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The Effect of Conjugated Linoleic Acid (CLA) on Feed Efficiency and Carcass Composition in Barrows

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The Effect of Conjugated Linoleic Acid (CLA) on Feed Efficiency and Carcass Composition in Barrows

Natasha R. Winslow

Thesis submitted to the
Davis College of Agriculture, Natural Resources, and Design
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ABSTRACT

The Effect of Conjugated Linoleic Acid (CLA) on Feed Efficiency and Carcass Composition in Barrows

Natasha R. Winslow

The purpose of this study was to determine if conjugated linoleic acid (CLA) would have an effect on feeding efficiency and carcass composition of 20 finishing barrows obtained from the West Virginia University Animal Science Farm. A posttest experimental design was used to obtain data for the study. The barrows were matched for weight and placed two in a pen. The pens were randomly assigned to a diet consisting of either a 1% CLA oil or 1% soybean oil. The six week study found that weight gain, average daily feed intake, muscle lipids, loin eye area, and color were not affected by CLA. In week five average daily gain for the control group was significantly higher than the CLA group. In weeks one and five the gain to feed ratio was significantly greater for the control group. Subjective marbling scores were higher for the CLA group but not of significant value. Backfat decreased significantly in the CLA group compared to the control group. In conclusion, the use of CLA can create a leaner product with the possibility of increased marbling.

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Without the help of some very special in my life, I know that I would not have made it this far in my education and career. To them I want to say thank you.

My Family (Chuck, Becky, Josh, and Logan): Thank you so, so much for standing behind me and supporting me throughout all of this. Without all of you in my life, I would not have made it this far. Especially my father, who if it was not for him pushing me for the past year to complete this, I am not sure if I would have.

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throughout all of this.

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CHAPTER I

Introduction

The pork industry is a continually growing industry with over 74,000 farms in the United States producing hogs (*Census of Agriculture*, 2007). Producers are always looking for ways to be more efficient and increase performance of their pigs. The pork industry is trying to persuade producers to achieve a leaner more healthful product, because of consumer preference. Conjugated linoleic acid could be a solution to obtain improved animal performance, carcass composition, and quality of pork products.

Conjugated linoleic acid (CLA) is a type of fatty acid that contains positional and geometric conjugated double-bond isomers of linoleic acid. Linoleic acid (C18:2) has double bonds located on carbons 9 and 12 in *cis* configuration, however, conjugated linoleic acid has either the *cis* and/or *trans* configuration in the carbon chain. CLA occurs naturally in ruminant animals, but is now available in synthetic form. CLA is also found naturally in a variety of foods including oils, dairy products, and meat from ruminants. Conjugated linoleic acid potentially has many health benefits. As little as 0.1% CLA in the diet has shown to inhibit tumor development in rats (Ip, Singh, Thompson, & Scimeca (1994). In another study by Ip et al., (1999) a CLA enriched diet fed to rats decreased mammary cancer risk by ~50%. CLA has shown to reduce body fat in mice (Chin, Storkson, Albright, Cook, & Pariza 1994; Park et. al, 1997; Park, Storkson, Albright, Liu, & Pariza, 1999) and improve feed efficiency (Chin et al. 1994). In humans, Gaullier et al. (2005) reported that supplementation of CLA for 24 months reduces body weight, body mass index, and is well tolerated in overweight individuals. CLA has also

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reduced atherosclerosis in rabbits (Lee, Kritchevsky, and Pariza, 1994) and hamsters (Nicolosi, Rogers, Kritchevsky, Scimeca, & Huth, 1997).

Swine studies have produced similar results. They have shown to decrease backfat and increase feed efficiency in pigs fed a CLA supplemented diet (Dugan, Aalhus, Schaefer, & Kramer, 1997; Theil-Cooper, Parrish, Sparks, Wiegand, Ewan, 2001; Weigand, Parrish, Swan, Larsen & Bass, 2001). Studies have also indicated increased marbling when fed a CLA diet (Dugan, Aalhus, Jeremiah, Kramer, & Schaefer, 1999; Weigand et al., 2001). Due to the availability of feed-grade CLA, swine research has greatly increased to possibly improve carcass traits, feed efficiency, and a more beneficial pork product for the consumer.

Problem Statement

In order to improve feed efficiency and performance of swine for the producers and improve the quality of pork products for the consumer, research must continue to determine the best option to obtain these qualities for both the producer and consumer.

Purpose of the Study

The purpose of this study was to determine the effect of a 1% conjugated linoleic acid oil supplemented diet versus 1% soybean oil, the control supplement. Study was conducted on 20 growing barrow pigs produced at the West Virginia University Farm.

Objectives of the Study

The objective of this study is further reflected in the following research questions.

Research Questions

1. Will a 1% CLA diet fed to barrows have an effect on weight gain?

2. Will a 1% CLA diet fed to barrows have an effect on average daily gain?

3. Will a 1% CLA diet fed to barrows have an effect on average daily feed intake?

4. Will a 1% CLA diet fed to barrows have an effect on the gain to feed ratio?

5. Will a 1% CLA diet fed to barrows have an effect on the amount of backfat?

6. Will a 1% CLA diet fed to barrows have an effect on subjective marbling scores?

7. Will a 1% CLA diet fed to barrows have an effect on muscle lipids in the ham and loin?

8. Will a 1% CLA diet fed to barrows have an effect on the loin eye area?

9. Will a 1% CLA diet fed to barrows have an effect on the color of meat postmortem?

Limitations of this Study

This study was limited to pigs produced at the West Virginia University Animal Sciences Farm. It was also limited to barrows, because barrows tend to be fatter than gilts; therefore, able to produce results of fat reduction due to CLA. Diets were limited to only containing one supplemental fat source: CLA or the control, soybean oil.

CHAPTER II

Review of Literature

Conjugated linoleic acid (CLA) is a type of fatty acid that contains positional and geometric conjugated double-bond isomers of linoleic acid. The two most common CLA isomers research are cis-9, trans-11, found naturally in ruminant animals, and in synthetic preparations trans-10, cis-12. CLA has recently received much attention due to all the beneficial effects it has shown in research. CLA has been known to reduce body fat (Gaullier et al., 2005), and improve growth and performance (Chin et al., 1994; Dugan et al., 1997). The effects of CLA have been researched and reported on monogastrics including rodents, humans, and swine.

The pork industry, like any typical industry, is constantly looking for ways to improve efficiency and the quality of their products. In recent years, the research of conjugated linoleic acid on swine has become more popular due to earlier research on other mammals (Chin et al., 1994; Park et al., 1997), and the availability of feed-grade CLA. The pork industry is pushing producers to achieve products for the consumer that are leaner with increased marbling. Marbling and color of the meat is an important characteristic when it comes to consumer preferences. Marbling is what affects the flavor, juiciness, and tenderness of the meat; while color affects the consumers' preference when making a selection. Marbling is the intramuscular fat and it is what gives meat its palatability; therefore making it more desirable to the consumer. However, when an animal is leaner it tends to give up the intramuscular fat, but CLA has been shown to increase marbling while decreasing body fat (Wiegand et al., 2001; Wiegand et al., 2002).

CLA has also been shown to increase gain to feed ratio and feed efficiency (Chin et al., 1994; Dugan et al., 1997), both important to the producers.

