Dietary Carnitine and Chromium Improve Energy Status of Gestating Sows

Carnitine and chromium are both essential for proper energy metabolism in swine. Carnitine is a vitamin-like compound that is needed for the transport of long- and medium-chain fatty acids across the mitochondrial membrane for Vitamin B oxidation. Chromium is a trace mineral that is essential for activating specific enzymes and stabilizing proteins and nucleic acid. Chromium has been shown to improve insulin sensitivity and glucose uptake.

In experiments conducted over the past eight years, feeding sows a diet with either carnitine or chromium has been shown to improve sow reproductive performance, but only recently has an experiment been conducted to evaluate the effects when both are added to the diets fed to sows. In a previous Swine Update, we reported that when carnitine and/or chromium are added to diets of gestating sows, farrowing rate was improved with the greatest improvement observed from the diet containing both carnitine and chromium. We also observed that when the treatments were fed for two parities, more sows completed the entire test period and thus produced more pigs when fed diets with carnitine or chromium compared to control sows. Because both carnitine and chromium influence energy metabolism, these results suggest that associated improvements in reproductive performance may reflect enhanced energy status of the sows. In addition, an additive response may be observed from feeding both carnitine and chromium compared to control sows. Because both carnitine and chromium influence energy metabolism, these results suggest that associated improvements in reproductive performance may reflect enhanced energy status of the sows. In addition, an additive response may be observed from feeding both carnitine and chromium compared to control sows. Because both carnitine and chromium influence energy metabolism, these results suggest that associated improvements in reproductive performance may reflect enhanced energy status of the sows.

Procedures

A total of 44 sows (average birth weight=458 lb; parity=2.0) were used. Sows (PIC C-22) were randomly allotted to one of four dietary treatments based on parity and weight at initial breeding. Dietary treatments were corn-soybean meal-based and were formulated to meet or exceed National Research Council nutrient requirement estimates. Treatments were arranged in a 2 by 2 factorial design with main effects of dietary carnitine (0 or 50 ppm) and chromium (0 or 200 ppb). Sows were fed the experimental treatments starting at the initial breeding, through gestation, the following lactation, wean-to-breeding interval, and approximately 28 days into the subsequent gestation, at which time blood was collected. Sows were fed 4.5 pounds of gestation diet from breeding until day 100 of gestation, then 6.5 pounds until they farrowed. Lactation diet was fed ad libitum from farrowing until weaning.

Approximately five days before blood collection, the sows were fitted with indwelling cephalic vein catheters. Blood was collected from each sow at feeding – once every 15 minutes for the first 3 hours after feeding, and at 6, 9, 15, 20, and 24 hours after feeding – for a total of 18 collections from each sow. Samples were then analyzed to determine insulin, glucagon, glucose, insulin-like growth factor 1 (IGF-1), insulin-like growth factor binding protein-3 (IGFBP-3), non-esterfied fatty acids (NEFA), plasma urea nitrogen (PUN), glycerol, triglycerides, and leptin as indicators of energy status.

Results and Discussion

Both carnitine and chromium influenced the energy status of the sows in our experiment. Chromium had its greatest effect immediately after feeding by improving insulin sensitivity and glucose uptake, whereas carnitine had its greatest effect from six to 24 hours after the meal by improving fatty acid utilization and decreasing muscle breakdown. The most dramatic improvement in energy status occurred in the sows fed both carnitine and chromium because the benefits from both feed additives were realized.

Research has shown that chromium, as a component of the glucose-tolerance factor, will improve insulin sensitivity and consequently glucose uptake. In our study, sows fed diets containing chromium had lower glucose, insulin, and c-peptide concentrations compared to other sows. Insulin is the major anabolic hormone in the body, and rising insulin concentrations act as a signal for greater glucose uptake and overall energy storage. In our experiment, sows fed diets containing chromium had lower mean insulin concentrations compared to sows fed...
diets without chromium. We also observed that the food-induced glucose peak was lower for sows fed chromium, even though these sows also had lower insulin concentrations. This suggests that insulin sensitivity was enhanced and the uptake of glucose by peripheral tissue was more efficient. The fact that glucose was lower when sows were fed diets with chromium — even though all sows were fed the same amount of feed and consequently had the same amount of glucose intake — also supports our hypothesis that glucose uptake was enhanced.

We also observed that sows fed diets with chromium had higher IGF-1 and IGFBP-3 concentrations. Insulin-like growth factor binding protein 3 is the major binding protein of IGF-1 in swine and functions by binding free IGF-1, extending its half-life. The increase in IGF-1 and IGFBP-3 observed from feeding sows diets with carnitine could explain the improvements in offspring muscling previously observed.

Sows fed diets with carnitine also had higher leptin concentrations compared to other sows. Leptin acts as an energy abundance signal that is released from tissues such as adipose, placenta, and uterus. Leptin is needed for proper reproductive function in males and females. Increasing leptin in other animals has been shown to improve reproductive performance. Therefore, the improvements in reproductive performance previously observed from feeding sows carnitine may be explained by our finding that carnitine will increase circulating leptin.

