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## **An evaluation of peptone as a specialty protein source in diets for nursery pigs (2009)**

### **Authors**

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# An Evaluation of Peptone as a Specialty Protein Source in Diets for Nursery Pigs<sup>1</sup>

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## Summary

Two experiments were conducted to evaluate the effects of select menhaden fish meal (SMFM), spray-dried animal plasma (SDAP), and two forms of a spray-dried ultra-filtrated porcine intestinal mucosa (Peptone 1 and 2; Protein Resources, West Bend, IA) on nursery pig performance. In Exp. 1, 216 weanling pigs (initial BW 11.9 lb) were fed either (1) a control diet containing no specialty protein sources or the control diet with (2) 4% SMFM during Phase 1 and 2% SMFM during Phase 2, (3) 4% SDAP during Phase 1 and no specialty protein sources during Phase 2, (4) 4% SDAP during Phase 1 and 2% SDAP during Phase 2, (5) 4% Peptone 1 during Phase 1 and no specialty protein sources during Phase 2, or (6) 4% Peptone 1 during Phase 1 and 2% Peptone 1 during Phase 2. Pigs were fed Phase 1 diets from d 0 to 10 postweaning followed by Phase 2 diets from d 10 to d 20 and a common Phase 3 diet that contained no specialty proteins for 7 d. From d 0 to 10 or d 0 to 27, there were no differences ( $P > 0.05$ ) in ADG or F/G.

In Exp. 2, 180 weanling pigs (initial BW 13.0 lb) were fed either (1) a control diet containing no specialty protein sources or the control diet with (2) 4% SMFM during Phase 1 and 2% SMFM during Phase 2, (3) 4% SDAP during Phase 1 and no specialty protein sources during Phase 2, (4) 4% SDAP during Phase 1 and 2% SDAP during Phase 2, (5) 4% Peptone 2 during Phase 1 and no specialty protein sources during Phase 2, or (6) 4% Peptone 2 during Phase 1 and 2% Peptone during Phase 2. Pigs were fed Phase 1 diets from d 0 to 10 postweaning followed by a Phase 2 diet from d 10 to d 25. Pigs were then fed a common Phase 3 diet that contained no specialty proteins for 7 d. From d 0 to 10, pigs fed diets containing Peptone 2 had improved ( $P < 0.10$ ) F/G compared with pigs fed the control diet. Overall (d 0 to 32), pigs fed 4% Peptone 2 during Phase 1 and 2% Peptone 2 during Phase 2 had improved ( $P < 0.05$ ) ADG compared with pigs fed 4% SMFM during Phase 1 and 2% SMFM during Phase 2. Pigs fed 4% Peptone 2 during Phase 1 and 2% Peptone 2 during Phase 2 had improved ( $P < 0.05$ ) F/G compared with pigs fed all other diets. In conclusion, the Peptone products evaluated in these studies can be used in nursery pig diets without negatively affecting pig growth performance. However, the lack of response to animal plasma in these experiments indicates that further research is warranted.

Key words: growth, protein source, spray-dried intestinal mucosa

## Introduction

Weanling pig diets often contain animal protein sources, such as select menhaden fish meal (SMFM) and spray-dried animal plasma (SDAP), that are highly digestible, palat-

<sup>1</sup> The authors wish to thank Protein Resources, West Bend, IA, for providing the Peptone 1 and 2.

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<sup>3</sup> Protein Resources, West Bend, IA.

able to young pigs, and have desirable amino acid profiles. Spray-dried animal plasma is widely used in diets immediately postweaning because it has consistently been shown to improve weanling pig performance during the first week after weaning by improving feed intake. Fish meal is often an economical way to increase essential amino acid content of diets when an upper limit is placed on the amount of soybean meal that can be used in the diet.

Another possible protein source for nursery diets is Peptone (Protein Resources, West Bend, IA), which is a product made by ultra-filtrating porcine intestinal mucosa. This filtration process removes some of the impurities from the amino-acid-rich peptides, which are then spray dried. The resulting material contains a high level of digestible peptides and amino acids. This newly developed protein source may provide an alternative to other traditional animal protein sources in nursery diets. Therefore, the objective of these experiments was to evaluate the effects of SMFM, SDAP, and Peptone on growth performance of weanling pigs.