Feed Efficiency

Chin et al. (1994) reported that feeding CLA to female mice during gestation and lactation improved the postnatal weight gain of pups. These same pups, after weaning, continued to be fed a CLA-supplemented diet which showed a significantly greater body weight gain and improved feed efficiency compared to the control group (Chin et al., 1994).

In swine, a CLA diet tended to have decreased feed intake and improved feeding efficiency and average daily gain compared to the control group fed a sunflower oil based diet (Dugan et al., 1997). In genetically lean female pigs fed a CLA diet, the increase in gain to feed ratio was 6.3%, but no significant effect on average daily gain (ADG) or feed intake (Ostrowska, Muralitharan, Cross, Bauman, & Dunshea, 1999). However, in 2006, Weber et al. performed an eight week study and found that from weeks six to eight ADG increased and weeks four through eight gain to feed ratio increased for genetically lean female pigs fed a 1% CLA enhanced diet. In studies using barrows, male castrated pigs, similar results were found. Thiel-Cooper et al. (2001) found the greatest increase in ADG was at the 1% level of CLA supplementation. Also reported was an increase in gain to feed, because of the increase of ADG without an increase in feed intake compared to the controls (Thiel-Cooper et al., 2001). In similar studies using barrows fed CLA at 0.75% of the total diet, an increase in gain to feed ratio was reported; however, average daily gain was not affected (Wiegand et al., 200; Wiegand, Sparks, Parrish, & Zimmerman, 2002) nor was daily feed intake (Wiegand et al., 2002).

Several studies found that while CLA provided evidence in improved feed efficiency there were also contradictory results. Dietary CLA showed no effect on gilts or barrows on ADG or feed efficiency (Ramsay, Evock-Clover, Steele, & Azain, 2001) and in just gilts fed a CLA diet feed consumption and ADG was not affected (Gatlin, See, Larick, Lin, & Odle, 2002). In 2002, an 80 pig study on growing pigs, both barrows and gilts, reported no differences in feed intake, growth intensity, and feed conversion efficiency in a 2% CLA diet compared to a control group fed a 2% rapeseed oil diet (Tischendorf, Schone, Kirchheim, & Jahreis, 2002).

Body and Carcass Composition

Early studies have shown that CLA has reduced body fat in mice. Park et al (1997) found that mice fed CLA-supplemented diets caused a significant change in body composition relative to the control group. Compared to the controls, percentage of body fat was reduced by 57% in males and 60% in females; however weight gains of control vs. CLA was not significantly affected (Park et al., 1997). Park et al. (1997) reported an increase in whole-body protein and an increase in carcass water in mice fed CLA. In a similar study it was reported that mice fed the trans-10, cis-12 isomer of CLA also showed a reduction in body fat, while increasing muscle (Park et al., 1999).

Several swine studies have reported similar results. Dugan et al. (1997) reported pigs, barrows and gilts, fed 2% CLA oil diet increased lean and reduced subcutaneous fat in commercial cuts. Dugan et al. (1999) determined that pigs fed a 2% CLA diet showed increased subjective marbling scores, increased intramuscular fat, and did not affect color scores. The CLA diet did not affect palatability characteristics of the meat such as, tenderness, juiciness, and flavor when compared to the control diet (Dugan et al., 1999).

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Tischendorf et al. (2002) found that when fed a 2% CLA diet to both barrows and gilts the CLA diet had a significantly higher percentage of lean carcass than swine fed a 2% rapeseed oil (control) diet; however, the backfat thickness was lower in the CLA fed pigs but not of a significant difference. Although the CLA diet showed no significance difference in backfat as a group, the barrows did show a significant difference in decreased backfat compared to the control group (Tischendorf et al., 2002). There were no differences reported in intramuscular fat content or the color of meat of those given the CLA diet compared to the control group given the rapeseed oil (Tischendorf et al., 2002). In a study that only observed female growing pigs fed a dietary CLA diet, containing a number of isomers, there was a significant increase in lean tissue and a decrease in fat deposition (Ostrowska et al., 1999). In barrows fed a 1% or less CLA supplemented diet there was a decrease when compared with the control group in 10th rib backfat; however, loin eye area was not affected (Thiel-Cooper et al., 2001). In cross-bred growing-finishing barrows fed at 0.75% CLA, the diet showed decreased backfat along with increased marbling (Wiegand et al., 2001). In a similar study by Wiegand et al. (2002) there was a decrease in backfat and an increase in marbling scores in barrows when fed CLA during the last 56 kg of final weight gain. In both studies loin eye area and color were not affected in pigs fed the CLA supplemented diet (Wiegand et al., 2001; Wiegand et al., 2002). In 2002 Joo, Lee, Ha, & Park conducted a study by feeding different levels of CLA to gilts for four weeks. They discovered that increased levels of CLA in the diet elevated CLA concentration in the muscle. The intramuscular fat was higher in the 5% CLA-fed diet than the control diet containing no CLA. Also the color of

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the meat was not affected in gilts fed CLA versus the control diet, but the data indicated that the color stability of the CLA pork improved during cold storage (Joo et al., 2002).

Even though conjugated linoleic acid has shown to improve carcass composition, other studies have revealed conflicting results. In 2001, Ramsey et al., reported that CLA did not decrease backfat, but actually increased in pigs fed a 0.25 or 0.5% CLA diet compared to control animals. In genetically lean pigs CLA did show a slight decrease in backfat depth although it was not a significant difference (Gatlin et al., 2002; Weber et al., 2006); however, subjective intramuscular fat scores did increase (Gatlin et al., 2002). Ramsey et al., (2001) and Gatlin et al., (2002) postulated that the reason the pigs showed no decrease in backfat was due to the possibility that CLA supplementation has the greatest effect on pigs in the final stages of finishing.

Summary

Studies reflecting the research questions have shown conflicting results. Therefore, further research is needed to strengthen the outcomes of these studies. CLA is a possible nutritional alternative for producers to use to achieve a more desirable product. To convince companies and producers of the potential benefits of CLA supplements additional research is needed to support previous findings. Thus far there is evidence that producers will not only benefit from improved feeding efficiency, they will also achieve a more healthful sought-after unique end product and the possibility of increasing profits.

CHAPTER III

Methodology

Problem Statement

In order to improve feed efficiency and performance of swine for the producers and improve the quality of pork products for the consumer, research must continue to determine the best option to obtain these qualities for both the producer and consumer.

Purpose of the Study

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8. Will a 1% CLA diet fed to barrows have an effect on the loin eye area?

9. Will a 1% CLA diet fed to barrows have an effect on the color of meat
    postmortem?

Research Design

To meet the objectives of this study a variation of the pretest-posttest control
group using randomized subjects was used. This randomized experimental design is one
of the most widely used. Randomized experimental designs provide maximum control of
extraneous variables (Ary, Jacobs, Razavieh, & Sorensen, 2006). "The main strength of
this design is the initial randomization, which assures statistical equivalence between the
groups prior to experimentation." (Ary et. al., 2006, p. 332). A randomized pretest-
posttest design was determined to be the best option. This design can determine the
weights prior to and after administrating the treatment, and control most of the variables
that could threaten internal validity.

