INTERACTIVE EFFECTS OF CARNITINE STATUS, DIETARY CARNITINE, AND ADDED FAT ON GROWTH PERFORMANCE OF WEANLING PIGS [1]

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Summary

Two experiments were conducted to determine the interactive effects of carnitine status (with or without carnitine in diets fed to sows in gestation and lactation), and added fat and dietary carnitine in nursery diets on growth performance of weanling pigs. Feeding sows diets containing carnitine in gestation and lactation had no effect on growth performance of their pigs through 27-d after weaning. A carnitine by fat interaction ($P<0.05$) was observed for ADFI from d 0 to 7 and ADG from d 0 to 27 in Exp. 1 with pigs fed carnitine and no added fat appearing to have the best performance. In Exp. 2, added carnitine had little effect on growth performance, whereas added fat improved feed efficiency. In conclusion, no benefit to growth performance was observed from adding both carnitine and fat to the diet of weanling pigs in these experiments.

(Key Words: Weanling Pigs, Carnitine, Fat.)

Introduction

L-carnitine is a vitamin-like compound needed for proper utilization of medium- and long-chain fatty acids. Previous research has shown that carnitine added to diets of nursery pigs improved feed efficiency in phase II and III. Feed efficiency has also been shown to improve linearly when fat is added to the diets of pigs. Research conducted at Oklahoma State University showed that dietary carnitine improved growth performance of weanling pigs when fat was also added to the diet; however, no beneficial response was observed when carnitine was fed alone.

Previous research conducted at Kansas State University showed that pigs farrowed from sows fed diets containing carnitine had improved carcass characteristics at slaughter compared to pigs from sows fed diets not containing carnitine. In that experiment no differences in weight gain were observed for the pigs from d 0 to 35 after weaning. The objectives of these experiments were to: 1) further determine the growth performance of pigs in the nursery that were farrowed from sows fed diets with or without carnitine and 2) further evaluate the interactive effects of dietary carnitine and/or fat on growth performance of weanling pigs.

Procedures

Animals and Facilities. Two experiments were conducted at the Kansas State University Swine Teaching and Research Center. Pigs (PIC line C22 × 326) were blocked by initial weight, equalized for sex and litter, and randomly allotted to their respective dietary treatments. Creep feed was not offered to the pigs during lactation. Pigs were housed in an environmentally controlled nursery in 4 × 5 ft pens with woven wire flooring and had ad libitum access to

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feed and water. Initial temperature of the nursery was 90°F and was lowered approximately 3°F each week thereafter. Pigs were weighed and feed disappearance was determined on d 7, 14, 21, and 27 after weaning to calculate ADG, ADFI, and feed to gain ratio (F/G).

Experiment 1. A total of 176 weanling pigs (initially 14.4 lb and 21 d of age) were used to determine the interactive effects of carnitine status (0 or 50 ppm of carnitine fed to sows in gestation and lactation diets), carnitine (0 vs. 50 ppm in nursery diets), and fat (0 vs. 6% in nursery diets) on growth performance. At weaning, pigs were allotted to one of four experimental treatments with four or five pigs per pen and five replications (pens) per treatment.

All experimental diets were fed in meal form. Diets (Table 1) were fed in two phases, d 0 to 7 and 7 to 27. Diets were formulated on an equal lysine:calorie basis and met or exceeded all NRC (1998) nutrient requirement estimates. The corn-soybean meal ratio was adjusted when diets contained added fat to equalize the lysine:calorie ratio. L-carnitine replaced cornstarch in the basal diet to form the experimental treatments.

Experiment 2. A total of 150 weanling pigs (initially 12.1 lb and 21 d of age) were used in a 27-d growth trial to determine the interactive effects of dietary carnitine (0 vs. 50 ppm) and fat (0, 3, and 6%). Pigs were farrowed from sows fed diets that did not contain carnitine. Pigs were allotted to one of six treatments with five pigs per pen and five replications (pens) per treatment. Diets were formulated similar to those described in Exp. 1.

Statistical Analysis. Data were analyzed as a randomized complete block design with pen as the experimental unit. Analysis of variance was performed using the Mixed procedure of SAS. The model included all main effects as well as two- or three-way interactions.

