Evaluation of Conjugated Linoleic Acid (CLA) and Dietary Antibiotics as Growth Promotants in Weanling Pigs

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Introduction

There has been considerable pressure placed on pig producers worldwide to decrease the use of antibiotic growth promotants. This makes it necessary to search for viable alternatives to feeding antibiotics. One alternative may be the incorporation of conjugated linoleic acid (CLA) into swine diets. CLA is a fatty acid that is a positional and geometrical isomer of the n-6 fatty acid linoleic acid. CLA has been shown to modulate immune system function in chickens, rats, and mice by decreasing the amount of body weight lost due to an experimental immune system challenge with *E. coli* lipopolysaccharide (Cook et al., 1993; Miller et al., 1994). Preliminary research indicates that CLA can modify the immune system of weanling pigs by increasing immune system activation (Bassaganya et al., 1999). Research has shown that finishing pigs fed diets containing added CLA have increased feed efficiency and carcass leanness (Dugan et al., 1997; Eggert et al., 1999). However, limited research has been conducted on the effectiveness of dietary CLA on growth performance characteristics of pigs during the nursery stage of production.

Our objective was to examine the effectiveness of CLA and a dietary sequence of antibiotics consisting of carbadox, tilmicosin, and tylosin/sulfamethazine as growth promotants and immune system modulators in weanling pigs reared under a one-site, continuous flow management scheme.

Materials and Methods

Animals and Experimental Design

A total of 192 conventionally weaned, crossbred pigs (16.7 lb and 28.5 days of age) were used. Pigs were randomly assigned to a 2 x 2 factorial arrangement of treatments consisting of dietary fat type and dietary antibiotic treatment. Dietary fat treatments consisted of either 1% of a CLA product containing 60% CLA isomers (CLA), providing .6% added CLA, or 1% soybean oil (SBO). Antibiotic treatments were diets containing added antibiotics (M) or diets containing no added antibiotics (NM).

Pigs were housed in groups of eight in pens (2.5 ft^2/pig) with woven wire metal flooring in an environmentally controlled nursery facility from week 0 to week 5 postweaning. The nursery facility had previously been emptied of all pigs, cleaned, and disinfected prior to loading with the experimental pigs. At week 5 postweaning, pigs were moved to a grower-finisher facility and housed in groups of eight in pens (6.1 ft^2/pig) with slotted concrete flooring. Pigs were moved to a curtain sided finishing facility at week 9 postweaning and housed in groups of eight pigs per pen (6.9 ft^2/pig). The pen groups remained intact in all three facilities. Water was

offered from a nipple waterer and *ad libitum* consumption of feed was allowed through a self-feeder.

Diets

All diets (Table 1) were formulated to meet or exceed the requirements recommended by NRC (1998). Phase I diets were formulated to contain 1.5% lysine and were fed for a period of one week postweaning. Pigs were then fed diets that contained 1.35% lysine for weeks 2 to 3 postweaning (phase II). M diets for phases I and II provided 50.0 g carbadox per ton of complete diet. Antibiotics were added to the M diets at the expense of corn. Additionally, during phase II, pigs from all treatment groups were fed diets that contained 95.5 g Banminth® per ton of complete diet for a period of three days. Phase III diets were formulated to provide 1.1% lysine and were fed between weeks 4 and 6 postweaning. The M treatment group received diets that contained 272 g tilmicosin per ton of complete diet for the duration of dietary phase III. Phase IV diets were offered to the pigs weeks 7 to 9 postweaning and were formulated to contain 1.0% lysine. Medicated (M) phase IV diets contained 100 g tylosin and 100 g sulfamethazine per ton of complete diet. At the completion of phase IV, all pigs received identical diets that contained added antibiotics of 100 g/ton for 4 weeks followed by 40 g/ton tylosin until market.

Data, Serum Sample Collection, and Analysis

Pig weights and feed consumption were measured at the completion of each dietary phase and prior to moving the pigs from the nursery to the grower-finisher facility (weeks 1, 3, 5, 6, and 9 postweaning). These data were utilized to calculate average daily gain (ADG), average daily feed intake (ADFI), pen variability, and feed efficiency. Weights were recorded at week 17 postweaning to determine whether the dietary treatments had an effect on subsequent ADG, and weights were recorded on each pig at marketing.