Population

Animal procedures were approved by the West Virginia University Animal Care
and Use Committee. The target population for this study was 20 barrow pigs from the
West Virginia University Animal Sciences Farm. All barrows were of similar genetics,
fed same diet, housed in same building together in a large pen, and under the same
conditions until an average weight of 50 kilograms (kg) was reached. Once the desired
average weight was reached the pigs were balanced for weight. They were randomly
placed in pens of two and randomly assigned a corn-soybean diet with the fat supplement
either being the 1% CLA oil or the 1% soybean oil (control). The corn-soybean diet
consisted of: ground corn (84.99%), soybean meal (10.83%), meat and bone meal

(2.11%), fat supplement-soybean oil or CLA oil (1%), limestone (.65%), NB 3000 (.25%), salt (.17%), and lysine (.005%). All barrows were still housed in same building under the same conditions and were given feed and water *ad libitum*.

Instrumentation

During weekly weigh-ins the same scale was used and the same trained people did the weighing. For the post-mortem analysis trained individuals used a steel ruler to measure backfat and a plastic grid to measure the loin eye area. Color and subjective marbling scores were measured by trained individuals on a point scale, 1.0 - 6.0 for color and 1.0 – 10.0 for marbling, based on pork quality standards from the National Pork Producers Council. Proximate analysis of muscle lipids were performed by a trained individual through ether extraction.

Internal Validity

Internal threats of history, maturation, pretesting, instrumentation, regression, differential selection, selection-maturation interaction, and mortality were controlled due to random assignment. The experimenter effect was eliminated during weigh-ins by having the researcher and another unbiased individual record the weights. In addition the experimenter effect was also eliminated during post-mortem analysis by pigs being assigned numbers and not by the treatment to prevent biased opinions. Subject effect was eliminated because the pigs were treated the same in all aspects of feeding, weighing, housing, etc. Due to the use of animals as the subjects, diffusion and sensitivity effects do not apply to this study.

External Validity

Threats to external validity were controlled by random homogenous selection and the pigs were all kept in the same environment and fed the same diet, except for the variable treatment. The same scale was used to weigh the pigs and feed each time by the same trained individuals. For post-mortem analysis trained individuals did the subjective and proximate analysis and did not know treatments on each particular pig carcass.

Data Collection Procedures

Data were collected for this study by using a record book and a scale that recorded in pounds. Weights were converted into kilograms. All the pigs were weighed several times until they reached an average of about 50 kg. After they had reached the average weight a computer was used to randomly place the weight balanced pigs in pens of two and then randomly selected a diet treatment for that particular pen. Each pig was housed in the same building, exposed to the same environment, and was given feed and water *ad libitum*. Feed that was placed into the feeders was weighed each time. During each week on the same day the pigs and feeders were weighed to calculate feed intake, average daily gain, and gain to feed ratio. When the average weight of about 100 kg was reached the pigs were then humanely slaughtered at a commercial packing plant, Country Pride Meats in Friendsville, MD. Carcasses were then chilled for more than 24 hours and tissue collections of the ham and loin were made. Carcasses were ribbed between the 10th and 11th rib. Backfat was measured to the nearest one-tenth using a steel ruler and loin eye area was measured to the nearest tenth of a square centimeter by using a standard plastic grid. Subjective marbling and color scores were given by using comparative

pictures on a scale of 1.0 to 10.0 and 1.0 to 6.0 based on the pork industry standards by the National Pork Producers Council.

Tissue collections from the loin and ham were kept frozen until an ether extraction could be performed to test intramuscular lipid content. About 1 gram was cut and weighed accurately on #41 Whatman filter paper from the tissues of the ham and loin from each pig. Tissues were then freeze-dried for 48 hours and re-weighed to determine moisture content. After freeze-drying, the samples went through ether extraction for 48 hours and then placed in a 105 degree Celsius oven. Samples were weighed and calculated to determine the amount of intramuscular lipids.

Data Analysis

Data were entered into Excel and then analyzed using mixed procedures in SAS (SAS Institute Inc., Cary, NC). The control and CLA factors were compared by using F-value, least square means, and standard error of means. Tests were considered significant at $\alpha \leq 0.05$.

CHAPTER IV

Findings

Problem Statement

In order to improve feed efficiency and performance of swine for the producers and improve the quality of pork products for the consumer, research must continue to determine the best option to obtain these qualities for both the producer and consumer.

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8. Will a 1% CLA diet fed to barrows have an effect on the loin eye area?

9. Will a 1% CLA diet fed to barrows have an effect on the color of meat postmortem?

Results

The population for this study consisted of 20 barrows obtained from the West Virginia University Animal Science Farm. Barrows were of similar genetics, fed the same diet, and kept in the same building in one large pen under identical conditions. Once the average weight of 50 kg was reached they were randomly paired for weight. The pairs were randomly placed in a pen for a total of 10 pens. The pens were randomly divided into two groups: a control group fed a 1% soybean oil supplemented diet ($n = 5$) and a treatment group fed a 1% CLA supplemented diet ($n = 5$). The barrows continued to be housed in the same building, under identical conditions, and were given feed and water *ad libitum* until an average of 100 kg was reached. The barrows were then humanely slaughtered at a commercial packing plant, Country Pride Meats in Friendsville, MD.

Feed Efficiency

Weight Gain. The barrows were weighed each week using the same scale and a pen average was determined. The ANOVA mixed statistical procedure was used to determine if statistical differences existed in the means of each group for each week of weight gain (WG). The following hypotheses were tested:

$H_0 = M_{\text{SBO WG Week 1}} = M_{\text{CLA WG Week 1}}$

$H_1 = M_{\text{SBO WG Week 1}} \neq M_{\text{CLA WG Week 1}}$

and

$H_0 = M_{\text{SBO WG Week 2}} = M_{\text{CLA WG Week 2}}$

$H_2 = M_{\text{SBO WG Week 2}} \neq M_{\text{CLA WG Week 2}}$

and

$H_0 = M_{\text{SBO WG Week 3}} = M_{\text{CLA WG Week 3}}$

$H_3 = M_{\text{SBO WG Week 3}} \neq M_{\text{CLA WG Week 3}}$

and

$H_0 = M_{\text{SBO WG Week 4}} = M_{\text{CLA WG Week 4}}$

$H_4 = M_{\text{SBO WG Week 4}} \neq M_{\text{CLA WG Week 4}}$

and

$H_0 = M_{\text{SBO WG Week 5}} = M_{\text{CLA WG Week 5}}$

$H_5 = M_{\text{SBO WG Week 5}} \neq M_{\text{CLA WG Week 5}}$

and

$H_0 = M_{\text{SBO WG Week 6}} = M_{\text{CLA WG Week 6}}$

$H_6 = M_{\text{SBO WG Week 6}} \neq M_{\text{CLA WG Week 6}}$

The initial mean weight of the control group was 51.34 kg (*SEM* = 1.56). In following weeks, respectively, the mean weight of the control group was 59.37 kg (*SEM* = 1.77), 69.02 kg (*SEM* = 2.15), 78.96 kg (2.49), 86.35 kg (*SEM* = 2.67), 95.32 kg (*SEM* = 2.93), and 101.54 kg (*SEM* = 3.02). The initial mean weight for the CLA group was 53.97 kg (*SEM* = 1.56). In following weeks, respectively, the mean weight of the CLA group was 61.09 kg (*SEM* = 1.77), 71.02 kg (*SEM* = 2.15), 80.36 kg (*SEM* = 2.49), 88.44 kg (*SEM* = 2.67), 96.10 kg (*SEM* = 2.93), and 102.95 kg (*SEM* = 1.56) (see Figure 1) (see Table 1).

