REPRODUCTIVE PERFORMANCE OF GILTS FED DIETS LOW IN PROTEIN DURING GESTATION AND LACTATION

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Summary

TWO experiments involving 81 litters were conducted to determine the effect of low protein (45 g/day, from corn) and adequate protein (309 g/day, from corn and soybean meal) on reproductive performance of gilts. Gain during gestation was significantly decreased by the low level of protein, but litter size and pig weight at birth were not significantly affected by dietary treatment. Weight loss was greater in gilts fed the low-protein level, and preweaning rate of gain by pigs was reduced significantly (P < .01) by feeding the low-protein diet. Cross-fostering of newborn pigs did not affect the performance of pigs in experiment 1. A carry-over effect of gestation treatment to lactation was observed in the first experiment as evidenced by reduced gains of pigs nursing sows fed the low protein during gestation but high protein during lactation. Progeny survival was unaltered by dietary treatment in experiment 1; however, in the second experiment, in which an outbreak of enteritis occurred, survival rates were markedly lower for progeny of gilts fed low protein during gestation, lactation or both.

Introduction

Early work by Evward, Arthur and Guernsey (1914), Davidson (1930), Jesperson and Olsen (1940) and Hanson, Terrin and Aunan (1953) indicates that birth weight, viability, udder development and milk production are impaired by dietary protein restriction. Davidson (1930), Lenkeit and Gutte (1957), Boaz (1962), Clawson et al. (1963), Rippel et al. (1965a), Frobish, Speer and Hays (1966), Holden et al. (1968) and MacPherson, Elsley and Smart (1969) reported that protein intakes once considered to be inadequate are sufficient for normal numbers and size of pigs at birth. More recently, Pond et al. (1968) fed gilts only 9 g of crude protein daily and found no significant effects either on number or weight of newborn pigs; however, in a later study Pond et al. (1969) observed a significant decrease in birth weight of pigs born to gilts fed this level of protein intake. Rippel et al. (1965b) fed 0 to 273 g of protein per day from day 70 to day 109 of gestation and found that litter size and weight were not significantly affected by dietary protein level. They concluded that dietary protein intake equivalent to 3% protein was slightly in excess of the maintenance requirement.

The objective of these experiments was to further evaluate the effects of protein malnutrition during gestation and lactation on reproductive performance of gilts.

Experimental Procedure

Eighty-nine gilts of Yorkshire, Hampshire and Yorkshire x Hampshire breeding were used in two experiments. In experiment 1, 43 gilts averaging 141 kg and 330 days of age at breeding were allotted to a randomized complete block design with two dietary treatments. In the second experiment, 46 crossbred gilts averaging 153 kg body weight and 450 days of age were assigned to a completely randomized design with the same dietary treatments as in experiment 1.

Methallibure \(^3\) was added to the diet for 20 days to provide 125 mg per day to synchronize estrus. The gilts were mated, twice if possible, at the ensuing estrus to Hampshire or Yorkshire boars in experiment 1 and Yorkshire boars in experiment 2.

All gilts were housed in open-front sheds with concrete floors and were individually fed 1.8 kg of feed daily during gestation. The composition of the diets is shown in table 1. The diets were calculated to contain 17% or 2% protein and were fed at a level to provide 309 or 36 g of crude protein daily during

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LOW PROTEIN DIETS FOR GILTS

Table 1. Composition of Diets

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Gestation</th>
<th>Lactation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gall yellow corn</td>
<td>66.47</td>
<td>66.47</td>
</tr>
<tr>
<td>Dextrine</td>
<td>22.80</td>
<td>22.80</td>
</tr>
<tr>
<td>Fat (HEF)</td>
<td>7.00</td>
<td>7.00</td>
</tr>
<tr>
<td>Ground lime stone</td>
<td>1.20</td>
<td>1.20</td>
</tr>
<tr>
<td>Dicalcium phosphate</td>
<td>1.60</td>
<td>1.60</td>
</tr>
<tr>
<td>Salt, iodized</td>
<td>0.50</td>
<td>0.50</td>
</tr>
<tr>
<td>Trace mineral premix b</td>
<td>0.20</td>
<td>0.20</td>
</tr>
<tr>
<td>Vitamin additive premix c</td>
<td>0.23</td>
<td>0.23</td>
</tr>
<tr>
<td>Total</td>
<td>100.00</td>
<td>100.00</td>
</tr>
</tbody>
</table>