Table 1. Influence of L-carnitine and(or) chromium picolinate on blood parameters

<table>
<thead>
<tr>
<th>Item</th>
<th>Carnitine, ppm</th>
<th>Chromium, ppb</th>
<th>0</th>
<th>50</th>
<th>0</th>
<th>200</th>
<th>200</th>
<th>SEM</th>
<th>Probability, P &lt;</th>
<th>Carn.</th>
<th>Chrom.</th>
<th>C x C</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-peptide of insulin</td>
<td>0.485</td>
<td>0.417</td>
<td>0.391</td>
<td>0.430</td>
<td>0.018</td>
<td>0.31</td>
<td>0.004</td>
<td>0.0001</td>
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<tr>
<td>Insulin, pmol/L</td>
<td>190.5</td>
<td>148.3</td>
<td>135.0</td>
<td>158.5</td>
<td>15.6</td>
<td>0.32</td>
<td>0.02</td>
<td>0.0004</td>
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<tr>
<td>Glucose, mmol/L</td>
<td>4.42</td>
<td>4.41</td>
<td>4.30</td>
<td>4.22</td>
<td>0.07</td>
<td>0.25</td>
<td>0.0006</td>
<td>0.42</td>
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<tr>
<td>NEFA, mmol/L</td>
<td>0.145</td>
<td>0.135</td>
<td>0.167</td>
<td>0.138</td>
<td>0.008</td>
<td>0.002</td>
<td>0.03</td>
<td>0.10</td>
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</tr>
<tr>
<td>IGF-1, nmol/L</td>
<td>14.34</td>
<td>17.91</td>
<td>14.08</td>
<td>15.12</td>
<td>0.97</td>
<td>0.11</td>
<td>0.28</td>
<td>0.37</td>
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<tr>
<td>Glucagon, pmol/L</td>
<td>30.95</td>
<td>30.84</td>
<td>32.85</td>
<td>30.81</td>
<td>1.24</td>
<td>0.33</td>
<td>0.39</td>
<td>0.37</td>
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<tr>
<td>Urea nitrogen, mmol/L</td>
<td>4.61</td>
<td>3.64</td>
<td>4.32</td>
<td>4.46</td>
<td>0.21</td>
<td>0.04</td>
<td>0.18</td>
<td>0.005</td>
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<tr>
<td>Glycerol, mmol/L</td>
<td>0.043</td>
<td>0.042</td>
<td>0.051</td>
<td>0.049</td>
<td>0.005</td>
<td>0.73</td>
<td>0.008</td>
<td>0.70</td>
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<tr>
<td>Triglyceride, mmol/L</td>
<td>0.263</td>
<td>0.277</td>
<td>0.276</td>
<td>0.276</td>
<td>0.026</td>
<td>0.60</td>
<td>0.69</td>
<td>0.61</td>
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<tr>
<td>IGFBP-3, nmol/L</td>
<td>4.70</td>
<td>4.86</td>
<td>4.72</td>
<td>5.40</td>
<td>0.23</td>
<td>0.06</td>
<td>0.19</td>
<td>0.22</td>
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<tr>
<td>Leptin, mg/L</td>
<td>0.80</td>
<td>1.84</td>
<td>1.12</td>
<td>1.22</td>
<td>0.38</td>
<td>0.02</td>
<td>0.56</td>
<td>0.06</td>
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</tbody>
</table>

*Values represent a total of 44 sows (BW = 208 kg; parity = 2.0) with 10 or 12 sows per treatment.

*Values represent the mean of samples collected at feeding, once every 15 minutes for the first 3 hours after feeding, and at 6, 9, 15, 20, and 24 hours after feeding.

*Values represent the mean of samples collected at feeding, 30 minutes, 1, 2, 6, and 20 hours after feeding.
Figure 1. Influence of L-carnitine and(or) CrP on insulin (pmol/L).

- Control > Carn.: P < 0.05.
- Control > others: P < 0.05.
- Carn./Chrom. > Carn.: P < 0.05.
- Control > Chrom.: P < 0.05.
- Carn. > Carn./Chrom.: P < 0.05.

Figure 2. Influence of L-carnitine and(or) CrP on glucose (mmol/L).

- Control > Carn./Chrom.: P < 0.05.
- Control > others: P < 0.05.
- Carn./Chrom. > others: P < 0.05.
- Control > Chrom.: P < 0.05.
- Carn. > Carn./Chrom.: P < 0.05.

Figure 3. Influence of L-carnitine and(or) CrP on NEFA (mmol/L).

- Chrom. > Carn.: P < 0.05.
- Chrom. > Carn./Chrom.: P < 0.05.
- Control > Carn. and Carn./Chrom.: P < 0.05.

Figure 4. Influence of L-carnitine and(or) CrP on plasma urea nitrogen (mmol/L).

- Control > Carn.: P < 0.05.
- Carn./Chrom. > Carn.: P < 0.05.
Swine UPDATE

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