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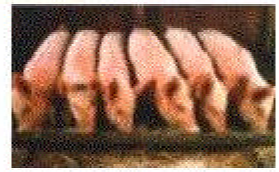

EFFECTS OF DIETARY L-CARNITINE SUPPLEMENTATION ON WEANLING PIG PERFORMANCE

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Summary
Weanling pigs (n = 120; 20.9 ± 1.97 d; 6.42 ± .23 kg;) were used to study the effects of L-carnitine on growth performance when fed in conjunction with a diet formulated to contain primarily animal or plant protein. Piglets were provided ad-libitum access to feed and water. Diets were fed in three phases. Phase I diets were fed from d 0 – 7, Phase II diets were fed from d 7 – 14, and Phase III diets were fed from d 14 – 35. Weekly weights, and feed disappearance for each phase was recorded. Subsequently, ADG, ADFI, and G/F were determined within each of the three phases. Dietary L-carnitine had no effect on growth performance during any of the three phases, or on overall performance ($p > .10$). During Phase II, increasing plant protein in the diet decreased ADG and ADFI ($p < .03$, and $p < .02$, respectively).

Introduction
The transition from a liquid to a dry diet upon weaning can often result in a growth lag in young pigs. To ease pigs into this diet transition special attention must be paid to the dietary ingredients. Complex protein sources such as soybean meal are minimized in the young pig's diet, while animal protein sources are increased. The reasons for including more expensive animal proteins are based on the increased digestibility of these proteins, and also to guard against an immunological challenge that often leads to decreased feed intake and gain that may result from feeding of soybean meal. An additional benefit to feeding of animal proteins in the weanling pig diet is their likely contribution of dietary carnitine.

Since its discovery in 1905, research has proven the necessity of carnitine in long chain fatty acid oxidation. Carnitine serves as a co-substrate for carnitine acyl-transferase, and is required for the transport of long chain fatty acids into the mitochondria where they can undergo beta-oxidation. Long chain fatty acids are activated to their Co-A esters in the cytosol, since the mitochondrial membrane is impermeable to these Co-A esters, these activated long chain fatty acids cannot enter the mitochondria. Carnitine acyl-transferase exchanges carnitine for the Co-A to produce acyl-carnitine. This acyl-carnitine once inside the inner mitochondrial membrane serves as a substrate for a second carnitine acyl-transferase which completes the final transfer of the fatty acid into the mitochondria by exchanging the carnitine for mitochondrial Co-A. The reformed fatty acyl-CoA is then ready for beta-oxidation (McGarry and Brown, 1997). Due to its essential role in fatty acid metabolism carnitine has been classified as a quasi-vitamin, however, adult animals can adequately synthesize carnitine and it is therefore not considered an essential dietary component. However, in the young animal attenuated de novo synthesis of carnitine (Borum, 1983) may necessitate demand for dietary carnitine.

Carnitine can be found in both plant and animal products, however, its greatest concentrations are found in animal tissues while plants often contain little or no carnitine (Mitchell, 1978). Milk has been shown to contain carnitine, and therefore may be the source of carnitine which accumulates in tissues early in development (Borum, 1983). It is unknown when de novo synthesis of carnitine begins to sufficiently meet the carnitine needs of the pig. It has been hypothesized that when pigs are transitioned from a mixed diet containing animal products at 7-8 wk of age, to a primarily plant based diet, de novo synthesis is not adequate to compensate for the decrease in dietary carnitine (Heo et al., 2000). Due to varying research results, further research to determine if L-carnitine supplementation can positively impact growth performance in the nursery, and under what conditions these effects can be maximized, is warranted.

Materials and Methods

Weanling pigs (n = 120; 20.9 ± 1.97 d; 6.42 ± .23 kg) were housed in a nursery facility at the North Carolina State University Swine Educational Unit. Pigs were allotted to one of four dietary treatments according to a 2 x 2 factorial design (animal versus plant protein; 0 versus 100 ppm supplemental L-carnitine), and provided ad-libitum access to feed and water. Dietary treatments were fed in three phases. Phase I diets were offered from d 0 – 7 (Table 1), Phase II diets were fed from d 7 – 14 (Table 2), and Phase III diets were fed from d 14 – 35 (Table 2). Diets offered during Phases I and II were in pellet form, while diets offered during Phase III were in meal form. Pigs were weighed weekly, and feed disappearance recorded. Subsequently, ADG, ADFI, and G/F were determined within each of the three phases. Data was analyzed as a randomized complete block design with pen as the experimental unit. Pigs were blocked according to weaning weight, and analysis of variance was performed using GLM procedure of SAS.

