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## Evaluation of increasing select menhaden fish meal or peptone protein sources in nursery pig diets

### Abstract

A total of 350 nursery pigs (PIC 1050 x C327, initially 14.3 lb and 28 d of age) were used in a 24-d study to evaluate the effects of select menhaden fish meal (SMFM), PEP2 (also known as Ferm-O-Tide), and Peptone 50, on nursery pig performance. PEP2 and Peptone 50 are a combination of refined porcine intestinal mucosa that is co-dried with vegetable proteins. PEP2 contains an enzymatically processed vegetable protein, while Peptone 50 contains a complementary vegetable protein. There were 10 dietary treatments: a negative control containing no specialty protein, the negative control diet with 2, 4, or 6% SMFM, the negative control diet with 2, 4, or 6% PEP2, or the negative control diet with 2, 4, or 6% Peptone 50. A common pretest diet was fed in pellet form for the first 6 d postweaning. Experimental diets were fed in meal form from d 0 to 14 and a common diet was fed from d 14 to 24. From d 0 to 7, there were no differences among treatments for ADG. Pigs fed diets containing PEP2 had greater ( $P < 0.03$ ) ADFI compared with pigs fed diets containing SMFM and Peptone 50. From d 7 to 14, increasing PEP2 or SMFM increased (quadratic;  $P < 0.04$ ) ADG, but there were no differences between pigs fed the two protein sources. Also during this period, pigs fed increasing PEP2 had increased ( $P < 0.02$ ) ADFI compared to pigs fed SMFM or Peptone 50. In addition, as PEP2 increased from 2 to 4% ADFI increased (quadratic;  $P < 0.01$ ). In Phase 2, pigs previously fed Peptone 50 had decreased ( $P < 0.05$ ) ADG compared to pigs previously fed diets containing SMFM. Overall, pigs fed PEP2 had greater ( $P < 0.02$ ) ADFI compared to pigs fed Peptone 50. In addition, pigs fed PEP2 had improved ( $P < 0.03$ ) F/G compared to pigs fed SMFM. Finally, increasing PEP2 improved (quadratic;  $P < 0.04$ ) F/G, with the most improvement seen in pigs fed the 6% PEP2 diets. These results suggest that PEP2 or Peptone 50 are suitable replacements for SMFM.; Swine Day, Manhattan, KS, November 18, 2010

### Keywords

Swine Day, 2010; Kansas Agricultural Experiment Station contribution; no. 11-016-S; Report of progress (Kansas State University. Agricultural Experiment Station and Cooperative Extension Service); 1038; Swine; Fish meal; PEP2; PEP50

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# Evaluation of Increasing Select Menhaden Fish Meal or Peptone Protein Sources in Nursery Pig Diets<sup>1</sup>

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## Summary

A total of 350 nursery pigs (PIC 1050 × C327, initially 14.3 lb and 28 d of age) were used in a 24-d study to evaluate the effects of select menhaden fish meal (SMFM), PEP2 (also known as Ferm-O-Tide), and Peptone 50, on nursery pig performance. PEP2 and Peptone 50 are a combination of refined porcine intestinal mucosa that is co-dried with vegetable proteins. PEP2 contains an enzymatically processed vegetable protein, while Peptone 50 contains a complementary vegetable protein. There were 10 dietary treatments: a negative control containing no specialty protein, the negative control diet with 2, 4, or 6% SMFM, the negative control diet with 2, 4, or 6% PEP2, or the negative control diet with 2, 4, or 6% Peptone 50. A common pretest diet was fed in pellet form for the first 6 d postweaning. Experimental diets were fed in meal form from d 0 to 14 and a common diet was fed from d 14 to 24. From d 0 to 7, there were no differences among treatments for ADG. Pigs fed diets containing PEP2 had greater ( $P < 0.03$ ) ADFI compared with pigs fed diets containing SMFM and Peptone 50. From d 7 to 14, increasing PEP2 or SMFM increased (quadratic;  $P < 0.04$ ) ADG, but there were no differences between pigs fed the two protein sources. Also during this period, pigs fed increasing PEP2 had increased ( $P < 0.02$ ) ADFI compared to pigs fed SMFM or Peptone 50. In addition, as PEP2 increased from 2 to 4% ADFI increased (quadratic;  $P < 0.01$ ). In Phase 2, pigs previously fed Peptone 50 had decreased ( $P < 0.05$ ) ADG compared to pigs previously fed diets containing SMFM. Overall, pigs fed PEP2 had greater ( $P < 0.02$ ) ADFI compared to pigs fed Peptone 50. In addition, pigs fed PEP2 had improved ( $P < 0.03$ ) F/G compared to pigs fed SMFM. Finally, increasing PEP2 improved (quadratic;  $P < 0.04$ ) F/G, with the most improvement seen in pigs fed the 6% PEP2 diets. These results suggest that PEP2 or Peptone 50 are suitable replacements for SMFM

