NITROGEN METABOLISM OF GRAVID AND NONGRAVID FEMALE SWINE FED EVERY THIRD DAY

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Summary

Crossbred gilts were adapted for 40 d to a 12% crude protein corn-soybean meal gestation diet fed either as a single 1.9-kg meal every day (ED) or as an accumulated 5.7 kg meal every third day (E3D). In the first experiment the effect of meal frequency on N balance was evaluated using eight gravid gilts in a 12-d balance trial. Average N retention was greater (P<.08) for gilts fed ED (15.32 g/d) than for those fed E3D (12.64 g/d). Daily urinary N excretion showed a quadratic effect (P<.01) with the greatest N output occurring during the second 24-h period after the meal for gilts fed E3D. The effect of physiological state on the N metabolism response to E3D feeding was measured in a second experiment using four nongravid and four gravid gilts in a 12-d N balance experiment. Average daily N retention was greater (P<.04) for gravid gilts fed E3D (15.04 g) than for nongravid gilts fed E3D (11.82 g). Digestibility of N and energy was not affected (P>.10) by feeding regimen.

(Key Words: Meal Frequency, Swine, Every-Third-Day Feeding, Gestation, Nitrogen Metabolism.)

Introduction

Much attention has been given to the effect of meal frequency on energy metabolism in pigs, particularly in regard to adaptive changes in lipogenic activity (Allee et al., 1972) and glucose metabolism (Romsos et al., 1978). The effect of meal frequency on N metabolism has not been studied extensively. There is evidence that gluconeogenic activities affect the turnover rate of body protein (Schimke, 1962; Potter et al., 1968; Ogata et al., 1978). Moreover, meal size may have an influence on N digestibility (Parker and Clawson, 1967). Meal frequency is a practical question, given the current interest in every-third-day feeding programs for gravid swine.

Two N metabolism experiments have been reported in which gravid gilts were either fed daily or fed a quantity of feed equal to three times the daily meal, every third day. In one case (Allee and Meyer, 1973), every-third-day feeding resulted in a significant reduction in N retention; in the other (Michel, 1978), it did not. Reproduction studies have shown that first-litter gilts fed 5.7 kg of diet every third day during gestation weaned smaller pigs than those fed 1.9 kg of diet daily (Michel et al., 1980). Reduced piglet weight at weaning is often associated with inadequate amino acid nutrition of the dam during gestation (Mahan and Mangan, 1975).

The N metabolism experiments by Allee and Meyer (1973) and Michel (1978) used a switchback approach that allowed only 6 d for adjustment to the change in feeding program. The objective of our experiments was to measure the effect of every-third-day feeding on N balance following a 40-d adaptation period.

Materials and Methods

Crossbred gilts averaging 8 mo of age and weighing 132 kg initially were used in two experiments to determine the effect of meal frequency and pregnancy on N metabolism. The experimental diet in each case was a 12% crude protein formulation based on corn and soybean meal (table 1). The gilts were fed 1.9 kg of the diet each day during the prebreeding period and until the experimental treatments were imposed at d 30 postcoitus. Forty days
TABLE 1. PERCENTAGE COMPOSITION OF CORN-SOYBEAN MEAL DIETS USED IN EXPERIMENTS 1 AND 2

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground yellow corn (IFN 4-03-005)</td>
<td>88.85</td>
</tr>
<tr>
<td>Soybean meal (IFN 5-04-612)</td>
<td>9.00</td>
</tr>
<tr>
<td>Calcium phosphate (IFN 6-01-080)</td>
<td>1.00</td>
</tr>
<tr>
<td>Ground limestone (IFN 6-02-632)</td>
<td>.70</td>
</tr>
<tr>
<td>Trace mineralized saltb</td>
<td>.35</td>
</tr>
<tr>
<td>Vitamin mixb</td>
<td>.10</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100.00</td>
</tr>
</tbody>
</table>

Calculated composition

| Crude protein | 12.00 |

aDiets were formulated on an as-fed basis.

bMichel et al. (1980).

d, i.e., four every-third-day feeding periods, in each experiment. Daily urine samples were individually analyzed in Exp. 1; 3 d of urine collection, i.e., each 3-d feeding period, were pooled and analyzed in Exp. 2. Collection, sampling and N analysis procedures have been described previously by Easter and Baker (1976). Energy digestibility was obtained by calculation using energy content of feed and feces measured by bomb calorimetry.

Experiment 1 was conducted as a completely randomized design in a split-plot arrangement with time as the subplot and gilts as the main plot. Dietary effect was evaluated in the main plot analysis. Experiment 2 was analyzed as a completely randomized design. Statistical analysis was accomplished using the Statistical Analysis System (SAS).

Results

One gilt was removed from Exp. 1 due to the development of a foot lesion during the excreta collection phase of the experiment. All assigned animals successfully completed Exp. 2. Gilts that were considered gravid did indeed produce viable litters of piglets.

