Kansas Agricultural Experiment Station Research Reports

Volume 3
Issue 7 *Swine Day*

Article 21

2017

Effects of Feeding Increasing Levels of HP 300 on Nursery Pig Performance

A. M. Jones
Kansas State University, Manhattan, ajones33@k-state.edu

J. M. DeRouchey
Kansas State University, Manhattan, jderouch@k-state.edu

G. Fitzner
Hamlet Protein, Findlay, OH

See next page for additional authors

Recommended Citation

Jones, A. M.; DeRouchey, J. M.; Fitzner, G.; Woodworth, J. C.; Tokach, M. D.; Goodband, R. D.; and Dritz, S. S. (2017) "Effects of Feeding Increasing Levels of HP 300 on Nursery Pig Performance," *Kansas Agricultural Experiment Station Research Reports*: Vol. 3: Iss. 7. https://doi.org/10.4148/2378-5977.7474

Effects of Feeding Increasing Levels of HP 300 on Nursery Pig Performance

Abstract

A total of 1,215 pigs (PIC 337 × 1050; initial BW 11.3 lb) were used in a 43-d growth trial evaluating the effects of feeding increasing HP 300 (Hamlet Protein, Findlay, OH) on nursery pig performance. Pigs were weaned at 16 to 19 d of age and placed in pens, with each pen containing a mix of barrows and gilts. Pens of pigs were weighed and allotted by BW to 1 of 5 dietary treatments in a randomized complete block design with 27 pigs per pen and 9 pens per treatment. The control diet was a standard cornsoybean meal-based diet with 7.5 and 5.63% fish meal (FM) included in phases 1 and 2, respectively. First, the diet with the highest inclusion of HP 300 (phase 1 – 20%; phase 2 – 15%) was formulated and 2 intermediate diets (low and medium HP 300) were then created to have an equal stepwise increase in HP 300 with the HP 300 included at the expense of soybean meal and fish meal. A fifth treatment was then formulated to have the same amount of soybean meal as the control diet, with HP 300 replacing fish meal. From d 22 to 43, a common phase 3 diet was fed to all pigs. Phase 1 diets were fed in pellet form, while phases 2 and 3 were fed in meal form. From d 0 to 7 (phase 1), increasing HP 300 at the expense of soybean meal and fish meal decreased ADFI (quadratic, $P = 0.001$) in pigs fed the low HP 300 diet, but then increased as HP 300 was increased. No differences were observed for ADG or F/G. Furthermore, performance did not differ between pigs fed the fish meal control diet and pigs fed the diet with HP 300 replacing fish meal. During phase 2 (d 7 to 22), ADG and ADFI decreased (linear, $P < 0.05$) as HP 300 increased at the expense of soybean meal and fish meal resulting in a tendency for poorer F/G (quadratic, $P = 0.073$). However, no differences were observed between pigs fed the fish meal control diet and pigs fed HP 300 replacing fish meal. For the entire period when the specialty protein sources were fed (d 0 to 22), pigs fed increasing HP 300 had poorer ADG, ADFI, and final BW (linear, $P < 0.05$) as HP 300 increased, but there were no differences observed for F/G. In addition, there were no differences observed between pigs fed the fish meal control diet and pigs fed the HP 300 diet replacing fish meal. From d 22 to 43 (phase 3) when a common diet was fed, F/G tended (quadratic, $P = 0.075$) to improve as HP 300 increased in the previous diets with pigs previously fed the diet with the low inclusion of HP 300 having the best F/G. Overall (d 0 to 43), pigs fed increasing HP 300 had a tendency for poorer ADFI (linear, $P = 0.071$) resulting in a decreased final BW (linear, $P = 0.043$). However, no differences were observed for growth performance between pigs fed the fish meal control diet and pigs fed HP 300 replacing fish meal. For the economic analysis, feed cost per pig and cost per pound of gain decreased (linear, $P < 0.05$) for pigs fed increasing HP 300. However, there were no differences detected for revenue per pig and income over feed cost. In conclusion, increasing HP 300 up to 15 to 20% of the diet for the first 22 d post-weaning at the expense of soybean meal and fish meal resulted in a decrease in final BW at the end of the nursery period.