* Supplied by Procter and Gamble Company, Cincinnati, Ohio.
* Provided the following, milligrams per kilogram: potassium, 1,050; magnesium, 400; manganese, 200; zinc, 200; iron, 200; copper, 20; iodine, 6; and cobalt, 2.
* Provided the following per kilogram of diet: vitamin A, 4,400 IU; vitamin D, 800 IU; riboflavin, 8.8 mg; calcium pantothenate, 22 mg; niacin, 44 mg; vitamin B6, 22 mcg; folic acid, 2 mg; menadione, 5.5 mg; thiamine-HCl, 2 mg; pyridoxine-HCl, 1 mg; dl-alpha-tocopherol acetate, 83.5 mg; choline chloride, 910 mg; ethoxyquin, 126 mg and chlortetracycline, 110 milligrams.

Protein level in the low protein diet was increased from 2% to 5% for lactation. Dextrine was used to dilute the corn protein, and diets were made isocaloric by the addition of fat. Additional potassium and magnesium were added to the trace mineral premix and folic acid, menadione, thiamine-HCl, pyridoxine-HCl and alpha tocopherol acetate were added to the vitamin premix to correct deficiencies of these minerals and vitamins in the low-protein diet. Ethoxyquin and chlortetracycline were added to all diets. A minimum amount of straw bedding containing an average of 1.55% protein was provided.

On approximately the 110th day of gestation, diets were weighed and moved to farrowing stalls where they were limited to 1.8 kg of feed per day until farrowing. Thereafter they were fed all they would consume twice daily. The pigs were weaned at 4 weeks of age in experiment 1 and at 2 weeks of age in experiment 2.

In experiment 1, at parturition half of the gilts fed each level of protein during gestation were switched to the opposite level of protein, creating four gestating-lactating protein level sequences (high-high, high-low, low-high and low-low). Within 48 hr. after birth, pigs were randomly distributed between their dam and gilts fed the other three treatment combinations. This reciprocal transfer resulted in eight pig treatments: (1 to 4) pigs born to a dam fed low protein during gestation and nursed by a dam fed one of the four gestation-lactation combinations, and (5 to 8) pigs born to a dam fed high protein during gestation and nursed by dams fed one of the four gestation-lactation combinations. Within four of the eight pig treatments there were biological and fostered pigs, which created an incomplete factorial arrangement of 12 treatment combinations.

In experiment 2, gilts fed high or low protein during gestation were continued on high or low protein during lactation. Half of the pigs in each litter were reciprocally transferred to a gilt of the opposite treatment, resulting in four pig treatments, high-high, high-low, low-high, low-low and low-low.

Data were analyzed by the method of least-squares as described by Harvey (1960) and Steel and Torrie (1960). References to statistical significance pertain to a probability level of 5% unless stated otherwise.

Results and Discussion

The protein intake was calculated to be 36 g/day for gilts fed the low-protein gestation diet but was approximately 45 g/day based on analysis of the diet. A daily intake of 45 g would approach the estimated maintenance requirement of 55 g/day (Rippel et al., 1965c). The protein was supplied primarily by corn, thus the intake of certain essential amino acids, particularly lysine and tryptophan, was extremely low.

The summary of performance during gestation and at parturition is presented in Table 2. Of 43 gilts mated in the first experiment, two fed the diet containing 17% protein and one fed the diet with 2% protein returned to estrus and were removed from the experiment. In experiment 2, three gilts fed the low protein diet did not complete the gestation period; one returned to estrus, one became severely lame, and the third became extremely emaciated. Two gilts fed the high-protein diet also became lame and were removed from the experiment.

The results of these experiments and those of Pond et al. (1968, 1969) indicate that an extremely low level of protein during all or part of the gestation period will maintain pregnancy. Studies with the rat (Nelson and Evans, 1953; Venkatachalam and Ramana-than, 1964; Goettach, 1949) have shown that diets containing 5% protein will result in normal reproduction, but levels lower than 5%, beginning at mating, result in 86 to 100% embryonic loss even after normal im-
TABLE 2. EFFECT OF DAILY PROTEIN INTAKE ON PERFORMANCE OF GILTS DURING GESTATION AND LACTATION

