INFLUENCE OF L-CARNITINE ON GROWTH AND PLASMA IGF-I FROM GILTS HARVESTED AT THREE GESTATION LENGTHS[1]

K. R. Brown, B. J. Johnson, R. D. Goodband, M. D. Tokach, S. S. Dritz[2], J. L. Nelssen, N. Z. Frantz, R. O. Gottlob, C. N. Groesbeck, C. W. Hastad, C. R. Neill, J. D. Schneider, M. G. Young, and J. C. Woodworth[3]

Summary

A total of 59 gilts were used to determine the effects of supplemental L-carnitine on gilt growth and maternal insulin-like growth factor-I (IGF-I). Experimental treatments were arranged in a 2 × 3 factorial with main effects of L-carnitine (0 or 50 ppm) and day of gestation (40, 55, or 70). All gilts received a constant feed allowance of 3.86 lb/day and a topdress containing either 0 or 88 mg of L-carnitine, starting on the first day of breeding. No differences (P>0.05) between treatments were observed for BW, estimated protein mass, or estimated fat mass at any gestation length. At d 70 of gestation, there was a numeric increase (P>0.10) in BW for the gilts fed L-carnitine, compared with those fed the control diet. At d 40 of gestation, gilts fed L-carnitine tended to have greater (P = 0.10) backfat, compared with the gilts fed the control diet; but no differences (P>0.05) were observed in backfat on d 0, 55, or 70 of gestation. In addition, no differences (P>0.05) were observed in maternal IGF-I between treatments at any gestation length. Total and free plasma L-carnitine concentrations were similar (P>0.10) at d 0 of gestation, but concentrations were higher (P<0.01) by d 40 of gestation in the gilts fed L-carnitine. These results show that supplemental L-carnitine numerically increases BW of gestating gilts. This data represents the first part of an ongoing study, with the rest of the data being reported in subsequent publications.

(Key Words: Backfat, Gestation, Gilts, L-carnitine, Pigs, Weight.)

Introduction

L-carnitine is a vitamin-like, water-soluble quaternary amine that is a derivative of the amino acids lysine and methionine. It is found in tissues such as the liver, kidney, brain, heart, and skeletal muscle, which can use fatty acids as an energy source. The primary role of L-carnitine is to facilitate transport of long-chain fatty acyl groups to the mitochondrial matrix for β-oxidation for cellular energy production. In addition, L-carnitine increases glucose disposal and carbohydrate oxidation rate, therefore playing a role in carbohydrate metabolism.

Research has demonstrated that supplementing sow's diets with L-carnitine during gestation improves reproductive performance.

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[2]Food Animal Health & Management Center, College of Veterinary Medicine.
[3]Lonza, Inc., Allendale, NJ.

L-carnitine supplementation during gestation increased sow BW gain, and last-rib backfat, and in some studies has been shown to increase circulating IGF-I. In addition, supplemental L-carnitine in a sow's diet increased pig and litter weight at birth, reduced the number of stillborn pigs, and increased litter size.

To our knowledge, two research groups have studied the effect of L-carnitine supplementation on performance parameters in gilts. The addition of dietary L-carnitine to gestation diets has not shown consistent performance on first-parity reproductive performance. Therefore, our objective in this study was to determine the effects of supplementing with L-carnitine through the developmental stages of gestation. We examined gilt weight, backfat, circulating IGF-I, and free and total L-carnitine at d 0, 40, 55, and 70 of gestation.

This experiment is part of a large, comprehensive study designed to evaluate the effects of L-carnitine on gilt reproductive performance, the IGF system in maternal tissues, fetal traits such as IGF gene expression in fetal myoblasts, and fetal muscle cell proliferation and differentiation.

Procedures

Animals and Feeding Protocol. All animal procedures used in this study were reviewed and approved by the Kansas State University Animal Care and Use Committee. Fifty-nine terminal gilts (PIC, Franklin, KY; L327 × 1050; BW = 303.6 lb) were artificially inseminated (PIC; MQ 280) 12, 24, and 36 h after the onset of the second observed estrus. Gilts were housed in individual gestation crates (7 ft × 22 in) in an environmentally controlled gestation barn at the Kansas State University Swine Teaching and Research Center. Gilts were allowed *ad libitum* access to water, and were randomly allotted to one of two dietary treatments and one of three harvesting dates (d 40, 55, or 70 of gestation) on the basis of weight at breeding. All gilts were fed a corn-soybean meal gestation diet (Table 1) once daily (3.86 lb/day), and received a 50 g top-dress containing either none (control, n = 30) or 88 mg (equivalent to approximately 50 ppm on an as-fed basis) of L-carnitine (Carniking 10 (10% of L-carnitine), n = 29; Lonza, Inc., Allendale, NJ) from d 1 until d 39, 54, or 69 of gestation. Last-rib backfat and weight were determined at breeding and at d 39, 54, and 69 of gestation. Blood was collected by veni-puncture 6 hr after feeding, for determination of circulating IGF-I and free and total L-carnitine, at d 0, 39, 54, and 69 of gestation.

