Kansas Agricultural Experiment Station Research Reports

Volume 0
Issue 10 *Swine Day (1968-2014)*

Article 696

1997

# Effects of L-carnitine on performance of gestating and lactating sows

R E. Musser

K Q. Owen

S A. Blum

*See next page for additional authors*

# Effects of L-carnitine on performance of gestating and lactating sows


## Abstract

A total of 307 sows was used to determine the effects of adding 50 ppm of L-carnitine in gestation and lactation diets on sow and litter performance. Addition of 50 ppm L-carnitine in gestation increased both total litter (34.1 vs 32.1 lb) and pig (3.48 vs 3.27 lb) birth weight. Litter weaning weights increased (99.03 vs 90.71 lb) when sows were fed added L-carnitine during gestation. Sows fed added L-carnitine in gestation had increased IGF-I concentrations on d 60 and 90 (71.3 vs 38.0, and 33.0 vs 25.0 ng/ml, respectively). These results suggest that feeding 50 ppm of added L-carnitine during gestation increases litter birth and weaning weights.; Swine Day, Manhattan, KS, November 20, 1997



## Keywords

Swine day, 1997; Kansas Agricultural Experiment Station contribution; no. 98-142-S; Report of progress (Kansas State University. Agricultural Experiment Station and Cooperative Extension Service); 795; Swine; L-Carnitine; Gestation; Birth weight





## Authors

R E. Musser, K Q. Owen, S A. Blum, C A. Civis, Robert D. Goodband, Michael D. Tokach, Jim L. Nelssen, and Steven S. Dritz

# EFFECTS OF L-CARNITINE ON PERFORMANCE OF GESTATING AND LACTATING SOWS[1]

*R. E. Musser, R. D. Goodband M. D. Tokach[2], K. Q. Owen[3], J. L. Nelssen, S. A. Blum[3], S. S. Dritz[4], and C.A. Civis*


## Summary

A total of 307 sows was used to determine the effects of adding 50 ppm of L-carnitine in gestation and lactation diets on sow and litter performance. Addition of 50 ppm L-carnitine in gestation increased both total litter (34.1 vs 32.1 lb) and pig (3.48 vs 3.27 lb) birth weight. Litter weaning weights increased (99.03 vs 90.71 lb) when sows were fed added L-carnitine during gestation. Sows fed added L-carnitine in gestation had increased IGF-I concentrations on d 60 and 90 (71.3 vs 38.0, and 33.0 vs 25.0 ng/ml, respectively). These results suggest that feeding 50 ppm of added L-carnitine during gestation increases litter birth and weaning weights.


(Key Words: L-Carnitine, Gestation, Birth Weight.)

## Introduction

L-carnitine is involved in the transport of fatty acids across the mitochondrial membrane. Previous research at Kansas State University and the University of Georgia has demonstrated that the addition of L-carnitine to the diet decreases lipid accretion in weanling and growing-finishing pigs. L-carnitine also has been shown to affect several key enzymes involved in protein and lipid metabolism. Because of these effects on key metabolic enzymes, we speculated that L-carnitine may enhance productivity of the gestating and lactating sow. Therefore, the objective of this experiment was to determine if additional dietary L-carnitine during gestation and lactation would improve sow and litter performance during lactation.

## Procedures

A total of 307 sows (PIC C15 × 326) and the experiment was conducted from June to December, 1996 on a 1,400-sow commercial swine farm in Northeast Kansas. At breeding, sows were weighed and ultrasonically scanned (Renco, Minneapolis, MN) for last rib fat depth, then allotted to one of two dietary treatments. The gestation diet was formulated to contain .65% total lysine, .95% Ca, and .85% P, with all other amino acids, vitamins, and minerals in excess of NRC (1988) requirement estimates (Table 1). Sows were fed 4 lb/d of the control diet (no added carnitine) in a single feeding (8:00 am). Sows fed added carnitine were fed 3.5 lb of this same gestation diet, and the added L-carnitine (50 ppm) was supplied in an extra .5 lb/d topdressing of the same diet at the time of feeding. Sows were weighed and last rib fat depth was recorded on d 110 of gestation, at which time sows were moved to an environmentally regulated farrowing facility.