An ANOVA mixed statistical analysis procedure was used to compare the mean weights for each week. The statistical analysis results (Initial: $F = 1.42$, df = 8; Week 1: $F = 0.47$, df = 8; Week 2: $F = 0.43$, df = 8; Week 3: $F = 0.16$, df = 8; Week 4: $F = 0.30$, df = 8; Week 5: $F = 0.03$, df = 8; and Week 6: $F = 0.11$, df = 8) were not significant at $\alpha \leq 0.05$. Therefore, the researcher failed to reject the null hypothesis. The weight of the control group was equal to the CLA group for each of the six weekly periods.
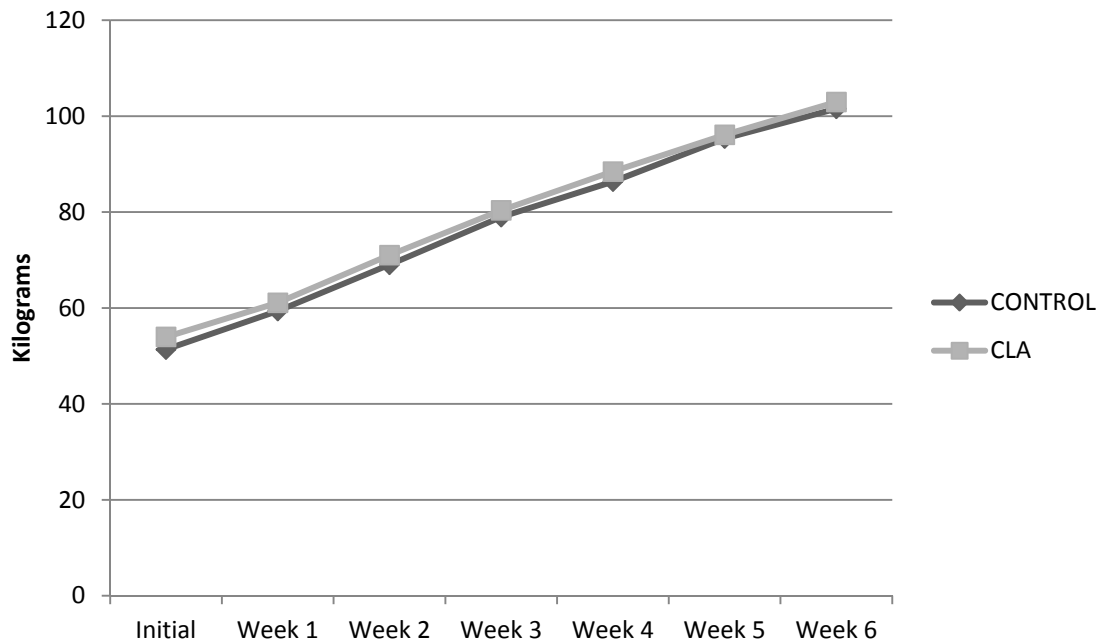
Figure 1. Comparison of the mean weights of the control group and CLA group each week.

Table 1

Comparison of the Body Weights of the Control Group and CLA Group

	N	*M*	*SEM*	*df*	*F*
SBO-Initial	5	51.34	1.56	8	1.42
CLA-Initial	5	53.97			
SBO-WK 1	5	59.37	1.77	8	0.47
CLA-WK 1	5	61.09			
SBO-WK 2	5	69.02	2.15	8	0.43
CLA-WK 2	5	71.02			
SBO-WK 3	5	78.96	2.49	8	0.16
CLA-WK 3	5	80.36			
SBO-WK 4	5	86.35	2.67	8	0.30
CLA-WK 4	5	88.44			
SBO-WK 5	5	95.33	2.93	8	0.03
CLA-WK 5	5	96.10			
SBO-WK 6	5	101.54	3.02	8	0.11
CLA-WK 6	5	102.95			

*$\alpha \leq .05$

Average Daily Gain. The barrows were weighed each week using the same scale and a pen average was determined. The ANOVA mixed statistical procedure was used to determine if statistical differences existed in the means of each group for each week of average daily gain (ADG). The following hypotheses were tested:

