Effects of L-Carnitine Fed During Lactation on Sow and Litter Performance[1,2]

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ABSTRACT: Sows of differing parities and genetics were used at different locations to determine the effects of feeding added L-carnitine during lactation on sow and litter performance. In Exp. 1, sows (n = 50 PIC C15) were fed a lactation diet (1.0% total lysine, .9% Ca, and .8% P) with or without 50 ppm of added L-carnitine from d 108 of gestation until weaning (d 21). No differences in litter weaning weight, survivability, sow ADFI, or sow weight and last rib fat depth change were observed. Number of pigs born alive in the subsequent farrowing were not different ($P > .10$). In Exp. 2, parity-three and -four sows (n = 115 Large White cross) were used to determine the effect of feeding 0, 50, 100, or 200 ppm of added L-carnitine during lactation (diet containing .9% total lysine, 1.0% Ca, and .8% P) on sow and litter performance. No improvements in the number of pigs or litter weights at weaning were observed ($P > .10$). Sows fed added L-carnitine had increased weight loss (linear; $P < .04$), but no differences ($P > .10$) were observed in last rib fat depth change or subsequent reproductive performance. In Exp. 3, first-parity sows (n = 107 PIC C15) were fed a diet with or without 50 ppm of added L-carnitine during lactation (diet containing 1.0% total lysine). Sows fed added L-carnitine tended ($P < .10$) to have fewer stillborn and mummified pigs than controls (.42 vs .81 pigs). No differences were observed for litter weaning weight, survivability, or subsequent farrowing performance. Feeding 50 to 200 ppm of added L-carnitine during lactation had little effect on sow and litter performance.

Key Words: Sows, Carnitine, Lactation

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Introduction

L-carnitine is required for transport of long-chain fatty acids into the mitchondrial matrix for β-oxidation (Borum, 1983). Carnitine can be synthesized in the body through a metabolic process using several cofactors such as protein-bound lysine and methionine, three vitamins (ascorbate, niacin, and vitamin B_6), and a metal ion (reduced iron) (Borum, 1983). Carnitine is an essential nutrient for newborns (Coffey et al., 1991), and sow's milk normally has an adequate supply to help establish normal tissue levels.

Research on the effects of added L-carnitine in lactation diets has been limited and has used lactation lengths longer (28 to 35 d) than those used in commercial operations (21 d or less) in North America. Fremaut et al. (1993) conducted two experiments (35 d lactation) and observed increased pig survivability when sows were fed 250 mg/d of added L-carnitine compared with control sows (93.9 vs 91.4% and 87.2 vs 84.3%). They also observed a slight increase in the number of pigs born alive (11.7 vs 11.4) when sows were fed 250 mg/d of added L-carnitine from 10 d before farrowing until weaning. Added L-carnitine (50 ppm) fed 4 wk prior to farrowing until weaning (d 35) resulted in increased number of pigs born alive (12.1 vs 11.8) and pig weight gain (244 vs 218 g/d) compared with litters from control sows (Harmeyer, 1993). Our objective was to determine whether the differences in litter weaning weights would be repeatable in sows lactating for 16 to 26 d.

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Table 1. Diet composition, (as-fed basis)

Ingredient, %[ab]	Exp. 1	Exp. 3
Corn	68.10	—
Sorghum	–	62.92
Soybean meal (46.5% CP)	27.57	28.41
Soybean oil	—	4.00
Monocalcium phosphate	2.05	2.33
Limestone	1.13	1.12
Salt	.50	.50
Sow vitamin premix[c]	.25	.25
Vitamin premix[d]	.25	.25
Trace mineral premix[e]	.15	.15
Vitamin E premix[f]	—	.05
DL-Methionine	—	.02

[a]Sows were provided ad libitum access to diet (meal form), with or without 50 ppm of added L-carnitine during lactation.

[b]The lactation diet was formulated to 18.74% CP, 1.0% lysine, .9% Ca, and .8% P.

[c]Supplied per kilogram of diet: 386 mg of choline, .22 mg of d-biotin, and 1.65 mg of folic acid.