Results and Discussion

Experiment 1. No three-way interactions were observed for any response criteria measured. An interaction between fat and carnitine in the nursery diet was observed ($P<0.05$) for ADFI from d 0 to 7 and ADG from d 0 to 27. Pigs fed the diet containing carnitine and no fat had greater ADFI or ADG compared to pigs fed the diet not containing carnitine and no fat; however, when fat was added to the diet, no benefit from dietary carnitine was observed. A tendency for a fat x carnitine interaction was also observed ($P<0.10$) for ADG from d 7 to 27 and ADFI from d 7 to 27 and 0 to 27. Again, pigs fed diets containing carnitine and no fat had greater ADG or ADFI compared to diets containing no carnitine, but when fat was also added to the diet no carnitine effect was observed.

Throughout the entire experiment, no main effect ($P>0.10$) of carnitine status or dietary carnitine was observed. Dietary fat had no effect ($P>0.10$) on ADG or ADFI, but improved ($P<0.01$) F/G from d 0 to 7, 7 to 27 and 0 to 27.

Experiment 2. No fat × carnitine interactions were observed for any response criteria. Added fat or carnitine had no effect ($P>0.10$) on ADG or ADFI from d 0 to 7, 7 to 27, or 0 to 27. Pigs fed diets containing fat had improved ($P<0.03$) F/G compared to those fed diets not containing fat from d 7 to 27 and 0 to 27. Pigs fed diets containing carnitine had poorer ($P<0.05$) F/G compared to those fed diets not containing carnitine from d 7 to 27 and 0 to 27.

These results suggest that nursery growth performance of pigs farrowed from sows fed diets with or without carnitine are similar. Previous research conducted at Kansas State University showed that pigs farrowed from sows fed carnitine had heavier muscled carcasses at slaughter compared to pigs obtained from sows fed diets not containing carnitine. These researchers suggested the improvement in muscling was reflective of a greater number of muscle fibers present from the pigs obtained from the sows fed diets

with carnitine, a factor that might not influence growth performance immediately after weaning, but may influence growth performance in the finishing phase (>120 lbs). Unfortunately, we were unable to determine the effects of maternal diet on growth performance in the finisher and carcass composition of pigs used in this experiment.

Contrary to our previous research and research conducted at Oklahoma State University, our experiment showed no benefit in growth performance when carnitine was added to diets containing fat. The Oklahoma State University researchers observed a greater response to carnitine when fat was also included in the diet compared to when diets contained no fat. Differences in diet formulation could account for the inconsistencies observed, because our diets were all balanced on an equal lysine:calorie, whereas the OSU diets were not. Also, because the body synthesizes carnitine from methionine and lysine, dietary carnitine may act to spare either of these amino acids if the diet is formulated to levels below the pig's requirement.

The inconsistent responses to growth performance from adding carnitine to the diets of weanling pigs are similar to those observed with other vitamins. The animal's demand for a vitamin is often dependent on the influence of factors such as basal dietary concentration of the vitamin, body storage of the vitamin, growth rate, and stress (health, temperature, etc.). Thus, the vitamin may not elicit a beneficial response to growth performance in every experiment in which it is tested, similar to dietary carnitine.

In conclusion, pigs obtained from sows fed diets containing carnitine will exhibit growth performance immediately after weaning similar to those obtained from sows fed diets without added carnitine. Carnitine added to nursery diets had little effect on growth performance of weanling pigs in these experiments. Including fat in the diets of weanling pigs improved feed efficiency, especially in the latter portion of this experiment. More research should be conducted to further define the interactive effects of dietary fat and carnitine on growth performance of weanling pigs.

Table 1. Diet Composition (As-Fed Basis)

	Day 0 to 7			Day 7 to 27		
Item, %	0% Fat	3% Fat[a]	6% Fat	0% Fat	3% Fat[a]	6% Fat
Corn	45.27	39.79	33.95	57.69	52.41	47.19
SBM (46.5% CP)	15.19	17.65	20.47	26.30	24.03	28.51
Dried whey	25.00	25.00	25.00	10.00	10.00	10.00
Spray-dried plasma	5.00	5.00	5.00	-	-	-
Select menhaden fish meal	6.00	6.00	6.00	4.50	4.50	4.50
Soy oil	-	3.00	6.00	-	3.00	6.00
Monocalcium phosphate (21% P)	0.75	0.75	0.75	1.05	1.05	1.05
Limestone	0.45	0.45	0.45	0.50	0.50	0.50
Salt	0.20	0.20	0.20	0.25	0.25	0.25
Vitamin premix	0.25	0.25	0.25	.025	.025	.025
Trace mineral premix	0.15	0.15	0.15	.015	.015	.015
Sow add pack	0.05	0.05	0.05	0.05	0.05	0.05
Antibiotic[b]	1.00	1.00	1.00	1.00	1.00	1.00
Zinc oxide	0.38	0.38	0.38	0.25	0.25	0.25
L-threonine	0.03	0.04	0.05	0.04	0.045	0.05
L-lysine HCl	0.15	0.15	0.15	0.15	0.15	0.15
DL-methionine	0.08	0.09	0.10	0.04	0.045	0.05
Cornstarch[c]	0.05	0.05	0.05	0.05	0.05	0.05
Calculated Analysis						
Total lysine, %	1.55	1.61	1.68	1.30	1.36	1.41
ME, kcal/lb	1,477	1,538	1,599	1,477	1,539	1,600
Lysine:ME, g/mcal	4.76	4.75	4.76	3.99	3.99	3.99
Calcium %	0.88	0.89	0.90	0.79	0.80	0.80
Phosphorus, %	0.84	0.84	0.84	0.76	0.76	0.76