## Procedures

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

A sample of Peptone 1 was collected and analyzed for nutrient composition (Table 1), and these values were used in diet formulation. Analyzed values were similar to those of SDAP, and because standardized ileal digestible (SID) values were not available for Peptone 1, diets were formulated with SID percentages for SDAP. For Peptone 2, analyzed amino acid values were unavailable at diet formulation. However, the analyzed CP level was similar to that of Peptone 1. Thus, diets were formulated with the same values as Peptone 1.

In Exp. 1, a total of 216 weanling pigs (PIC TR4 × 1050, initially 11.9 lb) were used in a 27-d growth trial. Pigs were blocked by weight and allotted to 1 of 6 diets. There were 6 pigs per pen and 6 pens per treatment. Each pen (5 × 5 ft) contained 1 self-feeder and 1 nipple waterer to provide ad libitum access to feed and water. Pigs were housed in the K-State Swine Teaching and Research Center.

The 6 experimental diets were: (1) control diet containing no specialty protein sources and the control diet with (2) 4% SMFM during Phase 1 and 2% SMFM during Phase 2, (3) 4% SDAP during Phase 1 and no specialty protein sources during Phase 2, (4) 4% SDAP during Phase 1 and 2% SDAP during Phase 2, (5) 4% Peptone 1 during Phase 1 and no specialty protein sources during Phase 2, and (6) 4% Peptone 1 during Phase 1 and 2% Peptone 1 during Phase 2 (Table 2). Phase 1 diets were fed from d 0 to 10, Phase 2 diets were fed from 10 to 20 d, and then all pigs were fed a common diet without any specialty protein sources for 7 d. All diets were fed in meal form. Average daily gain, ADFI, and F/G were determined by weighing pigs and measuring feed disappearance on d 5, 10, 17, 20, and 27 of the trial.

In Exp. 2, a total of 180 weanling pigs (PIC TR4 × 1050, initially 13.0 lb) were used in a 32-d growth trial. Pigs were blocked by weight and allotted to 1 of 6 diets. There were

5 pigs per pen and 6 pens per treatment. Each pen (5 × 5 ft) contained 1 self-feeder and 1 nipple waterer to provide ad libitum access to feed and water. Pigs were housed in the K-State Segregated Early Weaning Facility.

The 6 experimental diets were: (1) control diet containing no specialty protein sources and the control diet with (2) 4% SMFM during Phase 1 and 2% SMFM during Phase 2, (3) 4% SDAP during Phase 1 and no specialty protein sources during Phase 2, (4) 4% SDAP during Phase 1 and 2% SDAP during Phase 2, (5) 4% Peptone 2 during Phase 1 and no specialty protein sources during Phase 2, and (6) 4% Peptone 2 during Phase 1 and 2% Peptone during Phase 2 (Table 2). Phase 1 diets were fed from d 0 to 10, Phase 2 diets were fed from 10 to 25 d, and then all pigs were fed a common diet without specialty protein sources for 7 d. Phase 1 and 2 diets were pelleted, whereas the common Phase 3 diet was in meal form. Average daily gain, ADFI, and F/G were determined by weighing pigs and measuring feed disappearance on d 5, 10, 18, 25, and 32 of the trial.

Data were analyzed as a randomized complete block design with pen as the experimental unit. Analysis of variance used the MIXED procedure of SAS (SAS Institute, Inc., Cary, NC) with treatment as a fixed effect. Point estimations were used to determine the effects of the addition of specialty proteins. Means were considered significant at  $P < 0.05$  and trends at  $P < 0.10$ .

## Results and Discussion

Crude protein levels were similar between the two Peptones, but Peptone 2 had more than 3.5 percentage units more lysine than Peptone 1 (Table 1). Peptone 2 also had greater Thr, Met, and Trp levels than Peptone 1. Some differences in Peptone chemical analysis were expected because the two different forms of specialty protein were ultra-filtrated with different filters. However, the amplitude of change in some amino acid values, such as Lys, was surprising given that the Peptones had similar CP levels. Peptone 2 contained 5 percentage units more moisture and had higher crude fat, Na, and Cl concentrations than Peptone 1. Peptone 1 and 2 had similar S levels (4.7%).

