INTERACTIVE EFFECTS OF ADDED L-CARNITINE AND CHROMIUM PICOLINATE ON SOW REPRODUCTIVE PERFORMANCE [1]

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Summary

A total of 599 sows were used to determine the effects of added L-carnitine and/or chromium picolinate on reproductive performance. Experimental treatments were arranged in a 2 × 2 factorial with main effects of added L-carnitine (0 or 50 ppm) and chromium picolinate (0 or 200 ppb). Starting on the first day of breeding, sows were provided a daily top dress containing the carnitine and(or) chromium along with the standard gestation diet. Dietary treatments were administered daily through the initial gestation, lactation, and through a second gestation period (2 parities). During the first parity, there was a carnitine × chromium interaction ($P<0.01$) for first service farrowing rate. Added dietary chromium increased ($P<0.01$) first service farrowing rate, but not when carnitine was added. No differences ($P>0.05$) were observed in number of pigs born alive, still born, mummies, or total born in the first parity. Added dietary L-carnitine decreased ($P<0.05$) wean to estrus interval, and tended to increase ($P<0.08$) the number of sows in estrus by d 7. In the second parity, a tendency ($P<.08$) for a carnitine × chromium interaction was found for first service farrowing rate. Adding carnitine and chromium together in the diet increased first service farrowing rate compared to either product alone. Because of the change in wean-to-estrus interval and farrowing rate, feeding additional dietary carnitine and chromium increased ($P<0.04$) the percentage of sows that were weaned from parity 1 and farrowed in parity 2. When calculating the total number of pigs and number born alive based on all sows that were started on test, both added carnitine and chromium increased the number of pigs born and born alive. These results show that carnitine and chromium supplementation improved return-to-estrus interval and farrowing rate and, thus, total number born alive over two parities.

Introduction

Carnitine is a water soluble, vitamin-like compound that functions to transport fatty acids across the mitochondria membrane where they are processed to produce energy. However, carnitine may play a greater role in metabolism than just fatty acid transport. Recent studies have observed increases in the total number of pigs born and born alive by feeding L-carnitine during gestation or lactation.

Chromium is a trace mineral that is actively involved in the metabolism of carbohydrates, lipids, proteins, and nucleic acids in the body. Chromium potentiates insulin action by increasing the cellular uptake of glucose and intracellular carbohydrate and lipid metabolism. Studies have shown that feeding chromium in gestation and lactation increases number of pigs born alive, and some studies have observed increased farrowing rate. Because both of

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these nutrients influence sow reproductive performance, the objective of our study was to compare carnitine and chromium on sow reproductive performance. In addition, a second objective was to determine if the responses to carnitine and chromium were additive.

Procedures

This experiment was conducted on a commercial 1,500 sow farrow-to-wean operation in central Kansas and used 599 sows (PIC Line C22). Sows were started on test on the first day of breeding. Each sow remained on the same treatment through gestation, lactation, and through a second gestation period (2 parities). During gestation, all sows were fed a milo-soybean meal-based diet formulated to contain 0.65% lysine, 0.83 % Ca, and 0.76% P. In lactation, all sows were fed a grain sorghum-soybean meal-based diet formulated to contain 1.10% lysine, 0.90% Ca, and 0.80% P (Table 1). Dietary treatments were provided via a corn-based top dress fed at 30 g/d. The top dress was formulated to provide 90 mg/d and 250 mg/d carnitine in gestation and lactation, respectively. Chromium was provided at 360 mcg/d and 1,000 mcg/d during gestation and lactation, respectively. These inclusions were calculated to provide 50 mg/kg carnitine and 200 mcg/kg chromium when sows were fed 4 lb/d of the gestation diet and 11 lb/d of the lactation diet. The top dress was also color coded (1% died corncobs) by treatment to assure proper distribution of experimental treatments.

At farrowing, the number of pigs born alive (NBA), as stillborn (SB), as mummies (MUM), and total born (TB) were recorded. Sows were rebred after weaning (15 d lactation) and remained on the same treatment until farrowing a second litter. If a sow did not return to estrus within 18 days, she was taken off test. Sows that were bred at the start of the study, but were later found open, were taken off test when estrus was detected. Procedures and data collection were identical for the second gestation and lactation period. However, dietary treatments were not administered during the second lactation period.