The results of Exp. 1 are presented in table 2. For the purpose of statistical analysis, individual observations were the mean values calculated for each 3-d period regardless of whether the animal was fed daily or every third day. **Average daily N retention was depressed (P<.08) when gilts were fed every third day. Daily N excretion in the feces was not affected (P>.10). Urinary N, however, tended to be elevated when the gilts were fed every third day, suggesting poor metabolic utilization of absorbed amino acids.**

Within the 3-d period following each every-third-day meal, N excretion peaked during the second 24-h period and was notably reduced during the last 24-h of the postprandial period for gilts fed every third day (table 3). Gilts fed every day excreted similar quantities of urinary N each day, which resulted in an interaction (P<.01) between feeding frequency and day of collection.

Digestible energy (3.15 and 3.17 kcal/g for gilts fed every day or every third day, respectively) was not affected (P>.10) by treatment.

The effect of pregnancy on N retention is shown in table 4. Gravid gilts retained more N (P<.04) than did nongravid gilts. Average daily N intake was numerically, but not significantly

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4 Adibatic bomb calorimeter. Model 1241, Parr Instrument Co., Moline, IL.

5 Statistical Analysis System, the SAS Institute, Inc., Raleigh, NC.
TABLE 2. NITROGEN METABOLISM OF GRAVID GILTS FED EVERY DAY OR EVERY THIRD DAY

<table>
<thead>
<tr>
<th>Meal frequency</th>
<th>Daily N&lt;sup&gt;a&lt;/sup&gt;</th>
<th>g</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Urine</td>
<td>Feces</td>
<td>Retained&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Every day&lt;sup&gt;c&lt;/sup&gt;</td>
<td>15.56</td>
<td>5.03</td>
<td>15.32</td>
<td></td>
</tr>
<tr>
<td>Every third day&lt;sup&gt;d&lt;/sup&gt;</td>
<td>17.83</td>
<td>5.44</td>
<td>12.64</td>
<td></td>
</tr>
<tr>
<td>SE&lt;sup&gt;e&lt;/sup&gt;</td>
<td>1.49</td>
<td>.49</td>
<td>1.23</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup>Average daily N intake was 35.91 g.
<sup>b</sup>Treatment means were different (P<.08).
<sup>c</sup>Means of four gilts.
<sup>d</sup>Means of three gilts for the 12-d collection period. One gilt was removed from the experiment because of a foot lesion.
<sup>e</sup>Standard error for the difference between treatment means.

(P<.21) greater for gravid gilts in comparison with nongravid gilts. Nongravid gilts did not aggressively consume the 5.7 kg meal and there was, occasionally, diet remaining at the end of the 6-h period allowed for meal consumption. Fecal N was unaffected by dietary treatment. The greater (P<.02) urinary N loss by the nongravid gilts accounted for the difference in retention.

TABLE 3. URINARY NITROGEN EXCRETION BY GRAVID GILTS FED EVERY DAY OR EVERY THIRD DAY

<table>
<thead>
<tr>
<th>Collection period&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Meal frequency&lt;sup&gt;b&lt;/sup&gt;</th>
<th>g/d</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Every day&lt;sup&gt;c&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Every third day&lt;sup&gt;d&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>0 to 24 h</td>
<td>15.38</td>
<td>18.80</td>
</tr>
<tr>
<td>24 to 48 h</td>
<td>15.98</td>
<td>22.14</td>
</tr>
<tr>
<td>48 to 72 h</td>
<td>15.32</td>
<td>12.55</td>
</tr>
</tbody>
</table>

<sup>a</sup>Collection period is defined relative to hours after the meal was offered to those gilts fed every third day.
<sup>b</sup>Feeding frequency × day of collection quadratic effect (P<.01). Standard error for the difference between treatment means = 1.60.
<sup>c</sup>Each value is a mean of 16 samples (four gilts × four samples/gilt).
<sup>d</sup>Each value is a mean of 12 samples (three gilts × four samples/gilt).

Discussion

The experiments described herein show that gravid swine are not able to utilize dietary N as efficiently when fed every third day as when fed every day. The marked differences in urinary N excretion and relatively constant fecal N output suggest that metabolic utilization, not digestion, is the source of the inefficiency.

Previous research with meal frequency in swine has produced conflicting data. Allee and Meyer (1973) used gravid gilts and sows to compare feeding a 1.8 kg daily meal to either a 3.6 kg meal fed every other day or a 5.4 kg meal fed every third day. Nitrogen retention was reduced when the animals were switched from daily to the every-third-day feeding regimens. In contrast, Michel (1978) reported no difference in N retention when gravid gilts were switched from a daily 1.9 kg meal to an every-third-day 5.7 kg meal.