Keywords

growth, fish meal, HP 300, nursery pig

Cover Page Footnote

Appreciation is expressed to Dr. Gary Fitzner, Hamlet Protein, Findlay, OH, for technical support and to Hamlet Protein, Findlay, OH, for partial financial support. Appreciation is expressed to Allan Morris, Marty Heinz, and Craig Steck, New Horizon Farms, for their technical support and expertise in conducting the experiment.

Authors

A. M. Jones, J. M. DeRouchey, G. Fitzner, J. C. Woodworth, M. D. Tokach, R. D. Goodband, and S. S. Dritz

Effects of Feeding Increasing Levels of HP 300 on Nursery Pig Performance[1,2]

A.M. Jones, J.M. DeRouchey, G. Fitzner,[3] J.C. Woodworth, M.D. Tokach, R.D. Goodband, and S.S. Dritz[4]

Summary

A total of 1,215 pigs (PIC 337 × 1050; initial BW 11.3 lb) were used in a 43-d growth trial evaluating the effects of feeding increasing HP 300 (Hamlet Protein, Findlay, OH) on nursery pig performance. Pigs were weaned at 16 to 19 d of age and placed in pens, with each pen containing a mix of barrows and gilts. Pens of pigs were weighed and allotted by BW to 1 of 5 dietary treatments in a randomized complete block design with 27 pigs per pen and 9 pens per treatment. The control diet was a standard corn-soybean meal-based diet with 7.5 and 5.63% fish meal (FM) included in phases 1 and 2, respectively. First, the diet with the highest inclusion of HP 300 (phase 1 – 20%; phase 2 – 15%) was formulated and 2 intermediate diets (low and medium HP 300) were then created to have an equal stepwise increase in HP 300 with the HP 300 included at the expense of soybean meal and fish meal. A fifth treatment was then formulated to have the same amount of soybean meal as the control diet, with HP 300 replacing fish meal. From d 22 to 43, a common phase 3 diet was fed to all pigs. Phase 1 diets were fed in pellet form, while phases 2 and 3 were fed in meal form. From d 0 to 7 (phase 1), increasing HP 300 at the expense of soybean meal and fish meal decreased ADFI (quadratic, $P = 0.001$) in pigs fed the low HP 300 diet, but then increased as HP 300 was increased. No differences were observed for ADG or F/G. Furthermore, performance did not differ between pigs fed the fish meal control diet and pigs fed the diet with HP 300 replacing fish meal. During phase 2 (d 7 to 22), ADG and ADFI decreased (linear, $P < 0.05$) as HP 300 increased at the expense of soybean meal and fish meal resulting in a tendency for poorer F/G (quadratic, $P = 0.073$). However, no differences were observed between pigs fed the fish meal control diet and pigs fed HP 300 replacing fish meal. For the entire period when the specialty protein sources were fed (d 0 to 22), pigs fed increasing HP 300 had poorer ADG, ADFI, and final BW (linear, $P < 0.05$) as HP 300 increased, but there were no differences observed for F/G. In addition, there were no differences observed between pigs fed the fish meal control diet and pigs fed the HP 300 diet replacing fish meal. From d 22 to 43 (phase 3) when a common diet was

[1] Appreciation is expressed to Dr. Gary Fitzner, Hamlet Protein, Findlay, OH, for technical support and to Hamlet Protein, Findlay, OH, for partial financial support.

[2] Appreciation is expressed to Allan Morris, Marty Heinz, and Craig Steck, New Horizon Farms, for their technical support and expertise in conducting the experiment.

[3] Hamlet Protein, Findlay, OH.