Serum samples were harvested from three pigs per pen (n=72) at days 21, 42, and 63 postweaning. This corresponded to the completion of dietary phases II, III, and IV. The same pigs were sampled at each time point. Serum samples were divided into 1 mL aliquots and stored at -20°C until analyses for insulin-like growth factor-I (IGF-I), growth hormone (GH), and antibodies to *Mycoplasma hyopneumoniae* and porcine reproductive and respiratory syndrome (PRRS) could be performed.

Serum IGF-I and GH concentrations were quantified via previously validated radioimmunoassay (RIA) procedures (Taylor-Roth et al., 1998).

Serum samples were analyzed for the presence of antibodies to PRRS and *Mycoplasma hyopneumoniae* via enzyme linked immunosorbant assay (ELISA) methods carried out at the Purdue Animal Disease Diagnostic Laboratory. Sample to positive control ratios (S/P) above .45 were considered to mean a positive status.

The data were analyzed as a 2 x 2 factorial arrangement with added fat type and dietary antibiotic treatments as the main effects. Pen was considered the experimental unit for the performance data and individual pig was the experimental unit for serum analysis data. Analysis of variance was performed using the GLM procedure of SAS (1996). Serum GH and IGF-I data

were analyzed as a repeated measures analysis of variance. The frequency data for pigs testing positive for serum antibodies to *Mycoplasma hyopneumoniae* and PRRS and the number of pigs requiring therapeutic antibiotic treatment were analyzed using the adjusted chi-squared analysis found in the FREQ procedure of SAS.

Results

Growth Performance

Growth performance results are given in Table 2. Overall ADG (weeks 0-9 postweaning) was increased in pigs fed diets containing antibiotics (P<.05). There was a tendency for pigs fed medicated diets to have increased ADG versus pigs fed nonmedicated diets for phases I, III, and IV (P=.10, .06, and .07, respectively). A trend was present for ADG during the period the pigs were housed in the nursery facility (weeks 0-5 postweaning). In the nursery, pigs fed medicated diets had greater ADG (P=.07) than pigs fed nonmedicated diets. Pigs fed antimicrobials had improved feed efficiency (F/G) during dietary phase I (weeks 0-1 postweaning; P<.05) and during the time period that the pigs were housed in the nursery facility (weeks 0-5 postweaning; P<.05). Pigs fed diets containing antibiotics tended to be more efficient than control pigs during phase II (P=.10) and for the entire period of time that the pigs were fed experimental diets (weeks 0-9 postweaning, P=.08). Dietary CLA treatment had no effect (P>.10) on ADG, ADFI, or F/G at any time point. There were no significant effects (P>.10) of dietary fat type or dietary antibiotic treatment on ADFI, pen variation (pen CV), or adjusted days to 250 lbs. ADG for weeks 9-17 in the finisher was not impacted (P>.10) by previous CLA or antibiotic treatment. No interactions were detected (P>.10) between dietary CLA treatment and dietary antibiotic treatment for the performance data at any time period.

Serum IGF-I, GH, and Antibodies to Mycoplasma hyopneumoniae and PRRS

Overall IGF-I or GH concentrations were not affected (P>.10) by dietary CLA or antibiotic treatments. However, there was a tendency for pigs fed antibiotics to have greater concentrations of serum IGF-I at the completion of dietary phase IV at day 63 (P=.06; Table 3). There was a trend present (P=.10) for day 21 serum GH, in that pigs fed antibiotics had numerically greater GH than pigs fed diets containing no added antibiotics. A tendency for lower serum GH concentrations (P=.09) occurred at day 42, with pigs fed medicated diets having lower GH than pigs fed nonmedicated diets. Pigs fed diets containing added CLA had greater (P<.05) antibody titer levels (S/P) against *Mycoplasma hyopneumoniae* than pigs fed SBO diets at day 63.

The number of pigs testing positive for serum antibodies to *Mycoplasma hyopneumoniae* and PRRS did not vary (P>.30) with dietary fat or antibiotic treatment (Table 4). The percentage of pigs requiring injectable antibiotic treatment was not associated (P>.10) with either dietary fat or antibiotic treatments.