Calculations were made to determine the total number per sow of pigs born, born alive, as stillborns, or as mummies for the two parities. Total number of pigs were calculated using only sows that initially farrowed, then completed the second parity, as well as calculated from all the sows that were actually started on test.

Data were analyzed using the MIXED procedure of SAS. Sow was the experimental unit for the analysis with parity, previous lactation length, and/or week of farrowing was a covariate (Table 2) for TB, NBA, MUM, and SB. A chi-square statistic was calculated to determine differences among treatments when analyzing percentage in estrus and farrowing rate.

Results and Discussion

In the first parity, a carnitine × chromium interaction ($P<0.01$) was observed for first service farrowing rate (Table 2). Added dietary chromium improved ($P<0.01$) first service farrowing rate, but there was no added benefit with adding carnitine. There were no differences ($P>0.10$) in the total number of pigs born, born alive, or born mummified. However, sows fed added chromium tended to have increased ($P<0.07$) number of stillborn pigs/litter. Adding dietary carnitine improved ($P<0.05$) wean to estrus interval and tended to increase ($P<0.08$) the number of sows in estrus by d 7.

In parity 2, a tendency ($P<.08$) for a carnitine × chromium interaction was found for first service farrowing rate of sows. Adding carnitine and chromium together in the diet increased first service farrowing rate, while adding either carnitine or chromium alone did not influence farrowing rate. Feeding additional dietary carnitine and chromium increased ($P<0.04$) the percentage of sows that were weaned from parity 1 and farrowed in parity 2. This calculation is a combination of the return to estrus interval and farrowing rate. In parity 2, there were no differences ($P<0.19$) among treatments for total number of pigs born, born alive, stillborn, or born mummified. There were also no differences (P>0.14) among treatments for wean to estrus interval or percentage of sows returning to estrus by d 7 or 18.

We then calculated the total number of pigs born, born alive, still born, and born mummified over the entire trial for those sows that completed parity one (123, 140, 138, and 142, for control, added carnitine, added chromium, and both, respectively). This calculation resulted in sows fed added carnitine having more (P<0.05) total pigs, and pigs born alive. A second calculation using all the sows that were started on test, showed that total pigs and pigs born alive were increased (P<0.02) for sows fed added carnitine, and(or) chromium. No carnitine × chromium interactions (P>0.10) were observed for these response criteria, suggesting that the response to carnitine and chromium are additive. It also suggests that the two nutrients may improve sow reproductive functioning by different mechanisms.

In conclusion, supplementing gestation and lactation diets with added carnitine and chromium had minimal effects on the number of pigs born alive per litter; however, the improvements in return-to-estrus interval and farrowing rate resulted in greater overall number of pigs born for the two parity studies. These data are novel in that they are the first to examine the effects of combining added carnitine and chromium on sow reproductive performance. These data suggest that improvements in reproductive performance from the two nutrients is additive and that carnitine and chromium appear to be working via different mechanisms to improve sow productivity.

Table 1. Common Diet Compositions[a]

Ingredient, %	Gestation[b]	Lactation[c]
Diet		
Grain sorghum	80.18	64.10
Soybean meal (46.5%)	15.68	31.75
Other vitamin and trace mineral additions[d]	4.04	4.15
Total	100.00	100.00
Top dress[e]		
Corn[f]	99.00	99.00
Corncobs[g]	1.00	1.00

[a]All sows fed similar basal diet.
[b]Sows were fed 4 lb/d during gestation; (0.7% lysine, 0.83% Ca, and 0.76% P).
[c]Sows were fed ad libitum during lactation; (1.0% lysine, 0.90% Ca, and 0.80% P).
[d]Provided 10,000,000 IU vitamin A, 1,500,000 IU vitamin D_3, 40,000 IU vitamin E, 4,000 mg menadione, 40 mg vitamin B_{12}, 9,000 mg riboflavin, 30,000 mg pantothenic acid, 50,000 mg niacin, 150 g zinc, 150 g iron, 36 g manganese, 15 g copper, 270 mg iodine, 270 mg selenium, 500,000 mg choline, 200 mg biotin, 1,500 mg folic acid, and 13,750 mg pyridoxine per ton of diet.
[e]Fed to sows at 30 g/d to disperse dietary treatments.
[f]L-carnitine and/or chromium replaced corn to achieve dietary supplementation of 90 mg/d carnitine in gestation, 250 mg/d carnitine in lactation, 360 mcg/d chromium in gestation, and 1000mcg/d chromium in lactation.
[g]Colored corncobs were added to distinguish treatments from one another.