<table>
<thead>
<tr>
<th>Gestation protein level, %</th>
<th>Experiment 1</th>
<th>Experiment 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gilts mated</td>
<td>21</td>
<td>20</td>
</tr>
<tr>
<td>Gilts farrowed</td>
<td>21</td>
<td>21</td>
</tr>
<tr>
<td>Gestation weight gain, kg</td>
<td>5.4</td>
<td>3.4</td>
</tr>
<tr>
<td>Total pigs/litter</td>
<td>8.1</td>
<td>11.0</td>
</tr>
<tr>
<td>Live pigs born/litter</td>
<td>6.4</td>
<td>10.6</td>
</tr>
<tr>
<td>Birth weight/live pig, kg</td>
<td>1.30</td>
<td>1.10</td>
</tr>
<tr>
<td>Lactation weight loss, kg</td>
<td>12.8</td>
<td>3.0</td>
</tr>
</tbody>
</table>

**a** Significant difference between gestation protein level in experiment 1 (P<.01) and experiment 2 (P<.05).

In both experiments, gilts fed the low-protein diet gained significantly less during gestation than gilts fed the high level of protein (table 2). This agrees with the work of Pond et al. (1968) who reported a weight loss during the first 78 days of gestation by gilts fed 9 g of protein daily; whereas, control dams gained 26 kg during this same period.

The number of total or live pigs born per litter did not differ significantly between dietary treatments in either experiment, though litter size tended to be slightly smaller in the low-protein group in the first experiment. Litter size was larger in experiment 2 than in experiment 1 (11.0 vs. 8.4 pigs) and may be attributed to the older age of the gilts at breeding (450 vs. 330 days) and the use of crossbred gilts in the second experiment. Within each experiment birth weights were similar for the two treatments. The slightly lower birth weights observed in the second experiment were probably a result of the larger litter size.

The mean weight loss during lactation is presented in table 2. In experiment 1, gilts fed low-protein during gestation or lactation lost more weight (P<.01) than gilts fed high-protein diets, 28.0 vs. 24.4 kg and 41.3 vs. 11.0 kg, respectively. A significant gestation treatment by lactation treatment interaction also resulted as the weight loss by sows fed low protein during lactation was exaggerated by a low level of protein during gestation. The most pronounced weight losses in experiment 1 were observed during the third and fourth weeks of the 4-week lactation period, which according to Lodge (1959) is the time when milk output is near the maximum. Therefore, in this experiment, with the limited body reserves of gilts receiving low protein along with the increased stress on these dams during the third and fourth weeks of lactation, body weight changes were magnified even though protein content of the diets fed during lactation was increased from 2.0 to 5.0%. To reduce these lactation effects in the second experiment, pigs were weaned at 2 weeks of age. The mean lactation weight loss of gilts consuming low-protein diets in experiment 2 was greater (P<.01) than the loss by gilts receiving diets containing 17% protein (18.2 vs. 3.0 kg). The greater loss of weight by gilts receiving low protein is likely a combined effect of protein level and reduced feed intake during lactation. Gilts were allowed feed *ad libitum* but, in experiment 2, those on the low protein diet consumed significantly less feed (2.73±0.72 vs. 4.79±1.19 kg). Thus, the intake of all nutrients was less.

The summary of preweaning average daily gain and the analyses of variance are presented in tables 3 and 4. Preweaning weight gain of progeny from dams fed the low- and high-protein diets during gestation did not differ significantly (196 vs. 169 g/day). This trend does not, however, agree with responses in rats in which pre-weaning gains were lower for progeny of protein-restricted dams (Blackwell et al., 1969; Zeman, 1967). In reciprocal...
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Table 3. Effect of Protein Level During Gestation and Lactation on Preweaning Average Daily Gain and Survival of the Progeny

<table>
<thead>
<tr>
<th>Protein Level</th>
<th>Gestation</th>
<th>Lactation</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biological</td>
<td>17</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>Rearing</td>
<td>17</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Lactation</td>
<td>17</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

Experiment 1
- Preweaning avg daily gain, g:
  - Analysis 1: 182, 208, 178, 109, 215, 222, 192, 156
  - Analysis 2: 144, 95, 126, 67, 46, 42, 80
- Survival, 3 weeks, %:
  - Analysis 1: 100, 81, 70, 82, 100, 70, 91, 97
  - Analysis 2: 77, 67, 79, 93, 67, 89, 94
- Survival, 4 weeks, %:
  - Analysis 1: 100, 81, 70, 82, 100, 70, 91, 97
  - Analysis 2: 77, 67, 79, 93, 67, 89, 94

