Effects of L-Carnitine and Soybean Oil on Growth Performance in Weanling Pigs

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Story in Brief

Two-hundred sixteen weanling pigs (18 d) were used in a 2 x 2 factorial arrangement of treatments in two separate experiments to evaluate the effects of L-carnitine (0 vs 50 ppm) and soybean oil (SBO; 0 vs 5%) on growth performance. In Exp. 1, 96 pigs (6.0 kg) were randomly allotted based on BW, sex, and litter to four dietary treatments (6 pens/trt of 4 pigs/pen). In Exp. 2, 120 pigs (5.6 kg) were randomly allotted (6 pens/trt of 5 pigs/pen) to the same treatments as in Exp. 1. The four dietary treatments were: 1) 0% SBO and 0 ppm L-carnitine; 2) 0% SBO and 50 ppm L-carnitine; 3) 5% SBO and 0 ppm L-carnitine; and 4) 5% SBO and 50 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). Pigs were weighed and feed consumption was measured weekly for the determination of ADG, ADFI, and G:F. There were no treatment by experiment interactions; thus, data were pooled across experiments (12 pens/trt). Pigs fed SBO tended to grow slower and consume less feed compared to those not fed SBO, but G:F was not affected. The addition of L-carnitine did not affect ADG or ADFI; however, it did improve G:F. The increase in G:F associated with L-carnitine was more pronounced in pigs fed SBO than those not fed SBO. These results suggest that the addition of 50 ppm L-carnitine improved growth performance in weanling pigs; however, supplemental L-carnitine was more effective when SBO was provided in the diet.

Key Words: Carnitine, Fat, Weanling Pigs

Introduction

Carnitine is a naturally occurring vitamin B-like compound that is present in muscle and other tissues. The primary role of carnitine in intermediary metabolism is as a cofactor for enzymes that shuttle long-chain fatty acids across the otherwise impermeable inner mitochondrial membrane into the matrix of the mitochondria. Once in the mitochondrial matrix, long-chain fatty acids are utilized in the production of energy (adenosine triphosphate) via β-oxidation and oxidative phosphorylation (Fritz and Yue, 1963; Bray and Briggs, 1980).

In an effort to diminish post-weaning lag, nutritionists are developing complex, nutrient dense diets to be fed to early-weaned pigs (Tokach et al., 1994). The increase in caloric density within these complex diets is typically obtained from high inclusion levels of milk products (20 to 40%) and supplemental fat (5 to 10%). However, in research conducted by Mahan (1991) and Tokach et al. (1995), adding fat to the diet did not improve ADG of pigs less than 28 d of age. Yet, when fat was supplemented to the diet an improvement in ADG and feed efficiency was observed from d 14 to 35 post-weaning (Mahan, 1991; Tokach et al., 1995). Ironically, the period immediately post-weaning is when L-carnitine synthesis is lowest in weanling pigs (Kerner et al., 1984). Studies suggest that supplementing L-carnitine to the diet of weanling pigs can improve growth performance. Rincker et al. (2001) reported that supplementing 50 ppm L-carnitine to the diet improved growth performance in weanling pigs. Therefore, we speculated that immediately post-weaning, when carnitine stores are minimal, added dietary L-carnitine may be required before an improvement in growth performance due to supplemental fat is observed. Thus, the objective of this study was to evaluate the effects of supplementing L-carnitine and soybean oil to the diet on growth performance of weanling pigs.

Materials and Methods

Two-hundred sixteen Yorkshire, Hampshire, and crossbred (Yorkshire x Hampshire) pigs were weaned at 20 ± 2 d and utilized in two separate 38-d experiments. In each experiment, pigs were used in a 2 x 2 factorial arrangement of treatments and allotted randomly by initial BW, while equalizing ancestry and gender across treatments, to four dietary treatments in a randomized complete block design. The four dietary treatments were obtained from combining either 0 or 50 ppm L-carnitine with either 0 or 5% soybean oil (SBO). The four dietary treatments were: 1) 0% SBO and 0 ppm L-carnitine; 2) 0% SBO and 50 ppm L-carnitine; 3) 5% SBO and 0 ppm L-carnitine; and 4) 5% SBO and 50 ppm L-carnitine. The composition of the basal diet for the three dietary phases is shown in Table 1.

Table 1. Composition of basal 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	--	--
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]	5.05	5.10	5.10

[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 .05% and SBO substituted at 5.0% for cornstarch to obtain the four dietary treatments.

In Exp. 1, 96 weanling pigs (6.0 kg initial BW) were randomly allotted to the four dietary treatments with six pens per treatment of four pigs per pen. In Exp. 2, 120 weanling pigs, initially averaging 5.6 kg, were randomly allotted to the four dietary treatments with six pens per treatment of five 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. As well, lysine concentration of the diets was formulated to exceed NRC (1998) recommendations, thereby preventing any lysine deficiency effects on growth performance. 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 pigs were allowed *ad libitum* access to feed and water throughout the experiment.

Both experiments were conducted in an environmentally controlled nursery with room temperature maintained initially at 88°F, and decreased by 2°F weekly until the room temperature reached 78°F. Pigs were weighed and feed consumption was measured weekly for the determination of average daily gain (ADG), average daily feed intake (ADFI), and gain:feed (G:F).