$H_0 = M_{\text{SBO ADG Week 1}} = M_{\text{CLA ADG Week 1}}$

$H_1 = M_{\text{SBO ADG Week 1}} \neq M_{\text{CLA ADG Week 1}}$

and

$H_0 = M_{\text{SBO ADG Week 2}} = M_{\text{CLA ADG Week 2}}$

$H_2 = M_{\text{SBO ADG Week 2}} \neq M_{\text{CLA ADG Week 2}}$

and

$H_0 = M_{\text{SBO ADG Week 3}} = M_{\text{CLA ADG Week 3}}$

$H_3 = M_{\text{SBO ADG Week 3}} \neq M_{\text{CLA ADG Week 3}}$

and

$H_0 = M_{\text{SBO ADG Week 4}} = M_{\text{CLA ADG Week 4}}$

$H_4 = M_{\text{SBO ADG Week 4}} \neq M_{\text{CLA ADG Week 4}}$

and

$H_0 = M_{\text{SBO ADG Week 5}} = M_{\text{CLA ADG Week 5}}$

$H_5 = M_{\text{SBO ADG Week 5}} \neq M_{\text{CLA ADG Week 5}}$

and

$H_0 = M_{\text{SBO ADG Week 6}} = M_{\text{CLA ADG Week 6}}$

$H_6 = M_{\text{SBO ADG Week 6}} \neq M_{\text{CLA ADG Week 6}}$

In the control group the initial mean average daily gain was 1.04 kg (*SEM* = 0.14). In the following weeks, respectively, the mean ADG of the control group was 1.15 kg (*SEM* = 0.06), 1.38 kg (*SEM* = 0.09), 1.42 kg (*SEM* = 0.09), 1.06 kg (*SEM* = 0.06), 1.28 kg (*SEM* = 0.05), and 1.24 kg (*SEM* = 0.09). The initial mean ADG for the CLA group was 0.87 kg (*SEM* = 0.14). In following weeks, respectively, the mean ADG of the CLA group was 1.02 kg (*SEM* = 0.06), 1.42 kg (*SEM* = 0.09), 1.33 kg (*SEM* = 0.09), 1.15 kg (*SEM* = 0.06), 1.09 kg (*SEM* = 0.05), and 1.37 kg (*SEM* = 0.09) (see Figure 2) (see Table 2).
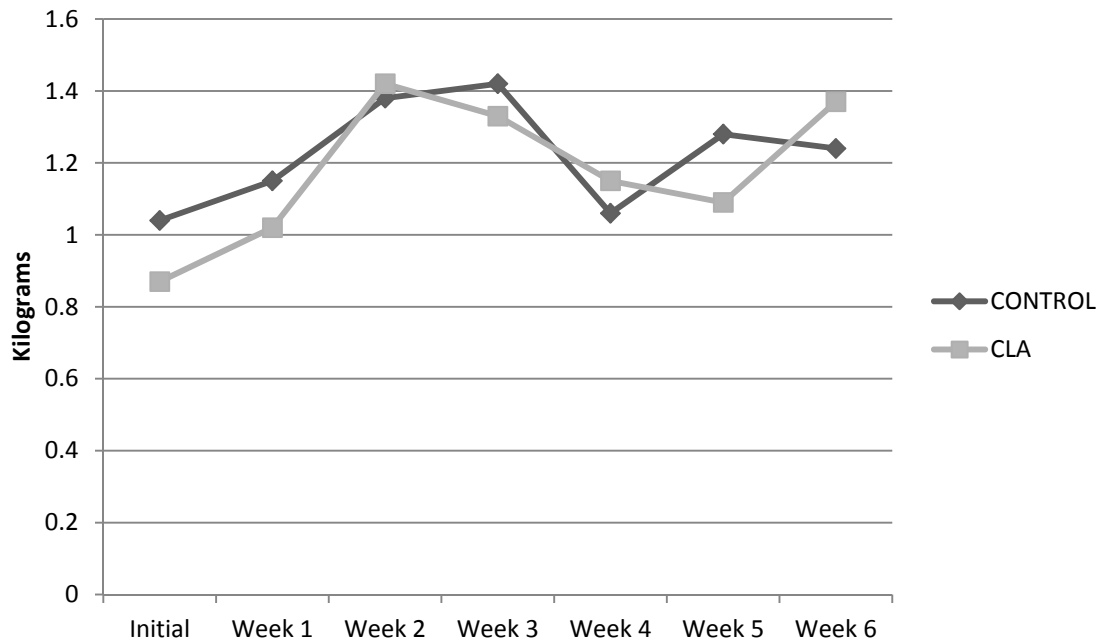
Figure 2. Comparison of the mean ADG of the control group and CLA group each week.

Table 2

Comparison of ADG of the Control Group and CLA Group

	N	*M*	*SEM*	*df*	*F*
SBO-Initial	5	1.04	1.34	8	0.75
CLA-Initial	5	0.87			
SBO-WK 1	5	1.15	0.06	8	2.25
CLA-WK 1	5	1.02			
SBO-WK 2	5	1.38	0.09	8	0.09
CLA-WK 2	5	1.42			
SBO-WK 3	5	1.42	0.09	8	0.52
CLA-WK 3	5	1.33			
SBO-WK 4	5	1.06	0.06	8	1.30
CLA-WK 4	5	1.15			
SBO-WK 5	5	1.28	0.05	8	7.16*
CLA-WK 5	5	1.09			
SBO-WK 6	5	1.24	0.09	8	0.94
CLA-WK 6	5	1.37			

*$\alpha \leq .05$

An ANOVA mixed statistical analysis procedure was used to compare the mean ADG for each week. The statistical analysis results (Initial: $F = 0.75$, df = 8; Week 1: $F = 2.25$, df = 8; Week 2: $F = 0.09$, df = 8; Week 3: $F = 0.45$, df = 8; Week 4: $F = 1.30$, df = 8; and Week 6: $F = 0.94$, df = 8) were not significant at $\alpha \leq 0.05$. Therefore, the researcher failed to reject the null hypotheses. The ADG of the soybean oil group was equal to the CLA group for five of the six weekly periods. In week five the statistical analysis results ($F = 7.16$, df = 8) was significant at $\alpha \leq 0.05$. The null hypothesis was rejected and the research hypothesis, $H_5 = M_{SBO\ ADG\ Week\ 5} \neq M_{CLA\ ADG\ Week\ 5}$, was accepted. The control group produced a greater average daily gain in week five than the CLA group.

Average Daily Feed Intake. Feed placed in feeders was weighed each day on the same scale. Each week the feeder was also weighed on the same scale. Daily feed intake per week for each pen was determined. The ANOVA mixed statistical procedure was used to determine if statistical differences existed in the means of each group for each week of average daily feed intake (ADFI). The following hypotheses were tested:

$H_0 = M_{SBO\ ADFI\ Week\ 1} = M_{CLA\ ADFI\ Week\ 1}$

$H_1 = M_{SBO\ ADFI\ Week\ 1} \neq M_{CLA\ ADFI\ Week\ 1}$

and

$H_0 = M_{SBO\ ADFI\ Week\ 2} = M_{CLA\ ADFI\ Week\ 2}$

$H_2 = M_{SBO\ ADFI\ Week\ 2} \neq M_{CLA\ ADFI\ Week\ 2}$

and

$H_0 = M_{\text{SBO ADFI Week 3}} = M_{\text{CLA ADFI Week 3}}$

$H_3 = M_{\text{SBO ADFI Week 3}} \neq M_{\text{CLA ADFI Week 3}}$

and

$H_0 = M_{\text{SBO ADFI Week 4}} = M_{\text{CLA ADFI Week 4}}$

$H_4 = M_{\text{SBO ADFI Week 4}} \neq M_{\text{CLA ADFI Week 4}}$

and

$H_0 = M_{\text{SBO ADFI Week 5}} = M_{\text{CLA ADFI Week 5}}$

$H_5 = M_{\text{SBO ADFI Week 5}} \neq M_{\text{CLA ADFI Week 5}}$

and

$H_0 = M_{\text{SBO ADFI Week 6}} = M_{\text{CLA ADFI Week 6}}$

$H_6 = M_{\text{SBO ADFI Week 6}} \neq M_{\text{CLA ADFI Week 6}}$

In the control group the average mean for week one for average daily feed intake was 2.86 kg ($SEM = 0.13$). In the following weeks, respectively, the mean average daily feed intake of the control group was 3.27 kg ($SEM = 0.15$), 3.51 kg ($SEM = 0.22$), 3.45 kg ($SEM = 0.22$), 3.75 kg ($SEM = 0.14$), and 3.82 kg ($SEM = 0.22$). The mean average daily feed intake for the first week for the CLA group was 2.97 kg ($SEM = 0.13$). In following weeks, respectively, the mean average daily feed intake of the CLA group was 3.32 kg ($SEM = 0.15$), 3.62 kg ($SEM = 0.22$), 3.59 kg ($SEM = 0.22$), 3.66 kg ($SEM = 0.14$), and 3.94 kg ($SEM = 0.22$) (see Figure 3) (see Table 3).