Key words: fish meal, PEP2, PEP50

## Introduction

Previous research at Kansas State University (K-State; Myers et al., 2009<sup>5</sup>) found that diets containing at least 4% or greater PEP2 can replace fish meal in Phase 2 diets. PEP2

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<sup>5</sup> Myers et al., Swine Day 2009, Report of Progress 1020, pp. 90-95.

is a porcine intestinal mucosa derived from small intestines collected at pork packing plants and cleaned of any digestive contents. The mucosa linings from the intestines are removed and then hydrolyzed. Following hydrolysis, resin beads are used to extract heparin for use in the human health industry. The remaining material consists of small chain peptides and has an excellent amino acid profile. In addition to the mucosa, unique co-products are added and co-dried to create a final product. PEP2 (proteins enzymatically processed; Protein Resources, West Bend, IA) is a blend of porcine intestinal mucosa and enzymatically processed vegetable protein. In addition to PEP2, we tested a new intestinal protein source, Peptone 50. In Peptone 50, instead of being co-dried, the intestinal mucosa is spray dried onto a complementary vegetable protein. The objective of this study was to evaluate the influence of PEP2, Peptone 50, and select menhaden fish meal on nursery pig growth performance.

## Procedures

The Kansas State University International Animal Care and Use Committee approved the protocol used in this experiment. The study was conducted at the K-State Segregated Early Weaning Facility in Manhattan, KS.

Samples of fish meal, PEP2, and Peptone 50 were collected and analyzed for CP, crude fat, mineral, and amino acid content (Table 1). The nutrient profiles for PEP2 and Peptone 50, along with their digestible amino acid values, were provided by the manufacturer and used in diet formulation.

A total of 350 nursery pigs (PIC 1050 × C327, initially 14.3 lb and 28 d of age) were used in a 24-d study to evaluate the effects on nursery pig performance of select menhaden fish meal (SMFM), PEP2, and Peptone 50. At the nursery facility, pigs were fed a common pretest diet (Table 2) for the first 6 days after weaning. Pigs were then allotted to 1 of 10 dietary treatments. There were 5 pigs per pen and 7 pens per treatment. Pigs were provided unlimited access to feed and water via a 4-hole dry self feeder and a cup waterer in each pen (4 x 4 ft).

The 10 dietary treatments included: negative control containing no specialty protein products, the negative control diet with 2, 4, or 6% SMFM; the negative control with 2, 4, or 6% PEP2; or the negative control with 2, 4, or 6% Peptone 50 (Table 2). A common pretest SEW diet was fed in pellet form for the first 6 d postweaning. Treatment diets were fed in meal form from d 0 to 14. From d 14 to 24, all pigs were fed a common diet. Average daily gain, ADFI, and F/G were determined by weighing pigs and measuring feed disappearance on d 0, 7, 14, and 24.

Data were analyzed as a completely randomized design with pen as the experimental unit. Analysis of variance was performed using the MIXED procedure in SAS (SAS Institute, Inc., Cary, NC). Contrast statements used were: (1) linear and quadratic effects of increasing fish meal, PEP2, and Peptone 50; (2) fish meal vs PEP2; (3) fish meal vs Peptone 50; and (4) PEP2 vs Peptone 50.

