PREGNANT swine exhibit a remarkable capacity to provide nutriment to the developing fetuses during periods of severe protein restriction. Clawson et al. (1963) and Rippel et al. (1965a) observed no deleterious effects on offspring at birth from feeding 5% protein diets during pregnancy. Even an essentially protein-free diet from day 24 of pregnancy to parturition has resulted in normal numbers and weights of pigs born (Strachan et al., 1968). The gravid female apparently has less capacity to buffer her offspring against an energy deficit than a protein deficit, as indicated by rather marked reductions in birth weight (but not in number of pigs born) when energy or total feed restriction is imposed during gestation (Lodge, Elsley and MacPherson, 1966; O’Grady, 1967; Elsley et al., 1969; Vermedahl et al., 1969; Baker et al., 1969).

The apparent lack of injurious effects on the dam or her offspring at birth from protein restriction during pregnancy raises the question of whether diets based entirely upon cereal grains might prove adequate for swine gestation. It was the purpose of this study to evaluate gestation diets based upon corn, opaque-2 corn or various mixtures of corn and soybean meal.

Experimental Procedure

Procedures used were essentially the same as those described previously (Baker et al., 1969). Five groups of first-litter gilts farrowed at bimonthly intervals. Two of the groups were Hampshires, two crossbred and one Yorkshire. A total of 269 gilts was placed on the experimental treatments.

Each gilt was fed 1.90 kg/day of the treatment diets (table 1) from breeding to parturition. Ground limestone and dicalcium phosphate levels were adjusted to provide approximately 0.75% calcium and 0.60% phosphorus in all diets. The corn used in the experimental diets contained 9.9% crude protein and 0.38% lysine. The opaque-2 corn contained 9.9% crude protein and 0.38% lysine.

After parturition all gilts were fed the 16%-protein corn-soybean meal diet shown in table 1. Individual gilts were allowed to consume all they could eat in two 1-hr. feedings/day. A standard creep diet was offered to baby pigs between day 7 and day 21 of lactation. Litters were weaned at 21 days of age.

Results

The results are shown in table 1 and table 2. Fifty-four gilts were mated for each of the five dietary gestation treatments, with the single exception that 53 were mated for the 12%-protein corn-soybean meal treatment. Farrowing percent was uniform among treatments with no evidence that gestation diet affected the capacity of gilts to remain gravid and farrow a litter.

The number of pigs born (total or live) was not affected significantly by gestation treatment. The number of pigs weaned, however, was reduced (P<.05) in litters from gilts fed the corn diet throughout gestation. Frobish, Speer and Hays (1966) reported a decrease in the number of pigs weaned from sows fed 182 g protein daily vs. those from sows fed 364 g protein daily.

There was a tendency for litter weight at birth to be less for the corn treatment than for the others. Also, litters from gilts fed opaque-2 corn or the 12% protein corn-soybean meal mixture tended to weigh less than those from gilts fed corn-soybean meal diets containing 16 or 20% protein. These effects were more a function of litter size at birth than of individual pig birth weights. Birth weights per pig, whether based upon total or live pigs, were very similar among treatments.

At 21 days (weaning) litters from gilts fed the corn diet during pregnancy weighed less (P<.05) than those from gilts fed the other diets. Differences among the other four treatments were slight and nonsignificant. The lesser weaning weight of litters from gilts on the corn treatment was due to the combined effects of fewer pigs weaned per litter and smaller weights per pig. The latter, however, was not

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statistically significant. Litter weight gains from birth to weaning were less (P<.05) when gilts were fed the corn diet than resulted when gilts received the other diets. Individual pig gains, however, did not differ significantly among treatments. Performance of pigs from birth to weaning was best for the 16% protein corn-soybean meal treatment, though differences between this treatment and the average of the other treatments (excluding the corn treatment) were not statistically significant.

Gestation weight gain from conception to either day 109 of gestation or immediately postfarrowing was significantly (P<.05) influenced by dietary treatment. Gilts fed the corn diet gained less (P<.05) than the average of those assigned to the remaining four treatments; and gain of gilts fed opaque-2 corn was less (P<.05) than of gilts fed the corn-soybean meal diets. The level of protein from corn and soybean meal did not significantly influence gestation weight gain.

Although lactation diet intake was remarkably similar across treatments, weight gained by gilts during the 21-day lactation period was greater (P<.05) for gilts that had received the corn diet in gestation than for those that were fed the other diets. All gestation diets except the corn diet resulted in weight loss during lactation. Gilts that had received the opaque-2 corn diet throughout pregnancy lost less (P<.05) weight in lactation than those that had received the corn-soybean meal diets.