In Exp. 1, from d 0 to 10, pigs fed different diets had similar ( $P > 0.10$ ) ADG. In addition, pigs fed the control diet tended to have improved ( $P < 0.10$ ) F/G compared with pigs fed diets including Peptone 1 (Table 3). During Phase 2 (d 10 to 20), pigs previously fed 4% Peptone 1 during Phase 1 and the control diet during Phase 2 had improved ( $P < 0.05$ ) ADG and ADFI compared with pigs previously fed 4% SDAP during Phase 1 and 2% SDAP during Phase 2 (Table 3). Pigs previously fed 4% Peptone 1 during Phase 1 and 2% Peptone 1 in Phase 2 and pigs fed the control diet tended to have improved ( $P < 0.10$ ) ADG compared with pigs previously fed 4% SDAP during Phase 1 and 2% SDAP during Phase 2. Pigs previously fed 4% Peptone 1 during Phase 1 and 2% Peptone 2 during Phase 2 tended to have improved ( $P < 0.10$ ) F/G compared with pigs previously fed 4% SDAP during Phase 1 and the control diet during Phase 2.

During the common period (d 20 to 27), ADG was similar ( $P > 0.54$ ) among pigs previously fed different diets. Pigs previously fed the control diet in Phase 1 had greater ( $P < 0.05$ ) ADFI than pigs previously fed 4% Peptone 1 during Phase 1 and tended to have greater ( $P < 0.10$ ) ADFI than pigs previously fed SMFM. Also, pigs previously fed

4% SDAP during Phase 1 and the control diet during Phase 2 tended to have improved ( $P < 0.10$ ) ADFI compared with pigs previously fed 4% Peptone 1 during Phase 1. Pigs previously fed diets containing 4% Peptone 1 during Phase 1 tended to have improved ( $P < 0.10$ ) F/G compared with pigs previously fed 4% SDAP or the control diet during Phase 1. Overall (d 0 to 27), pigs fed all diets had similar ( $P > 0.10$ ) ADG and ADFI. Pigs previously fed 4% Peptone 1 or SMFM during Phase 1 and 2% Peptone 2 or SMFM during Phase 2 tended to have improved ( $P < 0.10$ ) F/G compared with pigs previously fed 4% SDAP during Phase 1 and the control diet during Phase 2.

In Exp. 2, from d 0 to 10, pigs fed diets containing Peptone 2 had improved ( $P < 0.10$ ) F/G compared with pigs fed the control diet (Table 4). During Phase 2 (d 11 to 25), pigs fed different diets had similar ( $P > 0.14$ ) ADG and ADFI (Table 4). Pigs previously fed diets containing 4% SMFM or Peptone 2 during Phase 1 and 2% SMFM or Peptone 2 during Phase 2 had improved ( $P < 0.05$ ) F/G compared with pigs fed the control diet and tended to have improved ( $P < 0.10$ ) F/G compared with pigs previously fed 4% SDAP during Phase 1 and 2% SDAP during Phase 2 or 4% Peptone 2 during Phase 1 and the control diet during Phase 2.

During the common period (d 25 to 32), pigs previously fed 4% Peptone 2 during Phase 1 and 2% Peptone 2 during Phase 2 tended to have improved ( $P < 0.10$ ) ADG compared with pigs previously fed 4% SMFM during Phase 1 and 2% SMFM during Phase 2. Pigs previously fed different diets had similar ( $P > 0.21$ ) ADFI. Pigs previously fed the control diet or diets containing 4% Peptone 2 during Phase 1 and 2% Peptone 2 during Phase 2 had improved ( $P < 0.05$ ) F/G, whereas pigs previously fed 4% SDAP during Phase 1 and 2% SDAP during Phase 2 tended to have improved ( $P < 0.10$ ) F/G compared with pigs previously fed 4% SMFM during Phase 1 and 2% SMFM during Phase 2.

Overall (d 0 to 32), pigs fed 4% Peptone 2 during Phase 1 and 2% Peptone 2 during Phase 2 had improved ( $P < 0.05$ ) ADG compared with pigs fed 4% SMFM during Phase 1 and 2% SMFM during Phase 2 and tended to have improved ( $P < 0.10$ ) ADG compared with pigs fed the control diet. Pigs fed all diets had similar ( $P > 0.19$ ) ADFI. Finally, pigs fed 4% Peptone 2 during Phase 1 and 2% Peptone 2 during Phase 2 had improved ( $P < 0.05$ ) F/G compared with pigs fed all other diets.