## Results and Discussion

From d 0 to 7 there were no differences among treatments for ADG or F/G. However, pigs fed diets containing PEP2 had greater ( $P < 0.01$ ) ADFI compared to pigs fed diets containing SMFM and Peptone 50 (Tables 3 and 4).

From d 7 to 14, pigs fed increasing PEP2 or SMFM had increased (quadratic;  $P < 0.04$ ) ADG, while pigs fed diets containing PEP2 had improved ( $P < 0.02$ ) ADFI compared with pigs fed SMFM or Peptone 50. Pigs fed increasing PEP2 had improved (quadratic;  $P < 0.01$ ) ADFI, with the greatest increase observed when PEP2 increased from 2 to 4%. Pigs fed increasing SMFM had improved ( $P < 0.01$ ) F/G, with the greatest improvement seen as fish meal increased from 2 to 4% of the diet.

From d 0 to 14, pigs fed PEP2 tended to have improved ( $P < 0.08$ ) ADG compared to those fed Peptone 50. Pigs fed PEP2 had increased ( $P < 0.01$ ) ADFI compared to those fed SMFM and Peptone 50. As PEP2 increased from 2 to 4%, ADFI improved (quadratic;  $P < 0.01$ ).

From d 14 to 24, pigs previously fed SMFM had improved ( $P < 0.05$ ) ADG compared to pigs previously fed Peptone 50. In addition, pigs previously fed SMFM had a tendency for increased ( $P < 0.06$ ) ADFI compared to those previously fed Peptone 50.

Overall, there were no differences among treatments for ADG. However, pigs fed PEP2 had greater ( $P < 0.02$ ) ADFI compared to those fed diets containing Peptone 50. Pigs fed PEP2 had poorer ( $P < 0.03$ ) F/G compared to those fed SMFM. Feed efficiency became slightly poorer (quadratic;  $P < 0.04$ ) as PEP2 level increased in the diet.

In conclusion, PEP2 increased ADFI from d 0 to 14 when compared to SMFM and Peptone 50. The greatest improvement in d 0 to 14 feed intake was seen as PEP2 increased from 2 to 4%. Additionally, pigs fed PEP2 had overall increased ADFI when compared to those fed diets containing Peptone 50. Taking into consideration improvements in ADG and feed intake in pigs fed PEP2 compared to those fed Peptone 50, enzymatically processed vegetable protein maybe a more desirable carrier. These results suggest that 4% PEP2 can be a suitable replacement for SMFM in Phase 2 nursery diets.

**Table 1. Analyzed composition of specialty protein sources<sup>1</sup>**

| Nutrient,%     | Select menhaden<br>fish meal | Spray-dried<br>animal plasma | PEP2  | Peptone 50 |
|----------------|------------------------------|------------------------------|-------|------------|
| Dry matter     | 91.48                        | 91.52                        | 93.97 | 95.95      |
| CP             | 62.60                        | 75.9                         | 52.80 | 52.5       |
| Crude fat      | 8.80                         | 0.10                         | 12.10 | 7.0        |
| Crude fiber    | 0.50                         | 0.10                         | 3.70  | 2.8        |
| Ash            | 19.44                        | 9.01                         | 8.76  | 10.43      |
| Ca             | 5.20                         | 0.15                         | 0.31  | 0.32       |
| P              | 2.97                         | 1.94                         | 0.76  | 0.72       |
| S              | 0.89                         | 0.89                         | 1.05  | 1.43       |
| Amino acids, % |                              |                              |       |            |
| Arginine       | 3.53                         | 4.57                         | 3.28  | 4.42       |
| Histidine      | 1.46                         | 2.47                         | 1.29  | 1.29       |
| Isoleucine     | 2.54                         | 2.99                         | 2.36  | 2.27       |
| Leucine        | 4.25                         | 7.68                         | 4.01  | 4.04       |
| Lysine         | 4.68                         | 6.54                         | 3.42  | 3.43       |
| Methionine     | 1.62                         | 0.67                         | 0.81  | 0.76       |
| Phenylalnine   | 2.33                         | 4.39                         | 2.40  | 2.27       |
| Theronine      | 2.31                         | 4.28                         | 1.98  | 2.25       |
| Tryptophan     | 0.70                         | 1.39                         | 0.65  | 0.50       |
| Valine         | 2.95                         | 5.19                         | 2.69  | 2.87       |

<sup>1</sup> Values represent the mean of two samples.

