (n=46).

Trt[a]	L*	SE	A*	SE	b*	SE
Control	51.53	0.34	6.16	0.17	11.76a	0.09
CLA	52.18	0.33	6.53	0.17	12.15b	0.09

[a] Con = control diet; CLA = longest time on CLA diet.
Values within columns with different letters significant at P<.05.

Table 4. Least squares means and standard errors for pH, water holding capacity (WHC), and thiobarbituric TBA values at 1, 14, and 28 days at 2° C of storage of loin chops (n=46).

Trt[d]	Day	pH	SE	WHC	SE	TBA[c]	SE
Control	1	5.70	0.02	3.10	0.16	0.098a	0.003
CLA	1	5.70	0.02	3.03	0.16	0.081b	0.003
Control	14	5.80	0.02	2.77	0.16	0.098	0.038
CLA	14	5.79	0.02	2.92	0.16	0.158	0.038
Control	28	5.77	0.02	2.59	0.13	0.187	0.041
CLA	28	5.76	0.02	2.39	0.13	0.132	0.041

Means with different letter within a column are significant at P<.05.
[c] TBA values expressed as milligrams of malonaldehyde per kilogram sample.
[d] control= control diet at 28kg, CLA= CLA diet at 28kg

Table 5. Average daily gain of three genotypes (n=51)

Genotype	Diet	lb/day[d]	SE
Normal	Control	1.85[a]	.05
Normal	CLA	2.03[bc]	.05
Carrier	Control	2.04[b]	.05
Carrier	CLA	1.88[ac]	.05
Positive	Control	1.93[b]	.05
Positive	CLA	1.87[ac]	.05

[d] means within a column with different superscripts are significant at $p<.05$

Table 6. Gain to feed ratio of three stress genotypes (n=51)

Genotype	Diet	LSMean[de]	SE
Normal	Control	0.25[a]	.02
Normal	CLA	0.32[bc]	.02
Carrier	Control	0.28[ac]	.01
Carrier	CLA	0.27[ac]	.01
Positive	Control	0.24[a]	.02
Positive	CLA	0.25[a]	.02

[d] means within a column with different superscripts are significant at $p<.05$
[e] expressed as pounds of gain/pound of feed

Table 7. LEA, 10th rib fat and last rib fat depth of three stress genotypes (n=51)

Genotype	Diet	LEA[e]	SE	10th[f]	SE	Last[f]	SE
Normal	Con	7.03	.33	.97[ab]	.18	1.07[ac]	.11
Normal	CLA	6.86	.35	.98[ab]	.09	1.51[b]	.11
Carrier	Con	7.20	.32	1.01[a]	.09	1.36[bc]	.10
Carrier	CLA	7.53	.32	.91[ab]	.11	1.21[ab]	.10
Positive	Con	7.48	.35	.73[b]	.10	1.04[a]	.11
Positive	CLA	7.71	.38	.75[ab]	.12	1.05[a]	.11

[d] Means within a column with different letters are significant at $p<.05$
[e] expressed in $inches^2$
[f] expressed in inches

Table 8. Subjective quality scores of loin chops three stress genotypes (n=51)

Genotype	Diet	Color	SE	Marb	SE	Firm	SE
Normal	Con	2.55	.24	2.22[ac]	.30	2.22	.27
Normal	CLA	2.62	.26	2.87[a]	.32	2.88	.29
Carrier	Con	2.30	.23	2.50[a]	.29	2.30	.26
Carrier	CLA	2.50	.23	2.40[ac]	.29	2.30	.26
Positive	Con	2.25	.26	1.62[bc]	.32	2.13	.29
Positive	CLA	2.14	.28	1.71[bc]	.34	2.14	.31

[d] Means within a column with different letters are significant at p<.05

Table 9. Fat and moisture values for loin chops of three genotypes (n=51)

Genotype	Diet	Fat%	SE	H_2O%	SE
Normal	Con	3.29	.57	72.96	.95
Normal	CLA	4.36	.61	71.87	1.01
Carrier	Con	3.35	.51	72.69	.85
Carrier	CLA	4.28	.51	73.01	.85
Positive	Con	2.82	.57	73.95	.95
Positive	CLA	3.30	.61	73.42	1.02

Table 10. Hunter color values for loin chops of three stress genotypes (n=51)

Color	Day[a]	Con	SE	CLA	SE	p-value
L*	1	44.96	.87	46.24	.89	0.31
	3	45.09	1.01	47.32	1.04	0.13
a*	1	6.33	.33	6.64	.34	0.52
	3	5.00	.27	5.73	.28	0.07
b*	1	10.71	.30	11.26	.31	0.21
	3	10.07	.25	10.92	.26	0.02

[a] Retail storage at 2° C in self service case

Fig.1 Sensory attributes of CLA and control pork loin chops (n=46)

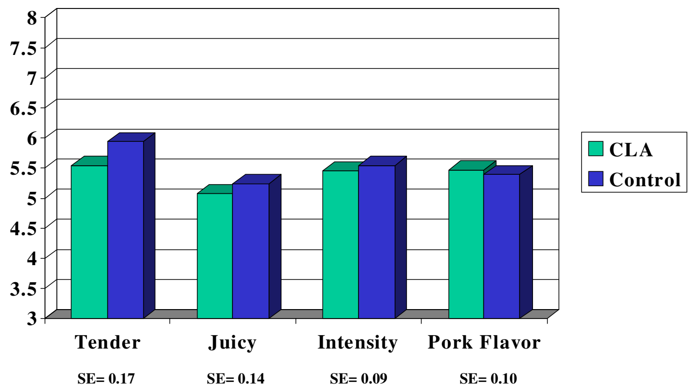
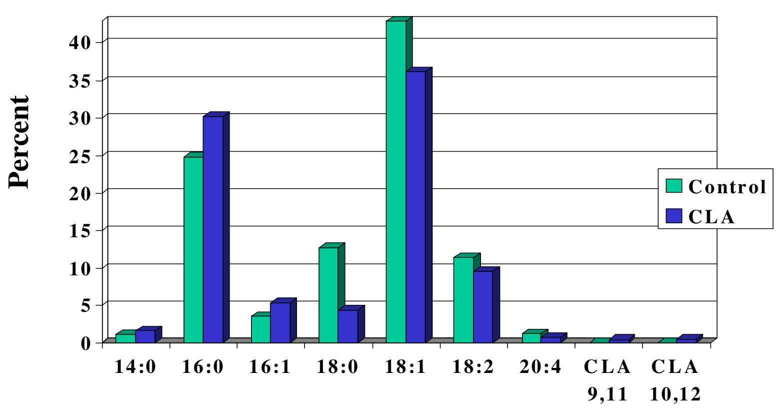


Fig. 2 Fatty acid profile of loin samples from experiment 1 (n=24).



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