---

[1]The authors thank Rick Richards, Don Reeves, Michelle Walter, Angie Bruna, and Dale Keesecker of Keesecker Agribusiness, Washington, KS for use of animals, facilities, and data collection. We also thank Joe Loughmiller and Loree Burum for data collection and Lonza Inc., Fair Lawn, NJ for partial financial support.

[2]Northeast Area Extension Office.

[3]Lonza, Inc., Fair Lawn, NJ.

[4]Food Animal Health and Management Center, College of Veterinary Medicine.

At farrowing, sows were fed a diet formulated to contain 1.0% total lysine, .95% Ca, and .85% P, with or without 50 ppm of added L-carnitine. All other amino acids, vitamins, and minerals were in excess of NRC (1988) requirement estimates (Table 1). At farrowing, the numbers of pigs born live, stillborns, and mummies were recorded. Pigs were ear notched for identification and individual pig weight was recorded. All litters were equalized within dietary treatment by d 2 of lactation. Individual pig weight and number of pigs per litter were recorded at weaning (d 15), when sow weight and last rib fat depth were recorded. Sow feed intake was measured daily, then pooled to determine the average daily feed intake for 7-d intervals throughout lactation. After weaning, sows were monitored once daily with a boar for estrus. If a sow did not return to estrus within 35 d, she was culled. A standard culling program is used at this farm for age and genetic line. Subsequent farrowing rate, total number of pigs born, and number born alive also were determined.

**Table 1. Diet Composition (As-Fed Basis)**

| Ingredient % | Gestation[a] | Lactation[b] |
|---|---|---|
| Milo | 79.51 | 62.91 |
| Soybean meal, (46.5% CP) | 15.22 | 28.41 |
| Soybean oil | — | 4.00 |
| Monocalcium phosphate | 2.51 | 2.33 |
| Limestone | 1.11 | 1.12 |
| Salt | .50 | .50 |
| Sow premix | .25 | .25 |
| Vitamin premix | .25 | .25 |
| Trace mineral premix | .15 | .15 |
| Medication[c] | .20 | — |
| Vitamin E | — | .05 |
| DL-Methionine | — | .02 |

[a]Gestation feeding levels of 4 lb/d, with or without a topdressing providing 50 ppm added L-carnitine.
[b]Sows were provided ad libitum access to feed and water during lactation.
[c]Provided 50 g of oxytetracyline/ton of complete feed.

Sows were bled on d 10, 60, 90, and 110 of gestation and at weaning (d 15). Plasma samples were analyzed for concentrations of free and total carnitine, insulin, and unsulin-like growth factor-I (IGF-I). In addition, 15 pigs per treatment (no more than one pig per litter) were selected randomly and bled at weaning for analysis of plasma IGF-I and insulin.

Data were analyzed by analysis of variance using GLM procedure of SAS (1988). Treatments were arranged in a split-plot to determine the effects of additional L-carnitine in gestation diets on sow and litter weaning performance. The whole plot included the effects of feeding added L-carnitine during gestation and the subplot included the effects of feeding L-carnitine during lactation. Because of the randomized treatment structure, the split-plot analysis allowed for determination of effects of added dietary L-carnitine in gestation and/or lactation on sow and litter lactation performance. Sow weight and last rib fat depth at breeding were used as covariates to determine the effects of additional L-carnitine on sow weight and last rib fat depth change throughout gestation. Variation in pig birth weight within treatment was analyzed using Levene's test. Briefly, this calculated the residual for each observation (absolute value of the differences between the

actual pig birth weight and the litter mean birth weight). A smaller residual mean would indicate less variation of pig birth weight within the litter.