**Table 2. Composition of diets, (as-fed basis)<sup>1,2</sup>**

| Item                      | Pretest diet | SBM control | PEP2 <sup>3</sup> |       |       | Fish meal |       |       | Peptone 50 <sup>3</sup> |       |       | Common diet |
|---------------------------|--------------|-------------|-------------------|-------|-------|-----------|-------|-------|-------------------------|-------|-------|-------------|
|                           |              |             | 2%                | 4%    | 6%    | 2%        | 4%    | 6%    | 2%                      | 4%    | 6%    |             |
| Corn                      | 39.70        | 55.10       | 61.50             | 62.10 | 62.70 | 61.90     | 62.95 | 63.95 | 61.50                   | 62.10 | 62.65 | 62.79       |
| Soybean meal, (46.5% CP)  | 22.90        | 40.10       | 31.30             | 28.70 | 26.10 | 31.30     | 28.7  | 26.10 | 31.30                   | 28.70 | 26.10 | 32.27       |
| Spray dried animal plasma | 6.00         | ---         | ---               | ---   | ---   | ---       | ---   | ---   | ---                     | ---   | ---   | ---         |
| PEP2                      | ---          | ---         | 2.00              | 4.00  | 6.00  | ---       | ---   | ---   | ---                     | ---   | ---   | ---         |
| Select menhaden fish meal | ---          | ---         | ---               | ---   | ---   | 2.00      | 4.00  | 6.00  | ---                     | ---   | ---   | ---         |
| Peptone 50                | ---          | ---         | ---               | ---   | ---   | ---       | ---   | ---   | 2.00                    | 4.00  | 6.00  | ---         |
| Spray-dried whey          | 25.00        | ---         | ---               | ---   | ---   | ---       | ---   | ---   | ---                     | ---   | ---   | ---         |
| Soybean oil               | 3.00         | 1.00        | 1.00              | 1.00  | 1.00  | 1.00      | 1.00  | 1.00  | 1.00                    | 1.00  | 1.00  | 1.00        |
| Monocalcium P, ( 21% P)   | 0.90         | 1.60        | 1.60              | 1.55  | 1.55  | 1.38      | 1.10  | 0.85  | 1.60                    | 1.55  | 1.55  | 1.25        |
| Limestone                 | 0.93         | 0.93        | 0.98              | 1.03  | 1.03  | 0.83      | 0.72  | 0.60  | 0.98                    | 1.03  | 1.03  | 1.05        |
| Salt                      | 0.30         | 0.35        | 0.35              | 0.35  | 0.35  | 0.35      | 0.35  | 0.35  | 0.35                    | 0.35  | 0.35  | 0.35        |
| Zinc oxide                | 0.38         | 0.25        | 0.25              | 0.25  | 0.25  | 0.25      | 0.25  | 0.25  | 0.25                    | 0.25  | 0.25  | 0.25        |
| Vitamin premix            | 0.25         | 0.25        | 0.25              | 0.25  | 0.25  | 0.25      | 0.25  | 0.25  | 0.25                    | 0.25  | 0.25  | 0.25        |
| Trace mineral premix      | 0.15         | 0.15        | 0.15              | 0.15  | 0.15  | 0.15      | 0.15  | 0.15  | 0.15                    | 0.15  | 0.15  | 0.15        |
| Lysine HCl                | 0.28         | 0.15        | 0.35              | 0.35  | 0.35  | 0.32      | 0.30  | 0.28  | 0.36                    | 0.36  | 0.37  | 0.33        |
| DL-Methionine             | 0.19         | 0.09        | 0.15              | 0.15  | 0.15  | 0.14      | 0.12  | 0.12  | 0.15                    | 0.16  | 0.16  | 0.14        |
| L-Threonine               | 0.08         | 0.04        | 0.13              | 0.13  | 0.13  | 0.12      | 0.11  | 0.11  | 0.13                    | 0.13  | 0.14  | 0.13        |
| Total                     | 100          | 100         | 100               | 100   | 100   | 100       | 100   | 100   | 100                     | 100   | 100   | 100         |