[d]Supplied per kilogram of diet: 11,025 IU of vitamin A, 1,654 IU of vitamin D_3, 44.1 IU of vitamin E, 4.4 mg of menadione sodium bisulfite, 8.3 mg of riboflavin, 28.7 mg d-pantothenic acid (as d-calcium pantothenate), 49.6 mg of niacin, 165.4 mg of choline, and .03 mg of vitamin B_{12}.

[e]Supplied per kilogram of diet: 39.7 mg of Mn (oxide), 165.4 mg of Fe (sulfate), 165 mg Zn (oxide), 16.5 mg of Cu (sulfate), .30 mg of I (as Ca Iodate), and .10 mg of Se (as Na selenite).

[f]Supplied 22.05 IU per kg of complete diet.

Materials and Methods

We conducted three studies using sows of differing parities and genetics at different locations and under various management and facility systems. The experiments were conducted under the guidelines of animal care and handling procedures used by the individual facilities.

Experiment 1. Second-parity sows (n = 50 PIC C15) were used at the Kansas State University Swine Teaching and Research Center from August through September 1995. During gestation, sows were housed in outdoor dirt lots and fed 1.8 to 2.3 kg/d of feed (based on body condition) in individual stalls. The sorghum-soybean meal-based gestation diet contained .65% total lysine, .90% Ca, and .80% P. On d 108 of gestation, sows were placed in an environmentally regulated farrowing facility until weaning (d 21). Sows were housed in farrowing crates (2.1 × .6 m) with an area (2.1 × .6 m) on either side of the crate for the pigs. Temperature was maintained at a minimum of 20°C, and heat lamps were provided for the pigs. Sows were farrowed in two groups approximately 30 d apart, and, within each group, all sows farrowed over a 7-d period. On d 108 of gestation, sows were allotted randomly to a lactation diet (1.0% total lysine, .9% Ca, and .8% P; Table 1) with or without 50 ppm of added L-carnitine, and feed intake was measured daily. On d 108 of gestation and at weaning, sow BW and last rib fat depth were measured. Last rib fat depth was measured with real-time ultrasound (Aloka 210; Corometrics Medical Systems, Wallingford, CT) 6 cm off the midline at the 10th rib. Individual pig weight and number of pigs born alive, mummified, and stillborn per litter were recorded at farrowing. All litters were equalized to at least nine pigs, within dietary treatment, by 48 h after farrowing. Litters were weighed on d 2, 7, 14, and 21 (weaning) to determine weight gain. After weaning, sows were monitored once daily for estrus with a boar. Sows exhibiting estrus were mated, whereas sows not returning to estrus within 10 d were culled. Sows were housed in gestation crates (2.13 × .61 m) and fed 1.8 to 2.2 kg of feed (based on body condition) until farrowing. Subsequent farrowing data were collected to determine effects on total number of pigs born and born alive.

A subsample of 12 sows per treatment was bled via venipuncture 2 h after eating on d 16 ± 2 d; 10 mL of blood was collected into heparin-bound tubes and centrifuged at 4,000 × *g* for 20 min for plasma extraction. The analysis of plasma carnitine levels used [^{14}C]acetyl coenzyme A in the presence of the enzyme carnitine acetyl transferase (Parvin and Pandle, 1977). This enzyme is specific for the L isomer of carnitine. The residual-labeled acetyl CoA was removed using a Dowex anion exchange column, and labeled acetyl carnitine was measured using a liquid scintillation analyzer. Free carnitine was measured directly in untreated plasma. Total carnitine was measured in plasma that had been subjected to heat and alkaline pH to hydrolyze the carnitine from acyl carnitine. Estrified carnitine was calculated as the difference between total and free carnitine.

Also on d 16, milk samples were collected from the same 12 sows per treatment for analysis of composition and carnitine concentration. Sows were separated from litters for a minimum of 30 min before milking. A total of 100 mL of milk was collected, half from the first gland on each side of the sow. Milk samples were analyzed within 48 h for milk fat, CP, DM, ash, and lactose. Milk fat was determined with the Monjonnier procedure, and CP (N × 6.38), DM, and ash were determined with procedures for milk samples (AOAC, 1990). Milk lactose concentration was calculated by subtracting the DM for CP, ash, and fat from the total DM. Carnitine analysis of the milk was conducted with the same procedure used for plasma analysis (Parvin and Pande, 1977).