An ANOVA mixed statistical analysis procedure was used to compare the mean weights for each week. The statistical analysis results (Week 1: $F = 0.30$, df = 8; Week 2: $F = 0.06$, df = 8; Week 3: $F = 0.11$, df = 8; Week 4: $F = 0.20$, df = 8; Week 5: $F = 0.20$, df = 8; and Week 6: $F = 0.15$, df = 8) were not significant at $\alpha \leq 0.05$. Therefore,

the researcher failed to reject the null hypothesis. The average daily feed intake of the control group was equal to the CLA group for each of the six weekly periods.
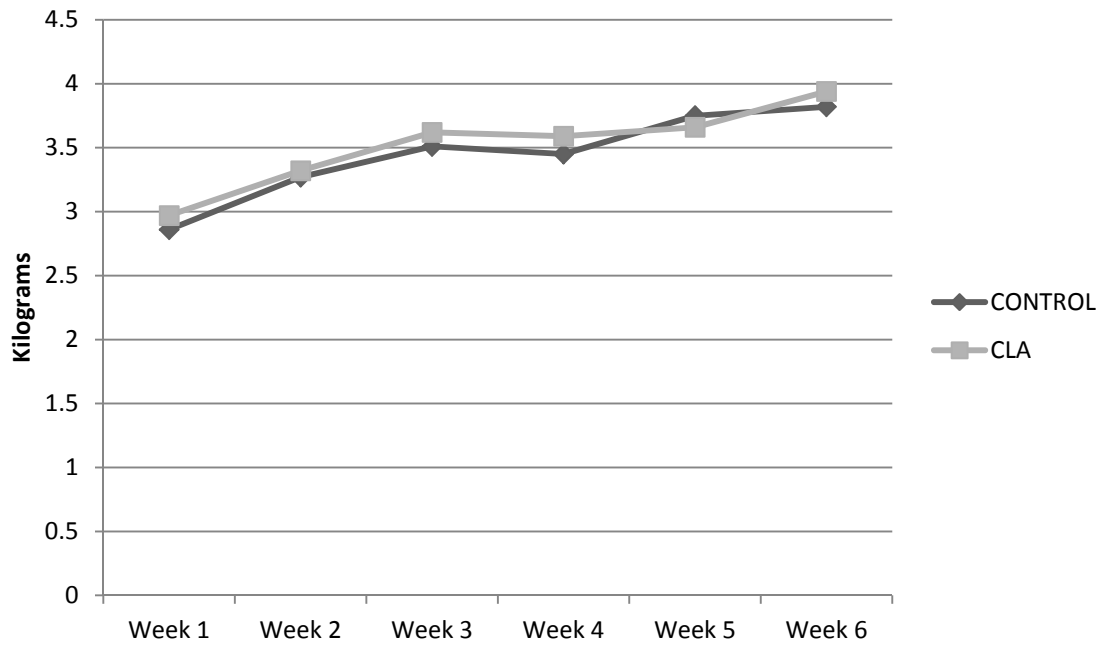
Figure 3. Comparison of the mean ADFI of the control group and CLA group each week.

Table 3

Comparison of ADFI of the Control Group and CLA Group

	N	*M*	*SEM*	*df*	*F*
SBO-WK 1	5	2.86	0.13	8	0.30
CLA-WK 1	5	2.97			
SBO-WK 2	5	3.27	0.15	8	0.06
CLA-WK 2	5	3.32			
SBO-WK 3	5	3.51	0.22	8	0.11
CLA-WK 3	5	3.62			
SBO-WK 4	5	3.45	0.22	8	0.20
CLA-WK 4	5	3.59			
SBO-WK 5	5	3.75	0.14	8	0.20
CLA-WK 5	5	3.66			
SBO-WK 6	5	3.82	0.22	8	0.15
CLA-WK 6	5	3.94			

$*\alpha \le .05$

Gain to Feed Ratio. The barrows were weighed each week using the same scale and a pen average was determined. Feed that was placed in feeders was weighed each day on the same scale. Each week the feeder was also weighed on the same scale. Daily feed intake per week for each pen was determined. The ANOVA mixed statistical procedure was used to determine if statistical differences existed in the means of each group for each week on the gain to feed ratio (GF). The following hypotheses were tested:

$H_0 = M_{\text{SBO GF Week 1}} = M_{\text{CLA GF Week 1}}$

$H_1 = M_{\text{SBO GF Week 1}} \neq M_{\text{CLA GF Week 1}}$

and

$H_0 = M_{\text{SBO GF Week 2}} = M_{\text{CLA GF Week 2}}$

$H_2 = M_{\text{SBO GF Week 2}} \neq M_{\text{CLA GF Week 2}}$

and

$H_0 = M_{\text{SBO GF Week 3}} = M_{\text{CLA GF Week 3}}$

$H_3 = M_{\text{SBO GF Week 3}} \neq M_{\text{CLA GF Week 3}}$

and

$H_0 = M_{\text{SBO GF Week 4}} = M_{\text{CLA GF Week 4}}$

$H_4 = M_{\text{SBO GF Week 4}} \neq M_{\text{CLA GF Week 4}}$

and

$H_0 = M_{\text{SBO GF Week 5}} = M_{\text{CLA GF Week 5}}$

$H_5 = M_{\text{SBO GF Week 5}} \neq M_{\text{CLA GF Week 5}}$

and

$H_0 = M_{\text{SBO GF Week 6}} = M_{\text{CLA GF Week 6}}$

$H_6 = M_{\text{SBO GF Week 6}} \neq M_{\text{CLA GF Week 6}}$

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In the control group for week one the mean average for gain to feed ratio was 0.40 kg ($SEM = 0.02$). In the following weeks, respectively, the mean average gain to feed ratio of the control group was 0.42 kg ($SEM = 0.02$), 0.40 kg ($SEM = 0.03$), 0.31 kg ($SEM = 0.02$), 0.34 kg ($SEM = 0.01$), and 0.33 kg ($SEM = 0.02$). The mean average of gain to feed ratio for the first week for the CLA group was 0.34 kg ($SEM = 0.02$). In following weeks, respectively, the mean gain to feed ratio of the CLA group was 0.43 kg ($SEM = 0.02$), 0.38 kg ($SEM = 0.03$), 0.32 kg ($SEM = 0.02$), 0.30 kg ($SEM = 0.01$), and 0.35 kg ($SEM = 0.02$) (see Figure 4) (see Table 4).

An ANOVA mixed statistical analysis procedure was used to compare the mean gain to feed ratio for each week. The statistical analysis results (Week 2: $F = 0.02$, df = 8; Week 3: $F = 0.46$, df = 8; Week 4: $F = 0.57$, df = 8; and Week 6: $F = 0.43$, df = 8) were not significant at $\alpha \leq 0.05$. Therefore, the researcher failed to reject the null hypotheses. The gain to feed ratio of the control group was equal to the CLA group for four of the six weekly periods. The statistical analysis results (Week 1: $F = 6.98$, df = 8; Week 5: $F = 20.87$, df = 8) was significant at $\alpha \leq 0.05$. The null hypothesis was rejected and the research hypotheses, $H_1 = M_{SBO\ GF\ Week\ 1} \neq M_{CLA\ GF\ Week\ 1}$ and $H_5 = M_{SBO\ GF\ Week\ 5} \neq M_{CLA\ GF\ Week\ 5}$, were accepted. The control group had a greater gain to feed ratio in weeks one and five than the CLA group.
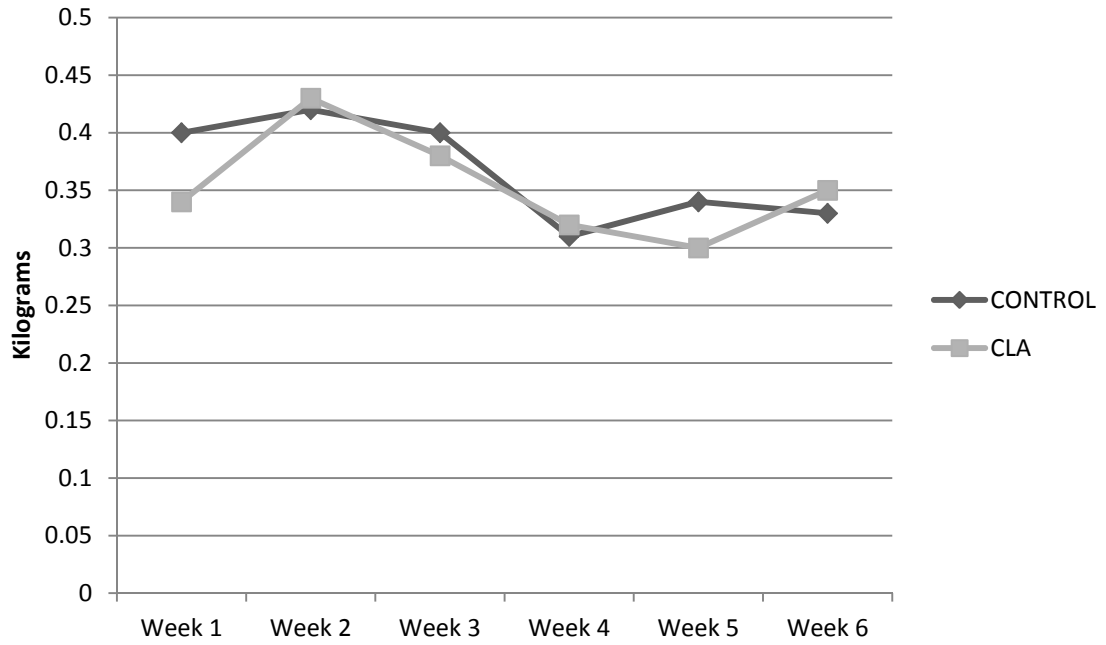
Figure 4. Comparison of the mean gain to feed ratio of the control group and CLA group