*continued*

**Table 2. Composition of diets, (as-fed basis)<sup>1,2</sup>**

| Item  | Pretest diet | SBM control | PEP2 <sup>3</sup> |       |       | Fish meal |       |       | Peptone 50 <sup>3</sup> |       |       | Common diet |
|---|--------------|-------------|-------------------|-------|-------|-----------|-------|-------|-------------------------|-------|-------|-------------|
|   |              |             | 2%                | 4%    | 6%    | 2%        | 4%    | 6%    | 2%                      | 4%    | 6%    |             |
| Calculated analysis   |              |             |                   |       |       |           |       |       |                         |       |       |             |
| Standardized ileal digestible (SID) amino acids, % <sup>4</sup> |              |             |                   |       |       |           |       |       |                         |       |       |             |
| Lysine  | 1.50         | 1.32        | 1.32              | 1.32  | 1.32  | 1.32      | 1.32  | 1.32  | 1.32                    | 1.32  | 1.32  | 1.26        |
| Isoleucine:lysine   | 54           | 69          | 60                | 60    | 59    | 61        | 61    | 61    | 60                      | 60    | 59    | 61          |
| Methionine:lysine   | 31           | 32          | 34                | 34    | 34    | 34        | 35    | 36    | 34                      | 34    | 34    | 34          |
| Met & Cys:lysine  | 58           | 58          | 58                | 58    | 58    | 58        | 58    | 59    | 58                      | 58    | 57    | 59          |
| Threonine:lysine  | 63           | 62          | 62                | 62    | 62    | 62        | 62    | 62    | 62                      | 62    | 62    | 63          |
| Tryptophan:lysine   | 17.7         | 19.9        | 17.1              | 16.9  | 16.7  | 17.1      | 16.9  | 16.7  | 16.9                    | 16.7  | 16.7  | 17.5        |
| Valine:lysine   | 65           | 75          | 67                | 67    | 67    | 68        | 68    | 69    | 67                      | 67    | 68    | 68          |
| Total lysine, %   | 1.65         | 1.47        | 1.45              | 1.45  | 1.45  | 1.45      | 1.45  | 1.45  | 1.45                    | 1.45  | 1.44  | 1.39        |
| CP, %   | 22.1         | 23.6        | 21.4              | 21.3  | 21.3  | 21.5      | 21.6  | 21.8  | 21.4                    | 21.4  | 21.3  | 20.8        |
| ME kcal/lb  | 1,560        | 1,513       | 1,513             | 1,511 | 1,509 | 1,521     | 1,526 | 1,532 | 1,513                   | 1,511 | 1,509 | 1,519       |
| Ca, %   | 0.80         | 0.80        | 0.80              | 0.80  | 0.80  | 0.80      | 0.80  | 0.80  | 0.80                    | 0.80  | 0.80  | 0.76        |
| P, %  | 0.74         | 0.77        | 0.74              | 0.73  | 0.73  | 0.74      | 0.73  | 0.72  | 0.74                    | 0.73  | 0.73  | 0.66        |
| Available P, %  | 0.51         | 0.42        | 0.42              | 0.42  | 0.42  | 0.42      | 0.42  | 0.42  | 0.42                    | 0.42  | 0.42  | 0.42        |

<sup>1</sup> A total of 350 nursery pigs (initial BW 12.0) were used in a 24-d trial to determine the effects of protein sources on nursery pig growth performance.

<sup>2</sup> The pretest diet was a common diet fed the first 6 days postweaning.