Experiment 2. The second study was conducted from February through March 1996 at the research facility of Bunge Meats Ltd., Carowa, NSW, Australia. Parity-three and -four sows (n = 115 Large White cross) were used to determine the effects of feeding 0, 50, 100, or 200 ppm of added L-carnitine on sow and litter performance. Sows were delivered to the farrowing facility on d 107 of gestation and allotted randomly to dietary treatment. From d 107 until farrowing, sows were fed 2 kg/d of the control lactation diet formulated to contain .9% total lysine, 1.0% Ca, and .8% P (Table 2). All other amino acids, vitamins, and minerals were calculated to be in excess of NRC (1988) requirement

Table 2. Diet composition, Exp. 2 (as-fed basis)

Ingredient	Percentage[ab]
Wheat (11.0% CP)	43.52
Barley (10.5% CP)	17.07
Lupin kernels (34.0% CP)	10.00
Wheat midds	12.50
Soybean meal (48.0% CP)	4.00
Meat meal	8.37
Fish meal (67.0% CP)	1.00
Water	1.00
Tallow	1.80
Salt	.29
Limestone	.20
L-Lysine-HCl	.09
DL-Methionine	.01
Vitamin and mineral premix[c]	.15

[a]Sows were provided ad libitum access to diet (meal form), with 50, 100, or 200 ppm of added L-carnitine during lactation.
[b]The lactation diet was formulated to 17.92% CP, .90% lysine, 1.0% Ca, and .81% P.
[c]Supplied per kilogram of diet: 200 mg of choline, .20 mg of d-biotin, .50 mg of folic acid, 15,000 IU of vitamin A, 3,000 IU of vitamin D_3, 80 mg of vitamin E, 2.0 mg of menadione sodium bisulfite, 3.5 mg of riboflavin, 10.0 mg d-pantothenic acid (as d-calcium pantothenate), 15.0 mg of niacin, .02 mg of vitamin B_{12}, 55 mg of Mn (oxide), 80 mg of Fe (sulfate), 75 mg Zn (oxide), 20 mg of Cu (sulfate), 1.0 mg of I (as Ca Iodate), and .20 mg of Se (as Na selenite).

estimates. At parturition, sows were divided into four groups and fed diets containing three levels of L-carnitine or the control diet until weaning (26 d). Litter birth weight and number of pigs born alive, mummified, or stillborn per litter were recorded. Sows were fed four to five times daily and were provided ad libitum access to water. Feed intake was recorded daily. Pigs were weighed and counted on d 2, 7, 14, 21, and 26 for determination of weight gain and survivability throughout lactation. Sows were monitored for estrus after weaning with a boar. The weaning-to-estrus interval was determined, and subsequent farrowing performance data were collected.

Experiment 3. This experiment was conducted from June through December 1996 on a commercial swine farm in North Central Kansas. First-parity sows (n = 107 PIC C15) were used. Sows were housed during gestation in pens and group-fed an average of 1.81 kg/d of gestation diet (.65% total lysine, .95% Ca, and .85% P). On d 112 of gestation, sows were weighed and ultrasonically scanned (Renco, Minneapolis, MN) for last rib fat depth then moved to crates (1.52 × 2.13 m) in an environmentally regulated farrowing facility and randomly allotted to lactation treatments. From d 112 of gestation to farrowing, sows were fed 1.81 kg/d of their designated lactation diet, formulated to contain 1.0% total lysine, .95% Ca, and .85% P (Table 1), with or without 50 ppm of added L-carnitine. All other amino acids, vitamins, and minerals were calculated to be in excess of NRC (1988) requirement estimates.

At farrowing, the numbers of pigs born alive, mummified, and stillborn per litter were recorded. Individual pig weight was recorded at birth and weaning. Litters were equalized within dietary treatment to at least 10 pigs within 48 h.

During lactation, sows were fed three times daily. Sow feed intake was recorded daily. After weaning at d 16, sows were monitored once daily with a boar for estrus detection. If a sow did not return to estrus within 35 d, she was culled. Subsequent farrowing rate (not including culled sows), total number of pigs born, and number born alive also were determined.