[a]Experiment 2 only. [b]Provided 50 g/ton carbadox. [c]Cornstarch was replaced with 50 ppm L-carnitine to form the experimental treatments.

Table 2. Influence of Dietary Carnitine and/or Fat on Growth Performance of Weanling Pigs Obtained from Sows Fed Diets With or Without Carnitine, Exp. 1[a]

	Negative Carnitine Status[b]				Positive Carnitine Status[b]							
Carnitine, ppm:	0	50	0	50	0	50	0	50		Probability, P<		
Item Fat, %:	0	0	6	6	0	0	6	6	SEM	Status	Carnitine	Fat
Day 0 to 7												
ADG, lb	.53	.60	.65	.59	.53	.56	.60	.57	.04	.53	.88	.12
ADFI, lb[c]	.60	.68	.67	.62	.56	.60	.62	.59	.04	.22	.66	.64
F/G	1.14	1.14	1.03	1.06	1.06	1.07	1.04	1.02	.04	.10	.80	.01
Day 7 to 27												
ADG, lb[d]	.93	1.04	1.03	1.00	.94	.98	1.03	1.01	.05	.68	.37	.12
ADFI, lb[d]	1.37	1.56	1.40	1.36	1.41	1.45	1.43	1.43	.08	.87	.24	.32
F/G	1.47	1.51	1.37	1.36	1.50	1.48	1.40	1.42	.04	.41	.77	.001
Day 0 to 27												
ADG, lb[c]	.83	.93	.93	.89	.83	.87	.92	.90	.05	.57	.45	.10
ADFI, lb[d]	1.17	1.34	1.21	1.17	1.19	1.23	1.22	1.21	.07	.81	.27	.43
F/G	1.41	1.44	1.31	1.31	1.43	1.41	1.34	1.35	.03	.55	.71	.001

[a]A total of 176 pigs (initially 14.4 lb and 21 d of age) with four or five pigs per pen and five pens per treatment. [b]Negative carnitine status refers to pigs farrowed from sows fed diets not containing carnitine and positive carnitine status refers to pigs farrowed from sows fed diets containing 50 ppm carnitine in the previous gestation and lactation. [c]Fat × carnitine, (P<0.05). [d]Fat × carnitine, (P<0.10).

Table 3. Interactive Effects of Dietary Fat and L-carnitine on Growth Performance of Weanling Pigs, Exp. 2[a]

	Fat, %:	0	0	3	3	6	6		Significance, P<		
Item	Carnitine,	0	50	0	50	0	50	SEM	Fat	Carnitine	Fat × Carn.
Day 0 to 7											
ADG, lb		0.62	0.61	0.65	0.60	0.60	0.68	0.03	0.72	0.90	0.13
ADFI, lb		0.72	0.74	0.77	0.72	0.75	0.80	0.05	0.71	0.90	0.60
F/G		1.16	1.22	1.18	1.20	1.25	1.20	0.05	0.72	0.81	0.48
Day 7 to 27											
ADG, lb		0.88	0.93	0.96	0.90	0.96	0.96	0.04	0.37	0.99	0.30
ADFI, lb		1.36	1.45	1.41	1.40	1.38	1.42	0.06	0.98	0.29	0.59
F/G		1.54	1.56	1.47	1.56	1.45	1.48	0.03	0.007	0.04	0.31
Day 0 to 27											
ADG, lb		0.81	0.85	0.88	0.82	0.86	0.89	0.04	0.39	0.97	0.29
ADFI, lb		1.20	1.27	1.24	1.23	1.22	1.26	0.05	0.99	0.38	0.58
F/G		1.47	1.50	1.41	1.49	1.41	1.42	0.02	0.03	0.05	0.30

[a]Values represent a total of 150 pigs (initially 12.1 lb and 21 d of age) with five pigs per pen and five pens per treatment.