[4] Department of Diagnostic Medicine/Pathology, College of Veterinary Medicine, Kansas State University.

fed, F/G tended (quadratic, $P = 0.075$) to improve as HP 300 increased in the previous diets with pigs previously fed the diet with the low inclusion of HP 300 having the best F/G. Overall (d 0 to 43), pigs fed increasing HP 300 had a tendency for poorer ADFI (linear, $P = 0.071$) resulting in a decreased final BW (linear, $P = 0.043$). However, no differences were observed for growth performance between pigs fed the fish meal control diet and pigs fed HP 300 replacing fish meal. For the economic analysis, feed cost per pig and cost per pound of gain decreased (linear, $P < 0.05$) for pigs fed increasing HP 300. However, there were no differences detected for revenue per pig and income over feed cost. In conclusion, increasing HP 300 up to 15 to 20% of the diet for the first 22 d post-weaning at the expense of soybean meal and fish meal resulted in a decrease in final BW at the end of the nursery period.

Introduction

Soybean meal is the most commonly used protein source fed to swine in the United States.[5] Its use is largely influenced by it being one of the most readily available and economical protein sources that contains an excellent balance of AA.[6] However, soybean meal contains a number of anti-nutritional factors that, when fed in high amounts, produce what is known as soybean meal transient hypersensitivity. This form of transient hypersensitivity results in abnormalities in the gastrointestinal tract (GIT) that include decreased villous height and hypertrophy of intestinal crypts.[7] As a result, a decrease in growth performance is usually observed when high levels of soybean meal are fed to weanling pigs. Thus, specialty animal protein sources have been commonly added as highly digestible AA sources in starter diets as a substitute for soybean meal.

The cost and variability of many specialty animal proteins has increased while availability of some sources, such as fish meal, has decreased. As a result, swine producers have sought more readily available and economical protein sources. One such protein source that has shown significant promise is HP 300 (Hamlet Protein, Findlay, OH). HP 300 is a finely ground soy protein, produced from conventional soybean meal that has been enzymatically treated to remove anti-nutritional factors.[8, 9] Thus, the objective of this study was to determine the effects of increasing HP 300 on nursery pig performance under commercial settings.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol for this experiment. The study was conducted at a commercial research nursery in southwestern Minnesota. The facility was totally enclosed, environmentally controlled, and mechanically ventilated. Each pen (12.1 × 7.5 ft) had completely slatted plastic floors and was equipped with a 6-hole, stainless-steel, dry self-feeder, and a

[5] Cromwell, G. L. 2000. Utilization of soy products in swine diets. Fed. Anim. Sci. Soc. 274-280.

[6] Nutrient requirements of swine. 11th edition, National Research Council, Washington DC.

[7] Li, D. F., J. L. Nelssen, P. G. Reddy, F. Blecha, J. D. Hancock, G. L. Alle, R. D. Goodband, and R. D. Klemm. 1990. Transient hypersensitivity to soybean meal in early-weaned pig. J. Anim. Sci. 68:1790-1799. doi:/1990.6861790x.

[8] Cervantes-Pahm, S. F., and H. H. Stein. 2010. Ileal digestibility amino acids in conventional, fermented, and enzyme treated soybean meal and in soy protein isolate, fishmeal, and casein fed to weanling pigs. J. Anim. Sci. 88:2674-2683. doi: 10.2527/jas.2009-2677.

[9] Goebel, K. P., and H. H. Stein. 2011. Phosphorous and energy digestibility of conventional and enzyme treated soybean meal fed to weanling pigs. J. Anim. Sci. 89:764-772. doi:10.2527/jas.2010-3253.

pan waterer for ad libitum access to feed and water. Phase 1 diets were manufactured at Hubbard Feeds (Worthington, MN), while phases 2 and 3 were manufactured at New Horizon Farms (Pipestone, MN). Daily feed additions to each pen were made and recorded by a computerized feeding system (FeedPro; Feedlogic Corp., Willmar, MN).