Diet Analysis. In all experiments, diet samples were collected and analyzed (Table 3) for free carnitine concentration (Parvin and Pandle, 1977). Briefly, free carnitine was measured from a neutralized perchloric acid extract from finely ground feed samples. Each sample was extracted twice, each extract was analyzed for free carnitine three times, and the values were averaged. The allowed variation for this procedure is 10%. Analyzed values were similar to calculated L-carnitine concentrations with the exception of Exp. 1, for which the analyzed value was 38 ppm rather than the expected 50 ppm of L-carnitine.

Statistical Analysis. In all experiments, sow was considered the experimental unit. Data were analyzed using the GLM procedure of SAS (1988). In Exp. 1 and 2, farrowing group or room was used as a block. The analysis of sow BW and last rib fat depth at weaning and change during lactation used BW and last rib fat depth at farrowing as covariates. Litter and pig birth weights were used as covariates for weaning weights and weight gain during lactation. Lactation length was used as a covariate for number of pigs weaned, survivability, pig and litter weaning weights, sow ADFI, and sow weight and last rib fat depth change. Analysis of the subsequent number of pigs born alive used the number of pigs born alive in the prior farrowing as a covariate.

In Exp. 2, the coefficients for orthogonal polynomials were derived using the IML procedure of SAS (1988). The coefficients were determined for the analysis of unevenly spread L-carnitine concentrations.

Table 3. Analyzed free carnitine concentrations in diets[a]

Added L-carnitine, ppm	Total carnitine, ppm
Exp. 1[b]	
0	6.8
50	38.7
Exp. 2[c]	
0	17.2
50	57.5
100	115.3
200	182.1
Exp. 3[d]	
0	4.7
50	51.3

[a]Diets analyzed using the method of Parvin and Pande (1977).
[b]Values represent the mean of three samples analyzed in duplicate.
[c]Values represent the mean of one sample analyzed in duplicate.
[d]Values represent the mean of two samples analyzed in duplicate.

Results

Experiment 1. Feeding 50 ppm of added L-carnitine from d 108 of gestation until weaning had few positive effects ($P > .10$) on sow and litter performance (Table 4). Sows fed added L-carnitine during lactation had fewer pigs on d 14 ($P < .04$) than control sows, with no differences at weaning ($P > .10$). However, sows fed added L-carnitine tended to have more total pigs (born alive, stillborn, and mummified pigs; $P < .07$) and pigs born alive ($P < .11$) than control sows. Because treatments were initiated on d 108 of gestation and the differences seemed to be the result of increased total pigs born rather than a change in stillborns, we believe this response was not treatment-related and is due to chance. No differences ($P > .10$) were observed in pig weight at birth or weaning or in sow weight at farrowing or weaning. Neither number of pigs weaned nor survivability was affected ($P > .10$) by feeding 50 ppm of added L-carnitine during lactation. An increase in sow ADFI was observed in the first week of lactation ($P < .08$), but no differences were found thereafter ($P > .10$). Number of pigs born alive in the subsequent farrowing were not different ($P > .10$).

Analysis of sow's milk on d 16 (± 2 d) indicated sows fed added L-carnitine produced milk with higher concentrations of total carnitine ($P < .01$) and carnitine esters ($P < .04$) than control sows (Table 5). No significant differences were observed for milk fat, CP, DM, ash, or lactose between sows fed added L-carnitine and controls (Table 5). Analysis of lactating sow plasma indicated sows fed added L-carnitine had higher plasma concentrations of both total ($P < .09$) and free ($P < .03$) carnitine than control sows.

Experiment 2. No differences ($P > .10$) were observed in number of pigs born alive, stillborn, or mummified per litter (Table 6). Increasing L-carnitine decreased litter weights on d 14 (linear, $P < .02$) and 21 (linear, $P < .06$), but no differences were observed on litter weight ($P > .10$) at weaning. Number of pigs per litter and pig survival were not affected by dietary treatment ($P > .10$). No differences were observed in ADFI be-

Table 4. Effects of adding 50 ppm of L-carnitine to the lactation diet on sow and litter performance (Exp. 1)

