Effects of L-Carnitine in the Diet of Weanling Pigs
I. Growth Performance

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Story in Brief

An experiment was conducted to evaluate the effects of supplementing graded levels of L-carnitine to the diet of weanling pigs on growth performance. One-hundred twenty-eight weanling pigs (5.5 kg initial BW; 18 d) were randomly allotted based on BW, sex, and litter to four dietary treatments. There were 6 pens/trt of 4 to 6 pigs/pen. Dietary treatments were the control diet supplemented with 0, 25, 50, or 100 ppm L-carnitine. Pigs were fed in three dietary phases (P1: d 0-10; P2: d 11-24; and P3: d 25-38 with 1.6, 1.4, and 1.2% Lys, respectively). Phase 1 and 2 diets were complex corn-soybean meal-dried whey based containing lactose, animal plasma, blood meal, and fish meal, while diets for P3 were corn-soybean meal based. Pigs were weighed and feed consumption was measured weekly for the determination of ADG, ADFI, and G:F. For the 38-d study, ADG, ADFI, and G:F were, respectively: 337, 347, 370, and 363 g; 503, 502, 516, and 523 g; and .669, .692, .717, and .693. For pigs fed diets containing 0, 25, 50, and 100 ppm added L-carnitine, respectively, both ADG and G:F increased for d 0-38. However, this improvement in ADG and G:F associated with L-carnitine was greatest during Phase 2. These results suggest that the addition of L-carnitine to the diet improved growth performance in weanling pigs. The most effective level of L-carnitine for improving growth performance of weanling pigs was 50 ppm.

Key Words: Carnitine, Weanling Pigs, Performance

Introduction

Carnitine is a naturally occurring compound that is synthesized from the essential amino acids lysine and methionine. It is also known as vitamin B_T, to indicate its place in the B-group of vitamins (Fraenkel, 1948). The presence of carnitine in muscle and other tissues is necessary to facilitate the transfer of long-chain fatty acids into the enzymatically active intra-mitochondrial matrix, resulting in the production of adenosine triphosphate (energy) via β-oxidation and oxidative phosphorylation (Fritz and Yue, 1963; Bray and Briggs, 1980).

Kerner et al. (1984) reported that the biosynthesis of carnitine is limited in pigs directly after weaning. This finding suggests that minimal carnitine stores in the weanling pig may hinder the response to supplemental fat sources. Therefore, studies (Newton and Haydon, 1988; Weeden et al., 1990) to determine the effects of supplemental L-carnitine on weanling pig performance have been conducted. Newton and Haydon (1988) reported that pigs fed 1,000 ppm L-carnitine initially post-weaning grew faster and consumed more feed than pigs not fed carnitine. Improvements in ADG and increases in feed intake from 22 to 36 d of age, due to added L-carnitine (1,000 ppm), were also reported by Weeden et al. (1990). However, because of increased dietary costs due to supplementing maximal levels of L-carnitine, the addition of L-carnitine to the diet of weanling pigs may not be economically feasible for the producer.

Therefore, the objective of our study was to determine the effects of lower dietary concentrations of L-carnitine (0 to 100 ppm) on growth performance of weanling pigs.

Materials and Methods

One-hundred twenty-eight Yorkshire, Hampshire, and crossbred (Yorkshire x Hampshire) pigs were weaned at 18 ± 4 d and placed in temperature-controlled nursery rooms in a 38-d experiment. Initially averaging 5.5 kg, pigs were allotted randomly on the basis of weight, sex, and litter to four dietary treatments in a randomized complete block design. Dietary treatments were formulated by supplementing the control diet (Table 1) with 0, 25, 50, and 100 ppm L-carnitine. There were six pen replicates per treatment and pigs were grouped with four to six pigs per pen. Pigs were fed in three dietary phases: [Phase 1 (P1): d 0-10; Phase 2 (P2): d 11-24; and Phase 3 (P3): d 25-38]. Complexity of the diet changed with phases to satisfy the nutrient requirements (NRC, 1998) of the weanling pig. Phase 1 (1.6% Lys) and Phase 2 (1.4% Lys) diets were complex corn-soybean meal-dried whey based diets containing lactose, spray-dried animal plasma, spray-dried blood meal, and fish meal, while Phase 3 (1.2% Lys) diets were typical corn-soybean meal based. All diets were fed in pelleted form and contained 5.0% soybean oil as a dietary fat source.