Diets were assayed for L-carnitine concentrations. L-carnitine concentration was determined by methods described by Parvin and Pande (1977). Additionally, diets were assayed for gross energy by bomb calorimetry.

The data were analyzed as a randomized complete block design within each experiment using analysis of variance procedures (Steel et al., 1997). There were no treatment by experiment interactions as trends were similar within experiments. Thus, data were pooled across experiments with 12 pens per treatment and analyzed as a 2 x 2 factorial in a randomized complete block design. The model included the effects of block (rep), treatment, and block x treatment (error). Orthogonal contrasts were used to test the effects of L-carnitine level (0 vs 50 ppm), SBO level (0 vs 5%), and the L-carnitine level x SBO level interaction. Pen served as the experimental unit.

Results and Discussion

The chemical analyses of the four dietary treatments are presented in Table 2. Supplemented levels of L-carnitine were consistent with calculated levels, signifying proper diet mixing. Five percent added soybean oil increased the caloric density of the diet by approximately 200 to 225 kcal/kg.

Table 2. Chemical analysis of diets[a]

	Phase 1				Phase 2				Phase 3			
	Calculated concentration											
L-carnitine, ppm	0	50	0	50	0	50	0	50	0	50	0	50

SBO, %	0	0	5	5	0	0	5	5	0	0	5	5
	Analyzed concentration											
L-carnitine, ppm	37	92	37	75	19	70	19	74	1	50	1	48
GE, kcal/kg	3938	3928	4128	4128	4025	4016	4251	4231	3901	3932	4124	4161
	Supplemented level[b]											
L-carnitine, ppm	0	55	0	38	0	51	0	55	0	49	0	47

[a]Analysis reported on an as-is basis

[b]Supplemented level obtained by subtracting analyzed concentration from analyzed concentration of unsupplemented diets (Diets 1 and 3).

The effects of L-carnitine and SBO on pig performance are shown in Table 3. For the 38-d study, pigs fed SBO tended (P<.10) to grow slower and consume less feed compared with those not fed SBO, but G:F was not affected (P>.10). The addition of L-carnitine did not affect (P>.10) ADG or ADFI; however, it did improve (P<.01) G:F. Also, the increase in G:F associated with L-carnitine was more pronounced in pigs fed SBO than those not fed SBO (L-carnitine x SBO, P<.08). The greatest response to L-carnitine occurred in P2 with an increase in ADG (P<.05) and G:F (P<.01). As well, the addition of SBO to the diet decreased ADG (P<.04) and ADFI (P<.02) during P2. During P3, the inclusion of SBO had little effect on ADG (P>.20); however, pigs fed SBO consumed less feed (P<.02) resulting in increased G:F (P<.01). These results suggest that the addition of 50 ppm L-carnitine improved growth performance in weanling pigs; however, supplemental L-carnitine was more effective when SBO was included in the diet.

Table 3. Effects of L-carnitine and soybean oil on growth performance in weanling pigs[a]

Carnitine, ppm	0	50	0	50		P <:[b]		
SBO, %	0	0	5	5	SE	SBO	Carnitine	Int[c]
Phase 1, d 0-10								
ADG, g/d	186	189	177	179	8.9	--	--	--
ADFI, g/d	213	211	208	208	7.7	--	--	--
G:F	.873	.897	.845	.862	.03	.19	--	--
Phase 2, d 11-24								
ADG, g/d	420	428	386	418	9.8	.03	.05	--
ADFI, g/d	565	564	534	537	11.5	.02	--	--
G:F	.742	.759	.724	.778	.01	--	.01	.14
Phase 3, d 25-38								
ADG, g/d	517	518	493	516	12.7	--	--	--
ADFI, g/d	819	824	773	780	18.0	.02	--	--
G:F	.632	.629	.638	.662	.01	.01	--	.14
Overall, d 0-38								
ADG, g/d	394	398	370	392	8.7	.09	.16	--
ADFI, g/d	566	567	536	540	11.4	.02	--	--

G:F	.696	.703	.690	.725	.01	.18	.01	.08

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

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

[c]Int = SBO level x L-carnitine level interaction

Results from this study are in agreement with data reported by Owen et al. (1996). These authors reported that L-carnitine and SBO had no affect on pig performance immediately post-weaning (d 0-14). However, from d 14-35 and d 0-35 after weaning, increasing dietary L-carnitine improved G:F, while SBO improved ADG and G:F during these periods. It is worth noting that Owen et al. (1996) supplemented up to 1,000 ppm L-carnitine and 10% soybean oil. In contrast, previous research conducted in our lab suggests that lower inclusion levels of L-carnitine could enhance growth performance of weanling pigs when included at 50 ppm of the diet (Rincker et al., 2001).

Implications

Soybean oil and other fat sources are supplemented to the diet of weanling pigs to increase the energy density of the diet in an effort to diminish the effects of post-weaning lag. However, the biosynthesis of carnitine is minimal immediately after weaning in pigs, possibly hindering the utilization of the increased fat content of the diet. Results from the present study suggest that supplemental L-carnitine in the diet of weanling pigs does not improve the response to added soybean oil immediately post-weaning (d 0-10). After an adaptation period, added L-carnitine enhances growth performance of weanling pigs when soybean oil is provided in the diet.

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