A total of 1,215 pigs (PIC 337 × 1050, initial BW 11.3 lb) were used in a 43-d growth trial. Pigs were weaned at 16 to 19 d of age and placed in pens with each pen containing a mix of barrows and gilts. Pens of pigs were weighed and allotted by average BW to 1 of 5 dietary treatments in a randomized complete block design, with 27 pigs per pen and 9 pens per treatment. Pigs and feeders were weighed on d 0, 7, 14, 22, 29, 36, and 43 of the trial to determine ADG, ADFI, and F/G.

Experimental diets (Tables 1 and 2) were fed in two phases, with the first phase budgeted at 4 lb/pig at weaning. The second phase was fed until d 22 post-weaning, when pigs weighed approximately 21 lb. The control diet was a standard corn-soybean meal-based diet with 7.5 and 5.63% FM included in phases 1 and 2, respectively. First, the diet with the highest inclusion of HP 300 (phase 1 – 20%; phase 2 – 15%) was formulated and two intermediate diets (low and medium HP 300) were then created to have an equal stepwise increase in HP 300 with the HP 300 included at the expense of soybean meal and fish meal. A fifth treatment was then formulated to have the same inclusion rate of soybean meal as the control diet, with HP 300 replacing fish meal. After d 22, a common phase 3 diet (Table 2) was fed to all pigs. Phase 1 diets were fed in pellet form, while phases 2 and 3 were fed in meal form.

Diet samples were taken from 6 feeders per dietary treatment on each weigh day and combined to form a composite sample within each phase. Samples were stored at -4°F until being analyzed for DM, CP, ether extract, calcium (Ca), and phosphorus (P) (Ward Laboratories, Kearney, NE). In addition, a composite sample of each protein source (fish meal, HP 300, and soybean meal) was collected during the manufacturing of diets and analyzed for DM, CP, ether extract, Ca, and P (Ward Laboratories, Kearney, NE). All diets were analyzed in duplicate for total amino acids by Ajinomoto Heartland (Chicago, IL). Soybean meal and HP 300 were analyzed for trypsin content (Hamlet Protein, Findlay, OH). Water holding capacity for complete diets as well as soybean meal, HP 300, and fish meal was determined using the centrifugation method described by Kyriazakis and Emmans.[10] Each sample was assessed in duplicate with a coefficient of variation less than 10%. Flowability was measured using a Flowdex device (Hanson Research, Chatsworth, CA), which measures flowability based on an ingredient's ability to fall freely through a hole in the center of the disk three consecutive times. Additionally, flowability was measured using angle of repose in which grain was placed in a cylinder on top of an 8.7 cm diameter pedestal. The cylinder was then lifted to allow the grain to fall freely. The height of the remaining grain was measured and used to calculate angle of repose.

An economic analysis was performed at the conclusion of the trial to determine the financial impact of the treatments. For all economic calculations, ingredient prices from

[10] Kyriazakis, I., and G. C. Emmans. 1995. The voluntary feed intake of pigs given feeds based on wheat bran, dried citrus pulp and grass meal, in relation to measurements of feed bulk. Brit. J. Nutr. 73:191-207. doi: http://dx.doi.org/10.1079/BJN19950023.

July 2016 were used with corn valued at $125/ton, soybean meal at $280/ton, dried distillers grains with solubles (DDGS) at $115/ton, whey permeate at $700/ton, fish meal at $1,900/ton, and HP 300 at $886/ton. The total feed cost per pig was calculated by multiplying the ADFI by the diet cost and the number of days it was fed for the respective period. Cost per pound of gain was calculated by dividing the total feed cost per pig by the overall pounds gained. Revenue per pig was calculated by multiplying ADG times the total days in the trial times an assumed live price of $63.00 per cwt. To calculate income over feed cost (IOFC), total feed cost was subtracted from revenue per pig.