each week.

Table 4

Comparison of gain to feed ratio of the Control Group and CLA Group

	N	M	SEM	df	F
SBO-WK 1	5	0.40	0.02	8	6.98*
CLA-WK 1	5	0.34			
SBO-WK 2	5	0.42	0.02	8	0.02
CLA-WK 2	5	0.43			
SBO-WK 3	5	0.38	0.03	8	0.46
CLA-WK 3	5	0.40			
SBO-WK 4	5	0.31	0.02	8	0.57
CLA-WK 4	5	0.32			
SBO-WK 5	5	0.34	0.01	8	20.87*
CLA-WK 5	5	0.30			
SBO-WK 6	5	0.33	0.02	8	0.43
CLA-WK 6	5	0.35			

*$\alpha \leq .05$

Carcass Composition

Backfat. A steel ruler was used to measure the amount of backfat of each carcass

between the 10th and 11th rib and a pen average was determined. The ANOVA mixed

statistical procedure was used to determine if statistical differences existed in the means

of backfat of the control group and CLA group. The null hypothesis,

$H_0 = M_{SBO\ backfat} = M_{CLA\ backfat}$, was tested. The alternative hypothesis was, $H_1 =$

$M_{SBO\ backfat} \neq M_{CLA\ backfat}$.

The mean backfat of the control group was 30.23 mm with a standard error of

means of 1.28. The mean backfat of the CLA group was 25.40 mm with a standard error

of means of 1.28 (see Table 5).

The ANOVA statistical analysis results ($F = 7.08$, df = 8) were significant at $\alpha \leq$

0.05. The null hypothesis was rejected and the research hypothesis $H_1 = M_{SBO\ backfat} \neq$

$M_{CLA\ backfat}$ was accepted. The CLA group had a decreased amount of backfat compared

to the control group.

Table 5

Comparison of the Amount of Backfat of the Control Group and CLA Group

	N	*M*	*SEM*	*df*	*F*
SBO	5	30.23	1.28	8	7.08*
CLA	5	25.40			

*$\alpha \leq .05$

Subjective Marbling Scores. Subjective marbling scores were given to each pig carcass by using comparative pictures on a scale of 1.0 to 10.0 based on the pork industry standards by the National Pork Producers Council. A pen average was then determined. The ANOVA mixed statistical procedure was used to determine if statistical differences existed in the means of subjective marbling scores (SMS) of the control group and CLA group. The null hypothesis, $H_0 = M_{\text{SBO SMS}} = M_{\text{CLA SMS}}$, was tested. The alternative hypothesis was, $H_1 = M_{\text{SBO SMS}} \neq M_{\text{CLA SMS}}$.

The mean subjective marbling score of the control group was 2.43 ($SEM = 0.31$). The mean subjective marbling score of the CLA group was 3.10 ($SEM = 0.31$) (see Table 6).

The ANOVA statistical analysis results ($F = 2.35$, df = 8) were not significant at $\alpha \leq 0.05$. Therefore, the researcher failed to reject the null hypothesis. The subjective marbling scores for the control group was equal to the subjective marbling scores of the CLA group.

Table 6

Comparison of Subjective Marbling Scores of the Control Group and CLA Group

	N	*M*	*SEM*	*df*	*F*
SBO	5	2.43	0.31	8	2.35
CLA	5	3.10			

*$\alpha \leq .05$

Muscle Lipids in Ham and Loin. Tissue samples from the ham and loin were taken from each pig and frozen. Ether extraction was performed to determine percent lipid amount of each tissue sample and a pen average was determined. The ANOVA mixed statistical procedure was used to determine if statistical differences existed in the means of the percentage of muscle lipids (ML) in the ham and loin of the control group and CLA group. The following hypotheses were tested:

$H_0 = M_{\text{SBO ML Ham}} = M_{\text{CLA ML Ham}}$

$H_1 = M_{\text{SBO ML Ham}} \neq M_{\text{CLA ML Ham}}$

and

$H_0 = M_{\text{SBO ML Loin}} = M_{\text{CLA ML Loin}}$

$H_2 = M_{\text{SBO ML Loin}} \neq M_{\text{CLA ML Loin}}$

The mean percentage of muscle lipids of the ham and loin, respectively, for the control group was 2.32 ($SEM = 0.34$), and 4.84 ($SEM = 0.50$). The mean percentage of muscle lipids of the ham and loin, respectively, for the CLA group was 2.20 ($SEM = 0.34$), and 5.07 ($SEM = 0.50$) (see Table 7).

The ANOVA statistical analysis results (Ham: $F = 0.07$, df $= 8$; and Loin: $F = 0.08$, df $= 8$) were not significant at $\alpha \leq 0.05$. Therefore, the researcher failed to reject the null hypotheses. The muscle lipids for both the ham and loin for the control group was equal to the CLA group.

Table 7

Comparison of Muscle Lipids in the Ham and Loin of the Control Group and CLA Group

	N	M	SEM	df	F
SBO-Ham	5	2.32	0.34	8	0.07
CLA-Ham	5	2.20			
SBO-Loin	5	4.84	0.58	8	0.08
CLA-Loin	5	5.07			

*$\alpha \le .05$

Loin Eye Area. Loin eye area of each pig was measured to the nearest tenth of a square centimeter by using a standard plastic grid. A pen average was then determined. The ANOVA mixed statistical procedure was used to determine if statistical differences existed in the means of the size of the loin eye area (LEA) of the control group and CLA group. The null hypothesis, $H_0 = M_{SBO\ LEA} = M_{CLA\ LEA}$, was tested. The alternative hypothesis was, $H_1 = M_{SBO\ LEA} \ne M_{CLA\ LEA}$.