<sup>3</sup> Tech Mix Inc., Stewart, MN, and Midwest Ag Enterprises, Marshall, MN.

<sup>4</sup> Amino acid digestibility values for spray-dried plasma were used as the estimate of standardized amino acid digestibility of amino acids in PEP2.



**Table 3. Effects of protein source on nursery pig performance<sup>1</sup>**

| Item       | Negative Control | PEP2 |      |      | Fish meal |      |      | Peptone 50 |      |      | SEM  |
|------------|------------------|------|------|------|-----------|------|------|------------|------|------|------|
|            |                  | 2%   | 4%   | 6%   | 2%        | 4%   | 6%   | 2%         | 4%   | 6%   |      |
| d 0 to 7   |                  |      |      |      |           |      |      |            |      |      |      |
| ADG, lb    | 0.64             | 0.61 | 0.70 | 0.67 | 0.56      | 0.62 | 0.65 | 0.62       | 0.57 | 0.68 | 0.04 |
| ADFI, lb   | 0.77             | 0.81 | 0.89 | 0.83 | 0.74      | 0.74 | 0.81 | 0.79       | 0.72 | 0.83 | 0.05 |
| F/G        | 1.22             | 1.33 | 1.28 | 1.24 | 1.39      | 1.19 | 1.27 | 1.28       | 1.31 | 1.25 | 0.09 |
| d 7 to 14  |                  |      |      |      |           |      |      |            |      |      |      |
| ADG, lb    | 0.81             | 0.93 | 0.92 | 0.87 | 0.87      | 0.94 | 0.83 | 0.84       | 0.83 | 0.88 | 0.04 |
| ADFI, lb   | 1.17             | 1.30 | 1.34 | 1.20 | 1.17      | 1.23 | 1.17 | 1.19       | 1.12 | 1.23 | 0.05 |
| F/G        | 1.45             | 1.39 | 1.46 | 1.39 | 1.35      | 1.32 | 1.41 | 1.41       | 1.37 | 1.41 | 0.05 |
| d 0 to 14  |                  |      |      |      |           |      |      |            |      |      |      |
| ADG, lb    | 0.72             | 0.77 | 0.80 | 0.77 | 0.72      | 0.78 | 0.74 | 0.73       | 0.70 | 0.78 | 0.03 |
| ADFI, lb   | 0.97             | 1.05 | 1.12 | 1.02 | 0.96      | 0.98 | 0.99 | 0.99       | 0.92 | 1.03 | 0.05 |
| F/G        | 1.34             | 1.36 | 1.38 | 1.32 | 1.35      | 1.27 | 1.35 | 1.35       | 1.34 | 1.33 | 0.05 |
| d 14 to 24 |                  |      |      |      |           |      |      |            |      |      |      |
| ADG, lb    | 1.22             | 1.17 | 1.17 | 1.18 | 1.21      | 1.19 | 1.25 | 1.10       | 1.20 | 1.16 | 0.05 |
| ADFI, lb   | 1.81             | 1.77 | 1.84 | 1.78 | 1.79      | 1.82 | 1.83 | 1.69       | 1.74 | 1.78 | 0.05 |
| F/G        | 1.48             | 1.53 | 1.57 | 1.51 | 1.48      | 1.53 | 1.47 | 1.54       | 1.45 | 1.54 | 0.03 |
| d 0 to 24  |                  |      |      |      |           |      |      |            |      |      |      |
| ADG, lb    | 0.93             | 0.94 | 0.96 | 0.94 | 0.92      | 0.95 | 0.95 | 0.88       | 0.91 | 0.94 | 0.03 |
| ADFI, lb   | 1.32             | 1.35 | 1.42 | 1.33 | 1.31      | 1.33 | 1.34 | 1.27       | 1.26 | 1.34 | 0.05 |
| F/G        | 1.42             | 1.45 | 1.48 | 1.42 | 1.42      | 1.40 | 1.41 | 1.45       | 1.40 | 1.44 | 0.03 |

<sup>1</sup>A total of 350 nursery pigs (initial BW 14.3) were used in a 24-d to determine the effects of protein sources on nursery pig growth performance. There were 5 pigs per pen with 6 pens per treatment.