Data were analyzed using the PROC GLIMIX procedure in SAS version 9.4 (SAS Institute, Inc., Carry, NC) with pen as the experimental unit. Dietary treatment served as the fixed effect and block served as the random effect in the model. The effects of increasing HP 300 on performance criteria were determined by linear and quadratic polynomial contrasts. A pairwise comparison between the control and the diet with HP 300 replacing fish meal was performed using the DIFFS option from the LSMEANS statement of SAS. A P-value ≤ 0.05 was considered significant and 0.05 < P ≤ 0.10 was considered a tendency.

Results and Discussion

Proximate analysis of diets and protein sources showed that most nutrients were similar to formulated values for all three phases, with the exception of Ca in the phase 1 control diet (Tables 3,4, and 5). The amino acid profiles of complete diets for phase 1 were consistently lower across dietary treatments. However, analyzed values for phase 2 generally matched formulated values. Flowability characteristics of diets fed in phase 2 were similar as indicated by similar flowability index scores using the Flowdex device as well as angle of repose. As expected, the trypsin inhibitor content of HP 300 was lower than soybean meal.

During phase 1 (d 0 to 7), increasing HP 300 at the expense of soybean meal and fish meal decreased ADFI (Table 4; quadratic, P = 0.001) in pigs fed the low HP 300 diet, but then increased as HP 300 increased. No differences were observed for ADG or F/G. Furthermore, performance did not differ between pigs fed the fish meal control diet and pigs fed the diet with HP 300 replacing fish meal.

During phase 2 (d 7 to 22), ADG and ADFI decreased (linear, P < 0.05) as HP 300 increased at the expense of soybean meal and fish meal resulting in a tendency for poorer F/G (quadratic, P = 0.073). However, no differences were observed between pigs fed the fish meal control diet and pigs fed HP 300 replacing fish meal.

For the entire period when the specialty protein sources were fed (d 0 to 22), pigs fed increasing HP 300 had poorer ADG, ADFI, and final BW (linear, P < 0.05) as HP 300 increased. However, there were no differences observed for F/G. In addition, there were no differences observed between pigs fed the fish meal control diet and pigs fed the HP 300 diet replacing only fish meal.

From d 22 to 43 (phase 3) when a common diet was fed, F/G tended (quadratic, P = 0.075) to improve as HP 300 increased in the previous diets, with pigs previously fed the diet with the low inclusion of HP 300 having the best F/G. Overall (d 0 to 43), pigs fed increasing HP 300 had a tendency for poorer ADFI (linear, $P = 0.071$) and a decreased final BW (linear, $P = 0.043$). However, no differences were observed for growth performance between pigs fed the fish meal control diet and pigs fed HP 300 replacing only fish meal.

For the economic analysis, feed cost per pig and cost per pound of gain decreased (linear, $P < 0.05$) for pigs fed increasing HP 300. However, no differences were detected for revenue per pig and IOFC. Additionally, feed cost per pig and cost per pound of gain was significantly greater (linear, $P < 0.05$) for pigs fed the fish meal control diet compared to pigs fed the HP 300 diet replacing fish meal. However, no differences were observed between pigs fed the fish meal control diet and pigs fed HP 300 replacing fish meal for revenue per pig and IOFC.

In conclusion, increasing HP 300 in phase 1 and 2 nursery diets resulted in a tendency for poorer ADFI and a decrease in final BW. A possible explanation for the poorer feed intake observed in pigs fed increasing levels of HP 300 could be attributed to its greater water holding capacity compared to the other protein sources it replaced. Kyriazakis and Emmans[10] demonstrated that an increase in water holding capacity resulted in a reduction of feed intake in their research. Chemical analysis of the 3 protein sources used for this trial indicated that HP 300 had the greatest water holding capacity. In comparison to complete diets, water holding capacity did increase as HP 300 was included at the expense of soybean meal and fish meal. However, despite the numerical differences, it is unclear if the magnitude of the difference would be significant enough to elicit satiety. Thus, the increase in HP 300 at the expense of soybean meal and fish meal, could have potentially resulted in greater gut fill because of its greater water holding capacity. However, further research is needed to confirm whether the responses observed in this study are indeed related to water holding capacity or some other factor related to the HP 300.

