ADDITIONAL L-CARNITINE IN THE GESTATING SOW DIET IMPROVES CARCASS CHARACTERISTICS OF THE OFFSPRING[1]

R. E. Musser, S. S. Dritz[2], R. D. Goodband, M. D. Tokach[3], D. L. Davis, J. L. Nelssen, K. Q. Owen[4], R. E. Campbell, S. Hanni, J. S. Bauman[5], and M. Heintz[5]

Summary

A total of 232 sows was used to determine the effects of an additional 50 ppm of L-carnitine in the gestation diet on sow and offspring performance. No differences were observed in either the immediate or subsequent number of pigs born or born alive per litter (P>.10). No differences were observed in pig weight at birth, weaning, or d 60 of age. Muscle fiber analysis of newborn pigs indicated a tendency for a larger cross-sectional area of the semitendinosus muscle; increased primary (slow-twitch, red) fibers; and a higher ratio of primary to secondary fibers (fast-twitch, white). No differences were observed in the hot carcass weight, but loin depth and percentage lean were increased in offspring of sows fed L-carnitine during gestation. Therefore, although feeding L-carnitine during gestation had no effect on the number of pigs born, it improved carcass leanness of the offspring consistent with changes in muscle fiber characteristics. More research is needed to determine the optimum level of L-carnitine to use in the gestation diet.

(Key Words: L-Carnitine, Gestation, Muscle Development)

Introduction

L-carnitine affects several key enzymes involved in protein and lipid metabolism; therefore, it may enhance productivity of the gestating sow. Previous research has shown that added L-carnitine in the gestating sow diet increased maternal IGF-I concentrations on days 60 and 90 of gestation. Research also has shown that both IGF-I and insulin are key factors that influence muscle development in the fetal pig. Studies have focused on treatments that affect fetal muscle development because muscle fiber hyperplasia (increasing cell number) is completed by birth. European researchers have reported a correlation between muscle fiber number and ADG (average daily gain) from d 70 to 130. Therefore, this experiment was designed to determine the effect of adding 50 ppm L-carnitine to the gestating sow diet on the number of pigs born alive, fetal muscle development, and carcass characteristics of the offspring.

Procedures

The experiment was conducted on a 3,000 sow farrow-to-wean operation in southwest Minnesota and utilized 232 sows (PIC Line C22). Sows were assigned to treatment on d 1 of gestation. Sows were fed a gestation diet (.7% lysine, 1.0% Ca, and

[1]The authors thank Dave Logan, Linda Flanagan, Jay Schiebout, and Richard Feucht of Global Ventures, Inc., for their assistance in animal care, data collection, and partial funding and Lonza Inc., Fair Lawn, NJ, for partial funding.

[2]Food Animal Health and Management Center.

[3]Northeast Area Extension Office, Manhattan, KS.

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

[5]Global Ventures, I, Inc., Pipestone, MN.

.90% P; Table 1) with or without 50 ppm L-carnitine. Sows were fed 4 lb/d until day 100 of gestation, after which they were fed 6 lb/d until moved to the farrowing facility and dietary treatments ceased.

Table 1. Gestation Diet Composition[a]

Ingredient	Percent[b]
Corn	74.9
Soybean meal (46.5%)	15.6
Alfalfa meal	5.0
Other vitamin and trace mineral additions	4.5
Total	100.0

[a]Sows were fed 4 lb/d.

[b]Formulated to contain .7% lysine, 1.0% Ca, and .90% P.

At farrowing, the numbers of pigs born alive, stillborn, and mummified were recorded. A subsample (15 litters/treatment) were weighed at birth. Of the subsample, 181 pigs (4 per litter) were tagged and weighed at weaning and at the end of the nursery phase (42 lb). The third lightest gilt from 15 litters per treatment was euthanized, and the semitendinosus muscle was removed from the right side. This is one of few muscles in which the fibers run through the entire length, allowing for accurate counting by examining the muscle in cross-section. The muscle was weighed, and three sections (5 mm in depth and a complete cross-section of the muscle) were removed from the mid-belly of the muscle. Segments were placed on a piece of cork, covered with a protective coating, and snap frozen in isopentane that had been cooled on dry ice. Samples were stored in a ultralow freezer (-80°C) until analysis. Cross-sections (10 microns) were placed on a microscope slide and stained for myosin adenosine triphosphate (ATPase) activity. The procedure was optimized for our laboratory conditions and used a pre-incubation of pH 4.2 and ATP incubation of pH 9.4. Once staining was completed, images were taken at 400 X moving from the light side to the darker stained side of the semitendinosus (approximately 30 views). Images were captured with a Nipikon™ microscope with a 40 power lens and a 10 power optical with the Optimas™ system, then images were imported into Optimas™ 5.2 software program. Once images were saved, fibers were counted as primary (stained dark) and secondary (stained light) in the software program of Paintbrush™. Approximately 1 to 2% (3,000 to 5,000 fibers / pig) of the cross-section was counted (15 to 20 frames). After fibers were counted, an overall area of the cross-section was determined by an overhead view of the slide. Total fiber number was determined by multiplying the average number of primary and secondary fibers in each square mm by the overall area in sq mm of the muscle.