Experiment 2
- Preweaning avg daily gain, g:
  - Analysis 1: 144, 95, 126, 46, 42
  - Analysis 2: 80
- Survival, 2 weeks, %:
  - Analysis 1: 100, 81, 70, 82, 100, 70, 91, 97
  - Analysis 2: 77, 67, 79, 93, 67, 89, 94
- Survival, 8 weeks, %:
  - Analysis 1: 100, 81, 70, 82, 100, 70, 91, 97
  - Analysis 2: 77, 67, 79, 93, 67, 89, 94

a Pigs were weaned at 4 and 2 weeks of age in experiment 1 and 2, respectively.
b Significant (P<.01) effect of gestation treatment and lactation treatment of the rearing dam.
c Significant (P<.05) rearing x biological dam interaction.
d For example, this mean represents the gain of pigs from gilts fed 17% protein during gestation and nursed by gilts fed 2% protein during gestation and 5% during lactation.
e Significant (P<.01) effect of gestation and lactation level.

Transfer studies with rats, it has been reported that gestation effects due to low-protein diets are magnified by dietary restriction during lactation (Chow and Lee, 1964; Blackwell et al., 1969).

A significant growth depression (159 vs. 207 g/day) was observed in this experiment for offspring which nursed gilts fed diets low in protein during gestation in comparison with those fed high-protein diets. The fostering x gestation treatment interaction was significant and is attributed to a greater difference in response by biological and foster pigs nursing dams fed low protein diets during gestation as compared with the small difference in response between biological and fostered pigs suckling dams fed adequate protein levels during gestation. These differences in response may be a result of transferred pigs not competing as effectively for a limited supply of milk; whereas, in sows fed high protein, the milk supply was more adequate for both their own and fostered pigs. The greater gain (P<.01) by progeny nursing dams fed high protein during both gestation and lactation in comparison with the gain by progeny nursing gilts fed low-protein diets during gestation, but high-protein diets during lactation, resulted in a significant gestation x lactation treatment interaction. The same trends existed for the progeny nursing gilts fed diets containing low protein during lactation, but the differences were not as large. In other words, the level of protein fed during gestation markedly affected the milk production, as measured by pig gain.

In the second experiment, the difference in rate of gain (103 vs. 120 g/day) between pigs from dams fed low protein and those from dams fed adequate protein during gestation was significant. Also the level of protein fed during lactation markedly affected (P<.01) the preweaning gain by pigs (88 vs. 135 g/day) from dams fed low and high protein, respectively.

These data indicate that both the gestation treatment as well as the lactation treatment affects preweaning performance of progeny. These effects were probably a reflection of quantity of milk produced, though composition of milk may have differed and influenced performance. Holden et al. (1968) reported that the protein content of sows’ milk decreased linearly with decreasing dietary protein intakes. Mahan et al. (1971) also reported that the albumin fraction of sow milk decreased with decreasing dietary pro-
tein level, but the relative composition of other milk fractions was unaffected by levels of protein as low as 10%. Lenkeit and Gutte (1957) also reported a decrease in milk yield from 10.7 to 3.6 kg/day as dietary protein intakes were reduced from 736 to 246 g/day.

The survival data from birth to weaning are presented in table 3. No significant differences due to dietary treatments were observed in experiment 1, though the average survival was slightly lower for pigs nursing sows fed low protein during lactation. In the second experiment, pig survival on all treatments was lower than normal owing to an outbreak of enteritis during the farrowing and early lactation period. The data of experiment 2 suggest that livability of progeny from dams fed low dietary protein during gestation and lactation was markedly inferior to the survival rate of progeny from dams fed adequate protein levels. The mortality of offspring from dams fed low-protein diets during only gestation or lactation was intermediate between that of sows fed high or low protein during both gestation and lactation. It would appear that resistance to infection was decreased and that antibody production may have been altered in the offspring. This hypothesis would support the data reported by Frobish et al. (1966) in which livability of pigs prior to weaning, at 2 weeks of age, was significantly improved when sows were fed 364 g of crude protein daily as compared with those fed 182 grams. Also, Pond et al. (1968) found a difference in serum protein levels (5.87 vs. 5.58 g/100 ml) of progeny farrowed by gilts receiving 216 vs. 9 g of protein daily. Hesby et al. (1970), Boaz (1962) and Holden et al. (1968) have reported that daily crude protein intakes as low as 90 g do not adversely affect number of pigs weaned. The excessive mortality in experiment 2 may have resulted in a confounding of treatment effects and livability, hence masking or exaggerating the treatment effects.

**Literature Cited**


