EFFECTS OF DIETARY L-CARNITINE ON GROWTH PERFORMANCE OF NURSERY PIGS

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Summary

Four experiments were conducted to evaluate the effects of added dietary L-carnitine on growth performance of nursery pigs. Pigs were fed a control diet containing no added L-carnitine or the control diet with 25, 50, 75, or 100 ppm of added L-carnitine (25, 50, or 100 ppm in Exp. 4). In Exps. 1, 2, and 3 for the overall study, ADG and F/G improved with increasing dietary L-carnitine. In Exp. 4, pigs fed increasing L-carnitine had improved ADG from d 0 to 3 and d 10 to 24. Increasing added carnitine improved F/G from d 10 to 24 and for the overall study. The results suggest that 25 to 50 ppm of added L-carnitine can improve ADG and F/G in nursery pigs. The largest response in pig growth performance was found when carnitine was supplemented to the phase II diet.

(Key Words: Carnitine, Nursery Pigs, B-Vitamin.)

Introduction

Carnitine, a B-vitamin-like compound naturally occurring in the body, functions to transport long chain fatty acids into the mitochondria. Increasing the amount of dietary carnitine might improve that transport, resulting in better energy utilization by the pig. Previous studies have observed decreased lipid deposition in weanling pigs fed up to 1,000 ppm of added L-carnitine. If these improvements in leanness could be observed at lower concentrations, L-carnitine additions would be justified economically. Therefore, the objective of these experiments was to determine if adding 25 to 100 ppm of L-carnitine to nursery pig diets would improve growth performance.

Procedures

In Exp. 1, a 34-d growth assay, 190 (initially 12.4 lb and 16 ± 2 d of age) pigs were housed in an environmentally regulated nursery at the Kansas State University Segregated Early-Weaning Facility. Pigs were provided ad libitum access to feed and water and housed in 4 × 4-ft pens. Pigs were blocked based on initial weight in a randomized complete block design. There were eight pens (replications) per treatment and each pen contained four or five pigs.

The trial was divided into four phases based on diet complexity (Table 1). Four diets were fed from d 0 to 7, d 7 to 14, d 14 to 24, and d 24 to 34. Pigs were weighed and feed disappearance was determined at the end of each phase to determine ADG, ADFI, and F/G

In Exps. 2 and 3, 240 pigs (10.8 lb and 12 ± 2 d of age) were used in 38-d growth trials. Pigs were blocked by weight and allotted to one of five dietary treatments. There were eight pigs per pen and six pens per treatment in each trial. Pigs were housed in an environmentally controlled nursery in

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5 × 5-ft pens on a commercial farm in northeastern Kansas. All pens contained one self-feeder and a nipple waterer to provide ad libitum access to feed and water.

Diets used in these two experiments were similar to those used in commercial production and were fed in four phases (d 0 to 4, 4 to 10, 10 to 24, and 24 to 38; Table 2). All phases consisted of five treatments: a control or the control diet with 25, 50, 75, or 100 ppm of added L-carnitine. Average daily gain, ADFI, and feed efficiency were determined by weighing pigs and measuring feed disappearance on day 4, 10, 24, and 38 after weaning (Table 4).

In Exp. 1, 2, and 3, the first two diets were pelleted at the Kansas State University Grain Science Feed Mill using a 5/32-in. diameter die and conditioned at 140°F. The last two diets were fed in meal form. All data in these three trials were analyzed as a randomized complete block design with pen as the experimental unit. Pigs were blocked on postweaning weight, and analysis of variance was performed using the GLM procedure of SAS.

The fourth trial was conducted at the Oklahoma State University Swine Research Center. One hundred twenty eight pigs (initially 12.1 lb and 21 ± 2 d of age) were used in a 38-d growth study. There were four to six pigs per pen and six pens/treatment. Pigs were allowed ad libitum access to feed and water.

Diets were fed in four phases (d 0 to 3, 3 to 10, 10 to 24, and 24 to 38; Table 3). Four experimental treatments were used: a control diet or the control diet with 25, 50, or 100 ppm of added L-carnitine. All diets were fed in meal form.