	Added L-carnitine, ppm			
Item	0	50	$P <$	SEM
No. of sows	25	25		
Parity	2.0	2.0	.82	.12
Lactation length, d	21.4	21.9	.43	.47
No. of pigs per litter				
Total born	12.3	13.5	.07	.48
Born alive	11.5	12.5	.11	.42
Stillborn and mummified	.76	1.04	.41	.23
No. of pigs per litter				
d 2	11.4	11.8	.16	.24
d 7[a]	11.1	10.8	.19	.16
d 14[a]	10.9	10.3	.04	.23
Weaned[ab]	10.5	10.1	.27	.25
Pig survivability to weaning, %[ab]	90.6	87.9	.33	2.20
Litter weight, kg				
Birth	16.7	17.4	.39	.54
d 7[c]	27.0	25.8	.20	.73
d 14[c]	39.8	38.9	.62	1.46
Weaning[bc]	50.9	50.4	.85	1.91
Sow weight, kg				
d 108 of gestation	197	198	.79	2.80
Farrowing	181	183	.68	2.50
Weaning[b]	185	186	.59	1.50
Sow ADFI, kg/d				
Wk 1	4.99	5.28	.08	.12
Wk 2	5.63	5.73	.74	.20
Wk 3	5.27	5.54	.36	.21
Overall	5.36	5.51	.15	.07
Subsequent performance				
No. of sows (subsequent)[d]	15	17		
Pigs born alive per litter	10.8	12.3	.18	.80

[a]Data were analyzed using number of pigs on d 2 and parity as covariates.
[b]Data were analyzed using lactation length as a covariate.
[c]Data were analyzed using litter weight on d 2 and parity as covariates.
[d]Data were analyzed using number of pigs born alive in the prior litter as a covariate.

Table 5. Effects of adding 50 ppm of L-carnitine to the lactation diet on sow milk and plasma carnitine concentrations and milk composition (Exp. 1)

Item	Added L-carnitine, ppm			
	0	50	$P <$	SEM
No. of sows	12	12		
Milk carnitine concentrations, nmol/mL[a]				
Total	135.9	168.8	.01	8.1
Free	45.0	47.3	.79	5.9
Esters	90.9	121.5	.04	10.0
Plasma carnitine concentrations, nmol/mL[a]				
Total	9.68	11.30	.09	.64
Free	8.07	9.83	.03	.56
Esters	1.65	1.47	.67	.30
Milk composition, %				
Lipid	6.01	5.56	.26	16.1
DM	16.61	16.32	.41	5.0
CP	5.57	5.40	.44	9.4
Ash	.21	.21	.85	7.6
Lactose	4.81	5.15	.24	13.2

[a]Milk and plasma samples taken on d 16 (±2) of lactation.

tween dietary treatments (Table 6). Sows fed increasing L-carnitine lost more weight (linear, $P < .04$) during lactation, but last rib fat depth was unaffected.

The analysis of subsequent farrowing performance indicated no difference ($P > .10$) in the number of pigs born alive as a result of increasing L-carnitine fed during the previous lactation.

Experiment 3. Feeding 50 ppm of added L-carnitine to first-parity sows during lactation had no effect on sow and litter performance (Table 7). No differences were observed in number of pigs born alive or mummified per litter ($P > .10$). However, a trend was observed for fewer stillborn pigs from sows fed additional L-carnitine compared with controls ($P < .10$). Litter weight gain and number of pigs at weaning were not different for the two groups of sows. Sow weight and last rib fat depth changes throughout lactation were not different for sows fed added L-carnitine and control sows ($P > .10$; Table 7). Sows fed 50 ppm of added L-carnitine had lower ADFI ($P < .05$) the 1st wk of lactation than control sows.

Weaning-to-estrus interval was not different between sows fed added L-carnitine and control sows ($P > .10$; Table 7), nor were differences observed in the subsequent farrowing on the number of pigs born alive per litter ($P > .10$).

Discussion

Few differences in sow and litter performance were observed in response to the various additions of L-carnitine in lactation diets evaluated under differing sow parities and genetics, lactation lengths, and management systems. These findings contradict results of previous studies (Fremaut et al., 1993; Harmeyer, 1993), possibly because of differences such as feeding duration, lactation length, and dietary L-carnitine concentrations. When beneficial responses in litter performance from feeding L-carnitine were observed, sows were fed L-carnitine for at least 10 d, and usually 28 d, prior to farrowing (Fremaut et al., 1993; Harmeyer, 1993). We began feeding our experimental diets no more than 7 d prior to farrowing. This may be an important factor considering recent data from our laboratory (Musser et al., 1999) suggesting that feeding L-carnitine beginning on d 5 of gestation increases pig birth and weaning weights. Perhaps L-carnitine must be fed for a longer time (> 7 d) before farrowing to enhance milk production. A second hypothesis is that L-carnitine does not influence milk secretion, but rather, partitions nutrients to the fetus during gestation. We observed a decrease in stillborns in Exp. 3 but not in Exp. 1 (Exp. 2 began L-carnitine treatment at farrowing).