Discussion

Altering the fatty acid profile of the diets via the addition of .6% CLA failed to alter the growth performance or feed intake of weanling pigs in this trial. However, feeding antibiotics to nursery pigs did increase ADG and feed efficiency. CLA did elicit an increase in circulating

antibodies to *Mycoplasma hyopneumoniae*. This may demonstrate that CLA modifies the pig's immune system status. Perhaps CLA may be more beneficial as a feed additive in a less limiting environment with less pathogen exposure, such as a nursery managed under a segregated early weaning (SEW) scheme. Our experiment was conducted on a one-site facility and this could limit the potential response to dietary CLA. Furthermore, more research is warranted in looking at the environmental and rearing management-specific effects of feeding CLA, antibiotics, and other suspected growth enhancers and immune system modifiers.

Implications

The results of this trial indicate that CLA fed at .6% of the diet is not an effective growth promotant in weanling pigs reared in a one-site, continuous flow management system. However, feeding antibiotics did increase production performance. There was no carryover effect of antibiotics on performance of the pigs in the finisher phase in terms of ADG and days to market. These results warrant further investigation of the use of CLA as an immune system modifier in pigs reared under other types of management schemes.

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Table 1. Compositions of experimental diets (as fed basis).

Item	Phase I (Weeks 0-1)	Phase II (Weeks 2-3)	Phase III (Weeks 4-6)	Phase IV (Weeks 7-9)
Ingredient, %				
Corn	41.24-41.49	52.72-53.07	67.55-68.30	71.91-72.41
SBM (46.5% CP)	26.00	27.15	26.98	23.20
Dicalcium phosphate	1.50	1.59	2.14	1.91
Limestone	.12	.32	.65	.69
Salt	.25	.25	.35	.35
Vitamin premix[a]	.25	.25	.25	.15
Trace mineral premix[b]	.13	.13	.13	.09
DL-Methionine	.06	.05	--	--
Lysine-HCl	.15	.15	.15	.15
Selenium 600 premix[c]	.05	.05	.05	.05
Banminth[d]	--	0.00-.10	--	--
Soybean oil	3.00	2.00	--	--
Soybean oil / CLA-60[e]	1.00	1.00	1.00	1.00
Antibiotic[f]	0.00-.25	0.00-.25	0.00-.75	0.00-.50
Calculated analysis, %				
CP	22.5	19.6	18.4	17.2
Lysine	1.50	1.35	1.10	1.00
Lipid	6.30	5.30	3.29	3.38
Ca	.90	.90	.85	.80
P	.80	.80	.75	.70

[a] Provided per lb of complete diet: vitamin A, 2,750 IU; vitamin D3, 275 IU; vitamin E, 20 IU; menadione, .91 mg; vitamin B12, .02 mg; riboflavin, 3.2 mg; pantothenic acid, 10 mg; and niacin, 15 mg.

[b] Provided per kilogram of complete diet: Zn, 57 mg; Fe, 57 mg; Mn, 7.1 mg; Cu, 5.3 mg; and .2 mg.

[c] Provided .1mg Se per kilogram of complete diet.

[d] Pigs were fed diets containing 48 mg pyrantel tartrate/lb diet for a period of 3 days.

[e] Pigs were fed diets containing either 1% soybean oil or 1% of a product containing 60% CLA.

[f] Diets which contained antibiotics provided per ton of complete diet: phase I and II, 50.0 g carbadox; phase III, 272 g tilmicosin; and phase IV,100 mg tylosin and 100 mg sulfamethazine.

Table 2. Effects of CLA and antimicrobials on growth performance of weanling pigs[a].