Results and Discussion

The data for the first three experiments have been combined (Table 3). No differences in ADG, ADFI, or F/G occurred with additional L-carnitine during phase I of these trials. During phase II, pigs fed increasing L-carnitine had increased (linear $P<.03$; quadratic, $P<.10$) ADG and improved F/G (linear $P<.01$, quadratic $P<.01$). However, a treatment × trial interaction was observed ($P<.01$) for F/G during this phase (Figure 1). In Exp. 3, increasing L-carnitine did not improve F/G to the same magnitude as in Exps. 1 and 2. Overall, pigs fed additional L-carnitine had greater (linear, $P<.06$) ADG and improved (linear, $P<.01$) feed efficiency compared to pigs fed the control diet. Although the responses in ADG and F/G for the overall study were linear, the greatest improvement was observed in pigs fed 25 to 50 ppm.

In Exp. 4, pigs fed increasing L-carnitine from d 0 to 3 had increased (linear, $P<.05$; Table 4) ADG and tended to have increased (linear, $P<.08$) ADFI. Then, from d 0 to 10, pigs fed increasing L-carnitine tended to be more efficient in converting feed to gain (linear, $P<.10$). During d 10 to 24, pigs fed increasing carnitine had increased (linear, $P<.03$) ADG and improved (linear, $P<.01$) F/G. Also, from d 24 to 38, pigs fed carnitine tended to have improved (quadratic, $P<.08$) F/G. Overall, pigs fed increasing L-carnitine tended to have increased (linear, $P<.09$) ADG and improved (quadratic, $P<.03$) F/G. For overall F/G, the greatest response was observed in pigs fed 50 ppm of added L-carnitine.

Like many studies evaluating vitamin requirements of pigs, some variation occurred in the magnitude of response to added L-carnitine. However, in general, we observed the greatest improvements to added L-carnitine in the phase II portion of our studies, and this was carried over to improve overall performance. These results suggest that 25 to 50 ppm of added L-carnitine can improve ADG and F/G in nursery pigs.

Table 1. Compositions of Basal Diets (Exp. 1)

Ingredient, %	D 0 to 7[a]	D 7 to 14[a]	D 14 to 24[b]	D 24 to 34[b]
Corn[c]	43.68	45.25	52.43	59.16
Soybean meal (46.5%)	17.00	24.68	26.25	32.38
Dried whey	20.00	15.00	10.00	-
Soy oil	5.00	5.00	4.00	4.00
Spray-dried animal plasma	5.00	2.50	-	-
Fish meal	2.50	-	-	-
Spray-dried blood cells	2.50	2.50	2.50	-
Monocalcium P (21% P)	1.26	1.70	1.68	1.56
Medication[d]	1.00	1.00	1.00	1.00
Limestone	.79	.99	.97	.95
Zinc oxide	.38	.38	.25	-
Vitamin premix	.25	.25	.25	.25
Salt	.20	.30	.25	.35
L-Lysine HCl	.15	.15	.15	.15
Trace mineral premix	.15	.15	.15	.15
DL-methionine	.15	.15	.13	.05
Total	100.00	100.00	100.00	100.00

[a]Fed in pelleted form.
[b]Fed in meal form.
[c]Corn was replaced by L-carnitine (wt/wt) to provide supplemental dietary L-carnitine levels of 25, 50, 75, and 100 mg/kg.
[c]Provided 50 g/ton carbadox.

Table 2. Compositions of Basal Diets (Exp. 2 & 3)

Ingredient, %	D 0 to 4[a]	D 4 to 10[a]	D 10 to 24[b]	D 24 to 38[b]
Corn	33.07	39.71	48.65	56.46
Soybean meal (46.5%)	12.71	23.01	27.33	34.29
Spray-dried whey	25.00	20.00	10.00	-
Spray-dried animal plasma	6.70	2.50	-	-
Fish meal	6.00	2.50	5.00	-
Soybean oil	6.00	5.00	5.00	5.00
Lactose	5.00	-	-	-
Spray-dried blood meal	1.65	2.50	-	-
Medication[c]	1.00	1.00	1.00	0.50
Monocalcium P (21% P)	0.75	1.30	1.00	1.50
Limestone	0.45	0.73	0.55	0.95
Corn starch[d]	0.40	0.40	0.40	0.40
Zinc oxide	0.38	0.38	0.25	-
Salt	0.20	0.30	0.25	0.35
Vitamin premix	0.25	0.25	0.25	0.25
Lysine HCl	0.15	0.15	0.15	0.15
DL-methionine	0.15	0.13	0.01	-
Trace mineral premix	0.15	0.15	0.15	0.15
Total	100.00	100.00	100.00	100.00

