VALUE OF RAW SOYBEANS AND SOYBEAN OIL SUPPLEMENTATION IN SOW GESTATION AND LACTATION DIETS: A COOPERATIVE STUDY


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ABSTRACT

A cooperative study using 215 sows during two parities (349 litters) was conducted at six stations to determine the effect of raw soybeans in gestation and lactation diets on sow and litter performance. Sows were bred and allotted to fortified corn diets containing either soybean meal (control) or raw soybeans. A corn-soybean meal-soybean oil diet, isocaloric to the raw soybean diet, was included as a third treatment at three stations. All diets contained 14% CP. These diets were fed during both gestation and lactation through two parities. The daily gestation feed intake ranged from 1.8 to 2.3 kg/sow, depending on station. During lactation, the sows were allowed ad libitum access to their respective diets. Gestational weight gain was not influenced by diet, but sows fed raw soybeans consumed less (P < .01) feed during lactation and had greater (P < .01) lactational weight loss and their pigs were lighter in weight (P < .05) both at 21 d and at weaning (varied between 3 and 5 wk of age). Sows fed the diet with supplemental oil had reproductive and lactational performance similar to those fed the control diet. Milk obtained at d 10 to 14 of lactation from sows fed raw soybeans had lower (P < .05) protein content than milk from sows fed the other two diets, but fat content of the milk tended to be increased by raw soybeans or by added soybean oil. Return to estrus was not affected by diet. We conclude that feeding raw soybeans as the only source of supplemental protein during gestation had no deleterious effect on reproductive performance of gilts or sows through two parities, but this diet reduced feed intake, increased sow lactational weight loss and reduced pig weaning weights when it was fed during lactation.

Key Words: Soybeans, Soybean Oil, Sows, Gestation, Lactation, Diets


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W. H. Pfander, MO was Administrative Advisor of the Committee.
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TABLE 1. STATIONS INVOLVED IN THE STUDY

<table>
<thead>
<tr>
<th>Station</th>
<th>No. of sows</th>
<th>Breed</th>
<th>Gestation housing</th>
<th>Gestation feed intake, kg/d</th>
<th>Lactation length, d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kansas</td>
<td>63</td>
<td>Crossbred</td>
<td>Gestation stall</td>
<td>2.0</td>
<td>25</td>
</tr>
<tr>
<td>Kentucky</td>
<td>51</td>
<td>Yorkshire</td>
<td>Pasture</td>
<td>1.8&lt;sup&gt;d&lt;/sup&gt;</td>
<td>35</td>
</tr>
<tr>
<td>Michigan</td>
<td>10</td>
<td>Crossbred</td>
<td>Indoor pen</td>
<td>2.3&lt;sup&gt;e&lt;/sup&gt;</td>
<td>28</td>
</tr>
<tr>
<td>USDA-Beltsville</td>
<td>26</td>
<td>Crossbred</td>
<td>Open-front building</td>
<td>2.0</td>
<td>21</td>
</tr>
<tr>
<td>USDA-MARC</td>
<td>28</td>
<td>Crossbred</td>
<td>Gestation stall</td>
<td>1.8</td>
<td>28</td>
</tr>
<tr>
<td>Wisconsin</td>
<td>37</td>
<td>Crossbred</td>
<td>Gestation stall</td>
<td>1.8</td>
<td>21</td>
</tr>
</tbody>
</table>

<sup>a</sup>Trials at the six stations were conducted at Manhattan, Princeton, East Lansing, Beltsville, Clay Center and Madison, respectively.

<sup>b</sup>Includes 165 primiparous and 18 multiparous sows for soybean meal and raw soybean dietary treatments (all stations) and 32 primiparous sows for soybean oil treatment (USDA-Beltsville, USDA-MARC and Wisconsin).

<sup>c</sup>The crossbreds were: (Kansas) Yorkshire × Duroc × Yorkshire, (Michigan) Yorkshire × Duroc, (USDA-Beltsville) Yorkshire × Landrace, (USDA-MARC) Chester White × Landrace × Large White × Yorkshire and (Wisconsin) Duroc × Landrace × Large White.

<sup>d</sup>Sows were fed 1.8 kg/d during gestation except for the months of December, January and February, during which time the feeding level was increased to 2.3 kg/d.