Table 1. Composition of control diets (as-is basis)

	Diet[a]		
Ingredient, %	Phase 1	Phase 2	Phase 3
Corn	30.19	50.19	56.84
Soybean meal, dehulled	20.75	25.00	33.75
Dried whey	20.00	10.00	--
Lactose	10.00	--	--
Spray-dried animal plasma	5.00	2.50	--
Spray-dried blood meal	2.50	2.50	--
Fish meal, menhaden	2.50	--	--
Soybean oil	5.00	5.00	5.00
Dicalcium phosphate	1.53	2.11	2.37
Limestone	.42	.61	.68
DL-methionine	.20	.13	--
Ethoxyquin	.03	.03	.03
Salt	.25	.25	.35
Trace mineral/vitamin mix	.30	.30	.30
Zinc oxide	.28	.28	--
Copper sulfate	--	--	.08
Antibiotic[b]	1.00	1.00	.50
Cornstarch[c]	.05	.10	.10

[a]Diets formulated to contain 1.6, 1.4, and 1.2% total lysine for P1, P2, and P3, respectively.

[b]P1 and P2 contained neo-terramycin (100 g/ton oxytetracycline & 140 g/ton neomycin base) and P3 contained

lincomix (200 g/ton Lincomycin).

[c]L-carnitine substituted at 0, 25, 50, or 100 ppm for cornstarch to obtain the four dietary treatments.

Pigs were housed in elevated pens with wire flooring. Each pen contained a five-hole, stainless steel feeder and one nipple waterer that allowed *ad libitum* access to feed and water throughout the experiment. Room temperature was maintained initially at 88°F, and decreased by 2°F weekly until the room temperature reached 78°F. Pig weights and feed consumption were recorded weekly for the determination of average daily gain (ADG), average daily feed intake (ADFI), and gain:feed (G:F).

Chemical analysis of the four dietary treatments was performed. Diets were analyzed for L-carnitine concentration by methods described by Parvin and Pande (1977). Additionally, diets were assayed for gross energy by bomb calorimetry.

Data were analyzed as a randomized complete block design using analysis of variance procedures as described by Steel et al. (1997). The model included the effects of block (rep), treatment, and block x treatment (error). The effects of increasing dietary L-carnitine concentration were partitioned into linear, quadratic, and cubic components using orthogonal polynomial contrasts. Pen served as the experimental unit.

Results and Discussion

The chemical analysis of the four dietary treatments is detailed in Table 2. Supplemented levels of L-carnitine were in agreement with calculated levels, signifying proper diet mixing. Because of the inclusion of 5% soybean oil, all diets had a caloric density between 4,125 and 4,206 kcal/kg.

Table 2. Chemical analysis of diets[a]

	Phase 1				Phase 2				Phase 3			
	Calculated concentration											
L-carnitine, ppm	0	25	50	100	0	25	50	100	0	25	50	100
SBO, %	5	5	5	5	5	5	5	5	5	5	5	5
	Analyzed concentration											
L-carnitine, ppm	37	62	86	117	19	41	71	106	1	28	51	101
GE, kcal/kg	4125	4158	4138	4147	4170	4166	4166	4176	4187	4179	4206	4199
	Supplemented level[b]											
L-carnitine, ppm	0	25	49	80	0	22	52	87	0	27	50	100

[a]Analysis reported on an as-is basis

[b]Supplemented level obtained by subtracting analyzed concentration from analyzed concentration of control diet (Diet 1).