The mean loin eye area of the control group was 36.29 cm^2 (*SEM* = 0.67). The mean loin eye area of the CLA group was 34.16 cm^2 (*SEM* = 0.67) (see Table 8).

The ANOVA statistical analysis results (*F* = 5.09, df = 8) were not significant at $\alpha \le 0.05$. Therefore, the researcher failed to reject the null hypothesis. The loin eye area for the control group was equal to the loin eye area of the CLA group.

Table 8

Comparison of the Means of Loin Eye Area for the Control Group and CLA Group

	N	M	SEM	df	F
SBO	5	36.29	0.67	8	5.09
CLA	5	34.16			

*$\alpha \leq .05$

Color. Color scores were given by using comparative pictures on a scale of 1.0 to 6.0 based on the pork industry standards by the National Pork Producers Council. A pen average was then determined. The ANOVA mixed statistical procedure was used to determine if statistical differences existed in the means of the color scores for the control group and CLA group. The null hypothesis, $H_0 = M_{SBO\ Color} = M_{CLA\ Color}$, was tested. The alternative hypothesis was, $H_1 = M_{SBO\ Color} \neq M_{CLA\ Color}$.

The mean color score of the control group was 2.68 ($SEM = 0.17$). The mean color score of the CLA group was 2.70 ($SEM = 0.17$) (see Table 9). The ANOVA statistical analysis results ($F = 0.01$, df $= 8$) were not significant at $\alpha \leq 0.05$. Therefore, the researcher failed to reject the null hypothesis. The color score for the control group was equal to the color score of the CLA group.

Table 9

Comparison of the Means of Color Scores for the Control Group and CLA Group

	N	*M*	*SEM*	*df*	*F*
SBO	5	2.68	0.17	8	0.01
CLA	5	2.70			

*α ≤ .05

CHAPTER V

Summary, Conclusions, and Recommendations

Problem Statement

In order to improve feed efficiency and performance of swine for the producers and improve the quality of pork products for the consumer, research must continue to determine the best option to obtain these qualities for both the producer and consumer.

Purpose of the Study

The purpose of this study was to determine the effect of a 1% conjugated linoleic acid oil supplemented diet versus 1% soybean oil, the control supplement. Study was conducted on 20 growing barrow pigs produced at the West Virginia University Farm.

Objectives of the Study

The objective of this study is further reflected in the following research questions.

Research Questions

1. Will a 1% CLA diet fed to barrows have an effect on weight gain?

2. Will a 1% CLA diet fed to barrows have an effect on average daily gain?

3. Will a 1% CLA diet fed to barrows have an effect on average daily feed intake?

4. Will a 1% CLA diet fed to barrows have an effect on the gain to feed ratio?

5. Will a 1% CLA diet fed to barrows have an effect on the amount of backfat?

6. Will a 1% CLA diet fed to barrows have an effect on subjective marbling scores?

7. Will a 1% CLA diet fed to barrows have an effect on muscle lipids in the ham and loin?

8. Will a 1% CLA diet fed to barrows have an effect on the loin eye area?

9. Will a 1% CLA diet fed to barrows have an effect on the color of meat postmortem?

Summary

The population for this study consisted of 20 barrows obtained from the West Virginia University Animal Science Farm. Barrows were of similar genetics, fed the same diet, and kept in the same building in one large pen under identical conditions. Once the average weight of 50 kg was reached they were randomly paired for weight. The pairs were randomly placed in a pen for a total of 10 pens. The pens were randomly divided into two groups: a control group fed a 1% soybean oil supplemented diet and a treatment group fed a 1% CLA supplemented diet. The barrows continued to be housed in the same building, under identical conditions, and were given feed and water *ad libitum* until an average of 100 kg was reached. The barrows were then humanely slaughtered at a commercial packing plant, Country Pride Meats in Friendsville, MD.

Overall, feed efficiency was not affected by CLA. Weight gain and average daily feed intake showed no differences throughout the six week study. Average daily gain was affected only in week five, when the CLA group had a significant lower ADG than the control group ($\alpha \leq .05$). Gain to feed ratio was affected in weeks one and five, when the CLA group had a significantly lower gain to feed ratio than the control group ($\alpha \leq .05$).

Carcass traits did show an effect of supplementing conjugated linoleic acid. In the CLA fed barrows backfat was significantly decreased compared to the control group ($\alpha \leq .05$). Although subjective marbling scores did not show a significant difference, the mean for the CLA group ($M = 3.10$) was higher than the control group ($M = 2.43$). However,

when ether extraction was performed to determine amount of muscle lipids in the ham and loin, CLA showed no difference compared to the control group. The CLA group (M = 5.07) did have a higher percentage of fat in the loin than the control group (M = 4.84). In the ham tissue the control group (M = 2.32) showed a slightly higher percentage of lipids than the CLA group (M = 2.20). Loin eye area and color showed no differences between the two groups.

Conclusions

Based on the results of this six week study the following conclusions were made:

1. Weight gain, average daily feed intake, subjective marbling scores, percentage of lipids in the ham and loin tissues, loin eye area, and color were not affected by CLA.

2. In week five, the CLA group had a lower average daily gain than the control group.

3. In weeks one and five, the CLA group showed a decrease in gain to feed ratio compared to the control group.

4. A 1% CLA fed diet decreased the backfat on barrows compared to the control group.

Discussion

The findings of this study were comparable to other studies. Dietary CLA showed no effect on gilts or barrows on ADG or feed efficiency (Ramsay, Evock-Clover, Steele, & Azain, 2001). Thiel-Cooper et al. (2001) reported that barrows fed a 1% or less CLA supplement diet showed a decrease in backfat, but loin eye area was not affected. In

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similar studies done by Wiegand et al. (2001; 2002) backfat was decreased in the 0.75% CLA fed barrows; however, loin muscle area and color were not affected by CLA.

Although during the six week study feed efficiency and many carcass traits were not affected by the supplementation of CLA, this researcher believes there could be attributing factors skewing the results. The biggest factor was the sample size used. Only 20 barrows was used due to the limiting factor that the West Virginia University Animal Science Farm only had 22 barrows available. Another possible factor was the diets. The diets were fed in pellet form; therefore, the feeder doors had to be raised at a higher level. All the barrows, both CLA and control groups, tended to play in the feed and spilling it on the floor. This resulted in wasted feed and impacted the ability to achieve accurate weights on the amount of feed actually consumed. Also the genetics of the barrows could have skewed results on the carcass composition factors. The genetics used for this study were barrows of a maternal line rather than a terminal line. Therefore, the barrows matured early producing an inch of backfat at just an average weight of 100 kg.

Recommendations

Based on similar studies, the findings of this study, and the researcher's offer the following recommendations:

1. Replication of this study using a ground feed therefore, feeder doors can be lowered and accurate feed measurements taken.

2. Replication of this study using barrows of a different genetic background, more of a terminal line of genetics.

3. This study and other similar studies have shown that CLA does affect feed efficiency and carcass composition; therefore, studies should continue to be

conducted on swine to determine the optimum feeding level of CLA

supplementation, sex, and genetics to be used to produce the most cost

effective product.

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