Table 2. Effects of L-Carnitine and Chromium Picolinate on Reproductive Performance[a]

	Treatment					Probabilities, P<		
Item	Control	Carnitine[b]	Chromium[c]	Both[bc]	SEM	Carnitine	Chromium	Int.
First parity								
No. of sows								
Started on test	148	150	147	154				
Farrowed	123	140	138	142				
First service FR, %[dei]	82.9	91.9	95.5	92.2	2.38	0.22	0.01	0.01
No. of pigs								
Total born[e]	11.3	11.4	11.5	11.6	0.30	0.62	0.57	0.90
Born alive[e]	10.0	9.8	10.2	10.2	0.25	0.32	0.63	0.71
Still born[e]	0.95	0.98	1.26	1.13	0.130	0.68	0.07	0.52
Mummies	0.34	0.26	0.39	0.34	0.060	0.26	0.29	0.77
WEI, d[dgh]	4.9	4.6	4.7	4.5	0.01	0.05	0.23	0.75
% estrus by d 7[egi]	84.8	88.6	86.7	92.3	2.88	0.08	0.31	0.73
% estrus by d 18[egi]	88.1	91.5	91.7	94.4	2.49	0.20	0.17	0.89
Second parity								
No. of sows								
Weaned parity 1	123	140	138	142				
Bred by d 18	108	128	127	134				
Farrowed	87	104	102	122				
First service FR, %[degi]	81.2	81.3	79.7	91.1	3.49	0.07	0.20	0.08
Percent of weaned	70.7	73.9	74.3	85.9	3.81	0.04	0.03	0.24
No. of pigs								
Total born[eg]	11.1	11.2	11.0	11.4	0.37	0.50	0.94	0.81
Born alive[eg]	9.7	9.9	9.5	9.8	0.33	0.53	0.62	0.89
Still born[e]	1.02	1.02	1.09	1.31	0.149	0.43	0.19	0.45
Mummies	0.35	0.33	0.40	0.25	0.071	0.22	0.88	0.29
WEI, d[dgh]	4.6	4.7	4.6	4.8	0.01	0.14	0.94	0.46
% estrus by d 7[efgi]	80.3	76.9	81.0	75.0	4.32	0.23	0.88	0.75
% estrus by d 18 [efgi]	80.2	80.8	82.9	75.9	4.17	0.40	0.77	0.32
Total pigs per sow for sows that completed parity one								
Total born[eg]	19.4	19.8	19.5	21.3	0.59	0.04	0.15	0.25
Born alive[eg]	17.1	17.6	16.8	18.5	0.53	0.03	0.55	0.24
Still born[e]	1.7	1.7	2.1	2.3	0.19	0.46	0.01	0.66
Mummies	0.6	0.5	0.6	0.6	0.08	0.17	0.43	0.85
Total pigs per sow of all sows started on test for two parities								
Total born[eg]	15.8	18.4	18.8	19.7	0.71	0.01	0.003	0.24
Born alive[eg]	13.9	16.3	16.2	17.0	0.63	0.01	0.02	0.23
Still born[e]	1.4	1.6	2.0	2.1	0.17	0.35	0.002	0.94
Mummies	0.5	0.5	0.7	0.5	0.71	0.27	0.16	0.42

[a]Initially 599 sows bred. [b]50 mg/kg L-carnitine provided as top dress daily. [c]200 mcg/kg chromium picolinate provided as top dress daily. [d]FR = First service farrowing rate; WEI = wean to estrus interval. [e]Parity was used as a covariate; 6.0, 5.6, 5.2, and 5.5 for control, carnitine, chromium, and both, respectively. [f]Previous lactation length was used as a covariate; 15.2, 15.8, 15.7, and 15.4 for each treatment. [g]Week of year sow farrowed was used as a covariate; 23.6, 23.9, 23.7, and 23.9 for each treatment. [h]WEI analyzed as inverse of means, previous WEI analyzed as log of means. [i]P-values from chi-square statistic.