Fat[a]	CLA		SBO			Significance[c]	
Antibiotic[a]	Control	Med	Control	Med	SE	CLA	Med
ADG, lb							
Phase I[b]	.229	.306	.246	.293	.04	.95	.10
Phase II	.799	.891	.845	.845	.04	.99	.29
Phase III	1.24	1.33	1.27	1.35	.04	.52	.06
Phase IV	1.66	1.76	1.68	1.83	.06	.49	.07
Nursery	.746	.811	.753	.798	.03	.90	.07
Overall	1.14	1.25	1.17	1.25	.04	.83	.03
Finisher[d]	1.76	1.79	1.79	1.82	.06	.63	.57
ADFI, lb							
Phase I	.379	.403	.390	.366	.03	.69	.99
Phase II	1.13	1.16	1.22	1.17	.06	.40	.94
Phase III	2.24	2.30	2.26	2.34	.09	.73	.45
Phase IV	3.53	3.82	3.67	3.88	.15	.50	.11
Nursery	1.15	1.20	1.17	1.16	.04	.91	.60
Overall	2.16	2.27	2.31	2.22	.08	.56	.27
Feed/Gain							
Phase I	1.70	1.32	1.58	1.24	.07	.53	.03
Phase II	1.41	1.31	1.35	1.34	.02	.73	.10
Phase III	1.81	1.72	1.77	1.74	.01	.82	.12
Phase IV	2.12	2.13	2.18	2.12	.01	.43	.57
Nursery	1.54	1.48	1.56	1.46	.03	.98	.03
Overall	1.89	1.85	1.90	1.86	.01	.74	.08
Variation (CV)							
Nursery	11.3	9.3	13.0	12.3	1.4	.11	.33
Finisher	10.4	10.6	10.9	13.6	1.6	.29	.40
Adj. Days to 250 lb[e]	178	175	177	178	2.5	.61	.80

[a] Pigs (n=192; 28.5 days) were fed diets containing 1% of a product containing 60% conjugated linoleic acid (CLA) isomers or 1% soybean oil (SBO). Medicated diets (Med) contained per ton of diet: 50 g carbadox, phases I and II; 272 g tilmicosin, phase III; and 100 g tylosin and 100 g sulfamethazine, phase IV.

[b] The dietary phases are as follows: phase I, week 1 postweaning; phase II, weeks 2-3; phase III, weeks 4-6; and phase IV, weeks 7-9 postweaning.

[c] Interactions between fat type and antibiotic treatment were not observed (P>.10).

[d] ADG was monitored after pigs were removed from experimental diets (weeks 9-17).

[e] Adjusted days to 250 lb was calculated using: adjusted days = actual age + [(desired wt - actual wt) * (actual age - a)/actual wt] (NSIF, 1996).

Table 3. Least square means for serum concentrations of peptides.

Fat[a]:	CLA		SBO			Significance[d]	
Antibiotic[b]:	Control	Med	Control	Med	SE	Fat	Anti.
IGF-I, ng/mL							
day 21[c]	96.6	95.9	95.2	84.8	8.2	.46	.49
day 42	134	132	121	134	9.1	.56	.56
day 63	133	161	126	141	11	.22	.06
GH, ng/mL							
day 21[c]	7.51	9.45	9.36	9.84	.73	.13	.10
day 42	7.20	6.16	6.71	6.22	.44	.63	.09
day 63	6.02	5.83	5.62	6.23	.41	.99	.62
Myco. hyo., S/P							
day 21[c]	.564	.559	.542	.543	.05	.71	.97
day 42	.745	.721	.725	.697	.05	.67	.61
day 63	.964	.941	.838	.780	.06	.02	.49
PRRS-V, S/P							
day 21[c]	.160	.086	.222	.119	.06	.42	.14
day 42	1.25	1.57	1.25	1.24	.12	.16	.19
day 63	1.40	1.61	1.59	1.64	.08	.16	.11

[a] Pigs were fed diets containing 1% of a product containing 60% conjugated linoleic acid isomers (CLA) or 1% soybean oil (SBO).
[b] The experimental diets contained added antibiotics (Med) or no added antibiotics (Control).
[c] Serum samples were harvested from a subset of the pigs (n=72; 3 pigs/pen) on days 21, 42, and 63 postweaning.
[d] Interactions occurring between fat type and dietary antibiotic treatment were not observed (P>.10).

Table 4. Percentage of pigs testing positive for serum antibodies to *Mycoplasma hyopneumiae* and PRRS-V and the percentage of pigs requiring therapeutic treatments with injectable antibiotics.

	Fat[a]		Antibiotic[b]	
	CLA	SBO	Control	Medicated
Myco. hyo.				
day 21[c]	64	61	64	61
day 42	97	92	97	92
day 63	100	100	100	100
PRRS-V				
day 21[c]	6.0	8.0	8.0	6.0
day 42	100	100	100	100
day 63	97	100	97	100
% Treated	9.5	14	14	9.4

[a] Pigs were fed diets containing either 1% of a product containing 60 % CLA or 1% soybean oil (SBO).
[b] Diets contained antibiotics (medicated) or no antibiotics (control).
[c] Serum samples were harvested from pigs on days 21, 42, and 63 postweaning.