### TABLE 2. EFFECT OF DIETARY PROTEIN QUALITY AND QUANTITY DURING GESTATION ON REPRODUCTIVE PERFORMANCE AND PROGENY DEVELOPMENT

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Corn 8.8% CP</th>
<th>Opaque-2 corn 9.7% CP</th>
<th>Corn-soybean meal</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. gilts started b</td>
<td>54</td>
<td>54</td>
<td>53</td>
</tr>
<tr>
<td>No. gilts farrowing</td>
<td>41</td>
<td>39</td>
<td>38</td>
</tr>
<tr>
<td>Farrowing percent</td>
<td>76</td>
<td>73</td>
<td>70</td>
</tr>
<tr>
<td>No. pigs born/litter</td>
<td>8.7</td>
<td>8.8</td>
<td>8.8</td>
</tr>
<tr>
<td>No. live pigs born/litter</td>
<td>7.3</td>
<td>7.5</td>
<td>7.6</td>
</tr>
<tr>
<td>No. pigs weaned/litter</td>
<td>6.2</td>
<td>6.9</td>
<td>6.9</td>
</tr>
<tr>
<td>Litter wt. at birth</td>
<td>10.46</td>
<td>10.97</td>
<td>10.85</td>
</tr>
<tr>
<td>Litter wt. of live pigs at birth</td>
<td>8.99</td>
<td>9.43</td>
<td>9.65</td>
</tr>
<tr>
<td>Birth wt. per pig</td>
<td>1.24</td>
<td>1.26</td>
<td>1.25</td>
</tr>
<tr>
<td>Birth wt. per live pig</td>
<td>1.26</td>
<td>1.27</td>
<td>1.27</td>
</tr>
<tr>
<td>Litter wt. at 21 days c</td>
<td>28.04</td>
<td>34.29</td>
<td>34.42</td>
</tr>
<tr>
<td>Pig wt. at 21 days</td>
<td>4.58</td>
<td>4.77</td>
<td>4.86</td>
</tr>
<tr>
<td>Litter gain</td>
<td>19.94</td>
<td>24.87</td>
<td>25.16</td>
</tr>
<tr>
<td>Gestation gain (day 109) d</td>
<td>35.08</td>
<td>46.61</td>
<td>49.03</td>
</tr>
<tr>
<td>Gestation gain (farrowing) c</td>
<td>23.78</td>
<td>32.83</td>
<td>36.53</td>
</tr>
<tr>
<td>Lactation gain</td>
<td>4.46</td>
<td>-2.29</td>
<td>-2.34</td>
</tr>
<tr>
<td>Lactation diet intake</td>
<td>79.78</td>
<td>78.86</td>
<td>80.81</td>
</tr>
</tbody>
</table>

* All units of weight are expressed in kilograms.

b Gilts averaged about 120 kg at conception.

c Opaque-2 corn significantly (P<.05) different from other treatments.

de All dietary treatments were considered except the corn diet.
Discussion

Perhaps the most interesting finding in this experiment was the inability of the gilts fed the corn diet during gestation to perform at an optimal level during lactation. Fewer pigs weaned per litter together with lesser weaning weights per pig combined to result in average litter weaning weights that were markedly less for the corn treatment than for any of the others. Since performance through farrowing was similar among treatments, it must be concluded that the protein-amino acid intake during gestation exerted an effect on the offspring or, more likely, the dam during lactation.

Based upon the work of Rippel et al. (1965a), it had been postulated that a corn diet fed during gestation followed by a corn-soybean meal diet during lactation would prove quite adequate for optimal reproductive performance. An important distinction that should be made, however, is that in our study the treatment regimen included the entire 114-day gestation period; while in the report by Rippel et al. (1965a), the corn diet was imposed only during the last 50 days of gestation. Based upon recent work by Strachan et al. (1968) and unpublished data from the Illinois station, it appears that a period of adequate protein-amino acid feeding during early gestation may protect the gilt and her litter against deficiency symptoms attributable to protein-amino acid deficiency, i.e., reduced litter weaning weights, that might otherwise have become manifest.

The reduced litter weaning weights resulting from feeding a corn diet throughout pregnancy likely reflect an insufficient intake of certain amino acids rather than an insufficient intake of protein per se. Corn protein is very deficient in lysine and also in tryptophan. Allee and Baker (1969) recently confirmed the original observation of Rippel (1965b) that corn protein is first-limiting in lysine and second-limiting in tryptophan for the gravid gilt. Moreover, the opaque-2 corn diet, higher in lysine and tryptophan than regular corn, supported good postparturient performance of offspring, and this suggests that lysine and tryptophan may be involved.