## Results

**Gestation Performance.** Sows fed 50 ppm of added L-carnitine had greater gains of weight ($P<.01$) and last rib fat depth ($P<.02$) during gestation (Table 2). At farrowing, feeding 50 ppm of added L-carnitine during gestation increased both pig ($P<.01$) and litter ($P<.05$) birth weight. However, no differences were observed in the variation of birth weights between litters from sows fed either treatment ($P>.10$).

No differences were observed in total numbers of pigs born, born live, or mummies; however, sows fed 50 ppm of added L-carnitine during gestation had a decreased number of stillborn pigs per litter (.49 vs .76 pigs/litter; $P<.02$). The differences in number of stillborn pigs did not affect the total number of pigs born alive.

**Lactation Performance.** Split-plot analysis of the effects of added L-carnitine during gestation on weaning performance indicated increased pig and litter weaning weight for sows fed L-carnitine compared with sows fed the control diet during gestation ($P<.03$ and $P=.08$; respectively, Table 3). Gains of both pig and litter weights throughout lactation tended ($P=.03$ and $P=.12$, respectively) to be increased by feeding L-carnitine during gestation.

Sows fed L-carnitine in gestation were heavier at weaning compared to control sows ($P<.01$; Table 4). No differences were observed in last rib fat depth at weaning ($P>.05$). The addition of 50 ppm of added L-carnitine to the gestation diet had no effect on the subsequent total number of pigs born, but increased the number of pigs born live ($P<.05$; Table 5). No differences were observed in subsequent days to estrus or farrowing rate ($P>.10$).

No differences ($P<.10$) were observed in either sow or litter performance as a result of feeding 50 ppm of added L-carnitine during lactation.

**Plasma Analysis.** Plasma insulin concentrations were increased on d 10 and 60 of gestation in sows fed L-carnitine compared with control sows ($P=.07$). Concentrations of IGF-I were increased on d 60 and 90 in sows fed added L-carnitine ($P<.05$). No differences were observed in plasma insulin or IGF-I in blood samples collected from pigs at weaning ($P>.10$).

Plasma free-carnitine concentrations were increased ($P<.05$) on d 60 and 90 of gestation, with sows fed L-carnitine having higher concentrations compared to control sows. Total plasma carnitine concentrations tended to be numerically increased after d 10 of gestation, with the greatest increase observed on d 90 ($P<.02$).

## Discussion

These results suggest that the addition of L-carnitine to gestation diets may improve feed efficiency of the sow, as indicated by the increase in body tissue reserves. The increased pig weights may result from improved nutrient utilization, as suggested by the increased weight and backfat depth observed. The increase in sow weight and last rib fat depth gain in gestation could be influenced by the role of L-carnitine on beta-oxidation. Cooperative research between Kansas State University and Oklahoma State University reported that increasing dietary L-carnitine resulted in increased fatty-acid oxidation in finishing pigs. The increase in beta-oxidation may allow for enhanced lipid utilization, possibly sparing glucose.

Our results suggest that dietary L-carnitine fed during gestation increases both insulin and IGF-I in the sow. Other research has indicated that insulin and IGF-I may increase secondary muscle fibers in the fetal pig and that IGF-I may play a role in myogenic differentiation and proliferation. However, further research is necessary to confirm the mode of action by which dietary L-carnitine may increase pig and litter birth weights. Additional research is needed to

determine the effects of various inclusion rates of L-carnitine to the gestating sow diet on fetal development. Further research also is needed to determine the mode of action and confirm the increase in subsequent litter size.