**Table 4. Statistics of the effects of specialty protein sources<sup>1</sup>**

| Item       | Treatment | PEP2 vs.<br>Fish meal | PEP50 vs.<br>Fish meal | PEP2 vs.<br>PEP50 | PEP2   |           | Fish meal |           | PEP50  |           |
|------------|-----------|-----------------------|------------------------|-------------------|--------|-----------|-----------|-----------|--------|-----------|
|            |           |                       |                        |                   | Linear | Quadratic | Linear    | Quadratic | Linear | Quadratic |
| d 0 to 7   |           |                       |                        |                   |        |           |           |           |        |           |
| ADG, lb    | 0.20      | 0.10                  | 0.64                   | 0.25              | 0.29   | 0.92      | 0.59      | 0.17      | 0.64   | 0.10      |
| ADFI, lb   | 0.02      | <0.01                 | 0.47                   | 0.03              | 0.08   | 0.11      | 0.43      | 0.15      | 0.40   | 0.20      |
| F/G        | 0.49      | 0.99                  | 0.92                   | 0.92              | 0.93   | 0.22      | 0.84      | 0.42      | 0.65   | 0.31      |
| d 7 to 14  |           |                       |                        |                   |        |           |           |           |        |           |
| ADG, lb    | 0.25      | 0.44                  | 0.33                   | 0.08              | 0.36   | 0.04      | 0.48      | 0.03      | 0.31   | 0.85      |
| ADFI, lb   | 0.06      | 0.02                  | 0.75                   | <0.01             | 0.49   | <0.01     | 0.78      | 0.42      | 0.59   | 0.37      |
| F/G        | 0.16      | 0.07                  | 0.21                   | 0.54              | 0.46   | 0.85      | 0.37      | <0.01     | 0.27   | 0.30      |
| d 0 to 14  |           |                       |                        |                   |        |           |           |           |        |           |
| ADG, lb    | 0.37      | 0.16                  | 0.73                   | 0.08              | 0.25   | 0.18      | 0.46      | 0.59      | 0.37   | 0.28      |
| ADFI, lb   | 0.20      | <0.01                 | 0.92                   | <0.01             | 0.19   | <0.01     | 0.57      | 0.87      | 0.43   | 0.21      |
| F/G        | 0.34      | 0.14                  | 0.43                   | 0.49              | 0.84   | 0.15      | 0.60      | 0.27      | 0.76   | 0.67      |
| d 14 to 24 |           |                       |                        |                   |        |           |           |           |        |           |
| ADG, lb    | 0.42      | 0.17                  | 0.05                   | 0.53              | 0.45   | 0.42      | 0.74      | 0.38      | 0.55   | 0.30      |
| ADFI, lb   | 0.57      | 0.64                  | 0.06                   | 0.15              | 0.84   | 0.84      | 0.67      | 0.68      | 0.86   | 0.09      |
| F/G        | 0.27      | 0.14                  | 0.57                   | 0.36              | 0.38   | 0.13      | 0.89      | 0.40      | 0.56   | 0.62      |
| d 0 to 24  |           |                       |                        |                   |        |           |           |           |        |           |
| ADG, lb    | 0.78      | 0.89                  | 0.17                   | 0.13              | 0.73   | 0.68      | 0.52      | 0.90      | 0.77   | 0.19      |
| ADFI, lb   | 0.27      | 0.20                  | 0.29                   | 0.02              | 0.55   | 0.14      | 0.60      | 0.76      | 0.71   | 0.10      |
| F/G        | 0.19      | 0.03                  | 0.35                   | 0.22              | 0.63   | 0.04      | 0.75      | 0.84      | 0.88   | 0.74      |

<sup>1</sup>A total of 350 nursery pigs (initial BW 14.3) were used in a 24-d trial to determine the effects of protein sources on nursery pig growth performance. There were 5 pigs per pen and 6 pens per treatment.