Longer lactation lengths and, therefore, a longer duration of L-carnitine addition may account for the benefits observed in litter performance by Harmeyer (1993) with sows that lactated for 35 d. Lactation periods in our study were 21, 26, and 16 d in Exp. 1, 2, and 3, respectively.

The concentrations of added L-carnitine were similar among the experiments, and the inclusion rate (50 ppm) was based on data with finishing pigs (Owen et al., 1993). Those authors observed that 50 ppm of added L-carnitine reduced backfat thickness and increased percentage muscling in finishing pigs. However, subsequent data have indicated a linear relationship in backfat and increases in carcass leanness with improvements up to 125 ppm of added L-carnitine (Owen et al., 1997). They speculated that a higher L-carnitine concentration was necessary because pigs in the latter study were approximately 20 kg heavier at slaughter than those in the first study. Possibly, we did not evaluate high enough additions of L-carnitine

to affect lactating sows, and this may warrant further investigation.

In Exp. 1, we observed a numerical increase in the subsequent number of pigs born alive per litter (10.8 vs 12.3 pigs; $P < .18$) when 50 ppm of added L-carnitine was fed during the previous lactation. However, Exp. 2 and 3 showed no such response. Musser et al. (1999) observed that the addition of added L-carnitine during gestation, lactation, or both increased the subsequent number of pigs born alive compared with control sows (11.2, 11.2, and 12.0 vs 10.2 pigs, respectively; $P < .05$). Earlier researchers (Fremaut et al., 1993; Harmeyer, 1993) did not measure the subsequent number of pigs born alive. The differences in the subsequent number of pigs born alive could result from increased insulin concentration during lactation related to dietary L-carnitine. Musser et al. (1999) observed that feeding 100 mg/d added L-carnitine to the gestating sow increased plasma insulin concentrations in early gestation. Increases in insulin might stimulate LH pulses (Rhodes et al., 1986; Britt et al., 1987; Booth, 1990) and increase ovulation rate. Cox et al. (1987) observed that administration of exogenous insulin (.1 IU/d) increased ovulation rate. The former study reported an increase in LH secretion with the infusion of insulin, resulting in increased ovulation rate. Caution must be

Table 6. Effects of increasing L-carnitine in the lactation diet on sow and litter performance (Exp. 2)

	Added L-carnitine, ppm				Probability ($P <$)		
Item	0	50	100	200	Linear	Quadratic	SEM
No. of sows	30	29	29	27			
Parity	3.3	3.4	3.5	3.6			.11
Lactation length, d	25.6	25.6	25.5	25.0	.30	.69	.48
Pigs born per litter							
Total born	12.7	11.5	12.5	12.9	.48	.30	.59
Born alive	12.0	10.6	11.6	11.7	.89	.28	.57
No. of pigs per litter							
d 2	11.03	11.00	10.86	10.86	.25	.91	.13
d 7[a]	10.72	10.47	10.75	10.58	.80	.75	.13
d 14[a]	10.50	10.42	10.39	10.38	.57	.79	.17
d 21[a]	10.28	10.25	10.34	10.16	.76	.68	.21
Weaning[ab]	10.20	10.05	10.29	10.11	.98	.93	.25
Survivability, %[ab]	92.40	90.35	94.78	92.52	.60	.95	2.20
Litter weight, kg							
d 2	20.8	19.3	20.4	18.8	.06	.91	.65
d 7[c]	31.6	31.0	30.5	30.4	.10	.63	.65
d 14[c]	49.4	47.9	46.8	45.9	.02	.87	1.29
d 21[c]	65.4	64.5	64.9	61.1	.06	.31	1.57
Weaning[bc]	74.4	76.0	75.0	72.2	.36	.24	2.22
Litter weight gain, kg/d[bc]	2.15	2.21	2.17	2.06	.34	.21	.09
Sow ADFI, kg							
Wk 1	5.35	5.04	5.61	5.43	.40	.76	.26
Wk 2	7.24	7.27	6.92	6.95	.24	.99	.27
Wk 3	7.52	7.63	7.27	7.11	.10	.54	.24
Overall[d]	6.92	6.82	6.80	6.65	.34	.91	.21
No. of sows	16	14	11	12			
Sow last rib fat depth change d 110 to weaning, mm[de]	–2.60	–3.61	–2.36	–2.46	.63	.58	1.0
Sow weight change d110 to weaning, kg[df]	–17.02	–15.35	–19.27	–31.03	.04	.15	3.6
No. of sows culled	7	11	16	11			
No. with subsequent performance[g]	23	18	13	16			
Born alive	12.4	10.6	11.5	11.3	.49	.33	.68
Born dead	1.04	.48	.89	1.81	.03	.09	.38