**Table 2. Effects of L-Carnitine on Gestation Performance**

| Item | Control | Carnitine | SEM | P< |
|---|---|---|---|---|
| No. sows | 155 | 153 | | |
| Total born per litter | 11.28 | 11.11 | .26 | .62 |
| Born live per litter | 10.36 | 10.47 | .24 | .73 |
| Stillborns per litter | .761 | .490 | .09 | .02 |
| Mummies per litter | .168 | .144 | .04 | .64 |
| Average sow parity | 3.81 | 3.67 | .13 | .42 |
| Litter birth weight, lb | 32.07 | 34.13 | .70 | .04 |
| Pig birth weight, lb | 3.27 | 3.48 | .05 | .01 |
| Residual birth weight per pig, lb | .64 | .66 | .01 | .12 |
| Sow weight, lb | | | | |
| breeding | 403 | 407.2 | 5.31 | .58 |
| d 110[a] | 506.9 | 526.5 | 1.87 | .01 |
| change[a] | 102.5 | 122.1 | 2.28 | .01 |
| Sow last rib fat depth, mm | | | | |
| breeding | 15.9 | 15.8 | .29 | .75 |
| d 110[b] | 17.5 | 18.4 | .25 | .02 |
| change[b] | 1.7 | 2.6 | .25 | .02 |

[a]Analyzed with sow weight at breeding as the covariate.
[b]Analyzed with sow last rib fat depth at breeding as the covariate.

**Table 3. Effects of L-Carnitine on Lactation Performance**

| Item | Gestation: Lactation: | Dietary Treatment: Control Control | Control Carnitine | Carnitine Control | Carnitine Carnitine | SEM | Probability (P<): Gest | Lact | Gest. × Lact. |
|---|---|---|---|---|---|---|---|---|---|
| No. sows | | 75 | 75 | 86 | 58 | | | | |
| Parity | | 3.72 | 3.82 | 3.64 | 3.77 | .13 | .63 | .43 | .92 |
| Lactation length, d | | 15.7 | 15.9 | 15.3 | 15.7 | .16 | .15 | .30 | .62 |
| Pigs equalized by d 2 | | 9.98 | 10.09 | 10.20 | 10.01 | .32 | .85 | .91 | .67 |
| Litter birth weight, lb | | 31.50 | 32.73 | 34.46 | 34.49 | .98 | .03 | .55 | .57 |
| Pig birth weight, lb | | 3.22 | 3.32 | 3.45 | 3.53 | .06 | .01 | .17 | .81 |
| Pigs weaned per litter[a] | | 8.91 | 8.89 | 9.02 | 9.00 | .31 | .76 | .96 | .99 |
| Survivability, %[a] | | 89.57 | 86.08 | 86.87 | 90.45 | 1.84 | .69 | .98 | .10 |
| Litter weight at weaning, lb | | 90.71 | 91.91 | 97.69 | 99.03 | 3.41 | .07 | .75 | .99 |
| Pig wean weight, lb | | 10.33 | 10.38 | 10.94 | 10.99 | .18 | .01 | .79 | .99 |
| Litter weight gain, lb | | 58.69 | 58.59 | 62.83 | 64.25 | 2.71 | .12 | .84 | .81 |
| Pig weight gain, lb | | 7.08 | 7.11 | 7.52 | 7.45 | .15 | .03 | .91 | .76 |
| Average daily feed intake, lb | | | | | | | | | |
| wk 1 | | 11.70 | 11.55 | 11.52 | 11.88 | .19 | .73 | .64 | .28 |
| wk 2 | | 14.35 | 14.41 | 14.70 | 14.87 | .21 | .11 | .64 | .84 |
| overall | | 13.22 | 13.01 | 13.16 | 13.58 | .17 | .20 | .63 | .12 |

[a]Analyzed with pigs per litter on d 2 as the covariate.