<sup>e</sup>Sows were fed 2.3 kg/d during the first gestation and 2 kg/d during the second gestation.

Introduction

Raw soybeans contain antinutritional factors such as trypsin inhibitors and are nutritionally inferior to properly heated soybean meal for growing swine (Robison, 1930; Yen et al., 1974, 1977; Crenshaw and Danielson, 1985b). However, raw soybeans may be less deleterious to mature swine than to growing pigs. Jensen et al. (1971) observed similar reproductive performance in sows fed a gestation diet containing either raw soybeans or soybean meal. During gestation, sows fed raw soybeans gained less weight than those fed soybean meal. More recently, Crenshaw and Danielson (1985a) reported no difference in weight gain of sows fed raw soybeans vs soybean meal during gestation through three parities. When a soybean meal diet was fed during lactation, sows fed raw soybeans during gestation had a greater number of pigs surviving to d 21 of age in the first parity, but not in the subsequent parities. The average pig weight at birth was greater for sows fed raw soybeans when data were summarized over all three parities. This increased pig birth weight was attributed to the higher energy density of the raw soybean diet.

One objective of our study was to evaluate the effects of feeding raw soybeans as the source of supplemental protein in both gestation and lactation diets on sow and litter performance. Another objective was to determine whether soybean oil supplementation of soybean meal would affect the performance of the sow and litter.

Experimental Procedure

This cooperative study was conducted by members of the NCR-42 Committee on Swine Nutrition. The study involved six stations (Kansas State University, the University of Kentucky, Michigan State University, USDA-Beltsville Agricultural Research Center, USDA-Meat Animal Research Center and the University of Wisconsin). A total of 197 primiparous and 18 multiparous sows were involved in this study. The number, breed, gestation housing, gestation daily feed intake and lactation length of sows at each station are listed in Table 1.

Sows were bred and assigned randomly within station to dietary treatments. Each station procured its own feed ingredients, with the exception of soybean oil<sup>g</sup> and antioxidant<sup>g</sup>, which were from a single source. Raw soybeans from each station were analyzed locally for CP content (N × 6.25; AOAC, 1980) and samples were sent to the USDA

<sup>f</sup>Supplied by American Soybean Association, St. Louis, MO.

<sup>g</sup>Supplied by Monsanto, St. Louis, MO.
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TABLE 2. COMPOSITION OF RAW SOYBEANS

<table>
<thead>
<tr>
<th>Station</th>
<th>CP, %</th>
<th>Trypsin inhibitor, mg/g</th>
<th>Ether extract, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kansas</td>
<td>32.0</td>
<td>28.3</td>
<td>19.0</td>
</tr>
<tr>
<td>Kentucky</td>
<td>34.7</td>
<td>23.7</td>
<td>18.5</td>
</tr>
<tr>
<td>Michigan</td>
<td>35.0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>USDA-Beltsville</td>
<td>33.2</td>
<td>28.2</td>
<td>20.5</td>
</tr>
<tr>
<td>USDA-MARC</td>
<td>36.5</td>
<td>27.6</td>
<td>19.5</td>
</tr>
<tr>
<td>Wisconsin</td>
<td>36.5</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Northern Regional Research Center, Peoria, IL, for determination of trypsin inhibitor content with a standard analytical procedure (Hamerstrand et al., 1981) and for determination of ether extract (AOAC, 1980). The CP, trypsin inhibitor and ether extract contents of the raw soybeans are presented in Table 2. The soybean meal from USDA-MARC also was analyzed for trypsin inhibitor content and was found to have only 2.7 mg trypsin inhibitor per gram of sample. We assumed that the soybean meal from the other stations also had low trypsin inhibitor content.

The control diet (Table 3) was a corn-soybean meal diet formulated to contain 14% CP, .80% Ca, .70% P and 3,180 kcal ME/kg. The second diet was a corn-raw soybean diet formulated to contain the same levels of CP, Ca and P. The raw soybeans were ground in a hammermill with either a .64- or a .95-cm screen, depending on the station, prior to mixing; diets were mixed in quantities that would allow for a storage time of 4 wk or less. A corn-soybean meal diet with 1.8% added soybean oil was included as the third treatment at three stations (USDA-Beltsville, USDA-MARC and Wisconsin) and was fed to 32 gilts. This diet was calculated to be isonitrogenous to the control and raw soybean diets and isocaloric on an ME basis to the raw soybean diet. All diets were fortified with levels of minerals and vitamins to meet or exceed NRC (1979) requirements. An antioxidant (ethoxyquin) was added to all diets to prevent rancidity.