Adding SMFM resulted in no added benefit to weanling pig diets in this study; however, supplementing diets with SDAP yielded mixed effects. Little benefit was seen from adding SDAP in Exp. 1. However, improvements were seen in pig performance with SDAP supplementation in Exp. 2. Results of Exp. 2 are in agreement with previous research that has shown consistent growth performance improvements from supplementing weanling pig diets with SDAP. Generally, the improvements in pig growth performance are more prominent during the first week postweaning, and there is no added benefit in feeding SDAP after 1 wk postweaning. We saw a similar effect, as there was a significant improvement from adding SDAP from d 0 to 5 compared with the control, but there was no overall benefit at the end of the experiment.

It is unknown why diets with the same formulation yielded 2 different responses to specialty protein sources from 2 different groups of pigs housed in similar environments. The only difference between the diets was that diets in Exp. 1 were in meal form,

whereas those in Exp. 2 were pelleted. More research is needed, but it appears there may be a potential relationship between pelleting and level of response to SDAP supplementation.

Although there is no data showing the effects of Peptone on nursery pig growth performance, a similar protein product, dried porcine solubles, has shown consistent improvement in piglet growth performance. The Peptone products evaluated in these studies can be used in nursery pig diets without negatively affecting pig growth performance. The lack of a strong positive response to plasma and fish meal in these experiments indicates that further research is warranted to understand the response to Peptone in more challenging environments.

**Table 1. Analyzed composition of Peptone (as-fed basis)<sup>1</sup>**

Item	Peptone 1 <sup>2</sup>	Peptone 2 <sup>3</sup>
DM, %	96.60	91.23
CP, %	74.59	74.21
Crude fat, %	0.23	1.48
Ash, %	16.88	17.68
Ca, %	0.07	0.11
P, %	0.98	1.01
Na, %	5.33	6.57
Cl, %	0.42	2.88
S, %	4.67	4.69
Amino acids, %		
Arg	3.30	4.59
His	0.97	1.82
Ile	2.12	3.03
Leu	3.28	5.44
Lys	2.70	6.35
Met	0.62	1.02
Phe	1.35	2.46
Thr	1.99	3.01
Trp	0.33	0.44
Val	2.61	3.81
Ala	2.63	3.49
Cys	1.29	1.07
Gly	6.36	5.04
Orn	1.01	0.52
Pro	4.25	3.63
Ser	1.25	2.73
Tau	0.09	0.24
Tyr	1.07	2.54

<sup>1</sup> One sample of each was analyzed by the University of Missouri Agricultural Experiment Station Chemical Laboratories.

<sup>2</sup> Analyzed nutrient values were used in diet formulation. Analyzed values were similar to those of spray-dried animal plasma, and because standardized ileal digestible (SID) values were not available for Peptone 1, diets were formulated with SID percentages for spray-dried animal plasma.

<sup>3</sup> Analyzed amino acid values were unavailable at diet formulation. However, analyzed CP levels were similar to those of Peptone 1. Thus, diets were formulated with the same values as Peptone 1



Table 2. Diet composition (Exp. 1 and 2; as-fed basis)<sup>1</sup>

Ingredient, %	Phase 1 <sup>2</sup>			Phase 2 <sup>3</sup>			Phase 3 <sup>4</sup>	
	Control	4% Fish meal	4% SDAP <sup>5</sup>	Control	2% Fish meal	2% SDAP <sup>5</sup>	2% Peptone 1 or 2 <sup>6</sup>	Common
Corn	40.08	46.58	46.10	57.23	60.45	60.25	60.05	61.18
Soybean meal (46.5% CP)	40.28	30.35	30.37	37.82	32.86	32.87	32.85	33.85
SDAP	---	---	4.00	---	---	2.00	---	---
Peptone	---	---	---	---	---	---	2.00	---
Select menhaden fish meal	---	4.00	---	---	2.00	---	---	---
Spray-dried whey	15.00	15.00	15.00	---	---	---	---	---
Soybean oil	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.00
Monocalcium P (21% P)	0.93	0.45	0.70	1.15	0.90	1.00	1.08	1.65
Limestone	0.98	0.73	1.15	1.03	0.93	1.13	1.10	0.95
Salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.35
Vitamin premix	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
L-Lys-HCl	0.20	0.29	0.20	0.25	0.30	0.25	0.35	0.30
DL-Met	0.16	0.17	0.14	0.13	0.14	0.12	0.14	0.12
L-Thr	0.08	0.14	0.05	0.10	0.13	0.09	0.14	0.11
L-Val	---	---	---	---	---	---	---	---
Phytase <sup>7</sup>	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