Table 1. Diet Composition Fed During Gestation[a]

Item	Gestation Diet
Ingredient, %	
Corn	81.22
Soybean meal (46.5% CP)	14.55
Monocalcium P (21% P)	2.03
Limestone	1.05
Salt	0.50
Vitamin premix	0.25
Trace mineral premix	0.15
Sow add pack	0.25
Total	100.00
Calculated analysis	
Lysine, %	0.65
ME, kcal/lb	1,483
Protein, %	13.7
Ca, %	0.85
P, %	0.75
Available P, %	0.48

[a]Gestation feeding of 3.86 lb/d, with or without a top-dress providing 88 mg/d (equivalent to 50 ppm on an as-fed basis) added L-carnitine.

Statistical Analysis. Backfat, weight, and maternal blood concentrations of L-carnitine and IGF-I were compared by using the

MIXED procedure of SAS. Data were analyzed as repeated measures to include only the gilts harvested at d 70 of gestation (control, n = 10; L-carnitine, n = 10). The model included treatment as the fixed effect and day of sampling as the repeated measure. The Kenward-Roger adjustment was used to calculate the degrees of freedom. Significance was declared at $P<0.05$ unless otherwise noted.

Results and Discussion

No differences ($P>0.05$) between treatments were observed for BW, estimated protein mass, and estimated fat mass at any gestation length, although day of sampling was significant for these response criteria (Table 2; $P<0.0001$). At d 70 of gestation, there was a numerical increase ($P = 0.43$) in BW for the gilts fed L-carnitine, compared with that of gilts fed the control diet (L-carnitine = 375.5 lb vs. control = 366.6 lb). At d 40 of gestation, gilts fed L-carnitine tended to have greater ($P = 0.10$) backfat than did the gilts fed the control diet (L-carnitine = 17.9 mm vs. control = 16.3 mm), but no differences ($P>0.05$) were observed in backfat on day 0, 55, or 70 of gestation between dietary treatments. Backfat increased for gilts fed dietary treatments from d 0 to 55 gestation, but then decreased from d 55 to d 70 of gestation.

Maternal IGF-I concentrations decreased ($P<0.0001$) from d 0 to 70 of gestation for the gilts fed supplemental L-carnitine and those fed the control diet (Figure 1). No differences ($P>0.05$) were observed for maternal IGF-I collected at d 0, 40, 55, or 70 of gestation between the two treatments. No differences ($P>0.05$) were observed in total and free L-carnitine between the gilts fed L-carnitine and those fed the control diet at d 0 of gestation. Plasma total and free L-carnitine increased ($P<0.0001$) on d 40, 55, and 70 of gestation for gilts fed the L-carnitine top-dress (Figures 2 and 3).

Results of this study show that supplemental L-carnitine numerically increased gilt BW at d 70 of gestation, without a significant change in backfat. The underlying biochemical mechanisms are not clear, but the same trends have been observed in previous studies. One function of L-carnitine is to transport fatty acids to the inner mitochondrial membrane for β-oxidation, perhaps sparing more amino acids for protein deposition or providing additional energy to be used for intrauterine nutrient supply.

Previous research has shown that providing supplemental L-carnitine to sows increased circulating IGF-I. Pigs from the litters of these sows were heavier at birth. The role of IGF-I in normal growth and development has been well documented, and it plays an important role in muscle cell proliferation. Thus, the elevated levels of IGF-I may have improved muscling in these pigs. In contrast, other researchers have found no changes in circulating IGF-I in sows fed L-carnitine, when determined at d 55 of gestation, even though the litters from sows fed the L-carnitine were heavier. These researchers suggested that the heavier litter weights from sows fed L-carnitine were not due to increased maternal IGF-I. The results of the current study suggest that circulating IGF-I is similar for gilts fed supplemental L-carnitine and gilts fed diets without supplemental L-carnitine.

In conclusion, providing supplemental L-carnitine to gestating gilts increased maternal circulating total and free L-carnitine at each gestation day. This is beneficial because L-carnitine plays a role in protein synthesis, glucose homeostasis, and β-oxidation. At d 70 of gestation, L-carnitine supplementation resulted in numerically increased gilt BW. As gestation progressed, IGF-I decreased, but no treatment differences were observed in maternal IGF-I at any gestation length. Therefore,

any treatment differences in reproductive parameters may not be due to maternal IGF-I.

This experiment is one part of a large, comprehensive study designed to evaluate the effects of L-carnitine on litter characteristics such as weight, fetus number, and the IGF system. Also, the IGF system in tissues from the gilt placenta and the endometrium and myometrium from the gilt uterus will be examined to determine the effects of supplemental L-carnitine. Last, we will examine the effects of L-carnitine on IGF gene expression in fetal myoblasts and its effects on fetal muscle cell proliferation and differentiation.