These diets were fed during both gestation and lactation through two gestation-lactation cycles (hereafter referred to as parity). Parity 1 included both gilts (n = 197) and sows (n = 18). The daily gestation feed intake ranged from 1.8 to 2.3 kg/d, depending on station, but was constant across treatment within stations. During lactation, sows were allowed ad libitum access to their diets. The length of lactation

TABLE 3. COMPOSITION OF DIETS (%)

<table>
<thead>
<tr>
<th>Item</th>
<th>Soybean meal</th>
<th>Raw soybean</th>
<th>Soybean oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ingredients</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ground corn</td>
<td>81.65</td>
<td>76.70</td>
<td>79.2</td>
</tr>
<tr>
<td>Soybean meal (44% CP)</td>
<td>15.1</td>
<td></td>
<td>15.6</td>
</tr>
<tr>
<td>Ground soybeans (35% CP)</td>
<td>-</td>
<td>20.4a</td>
<td>-</td>
</tr>
<tr>
<td>Soybean oilb</td>
<td>-</td>
<td>-</td>
<td>1.8</td>
</tr>
<tr>
<td>Dicalcium phosphate, feed grade</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Ground limestone</td>
<td>.8</td>
<td>.8</td>
<td>.8</td>
</tr>
<tr>
<td>Saltc</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Trace mineral mixd</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Vitamin mixd</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Antioxidantd</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Calculated analysis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CP, %</td>
<td>14.0</td>
<td>14.0</td>
<td>14.0</td>
</tr>
<tr>
<td>Ca, %</td>
<td>.80</td>
<td>.80</td>
<td>.80</td>
</tr>
<tr>
<td>P, %</td>
<td>.70</td>
<td>.70</td>
<td>.70</td>
</tr>
<tr>
<td>ME, kcal/kg</td>
<td>3,180</td>
<td>3,260</td>
<td>3,260</td>
</tr>
</tbody>
</table>

aAssumes the raw soybeans contained 35% CP. Each station analyzed its raw soybeans and used the analyzed CP to formulate the 14% CP raw soybean diet.

bSupplied by American Soybean Association, St. Louis, MO.

cSalt or iodized salt was added at a level of .4 or .5%, depending on station.

dAdded to meet or exceed NRC (1979) requirement for vitamins and minerals.

eDepending on station, provided .01 to .0134% ethoxyquin as Santoquin supplied by Monsanto, St. Louis, MO.
ranged from 21 to 35 d, depending on station. Between d 10 and 14 of lactation, milk samples were obtained at two stations (USDA-MARC and Wisconsin) from 19 control sows and from 11 sows fed raw soybeans in Parity 1 and from nine sows per diet in Parity 2. These milk samples were obtained from udder sections 1 and 3 from the front, after sows were injected i.m. with 10 units of oxytocin. Milk protein was calculated as 6.38 (NRC-42, 1978) times the Kjeldahl N (AOAC, 1980). Milk fat was determined gravimetrically (Folch et al., 1957).

The weights of sows at breeding, prepertum, postpartum and weaning were recorded. Depending on station, the prepertum weight was obtained between d 105 and 112 of gestation, but the date was consistent at each station. The postpartum weight was obtained within 24 h after farrowing. Pigs were weighed at birth, at 21 d and at weaning. The mortality of pigs from birth to weaning was recorded. After weaning, the sows were fed 1.8 to 2.3 kg feed once daily, depending on station, and checked for estrus. They were bred at their first estrus, and the number of days from weaning to estrus after both parities were recorded.