Table 1. Phase I diet composition

	Animal protein		Plant protein	
Ingredient	**- carnitine**	**+ carnitine**	**- carnitine**	**+ carnitine**
Corn	29.391	29.391	22.721	22.721
Soybean oil	5	5	5	5
Spray dried blood meal	2.5	2.5	1.5	1.5
Spray dried plasma	3	3	3	3
Fish meal, menhaden	5	5	-	-
Soybean meal, w/o hulls	21.808	21.808	38.773	38.773
Whey, dried	20	20	-	-
Lactose	10	10	24.286	24.286
Corn Starch	0.1	-	0.1	-
L-Carnitine	-	0.1	-	0.1
Threonine	-	-	-	-
Methionine, DL	0.163	0.163	0.169	0.169
Dicalcium phosphate	0.874	0.874	1.959	1.959
Limestone	0.385	0.385	0.698	0.698
Salt	0.25	0.25	0.25	0.25
Zinc oxide	0.278	0.278	0.278	0.278
Vit/Min, pmx	0.25	0.25	0.25	0.25
Antibiotic	1	1	1	1
Total	100.0	100.0	100.0	100.0

Table 2. Phase II and Phase III diet composition

	Phase II				Phase III	
	Animal protein		Plant protein		Plant protein	
Ingredient	- carnitine	+ carnitine	- carnitine	+ carnitine	- carnitine	+ carnitine
Corn	48.76	48.76	44.26	44.26	56.50	56.50
Soybean oil	5	5	5	5	5	5
Spray dried blood meal	2.5	2.5	1.25	1.25	-	-
Spray dried plasma	-	-	-	-	-	-
Fish meal, menhaden	2.5	2.5	-	-	-	-
Soybean meal, w/o hulls	27.28	27.28	37.71	37.71	34.77	34.77
Whey, dried	10	10	-	-	-	-
Lactose	-	-	7.143	7.143	-	-
Corn Starch	0.1	-	0.1	-	0.1	-
L-Carnitine	-	0.1	-	0.1	-	0.1
Threonine	-	-	0.005	0.005	-	-
Methionine, DL	0.098	0.098	0.093	0.093	0.03	0.03
Dicalcium phosphate	1.455	1.455	1.954	1.954	1.628	1.628
Limestone	0.535	0.535	0.708	0.708	0.793	0.793
Salt	0.25	0.25	0.25	0.25	0.35	0.35
Zinc oxide	0.278	0.278	0.278	0.278	0.08	0.08
Vit/Min, pmx	0.25	0.25	0.25	0.25	0.25	0.25
Antibiotic	1	1	1	1	0.5	0.5
Total	100.0	100.0	100.0	100.0	100.0	100.0

Results and Discussion

Research findings examining the role of supplemental L-carnitine in weanling pigs allowed ad-libitum access to diets has been variable (Hoffman et al., 1993; Owen et al., 1996). While Hoffman and co-workers (1993) saw no benefit to feeding L-carnitine on growth performance, Owens and co-workers (1996) reported an increase in feed efficiency by supplementing diets with 500 ppm of L-carnitine. This increase in feed efficiency was due to a decrease in feed intake, and not an increase in ADG. However, subsequent studies by Real and co-workers saw an improvement in both ADG and feed efficiency when diets were supplemented with L-carnitine, with the greatest improvements occurring during Phase II of the nursery.

Results of the current study are summarized in Table 3. It was hypothesized that the addition of L-carnitine to nursery diets would enhance the growth performance of weanling pigs, and that this would be further accentuated by feeding a diet minimal in animal protein. The addition of 100 ppm L-carnitine to weanling pig diets had no effect on ADG, ADFI, and G/F in any of the three phases (Table 3). In addition, overall performance was also not affected by the addition of dietary L-carnitine. During phase II, increasing plant protein in the diet decreased ADG and ADFI ($p < .03$, and $p < .02$, respectively). It was predicted that performance during both Phase I and Phase II would be negatively impacted by feeding a primarily plant based diet, however protein source did not affect Phase I performance. The plant protein source diets were formulated to contain minimal levels of animal protein. The levels included during phase I appear to have been sufficient to maintain growth performance comparable to the controls. However, the further removal of animal protein during Phase II negatively impacted performance.

Table 3. Effects of protein source and dietary L-carnitine in weanling pig diets.

Protein:	Animal		Plant			Probability		
L-carnitine, ppm:	0	100	0	100	SE	Protein	L-carnitine	Interaction[a]
Phase I								
ADG	0.225	0.237	0.199	0.210	0.022	0.24	0.60	0.98
ADFI	0.220	0.235	0.208	0.226	0.018	0.59	0.37	0.94
G/F	1.021	1.001	0.948	0.934	0.039	0.09	0.67	0.94
Phase II								
ADG	0.424	0.428	0.378	0.386	0.018	0.03	0.75	0.91
ADFI	0.526	0.554	0.500	0.493	0.017	0.02	0.54	0.32
G/F	0.811	0.774	0.759	0.785	0.036	0.58	0.88	0.39
Phase III								
ADG	-	-	0.485	0.511	0.028	-	0.36	-
ADFI	-	-	0.807	0.862	0.042	-	0.19	-
G/F	-	-	0.600	0.597	0.026	-	0.90	-
Overall								
ADG	0.403	0.422	0.391	0.403	0.013	0.23	0.26	0.79
ADFI	0.579	0.615	0.563	0.587	0.020	0.31	0.16	0.76
G/F	0.698	0.686	0.695	0.693	0.025	0.92	0.79	0.85

[1]Values are LS means, n = 6 pens/treatment. During Phases I and II diets were formulated to include either optimal or minimal levels of animal protein, and two levels of L-carnitine were fed.
[a] Interaction between protein source and L-carnitine level .

Implications

In conclusion, the addition of 100 ppm of dietary L-carnitine to weanling pig diets was unable to improve growth performance, even when included in a diet formulated to contain minimal carnitine by using a plant protein source.

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