[a]Fed in pelleted form.
[b]Fed in meal form.
[c]Provided 50 g/ton carbadox from d 0 to 24 and 25 g/ton from d 24 to 38.
[d]Cornstarch was replaced by L-carnitine (wt/wt) to provide supplemental dietary L-carnitine levels of 25, 50, 75, and 100 mg/kg.

Table 3. Compositions of Basal Diets (Exp. 4)

Ingredient, %	D 0 to 10	D 10 to 24	D 24 to 38
Corn	30.14	50.19	56.84
Soybean meal (48%)	20.75	25.00	33.75
Spray-dried whey	20.00	10.00	-
Lactose	10.00	-	-
Spray-dried animal plasma	5.00	2.50	-
Fish meal	2.50	-	-
Soybean oil	5.00	5.00	5.00
Spray-dried blood meal	2.50	2.50	-
Medication[a]	1.00	1.00	0.50
Dical P	1.53	2.11	2.37
Limestone	0.42	0.61	0.68
Corn starch[b]	0.10	0.10	0.10
Zinc oxide	0.28	0.28	-
Salt	0.25	0.25	0.35
TM/Vitamin premix	0.30	0.30	0.30
Copper sulfate	-	-	0.08
Ethoxyquin	0.03	0.03	0.03
DL-methionine	0.20	0.13	-
Total	100.00	100.00	100.00

[a]Provided 50 g/ton oxytetracycline and 140 g/ton neomycin from d 0 to 24, and 200 g/ton Lincomycin from d 24 to 38.
[b]Cornstarch was replaced by L-carnitine (wt/wt) to provide supplemental dietary L-carnitine levels of 25, 50, and 100 mg/kg.

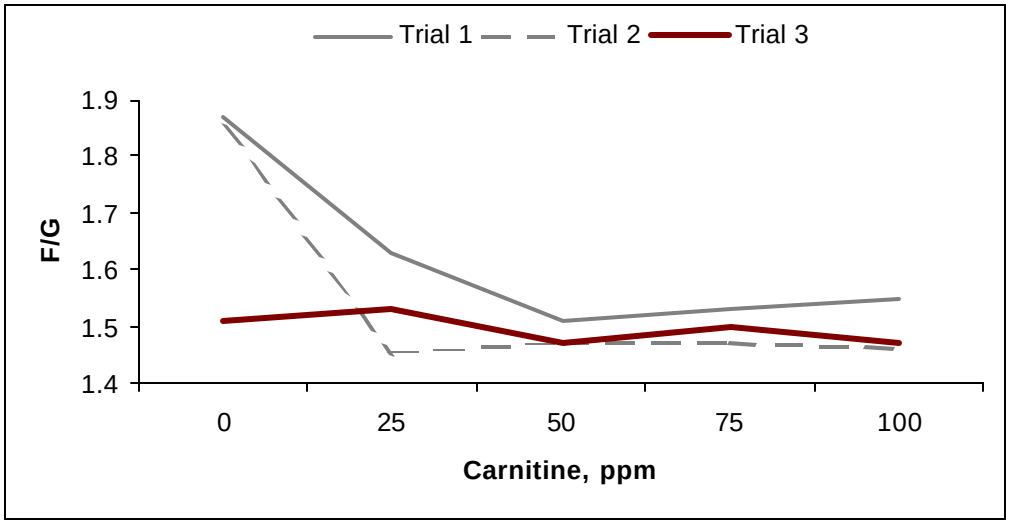

Figure 1. Effects of Increasing L-Carnitine on F/G in Exps. 1, 2, and 3. Treatment × trial interaction (P<.01) day 14 to 24 for Exp. 1, d 10 to 24 for Exps. 2 and 3.