The data were analyzed as a split-plot design with sow as the main plot and parity within sow as the subplot. The GLM procedure of SAS (1982) was used for the analysis. Type III sum of squares was used in all of the data analysis. The model included station, treatment, station × treatment interaction, and interactions for parity × station, parity × treatment and parity × station × treatment. The mean squares of sow within station × treatment was used as the error term to test the effects of station, treatment and the interaction between station and treatment. Effects of parity and interactions for parity × station, parity × treatment and parity × station × treatment were tested with the residual mean squares as the error term. Student's t-test was used to separate the three dietary treatment means when a significant (P < .05) treatment effect was detected. All data are reported as least squares means.

Results and Discussion

For most of the traits measured, differences among stations were detected. Significant station effects are typical results of regional cooperative research and have been reported in other North Central Regional Studies (NCR-42 1976, 1978, 1983; Lewis et al., 1991) and in studies conducted in the Southern Region (Cromwell et al., 1989a,b). However, the interaction between station and treatment was insignificant for most traits measured. For a few of the traits, an interaction was detected between station and parity or a three-way interaction between station, treatment and parity. Nevertheless, there was no consistent pattern in these interactions, and they did not seem to have any biological significance; therefore, only the pooled means of treatment within parity are given in the tables.

Effects of Raw Soybeans. Table 4 presents the data for sows that were fed the corn-soybean meal control diet and the corn-raw soybean diet. This data set includes data from 165 primiparous and 18 multiparous sows; 115 of these same sows completed a second parity (total of 298 litters).

Sows weights at breeding (Parity 1) averaged 139 kg and were similar for the two treatments. Gestation weight gains also were similar for sows fed the two diets during Parity 1, but sows fed raw soybeans lost almost twice as much weight during lactation (P < .01) as those fed the control diet. This resulted in lighter sow weights at weaning (P < .01) and at the subsequent breeding (P < .01) in these sows. During Parity 2, gestation weight gains were similar for the two treatment groups, but sows fed raw soybeans again lost more weight during lactation (P < .01). The greater lactational weight loss was associated with a reduced feed intake (P < .01) during lactation during each parity. At the end of the second parity, average weights of the sows at weaning differed by 17 kg (P < .01), a difference of approximately 10%. The similar gestation weight gains for sows fed raw soybean and soybean meal diets are in agreement with results observed by Crenshaw and Danielson (1985a) but are in conflict with the results of Jensen et al. (1971). In the study of Crenshaw and Danielson (1985a), sows fed a raw soybean diet during gestation were fed a soybean meal diet during lactation. The lactational weight loss and feed intake of these sows were similar to those of sows receiving a soybean meal diet through both gestation and lactation.

Litter size at birth (total and live pigs) was not influenced by dietary treatment in either parity. Unlike the results reported by Crenshaw
and Danielson (1985a), average live pig weights at birth were not different \( P > 0.05 \) for the two treatment groups, regardless of whether or not the data were adjusted by covariance for litter size. Litter size and pig survival rate to 21 d and to weaning were similar \( P > 0.05 \) for the two treatment groups, but average pig weights were less at 21 d \( P < 0.05 \) and at weaning \( P < 0.05 \) in sows fed raw soybeans vs the control diet. This pattern was similar in both parities. When litter size was used as a covariate, the magnitude of treatment differences in pig weights at 21 d and at weaning was increased and the \( P \)-value changed from 0.05 to 0.01. The reduced 21-d and weaning weights probably were due to reduced milk yield; however, this was not measured. Protein content of milk also was reduced \( P < 0.05 \) in this treatment group, which also may have contributed to reduced weaning weights. Fat content of the milk, however, tended to be greater in sows fed raw soybeans, apparently because of the greater fat content of the lactation diet. The number of days from weaning to estrus was similar for sows fed soybean meal and raw soybean diets.

As expected, sows in Parity 2 were heavier \( P < 0.01 \) at each weight period than at their