The extent of protein metabolism adaptation to meal frequency in swine is largely unknown. However, there is a definite change in adipose tissue metabolism and in volumetric capacity of the digestive tract in response to the stress of larger meals (O’Hea and Leveille, 1969; Romsos et al., 1978). Moreover, we and others (Romsos et al., 1978; Michel, 1978) have observed that a training period, variable in length, is required before the pig will readily consume the 5.7 kg of feed in a single feeding bout. These considerations suggest that the switchback approach (6 d of adaptation followed by 6 d of excreta...
EVERY-THIRD-DAY FEEDING AND NITROGEN METABOLISM

TABLE 4. NITROGEN METABOLISM OF GRAVID AND NONGRAVID GILTS FED EVERY THIRD DAY

<table>
<thead>
<tr>
<th>Physiological state</th>
<th>Daily N&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Urine&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Feces</th>
<th>Retained&lt;sup&gt;c&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>g</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gravid&lt;sup&gt;d&lt;/sup&gt;</td>
<td>15.72</td>
<td>5.70</td>
<td>15.04</td>
<td></td>
</tr>
<tr>
<td>Nongravid&lt;sup&gt;e&lt;/sup&gt;</td>
<td>18.73</td>
<td>5.23</td>
<td>11.82</td>
<td></td>
</tr>
<tr>
<td>SE&lt;sup&gt;f&lt;/sup&gt;</td>
<td>.97</td>
<td>.45</td>
<td>1.23</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup>Each value is the mean of four gilts.
<sup>b</sup>Treatment means were different (P<.02).
<sup>c</sup>Treatment means were different (P<.04).
<sup>d</sup>Average daily N intake was 36.46 g.
<sup>e</sup>Average daily N intake was 35.78 g.
<sup>f</sup>Standard error for the difference between treatment means.

collection) used in previous experiments does not allow sufficient time for adaptation to the feeding regimen. The 40-d adaptation period appears to be more appropriate.

The reduction in efficiency of N utilization may be caused by an inability to assimilate the large quantity of amino acids contained in the 5.7 kg every-third-day meal or by an increase in catabolic losses once the animal becomes postabsorptive. Our results indicate that neither N nor energy digestibility was altered by feeding regimen, thus the effect must be due to reduced utilization of absorbed amino acids. The marked increase in urinary N excretion during the second day suggests that a substantial portion of the dietary amino acids could not be used for protein synthesis and were thus catabolized.

A marked reduction in urinary N excretion during the third day of each 3-d period was observed which is not surprising. Shimada and Zimmerman (1973) have shown that amino acid absorption in the growing pig is essentially completed within 24 to 30 h after consumption of the meal; thus, it is reasonable to assume that the gilts were in a fasting state during the latter portion of the 3-d interval. Muscle protein breakdown is relatively stable during the first days of fasting and increases only after prolonged starvation (Young et al., 1971; Millward et al., 1974; Millward and Waterlow, 1978; Ogata et al., 1978). Periodic fasting and refeeding, however, may have forced adaptive changes in protein synthesis (Tepperman et al., 1970; Hopgood and Ballard, 1973); i.e., reduced protein synthesis during the later portion of the 72-h interval to provide carbon skeleton for gluconeogenesis.

Finishing pigs (49 to 90 kg) adapted to an every-third-day feeding program (Veum et al., 1970) exhibit an increase in blood urea N 10 h after the meal followed by gradual reductions at both 34 and 54 h postprandial. Our N excretion data follow the pattern of this blood urea N data. This response supports the suggestion that the gilt is unable to utilize the amino acids from the 5.7 kg meal and thus disposes of the excess N as urea.

The inefficient N utilization associated with every-third-day feeding may have been a factor in the tendency for reduced reproductive performance observed earlier when primaparous gilts were fed every third day (Michel et al., 1980). In that experiment pigs from gilts fed every third day weighed less at weaning than those from gilts fed every day. Amino acid inadequacy during pregnancy will impair lactation, resulting in reduced piglet weaning weights (Baker et al., 1970; Pond, 1973; Baker et al., 1974; Mahan and Mangan, 1975). It should be noted, however, that the gravid gilts fed every third day in our experiment retained in excess of 12 g of N/d, a quantity thought to be adequate for normal reproduction (Easter and Baker, 1976; Woerman and Speer, 1976).

It is quite possible that alterations in energy metabolism either alone or in conjunction with changes in protein metabolism, e.g., increased
gluconeogenesis may have been a factor in the reduced reproductive performance observed by Michel et al. (1980).

Pregnancy increased (P<.04) N retention in gilts fed every third day. This response is in agreement with earlier research (Easter et al., 1974) and confirms that every-third-day feeding does not mask the anabolic effect of pregnancy. There was reluctance on the part of the nongravid gilts to consume the 5.7 kg in a single meal; this was not the case with the gravid gilts.

Our data indicate that every-third-day feeding results in reduced N retention in gravid swine, possibly because of an inability to assimilate the quantity of amino acids provided in the 5.7 kg meal.

Literature Cited