Table 4. Effects of L-Carnitine on Nursery Pig Growth Performance[a]

	Carnitine, ppm						Probability				
Item	0	25	50	75	100	SEM	Carnitine	Trial	Trt×Trial	Linear	Quad.
Phase I[b]											
ADG, lb	.46	.47	.47	.47	.46	.015	.60	.01	.71	.66	.18
ADFI, lb	.50	.53	.52	.52	.50	.016	.27	.01	.30	.71	.62
F/G	1.10	1.15	1.12	1.12	1.13	.021	.31	.01	.87	.98	.17
Phase II[c]											
ADG, lb	.72	.78	.80	.81	.79	.027	.01	.01	.17	.03	.10
ADFI, lb	1.23	1.20	1.18	1.20	1.18	.030	.29	.01	.77	.29	.74
F/G	1.74	1.54	1.48	1.50	1.49	.033	.01	.01	.01	.01	.01
Phase III[d]											
ADG, lb	1.24	1.26	1.22	1.31	1.28	.037	.43	.26	.57	.19	.81
ADFI, lb	1.82	1.80	1.85	1.94	1.87	.051	.45	.19	.79	.14	.74
F/G	1.48	1.43	1.53	1.48	1.46	.024	.91	.88	.38	.94	.23
Overall											
ADG, lb	.80	.84	.83	.87	.84	.020	.04	.02	.74	.06	.30
ADFI, lb	1.10	1.18	1.19	1.23	1.20	.028	.70	.01	.86	.48	.81
F/G	1.48	1.41	1.43	1.42	1.40	.012	.01	.22	.54	.01	.13

[a]Values are representatives of three trials. Trial 1 had 196 pigs initially 10.6 lb and 10 to 14 days old with 8 pigs per pen and 5 pens per treatment. Trial 2 had 240 pigs initially 10.7 lb and 10 to 14 days of age with 8 pigs per pen and 6 replicates per treatment. Trial 3 had 190 pigs on test with 4 or 5 pigs per pen and 8 pens per treatment.
[b]Phase I is from day 0 to 14 in trial 1 and d 0 to 10 in trials 2 and 3.
[c]Phase II is from day 14 to 24 in trial 1 and from d 10 to 24 in trials 2 and 3.
[d]Phase III is from day 24 to 34 in trial 1 and from d 24 to 38 in trials 2 and 3.

Table 5. Effects of Added L-Carnitine on Weanling Pig Growth Performance (Exp. 4)[a]

	L-Carnitine, ppm					Probability		
Item	0	25	50	100	SEM	Linear	Quad.	Cubic
Day 0 to 3								
ADG, lb	.05	.12	.14	.16	.03	.05	.32	.78
ADFI, lb	.15	.17	.18	.20	.02	.08	.81	.88
F/G	2.72	1.33	1.61	1.37	.82	.37	.47	.54
Day 3 to 10								
ADG, lb	.41	.38	.46	.43	.04	.43	.71	.19
ADFI, lb	.48	.45	.50	.47	.03	.83	.79	.23
F/G	1.18	1.25	1.12	1.12	.07	.31	.90	.25
Day 0 to 10								
ADG, lb	.30	.30	.36	.35	.03	.18	.51	.32
ADFI, lb	.38	.37	.41	.39	.02	.55	.77	.30
F/G	1.28	1.30	1.14	1.14	.07	.10	.70	.31
Day 10 to 24								
ADG, lb	.75	.79	.84	.83	.02	.03	.16	.63
ADFI, lb	1.03	1.03	1.08	1.05	.02	.44	.35	.39
F/G	1.37	1.31	1.29	1.27	.02	.01	.12	.73
Day 24 to 38								
ADG, lb	1.06	1.08	1.13	1.09	.03	.49	.27	.66
ADFI, lb	1.72	1.72	1.74	1.80	.06	.31	.79	.96
F/G	1.63	1.59	1.54	1.66	.04	.61	.08	.68
Overall								
ADG, lb	.74	.76	.81	.80	.02	.09	.22	.48
ADFI, lb	1.11	1.11	1.14	1.15	.03	.27	.99	.68
F/G	1.50	1.45	1.39	1.44	.02	.16	.03	.58

[a]Values are means of 128 pigs (initially 12.1 lb and 21 ± 2 d of age) with 4 to 6 pigs per pen and 6 replicate pens per treatment.