| TABLE 4. EFFECT OF RAW SOYBEANS ON PERFORMANCE OF SOWS AND THEIR LITTERS AT SIX STATIONS |
|-----------------------------------------------|-------------------|-------------------|-----------------|------------------|
| Item                                         | Soybean meal | Raw soybeans | Soybean meal | Raw soybeans |
| Litters farrowed                             | 93            | 90             | 56            | 59              |
| Sow wt, kg                                   |               |                |               |                 |
| At breeding \( ^d \)                         | 140.4         | 137.8          | 172.4         | 161.2           |
| Prepartum                                    | 189.1         | 185.6          | 211.0         | 202.0           |
| Postpartum                                   | 174.5         | 169.5          | 196.7         | 186.9           |
| At weaning                                   | 167.0         | 156.1          | 191.8         | 174.8           |
| Sow wt changes, kg                          | 51.5          | 52.3           | 48.8          | 49.8            |
| Parturition                                  | -14.2         | -16.0          | -14.6         | -15.2           |
| Lactation                                    | -7.6          | -13.2          | -4.9          | -11.9           |
| Avg sow lactation feed intake, kg/d          | 5.31          | 4.55           | 5.43          | 4.75            |
| No. of pigs born                            | 10.2          | 10.0           | 9.9           | 9.8             |
| No. of pigs born alive                      | 9.5           | 9.4            | 9.0           | 9.2             |
| No. of pigs at d 21                         | 8.4           | 7.9            | 8.0           | 7.7             |
| Survival to 21 d, % of live born             | 88.2          | 84.9           | 87.5          | 85.1            |
| No. of pigs weaned                          | 8.3           | 7.9            | 7.9           | 7.7             |
| Survival to weaning, % of live born          | 87.4          | 84.5           | 86.6          | 84.9            |
| Birth wt of live pigs, kg                   |               |                |               |                 |
| Avg                                          | 1.43          | 1.46           | 1.50          | 1.55            |
| Avg (adjusted) \( ^e \)                     | 1.43          | 1.46           | 1.49          | 1.54            |
| Pig wt at d 21, kg                           | 5.33          | 5.00           | 5.57          | 5.21            |
| Avg                                          | 5.39          | 4.99           | 5.55          | 5.15            |
| Pig wt at weaning, kg                        |               |                |               |                 |
| Avg                                          | 6.28          | 5.76           | 6.68          | 6.19            |
| Milk protein, %                              | 5.11          | 4.82           | 5.07          | 4.40            |
| Milk fat, %                                  | 7.71          | 8.24           | 6.77          | 7.20            |
| Days from weaning to estrus                  | 6.4           | 6.5            | 7.2           | 5.6             |

\( ^a \)The six stations were Kansas, Kentucky, Michigan, USDA-Beltsville, USDA-MARC and Wisconsin.

\( ^b \)PAR and TRT denote parity and dietary treatment effects \( P < 0.05 \), respectively; PAR \( \times \) TRT denotes parity \( \times \) dietary treatment interaction \( P < 0.05 \).

\( ^c \)Station effect \( P < 0.05 \) for all traits except pig weight at birth, milk protein, milk fat and days from weaning to estrus.

\( ^d \)For Parity 2, data were from 44 and 47 sows for soybean meal and raw soybean treatments, respectively.

\( ^e \)Adjusted by covariance for number of pigs born alive.

\( ^f \)Adjusted by covariance for number of pigs at d 21.

\( ^g \)Adjusted by covariance for number of pigs at weaning.
respective weight periods in Parity 1, but weight changes were similar for both parities.
Litter size in Parity 2 was not different \( (P > .10) \) from litter size in Parity 1. Most of the Parity-1 animals were first-litter gilts, and it is generally believed that gilts have smaller litters than sows. The failure of litter size to increase from Parity 1 to Parity 2 in this study is consistent with the reduced second-litter prolificacy reported by Esbenshade et al. (1986) and Gatel et al. (1987). Depletion of body fat reserves has been suggested by Hall et al. (1987) as the reason for the reduced second-litter prolificacy when first-litter sows nurse large litters. However, the litters in the present study were not especially large. The greater pig birth weights in Parity 2 than in Parity 1 are in agreement with previous reports (Baker et al., 1969; Fahnny and Bernard, 1971; Gatel et al., 1987; Cromwell et al., 1989a,b).

**Effects of Soybean Oil.** Table 5 presents data from the stations at which a fortified diet of corn, soybean meal and soybean oil (isocaloric to the corn-raw soybean diet) was included as a third treatment. In this data set, a total of 91 litters from first-parity sows and 58 litters from second-parity sows are included. The data for Treatments 1 and 2, the corn-soybean and corn-raw soybean diets, also are included in the data of Table 4. Because the results of this subset of the two treatment were similar to the results of the entire data set given in Table 4, they will not be discussed.