Table 1. Phase 1 diet composition (as-fed basis)[1,2]

Ingredient, %	Fish meal control	HP 300 replacing FM and SBM			HP 300 replacing FM
		Low	Medium	High	
Corn	41.19	40.39	39.66	38.87	36.40
Soybean meal, 46.5% CP	19.35	15.62	11.88	8.15	19.35
Fish meal	7.50	5.00	2.50	---	---
HP 300[3]	---	6.67	13.33	20.00	10.21
Corn DDGS[4]	5.00	5.00	5.00	5.00	5.00
Whey permeate	18.75	18.75	18.75	18.75	18.75
Spray dried plasma	2.50	2.50	2.50	2.50	2.50
Tallow	3.00	3.00	3.00	3.00	3.95
Limestone	0.75	0.91	1.05	1.20	1.16
Monocalcium P, 21% P	0.25	0.52	0.74	1.00	1.08
Sodium chloride	0.25	0.25	0.25	0.25	0.25
L-Lys HCl	0.33	0.33	0.33	0.33	0.33
DL-Met	0.15	0.15	0.16	0.16	0.17
L-Thr	0.16	0.14	0.12	0.11	0.13
L-Trp	0.04	0.03	0.01	---	0.01
L-Val	0.11	0.07	0.04	---	0.05
Phytase[5]	0.01	0.01	0.01	0.01	0.01
Zinc oxide	0.42	0.42	0.42	0.42	0.42
Selenium, 0.06%	0.05	0.05	0.05	0.05	0.05
Trace mineral premix	0.13	0.13	0.13	0.13	0.13
Vitamin premix	0.05	0.05	0.05	0.05	0.05
Total	100	100	100	100	100

continued

Table 1, *continued*. Phase 1 diet composition (as-fed basis)[1,2]

	Fish meal control	HP 300 replacing FM and SBM			HP 300 replacing FM
		Low	Medium	High	
Calculated analysis					
Standardized ileal digestible (SID) amino acids, %					
Lys	1.35	1.35	1.35	1.35	1.35
Ile:Lys	55	58	60	63	61
Leu:Lys	117	119	122	125	122
Met:Lys	36	35	35	34	34
Met and Cys:Lys	57	57	57	57	57
Thr:Lys	63	63	63	63	63
Trp:Lys	20	20	20	20	20
Val:Lys	73	73	73	73	73
ME, kcal/lb	1,596	1,599	1,603	1,606	1,605
NE, kcal/lb	1,199	1,198	1,998	1,997	1,199
CP, %	21.9	22.1	22.4	22.6	22.3
Ca, %	0.78	0.78	0.78	0.78	0.78
P, %	0.64	0.65	0.65	0.66	0.67
Available, P %	0.56	0.56	0.56	0.56	0.56

[1] Phase 1 diets were fed at a budget of 4 lb per pig for approximately for 7 d or 12 lb BW.

[2] The diet with the highest amount of HP 300 was formulated and two intermediate diets (low and medium HP 300) were then blended to have an equal stepwise increase in HP 300 with the HP 300 included at the expense of soybean meal (SBM) and fish meal (FM).

[3] Hamlet Protein (Findlay, OH).

[4] DDGS = dried distillers grains with solubles.

[5] Quantum Blue (AB-Vista Americas, Plantation, FL) provided 227 phytase units (FTU)/lb.