*continued*

**Table 2. Diet composition (Exp. 1 and 2; as-fed basis)<sup>1</sup>**

Ingredient, %	Phase 1 <sup>2</sup>			Phase 2 <sup>3</sup>			Phase 3 <sup>4</sup>
	Control	4% Fish meal	4% SDAP <sup>5</sup>	Control	2% Fish meal	2% SDAP <sup>5</sup>	2% Peptone 1 or 2 <sup>6</sup>
Calculated analysis <sup>8</sup>							
Total Lys, %	1.61	1.60	1.60	1.49	1.48	1.48	1.42
SID <sup>9</sup> amino acids, %							
Lys	1.45	1.45	1.45	1.34	1.34	1.34	1.25
Met:Lys	33	35	31	33	35	31	33
Met & Cys:Lys	58	58	58	58	59	58	57
Thr:Lys	63	63	63	63	63	63	64
Trp:Lys	19	17	19	19	18	19	17
CP, %	24.3	22.9	23.3	22.8	22.1	22.3	21.4
ME, kcal/lb	1,517	1,530	1,528	1,530	1,536	1,536	1,518
SID Lys:ME, g/Mcal	4.34	4.30	4.30	3.97	3.96	3.96	4.23
Ca, %	0.80	0.80	0.80	0.75	0.75	0.75	0.80
P, %	0.69	0.66	0.66	0.66	0.65	0.64	0.75
Available P, %	0.48	0.48	0.48	0.42	0.42	0.42	0.42

<sup>1</sup> A total of 396 nursery pigs (initial BW 11.9 or 13.0 lb) were used in a 25- or 32-d growth assay to determine the effect of protein source on nursery pig growth performance.

<sup>2</sup> Phase 1 diets were fed from d 0 to 10.

<sup>3</sup> Phase 2 diets were fed from d 10 to 20 (Exp. 1) or from d 10 to 25 (Exp. 2).

<sup>4</sup> Phase 3 diets were fed from d 20 to 27 (Exp. 1) or from d 25 to 32 (Exp. 2).

<sup>5</sup> Spray-dried animal plasma

<sup>6</sup> Peptone 1 and 2 were used in Exp. 1 and 2, respectively.

<sup>7</sup> NatuPhos 600 (BASF Animal Nutrition, Mount Olive, NJ) provided 231 FTU/lb, with a release of 0.10% available P.

<sup>8</sup> Nutrient values for fish meal and SDAP were from NRC. 1998. Nutrient Requirements of Swine. 10th ed. Natl. Acad. Press, Washington, DC.

<sup>9</sup> Standardized ileal digestible.

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

	Phase 1 <sup>2</sup> :		4% SDAP <sup>4</sup>		4% Peptone 1		4% Fish meal		SEM
	Control	Control	Control	2% SDAP	Control	2% Peptone 1	2% Fish meal		
d 0 to 10									
ADG, lb	0.41	0.46	0.47	0.46	0.43	0.45	0.035		
ADFI, lb	0.41 <sup>b</sup>	0.50 <sup>ab</sup>	0.48 <sup>ab</sup>	0.51 <sup>a</sup>	0.49 <sup>ab</sup>	0.47 <sup>ab</sup>	0.034		
F/G	1.01 <sup>a</sup>	1.09 <sup>ab</sup>	1.01 <sup>a</sup>	1.12 <sup>ab</sup>	1.15 <sup>b</sup>	1.03 <sup>ab</sup>	0.051		
d 10 to 20									
ADG, lb	0.72 <sup>ab</sup>	0.65 <sup>ab</sup>	0.62 <sup>a</sup>	0.73 <sup>b</sup>	0.73 <sup>ab</sup>	0.67 <sup>ab</sup>	0.048		
ADFI, lb	0.95 <sup>ab</sup>	0.90 <sup>ab</sup>	0.84 <sup>a</sup>	0.99 <sup>b</sup>	0.95 <sup>ab</sup>	0.90 <sup>ab</sup>	0.056		
F/G	1.33	1.38	1.37	1.35	1.31	1.50	0.040		
d 20 to 27									
ADG, lb	0.99	0.97	0.97	0.98	0.99	0.99	0.032		
ADFI, lb	2.08 <sup>a</sup>	2.02 <sup>ab</sup>	2.00 <sup>ab</sup>	1.83 <sup>b</sup>	1.82 <sup>b</sup>	1.87 <sup>ab</sup>	0.080		
F/G	2.10	2.09	2.07	1.88	1.85	1.91	0.094		
d 0 to 27									
ADG, lb	0.66	0.66	0.65	0.69	0.69	0.67	0.031		
ADFI, lb	1.01	1.03	1.00	1.02	1.01	0.98	0.022		
F/G	1.54	1.57	1.54	1.48	1.48	1.48	0.052		