During the first parity, sows fed the diet with soybean oil added tended to gain more weight during gestation than sows fed the other two diets. This greater weight gain was due to larger conceptus and products of conception rather than to increased maternal tissue, as reflected by the greater sow weight loss at parturition. To some degree, the same pattern occurred in Parity 2. Lactational weight loss of sows fed the soybean oil diet was similar to that of sows fed the other two diets in both parities, as was daily feed intake during lactation. At the end of the second parity, sows fed the control soybean meal diet and those fed the soybean oil diet weighed approximately the same \( (190.1 \text{ vs } 195.8 \text{ kg}) \), indicating that supplemental fat had little effect on total weight change of sows over two parities.

Litter size (live pigs) at birth and at weaning tended to be increased by adding soybean oil in Parity 1, but this trend did not occur in Parity 2. Pig survival rate to 21 d and to weaning were not altered \( (P > .05) \) by soybean oil supplementation. Pig weights at birth were not increased, except for Parity 2 (parity \( \times \) treatment, \( P < .05 \)), when soybean oil was added. Weaning and 21-d weights also were not affected by supplementing the soybean meal diet with oil. Adjusting data by covariance for litter size did not change the outcome of the soybean oil effect on pig weights at birth, 21 d or weaning.

The failure of supplemental oil in gestation to increase average birth weights of pigs is consistent with most of the literature (Pettingrew, 1981; Moser, 1985; Pettingrew et al., 1989). However, the failure of supplemental oil in lactation to increase pig weaning weights is contradictory to the literature reviewed by Pettigrew et al. (1989) and probably resulted from relatively low numbers of animals per treatment or from the low level of supplemental oil (1.8%) used in this study. Pettigrew (1981) concluded that a minimum of 8% supplemental fat was needed to increase pig weaning weight. Supplemental oil increased fat content of the milk by about 10%, although this difference was not significant; added oil did not affect protein content of the milk, which is in agreement with results of others (Seerley et al., 1974; Stahly et al., 1980; Pettigrew, 1981; Coffey et al., 1982; Moser 1985; Schoenherr et al., 1989). The number of days from weaning to estrus was not influenced by supplemental fat, although the interval as reduced from 7.0 d in controls to 4.3 d in sows given fat-supplemented diets in Parity 2.

In conclusion, gestating swine can effectively utilize raw soybeans as the only source of supplemental protein when they are limited once daily approximately 2 kg of a corn-based diet. However, when sows had ad libitum access to a diet containing raw soybeans as the sole source of supplemental protein during the lactation period, feed intake was reduced, resulting in lighter-weight pigs and greater maternal weight loss during lactation. Extra dietary fat, when supplied either by raw soybeans or by 1.8% soybean oil supplementation, had no effect on the performance of the sow and litter.