The effects of graded levels of L-carnitine on pig performance are shown in Table 3. Increasing levels of supplemental L-carnitine improved ADG (linear, P<.09) and G:F (quadratic, P<.02) for the 38-d study. Pigs fed 50 ppm L-carnitine exhibited the greatest response to dietary L-carnitine, having the highest ADG (370 g) and best G:F ratio (.72) for d 0-38. However, this improvement in ADG and G:F associated with L-carnitine was greatest during Phase 2 (linear, P<.03). Again, the most efficacious level of L-carnitine was 50 ppm, as ADG and G:F tended to plateau at this concentration level, while the maximum level of 100 ppm L-carnitine did not elicit further improvements in performance criteria. Responses to increasing levels of dietary L-carnitine were also observed during Phases 1 and 3. A linear increase (P<.06) in G:F was observed as the level of L-carnitine increased in the diet during Phase 1. As well, there was a numerical increase (P=.17) in ADG from d 0-10. During Phase 3, supplemental L-carnitine improved (P<.08) G:F; however, it did not affect ADG or ADFI (P>.20). The supplementation of L-carnitine had little affect on ADFI (P>.10) during any of the dietary phases or for the entire experiment. These results suggest that the addition of L-carnitine improved growth performance in weanling pigs, with the most pronounced response to supplemental L-carnitine observed in pigs fed 50 ppm.

The effects of L-carnitine as a dietary supplement have been under considerable review. Studies by Weeden et al. (1990) and Owen et al. (1996) have shown beneficial responses when L-carnitine was added to the diet of weaned pigs. In contrast, Hoffman et al. (1993) reported that L-carnitine did not affect ADG and energy utilization in young pigs. However, these studies evaluated the effects of greater levels of L-carnitine supplementation. The results from our study are in agreement with results from Li et al. (1999) and Real et al. (2001). These authors also reported that the addition of 50 ppm L-carnitine to the diet of weanling pigs enhanced post-weaning performance.

Table 3. Growth performance of weanling pigs[a]

	Carnitine, ppm					P >:[b]		
Item:	0	25	50	100	SE	Linear	Quad.	Cubic
Phase 1, d 0-10								
ADG, g/d	137	136	165	159	13.5	.18	--	--
ADFI, g/d	173	166	185	178	10.2	--	--	--
G:F	.79	.80	.89	.89	.04	.06	--	--
Phase 2, d 11-24								
ADG, g/d	342	359	381	377	11.0	.03	.16	--
ADFI, g/d	467	468	489	477	11.2	--	--	--
G:F	.73	.76	.78	.79	.01	.01	.16	--
Phase 3, d 25-38								
ADG, g/d	479	491	511	494	15.8	--	--	--
ADFI, g/d	781	782	791	815	25.1	--	--	--
G:F	.61	.63	.65	.61	.02	--	.08	--
Overall, d 0-38								
ADG, g/d	337	347	370	363	10.8	.09	--	--
ADFI, g/d	503	502	516	523	14.1	--	--	--

G:F	.67	.69	.72	.69	.01	.15	.02	--

[a]Least squares means for six pens/trt of four to six pigs/pen

[b]Dashes indicate (P>.20).

Implications

Results from the present study suggest that the addition of L-carnitine to the diet at lower concentration levels (50 ppm) can enhance growth performance of weanling pigs. Even though a slight improvement in G:F was observed immediately post-weaning (d 0-10), an adjustment period of approximately 10 d post-weaning may be required before the greatest response to supplemental L-carnitine can be observed in the weanling pig. Although the exact mechanisms are unknown, we would speculate that the supplemental L-carnitine allows for the improved utilization of the added soybean oil (energy source) in the diet, thereby, increasing energy production, and subsequently, improving growth performance in the weanling pig. Further research is needed to determine the mode of action resulting in improved growth performance due to L-carnitine and whether the response to L-carnitine is dependent upon dietary fat content.

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