Clawson et al. (1963) fed throughout gestation 2.72 kg/day of a diet containing only 5% protein from soybean meal. There was no evidence that performance of offspring from birth to weaning was impaired. However, their regimen allowed a daily intake of lysine and tryptophan almost twice that which was consumed by gilts fed the corn diet in our study. In fact, based upon the suggested amino acid requirements of the gravid gilt for maximal nitrogen retention (Rippel et al., 1965c), the daily intake of neither lysine nor tryptophan would be limiting from 2.72 kg/day of their 5% protein diet. On the other hand, intakes of both threonine and sulfur-bearing amino acids were less (both about 84% of the requirement) than that needed for maximal nitrogen retention.

Holden et al. (1968) collected data on sows fed 1.82 kg of an 8% protein diet (70% of the protein from soybean meal and 30% from corn) throughout both gestation and lactation. Compared to Rippel’s requirements for pregnancy, their diet calculates to be slightly limiting in threonine (86% of requirement), sulfur amino acids (94%) and lysine (94%). These workers obtained a reduction in weight gains from birth to weaning in pigs from dams that had received 8% protein as compared with those from dams that had received 12, 16 or 20% protein. Based upon the lactation protein level studies of Mahan, Becker and Jensen (1968), it is probable that this effect was a result of the amino acid intakes during lactation rather than gestation. The data of Mahan and coworkers showed that weight gain of offspring was very responsive to the protein level of the dam’s lactation diet.

Thus, the severity of limitation of deficient amino acids perhaps explains why a pregnancy diet containing 8.8% protein from corn fails to allow optimal lactation performance while a 5%-protein diet from soybean meal or an 8%-protein diet from a mixture of corn and soybean meal apparently succeeds. The daily intake of lysine from 1.9 kg/day of the corn diet was only 55% of the requirement for maximal nitrogen retention; tryptophan was 75%. Hence, the limiting amino acids in our corn diet were considerably more limiting than those in the lower protein diets of Clawson et al. (1963) and Holden et al. (1968).

It is conceivable that at a certain degree of amino acid deficiency during pregnancy maternal tissues are sacrificed to an extent where subsequent lactation performance is impaired. The reciprocal transfer studies of Pond et al. (1968) suggest that severe protein-amino acid restriction during pregnancy affects the dam’s capacity to lactate optimally rather than having some direct effect on the offspring.

The uniform response in gestation weight gains and in birth and weaning weights among
the three corn-soybean meal dietary treatments could be taken as evidence for approximately equivalent metabolizable energy values of corn and soybean meal for the pregnant gilt, as has previously been shown for the growing pig (Diggs et al., 1965). If this is the case, various mixtures of corn and soybean meal can be used to study effects of protein-amino acid intake at a similar daily intake of energy.

Opaque-2 corn proved to be a satisfactory source of protein for the gestating gilt. This agrees with a similar observation made by Hesby, Conrad and Plumlee (1968). It would be interesting to know if an opaque-2 corn diet would permit maximal nitrogen retention in the gravid gilt. Based upon its amino acid composition relative to the requirements for maximal nitrogen retention (Rippel et al., 1965c), it appears to be nearly adequate in all essential amino acids. It does, however, provide less total protein than the 12% level established as optimal by Rippel and coworkers. However, corn protein plus supplemental lysine and tryptophan is not improved by nonspecific amino nitrogen administration during pregnancy (Allee and Baker, 1969), and thus it is unlikely that nonprotein nitrogen supplementation of opaque-2 corn would be efficacious.

Summary

Five farrowings with a total of 269 first-litter gilts were utilized to study effects of source and level of dietary protein fed during gestation on reproductive performance and progeny development. Five experimental diets were evaluated, all fed at 1.9 kg/day throughout gestation. Sources and levels of protein were: corn, 8.8% protein; opaque-2 corn, 9.7% protein and corn-soybean meal mixtures to provide 12, 16 or 20% protein.

Dietary treatment during gestation had no effect on number or weight of pigs farrowed (total or live). However, number of pigs weaned/litter, litter gain and total litter weaning weight were less in litters from gilts fed the corn diet as compared with those from gilts fed the other diets. Opaque-2 corn was superior to conventional corn and equal to the corn-soybean meal treatments in these criteria. Gilts fed the corn diet gained less during gestation than gilts on the other treatments, and gilts fed the opaque-2 corn diet gained less than those fed 12, 16 and 20% protein diets. Gilts fed the corn diet during gestation gained 4.5 kg during the 3-week lactation period, but those on the other treatments lost weight in proportion to the weight gained during gestation. Lactation diet intake was similar for all five treatments.

Literature Cited