Table 2. Phases 2 and 3 diet composition (as-fed basis)[1,2]

	Phase 2					Phase 3
		HP 300 replacing FM and SBM				
	Fish meal				HP 300	Common
Ingredient, %	control	Low	Medium	High	replacing FM	diet
Corn	53.53	52.98	52.41	51.80	49.98	56.48
Soybean meal, 46.5% CP	22.22	19.42	16.62	13.82	22.22	27.94
Fish meal	5.63	3.75	1.87	---	---	---
HP 300[3]	---	5.00	10.00	15.00	7.65	---
Corn DDGS[4]	5.00	5.00	5.00	5.00	5.00	10.00
Whey permeate	8.75	8.75	8.75	8.75	8.75	---
Tallow	2.00	2.00	2.00	2.00	2.70	2.00
Limestone	0.78	0.90	1.00	1.13	1.08	1.03
Monocalcium P, 21% P	0.55	0.70	0.90	1.10	1.15	1.10
Sodium chloride	0.36	0.36	0.36	0.36	0.36	0.40
L-Lys HCl	0.45	0.45	0.45	0.45	0.45	0.45
DL-Met	0.16	0.17	0.17	0.17	0.18	0.20
L-Thr	0.19	0.18	0.16	0.15	0.16	0.15
L-Trp	0.06	0.05	0.04	0.03	0.04	0.01
L-Val	0.08	0.05	0.03	---	0.03	---
Phytase[5]	0.03	0.03	0.03	0.03	0.03	0.03
Trace mineral premix	0.10	0.10	0.10	0.10	0.10	0.13
Vitamin premix	0.13	0.13	0.13	0.13	0.13	0.10
Total	100	100	100	100	100	100

continued

Table 2, *continued*. Phases 2 and 3 diet composition (as-fed basis)[1,2]

	Phase 2					Phase 3
		HP 300 replacing FM and SBM				
	Fish meal				HP 300	Common
Ingredient, %	control	Low	Medium	High	replacing FM	diet
Calculated analysis						
Standardized ileal digestible (SID) amino acids, %						
Lys	1.30	1.30	1.30	1.30	1.30	1.25
Ile:Lys	55	57	59	61	59	59
Leu:Lys	117	119	121	123	121	131
Met:Lys	37	37	36	36	36	40
Met and Cys:Lys	57	57	57	57	57	62
Thr:Lys	63	63	63	63	63	63
Trp:Lys	20	20	20	20	2	17
Val:Lys	68	68	68	68	68	66
ME, kcal/lb	1,557	1,560	1,563	1,565	1,565	1,529
NE, kcal/lb	1,166	1,166	1,165	1,165	1,166	1,131
CP, %	21.0	21.2	21.3	21.5	21.3	21.4
Ca, %	0.74	0.74	0.74	0.74	0.74	0.69
P, %	0.64	0.64	0.64	0.65	0.65	0.64
Available, P %	0.51	0.51	0.51	0.51	0.51	0.48

[1] Phase 2 diets were fed for 15 d or to approximately 22 lb BW. The phase 3 diet was fed from 22 lb to approximately 45 lb BW.

[2] The high HP 300 treatment was accomplished by including HP 300 at the expense of soybean meal (SBM) and fish meal (FM). The fish meal control diet and the HP 300 (high inclusion) replacing soybean meal and fish meal were blended to form the intermediate diets in phase 2.

[3] Hamlet Protein, Findlay, OH.

[4] DDGS = dried distillers grain with solubles.

[5] Optiphos 2000 (Huvepharma, Inc., Sofia, Bulgaria) provided 569 phytase units (FTU)/lb.

Table 3. Chemical analysis of soybean meal, HP 300, and fish meal (as-fed basis)[1,2]

Item	Soybean meal	HP 300[3]	Fish meal
Phase 1			
DM, %	88.02	94.29	92.17
CP, %	45.5	56.0	62.6
Ca, %	0.58	0.41	5.72
P, %	0.70	0.71	3.09
Ether extract, %	1.6	1.3	9.2
Water holding capacity, g H_2O/g product	1.82	3.99	1.30
Trypsin, mg/g	2.40	1.10	---
Phase 2			
DM	88.28	93.58	92.31
CP	47.60	55.80	67.90
Ca	0.53	0.45	7.10
P	0.68	0.73	3.09
Ether extract, %	1.4	1.5	9.8
Water holding capacity, g H_2O/g product	1.80	3.99	1.40
Trypsin, mg/g	2.50	1.10	---

[1] Proximate analysis for protein sources were analyzed by Ward Laboratories, Kearney, NE.