Pigs were ear notched at birth according to the maternal treatment in gestation and then were standardized across treatments. At weaning, pigs were mixed within sex and moved to offsite nurseries. Pigs were moved to finishing buildings at 60 days of age. As pigs reached market weight (270 lb), they were sorted and marketed by treatment and sex for a total of four different marketing groups (i.e., a load of barrows or gilts from each individual treatment). At the slaughter plant, experimental pigs were processed at the beginning of the day to decrease the potential variation in Fat-O-Meter™ measurements from operator fatigue. Individual carcass measurements were obtained on 1,256 pigs.

Data were analyzed using the GLM procedure of SAS. Sow was used as the experimental unit for the analysis of the farrowing data and parity as a covariate. The means for the subsequent farrowing performance were adjusted for both parity and the previous number of pigs born per litter. In the analysis of the muscle fiber data, sow was used as the experimental unit and one pig per sow. Analysis of both pig weight gain and carcass characteristics used pig as the experimental unit. The mean for hot carcass weight was adjusted with age at slaughter as the covariate. Hot carcass

weight was used as the covariate for the analysis of the remaining carcass characteristics.

Results and Discussion

No differences were observed in the initial or subsequent farrowing performance of sows fed supplemental L-carnitine (Table 2). Although previous research at Kansas State University observed increases in the number of pigs born alive per litter, no changes were observed in this experiment with regards to the number of pigs born, born alive, or born dead (stillborn and mummified) per litter (P>.10). No differences (P>.10; Table 2) were observed in pig weight at birth, weaning, or at the end of the nursery phase (d 60).

The analysis of the newborn pigs for muscle fiber number as an indicator of fetal muscle development showed trends (P = .15) for increased cross-sectional area of the semitendinosus muscle and increased number of primary (slow-twitch, red) fibers in the S.T. muscle (Table 3). A trend (P = .11) in changes of the secondary:primary fiber ratio also existed, indicating a possible change to a muscle with more primary (slow-twitch, red) fibers compared to control offspring.

Pigs from sows fed 50 ppm supplemental L-carnitine during gestation had less backfat (P<.01; Table 4), greater loin depth (P<.01), and a higher percentage lean (P<.01). No differences was observed in hot carcass weight (P>.10). A difference in age at slaughter was observed, with control pigs being 1.6 days younger on average; therefore, age was used as a covariate for hot carcass weight.

The results of this experiment indicated no difference in the number of pigs born in the subsequent farrowing. However, numerical trends existed for pigs from sows fed added L-carnitine to have increased semitendinosus muscle area and primary fiber numbers. Improvements were observed in the percentage lean and loin depth of the offspring from sows fed added L-carnitine during gestation and correspond to the changes in muscle fiber development observed at birth. More research is needed to help support the effect of L-carnitine on fetal muscle development and to determine the optimum level to add in the gestation diet.

Table 2. Effect of L-Carnitine Supplementation on Sow and Litter Performance

	L-Carnitine			
Item	0 ppm	50 ppm	SEM	P <
No. sows				
Average parity	2.73	2.75	.06	.77
Number of Pigs per Litter[a]				
Total born	12.93	12.41	.90	.25
Born alive	11.54	11.13	.92	.34
Born dead	1.38	1.29	.47	.69
Subsequent Number of Pigs per Litter[b]				
Total born	13.15	13.1	.92	.91
Born alive	11.60	11.29	.90	.48
Born dead	1.58	1.83	.52	.31
No. pigs	87	94		
Average Pig Weight, lb[a]				
Birth	3.40	3.56	.07	.15
Weaning	11.82	12.06	.43	.65
Nursery	43.04	40.78	1.22	.21
Nursery age, d	59.22	59.30	.49	.91
Birth to nursery ADG, lb/d	.67	.62	.02	.12

[a]Means were adjusted for parity by covariate analyses.
[b]Means were adjusted for parity and previous number born by covariate analyses.

Table 3. Effects of L-Carnitine Supplementation during Gestation on Fetal Muscle Fiber Development

Item	L-Carnitine 0 ppm	L-Carnitine 50 ppm	P <	SEM
No. of pigs	13	15		
Total fibers per mm^2	3913	3634	.45	264
Area per muscle, mm^2	112	128	.15	8.1
Total fibers per pig[a]	431,001	463,711	.43	31,155
Total primary fibers	39,609	47,664	.15	4,098
Total secondary fibers	391,367	417,150	.54	31,297
Secondary:Primary ratio	12.46	9.20	.11	1.43

[a]Represents total number of fibers located in the semitendinosus muscle of the pig.

Table 4. Effects of L-Carnitine Supplementation during Gestation on Offspring Carcass Characteristics

Item	L-Carnitine 0 ppm	L-Carnitine 50 ppm	P <	SEM
No. of pigs	671	585		
Age, d	178.0	179.6	.0001	.14
Hot carcass weight, lb[a]	193.6	193.0	.62	.76
10^{th} rib fat depth, mm[b]	18.44	17.83	.003	.15
Loin depth, mm[b]	57.0	59.37	.0001	.27
Percentage lean,%[b,c]	54.45	55.1	.0001	.102
Fat-free lean index[b,c]	49.4	49.69	.003	.073
New fat-free lean, lb[b,d]	110.21	111.22	.0001	.557
New fat-free lean percentage,%[b,e]	57.14	57.64	.0001	.09

[a]Means were adjusted for age at slaughter by covariate analyses.
[b]Means were adjusted for hot carcass weight by covariate analyses.
[c]Represents plant calculated values.
[d]Calculated as 17.2668 – 27.9344 * BF(in) + 3.5468 * LD(in) + 0.5449 * HCW(lb).
[e]Calculated as (lb FFL/HCW) * 100.