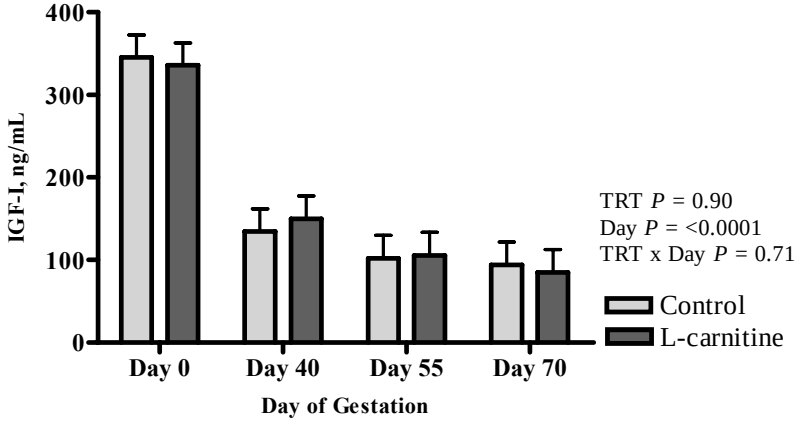

Figure 1. The Influence of Feeding Gilts L-carnitine on Serum IGF-I Concentrations.

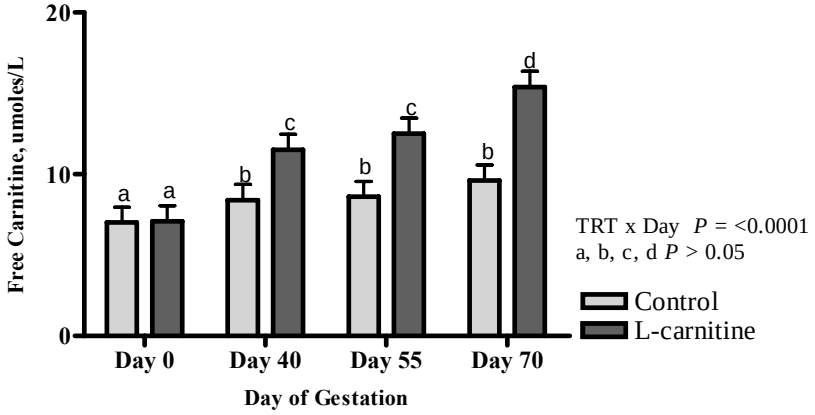

Figure 2. The Influence of Feeding L-carnitine to Gilts on Circulating Free Carnitine.

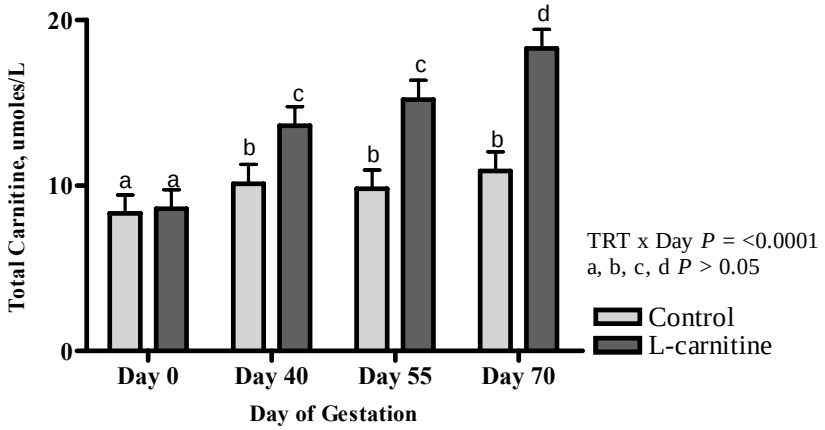

Figure 3. The Influence of Feeding Gilts L-carnitine on Circulating Total Carnitine.

Table 2. Effects of L-carnitine on Gilt Growth Characteristics[a]

Item	Control	L-carnitine	Probability, $P <$ Treatment	SE
No. of Gilts	10	10		
Weight, lb				
d 0	300.9	298.8	0.86	11.20
d 40	331.8	340.0	0.47	11.20
d 55	349.4	358.2	0.44	11.20
d 70	366.6	375.5	0.43	11.20
Estimated protein mass, lb[b]				
d 0	50.8	50.3	0.82	2.00
d 40	55.9	56.8	0.66	2.00
d 55	58.9	60.3	0.50	2.00
d 70	62.2	63.9	0.40	2.00
Backfat, mm				
d 0	15.0	15.2	0.83	0.95
d 40	16.3	17.9	0.10	0.95
d 55	16.7	17.2	0.60	0.95
d 70	15.9	15.4	0.60	0.95
Estimated fat mass, lb[c]				
d 0	60.2	60.2	0.99	2.86
d 40	68.7	72.9	0.16	2.86
d 55	73.2	76.0	0.34	2.86
d 70	75.9	77.4	0.61	2.86

	Trt	Day of Sample	Trt × Day of Sample
Weight, lb	0.58	<0.0001	0.11
Estimated protein mass, lb	0.64	<0.0001	0.20
Backfat, mm	0.30	0.0023	0.35
Estimated fat mass, lb	0.44	<0.0001	0.10

[a]d 0 to 70.
[b]Prediction equation from Dourmad et al. (1997), 2.28 + 0.178 (liveweight, lb) – 0.333 × (backfat, mm).
[c]Prediction equation from Dourmad et al. (1997), -26.40 + 0.221 × (liveweight, lb) + 1.331 × (backfat, mm).