[a]Data were analyzed using number of pigs on d 2 and parity as covariates.
[b]Data were analyzed using lactation length as a covariate.
[c]Data were analyzed using litter weight on d 2 and parity as covariates.
[d]Data were analyzed using lactation length as a covariate.
[e]Data were analyzed using last rib fat depth at farrowing as a covariate.
[f]Data were analyzed using sow weight at farrowing as a covariate.
[g]Data were analyzed using the number of pigs born alive in prior farrowing as a covariate.

Table 7. Effects of adding 50 ppm of L-carnitine to the lactation diet on sow and litter performance (Exp. 3)

Item	Added L-carnitine, ppm 0	50	$P <$	SEM
No. of gilts	52	55		
Lactation length, d	15.65	16.13	.05	.08
No. of pigs per litter				
Total born	11.25	11.09	.76	.17
Born alive	10.40	10.64	.65	.17
Stillborns and mummies	.81	.42	.06	.15
No. of pigs per litter				
d 2	10.04	10.00	.81	.07
Weaned[a]	9.69	9.74	.71	.05
Survivability, %[a]	96.8	97.2	.79	.44
Litter weight, kg				
d 2	12.2	13.7	.01	.40
Weaning[b]	41.6	42.6	.31	.75
Overall gain[b]	28.7	29.7	.31	.75
Sow weight, kg				
d 110 of gestation	180.5	184.7	.35	3.27
Weaning[c]	177.4	175.1	.23	1.36
Change during lactation[cd]	–5.37	–7.69	.23	1.36
Sow last rib fat depth, mm				
d 110 of gestation	17.24	16.93	.66	.24
Weaning[e]	14.86	14.77	.87	.17
Change during lactation[de]	–2.24	–2.33	.87	.17
Sow ADFI, kg				
wk 1	4.64	4.31	.05	.12
wk 2	4.53	4.30	.21	.14
Overall[e]	5.10	4.96	.37	.12
No. of gilts for subsequent analysis	37	41		
Length to estrus, d	8.70	6.85	.15	4.00
Subsequent farrowing, no. of pigs[f]				
Total born	10.84	10.59	.67	.42
Born alive	10.27	10.04	.69	.41
Stillborn	.54	.46	.63	.13
Mummified	.02	.09	.27	.04

[a]Data were analyzed using pigs per litter at d 2 and lactation length as covariates.
[b]Data were analyzed using litter weight at d 2 and lactation length as covariates.
[c]Data were analyzed using gilt weight at d 112 of gestation and lactation length as covariates.
[d]Analyzed with lactation length as a covariate.
[e]Analyzed with gilt last rib fat depth at d 112 of gestation and lactation length as covariates.
[f]Data were analyzed using total number of pigs born and pigs born alive in prior farrowing as a covariate.

used with our results because of the shorter breeding interval and the low number of sows that were rebred. More research is needed to determine whether the increase in subsequent number of pigs born alive is repeatable.

Implications

The addition of 50, 100, or 200 ppm of L-carnitine to the lactation diet had little beneficial effect on sow or litter performance. Our results contradict previous European data, possibly because of feeding duration (21 d compared with approximately 2 mo) and lactation length (16 to 26 vs 35 d).

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