**Implications**

A corn-raw soybean diet (14% CP), when fed at approximately 2 kg/d, supported normal
<table>
<thead>
<tr>
<th>Item</th>
<th>Parity 1</th>
<th>Parity 2</th>
<th>Parity 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Soybean meal</td>
<td>Raw soybeans</td>
<td>Soybean oil</td>
</tr>
<tr>
<td>Litters farrowed</td>
<td>33</td>
<td>26</td>
<td>32</td>
</tr>
<tr>
<td>Sow wt, kg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At breeding&lt;sup&gt;d&lt;/sup&gt;</td>
<td>138.9</td>
<td>138.1</td>
<td>140.5</td>
</tr>
<tr>
<td>Prepartum&lt;sup&gt;e&lt;/sup&gt;</td>
<td>193.6</td>
<td>193.3</td>
<td>201.6</td>
</tr>
<tr>
<td>Postpartum&lt;sup&gt;f&lt;/sup&gt;</td>
<td>177.3</td>
<td>174.7</td>
<td>180.5</td>
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<tr>
<td>At weaning&lt;sup&gt;g&lt;/sup&gt;</td>
<td>168.1</td>
<td>159.2</td>
<td>170.7</td>
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<tr>
<td>Sow wt changes, kg</td>
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</tr>
<tr>
<td>Gestation&lt;sup&gt;d&lt;/sup&gt;</td>
<td>54.2</td>
<td>54.7</td>
<td>61.1</td>
</tr>
<tr>
<td>Parturition</td>
<td>-15.6</td>
<td>-18.3</td>
<td>-21.0</td>
</tr>
<tr>
<td>Lactation</td>
<td>-9.3</td>
<td>-15.2</td>
<td>-9.9</td>
</tr>
<tr>
<td>Avg sow lactation feed intake, kg/df&lt;sup&gt;f&lt;/sup&gt;</td>
<td>4.56</td>
<td>3.89</td>
<td>4.70</td>
</tr>
<tr>
<td>No. of pigs born</td>
<td>9.7</td>
<td>9.8</td>
<td>11.2</td>
</tr>
<tr>
<td>No. of pigs born alive</td>
<td>9.0</td>
<td>9.2</td>
<td>10.6</td>
</tr>
<tr>
<td>No of pigs at d 21</td>
<td>8.1</td>
<td>7.7</td>
<td>8.9</td>
</tr>
<tr>
<td>Survival to 21 d, % of live born</td>
<td>91.2</td>
<td>84.6</td>
<td>84.8</td>
</tr>
<tr>
<td>No. of pigs at weaning</td>
<td>8.0</td>
<td>7.7</td>
<td>8.8</td>
</tr>
<tr>
<td>Survival to weaning, % of live born</td>
<td>90.9</td>
<td>84.2</td>
<td>84.1</td>
</tr>
<tr>
<td>Birth wt of live pigs, kg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avg</td>
<td>1.49</td>
<td>1.48</td>
<td>1.42</td>
</tr>
<tr>
<td>Avg (adjusted)&lt;sup&gt;§&lt;/sup&gt;</td>
<td>1.49</td>
<td>1.48</td>
<td>1.44</td>
</tr>
<tr>
<td>Pig wt at d 21, kg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avg</td>
<td>5.24</td>
<td>4.80</td>
<td>4.88</td>
</tr>
<tr>
<td>Avg (adjusted)&lt;sup&gt;f&lt;/sup&gt;</td>
<td>5.24</td>
<td>4.78</td>
<td>5.00</td>
</tr>
<tr>
<td>Pig wt at weaning, kg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avg</td>
<td>6.18</td>
<td>5.51</td>
<td>5.75</td>
</tr>
<tr>
<td>Avg (adjusted)&lt;sup&gt;f&lt;/sup&gt;</td>
<td>6.18</td>
<td>5.48</td>
<td>5.90</td>
</tr>
<tr>
<td>Milk protein content&lt;sup&gt;f&lt;/sup&gt;, %</td>
<td>5.11</td>
<td>4.82</td>
<td>5.25</td>
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<tr>
<td>Milk fat content, %</td>
<td>7.71</td>
<td>8.24</td>
<td>8.48</td>
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<tr>
<td>Days from weaning to estrus</td>
<td>6.2</td>
<td>6.6</td>
<td>7.4</td>
</tr>
</tbody>
</table>

<sup>a</sup>The three stations were USDA-Beltsville, USDA-MARC and Wisconsin.

<sup>b</sup>PAR and TRT denote parity and dietary treatment effects (P < .05), respectively; PAR × TRT denotes parity × dietary treatment interaction (P < .05).

<sup>c</sup>Station effect (P < .05) for all traits except number of pigs at d 21 and weaning, pig weight at birth, milk protein and milk fat.

<sup>d</sup>For Parity 2, data were from 13, 12 and 12 sows for soybean meal, raw soybean and soybean oil treatments, respectively.

<sup>e</sup>MMeans for soybean meal and raw soybean treatments are different (P < .05) from that for soybean oil treatment.

<sup>f</sup>MMeans for soybean meal and soybean oil treatments are different (P < .05) from that for raw soybean treatment.

<sup>§</sup>Adjusted by covariance for number of pigs born alive.

<sup>∥</sup>Adjusted by covariance for number of pigs at d 21.

<sup>’</sup>Adjusted by covariance for number of pigs at weaning.
gestational performance of sows. However, when sows are allowed to consume this diet ad libitum during the lactation period, feed intake was reduced, lactational weight loss was increased and weaning weight of pigs was decreased compared with sows fed a corn-soybean meal diet.

Literature Cited