<sup>1</sup> A total of 216 pigs (6 pigs per pen and 6 pens per treatment) with an initial BW of 11.9 lb were used in a 27-d experiment.

<sup>2</sup> Phase 1 diets were fed from d 0 to 10.

<sup>3</sup> Phase 2 diets were fed from d 10 to 20.

<sup>4</sup> Spray-dried animal plasma.

<sup>ab</sup> Within a row, means without a common superscript differ ( $P < 0.05$ ).

Table 4. Effects of protein source on nursery pig performance (Exp. 2)<sup>1</sup>

	Phase 1 <sup>2</sup> :		4% SDAP <sup>4</sup>		4% Peptone 2		4% Fish meal	
	Control	Control	Control	2% SDAP	Control	2% Peptone 2	Control	2% Fish meal
d 0 to 10								
ADG, lb	0.39 <sup>b</sup>	0.48 <sup>a</sup>	0.41 <sup>ab</sup>	0.46 <sup>ab</sup>	0.41 <sup>ab</sup>	0.40 <sup>b</sup>	0.42 <sup>b</sup>	0.028
ADFI, lb	0.43 <sup>b</sup>	0.50 <sup>a</sup>	0.45 <sup>ab</sup>	0.43 <sup>b</sup>	0.41 <sup>b</sup>	0.42 <sup>b</sup>	0.42 <sup>b</sup>	0.023
F/G	1.12 <sup>b</sup>	1.04 <sup>ab</sup>	1.11 <sup>b</sup>	0.95 <sup>a</sup>	1.01 <sup>ab</sup>	1.05 <sup>ab</sup>	1.05 <sup>ab</sup>	0.044
d 10 to 25								
ADG, lb	0.97	0.96	0.99	1.02	1.00	0.99	0.99	0.041
ADFI, lb	1.38	1.33	1.40	1.36	1.41	1.33	1.33	0.053
F/G	1.43 <sup>b</sup>	1.39 <sup>ab</sup>	1.41 <sup>ab</sup>	1.33 <sup>a</sup>	1.42 <sup>ab</sup>	1.34 <sup>a</sup>	1.34 <sup>a</sup>	0.043
d 25 to 32								
ADG, lb	1.32	1.33	1.31	1.39	1.35	1.23	1.23	0.082
ADFI, lb	2.00	2.07	2.00	2.07	2.12	2.00	2.00	0.095
F/G	1.52 <sup>a</sup>	1.56 <sup>ab</sup>	1.54 <sup>ab</sup>	1.50 <sup>a</sup>	1.58 <sup>ab</sup>	1.64 <sup>b</sup>	1.64 <sup>b</sup>	0.053
d 0 to 32								
ADG, lb	0.87 <sup>ab</sup>	0.89 <sup>ab</sup>	0.88 <sup>ab</sup>	0.93 <sup>a</sup>	0.89 <sup>ab</sup>	0.86 <sup>b</sup>	0.86 <sup>b</sup>	0.029
ADFI, lb	1.22	1.22	1.23	1.22	1.25	1.19	1.19	0.037
F/G	1.41 <sup>b</sup>	1.38 <sup>b</sup>	1.40 <sup>b</sup>	1.32 <sup>a</sup>	1.41 <sup>b</sup>	1.39 <sup>b</sup>	1.39 <sup>b</sup>	0.020

<sup>1</sup> A total of 180 pigs (6 pigs per pen and 6 pens per treatment) with an initial BW of 13.0 lb were used in a 28-d experiment.

<sup>2</sup> Phase 1 diets were fed from d 0 to 10.

<sup>3</sup> Phase 2 diets were fed from d 10 to 25.

<sup>4</sup> Spray-dried animal plasma.

<sup>ab</sup> Within a row, means without a common superscript differ ( $P < 0.05$ ).