**Table 4. Effects of L-Carnitine on Sow Body Condition during Lactation**

| Item | Gestation: Lactation: | Dietary Treatment: Control Control | Control Carnitine | Carnitine Control | Carnitine Carnitine | SEM | Probability (P<): Gest | Lact | Gest. × Lact. |
|---|---|---|---|---|---|---|---|---|---|
| No. sows | | 75 | 75 | 86 | 58 | | | | |
| Sow weight, lb | | | | | | | | | |
| d 110 | | 503.1 | 507.2 | 526.9 | 535.0 | 6.74 | .01 | .43 | .79 |
| weaning | | 493.0 | 488.2 | 511.0 | 524.9 | 7.36 | .01 | .61 | .29 |
| change during lactation | | -6.05 | -6.97 | -12.44 | -11.82 | 3.16 | .14 | .97 | .85 |
| Sow last rib fat depth, mm | | | | | | | | | |
| d 110 | | 17.54 | 17.55 | 18.36 | 17.31 | .48 | .58 | .32 | .31 |
| weaning | | 16.25 | 16.44 | 18.36 | 16.12 | .51 | .13 | .09 | .05 |
| change during lactation | | -1.34 | -.72 | .09 | -1.24 | .48 | .42 | .54 | .09 |



**Table 5. Effects of L-Carnitine on Subsequent Reproductive Performance**

| Item | Gestation: Lactation | Dietary Treatment: Control Control | Control Carnitine | Carnitine Control | Carnitine Carnitine | SEM | Probability (P<): Gest | Lact | Gest × Lact |
|---|---|---|---|---|---|---|---|---|---|
| No. sows | | 47 | 44 | 55 | 37 | | | | |
| No. sows removed[a] | | 28 | 31 | 31 | 21 | | | | |
| Days to estrus | | 5.28 | 5.82 | 6.11 | 5.37 | .38 | .64 | .80 | .12 |
| Farrowing rate, % | | 96.1 | 96.3 | 86.5 | 93.2 | .05 | .22 | .51 | .54 |
| Number total born | | 11.24 | 12.26 | 11.97 | 12.85 | .40 | .21 | .09 | .90 |
| Number born live | | 10.15 | 11.22 | 11.17 | 12.03 | 3.46 | .04 | .05 | .83 |

[a]Sows were removed for injury, no estrus by d 35, or age.

**Table 6. Effects of L-Carnitine on IGF-I and Insulin Concentrations[a]**

| Item | Control | L-Carnitine | SEM | P-Value |
|---|---|---|---|---|
| No. sows | 14 | 14 | | |
| Sow IGF-I, ng/ml | | | | |
| d 10 | 72.06 | 78.36 | 12.24 | .82 |
| d 60 | 37.95 | 71.25 | 8.17 | .01 |
| d 90 | 24.98 | 33.02 | 2.71 | .04 |
| Pig IGF-I at weaning[b] | 108.17 | 119.00 | 18.92 | .69 |
| Sow insulin, ng/ml | | | | |
| d 10 | 37.27 | 63.00 | 5.3 | .07 |
| d 60 | 51.38 | 81.67 | 11.0 | .07 |
| d 90 | 54.51 | 50.00 | 7.2 | .66 |
| Pig insulin at weaning[b] | 26.38 | 22.27 | 3.1 | .41 |

[a]Analysis of sows by gestation treatment.
[b]Analysis of plasma from 15 pigs at weaning from sows fed either control or additional L-carnitine throughout gestation and lactation.

**Table 7. Effects of L-Carnitine on Total and Free Carnitine Concentrations in Plasma**

| Item, | Control | L-Carnitine | SEM | P-Value |
|---|---|---|---|---|
| No. sows | 14 | 14 | | |
| Levels of free carnitine from sow plasma, nmol/ml | | | | |
| d 10 | 23.70 | 23.12 | 1.15 | .84 |
| d 60 | 15.30 | 19.16 | 1.27 | .01 |
| d 90 | 22.74 | 27.12 | 1.02 | .01 |
| d 110 | 29.29 | 30.97 | 1.54 | .42 |
| Levels of total carnitine from sow plasma, nmol/ml | | | | |
| d 10 | 27.60 | 26.32 | 1.38 | .70 |
| d 60 | 20.02 | 22.54 | 1.63 | .11 |
| d 90 | 26.63 | 31.29 | 1.24 | .02 |
| d 110 | 33.72 | 36.84 | 1.98 | .25 |