[2] Trypsin inhibitor analysis for soybean meal and HP 300 were analyzed by Hamlet Protein, Findlay, OH.

[3] Hamlet Protein, Findlay, OH.

Table 4. Chemical analysis of phase 1 and phase 2 experimental diets[1,2]

Item, %	Fish meal control	HP 300 Replacing SBM and FM			HP 300 replacing FM
		Low	Medium	High	
Phase 1 diets					
DM	90.35	90.47	91.17	90.58	90.7
CP	21.4	22.0	21.7	22.7	22.7
Ca	1.34	1.06	0.91	0.96	0.96
P	0.74	0.72	0.69	0.75	0.73
Ether extract	5.4	5.6	5.4	5.0	5.7
Water holding capacity, g H_2O/g feed	1.75	2.06	2.13	2.41	2.21
Total amino acids,[3] %					
Arg	1.17 (1.28)	1.23 (1.31)	1.28 (1.34)	1.32 (1.38)	1.38 (1.37)
His	0.50 (0.55)	0.50 (0.57)	0.52 (0.58)	0.54 (0.59)	0.55 (0.58)
Ile	0.86 (0.87)	0.88 (0.90)	0.91 (0.93)	0.94 (0.96)	0.94 (0.93)
Leu	1.72 (1.82)	1.77 (1.85)	1.81 (1.88)	1.85 (1.92)	1.85 (1.88)
Lys	1.37 (1.53)	1.33 (1.53)	1.34 (1.54)	1.40 (1.54)	1.41 (1.53)
Met	0.43 (0.54)	0.45 (0.52)	0.43 (0.51)	0.42 (0.49)	0.43 (0.49)
Met. + Cys.	0.76 (0.89)	0.81 (0.88)	0.79 (0.87)	0.80 (0.86)	0.83 (0.87)
Thr	0.91 (1.01)	0.94 (1.00)	0.94 (0.99)	0.95 (0.98)	0.98 (0.99)
Trp	0.27 (0.31)	0.28 (0.30)	0.27 (0.30)	0.27 (0.30)	0.28 (0.30)
Val	1.09 (1.15)	1.09 (1.13)	1.07 (1.12)	1.07 (1.11)	1.10 (1.12)
Phe	0.96 (0.98)	0.99 (1.02)	1.03 (1.05)	1.07 (1.09)	1.11 (1.07)
Free Lys	0.21 (0.33)	0.22 (0.33)	0.21 (0.33)	0.22 (0.33)	0.22 (0.33)

continued

Table 4, *continued*. Chemical analysis of phase 1 and phase 2 experimental diets[1,2]

Item, %	Fish meal control	HP 300 Replacing SBM and FM Low	HP 300 Replacing SBM and FM Medium	HP 300 Replacing SBM and FM High	HP 300 replacing FM
Phase 2 diet					
DM	87.02	88.96	88.65	87.16	88.6
CP	21.2	21.3	21.8	22.3	21.2
Ca	1.02	0.98	1.04	0.95	1.01
P	0.65	0.62	0.67	0.68	0.69
Ether extract	5.1	4.8	4.7	4.4	4.8
Water holding capacity, g H_2O/g feed	1.49	1.46	1.78	1.83	1.61
Flowdex (mm)[4]	30	30	30	30	28
Angle of repose	40.7	41.7	41.2	41.2	41.7
Total amino acids,[3] %					
Arg	1.24 (1.24)	1.27 (1.27)	1.29 (1.29)	1.30 (1.31)	1.25 (1.31)
His	0.52 (0.53)	0.53 (0.54)	0.54 (0.55)	0.54 (0.55)	0.52 (0.55)
Ile	0.88 (0.83)	0.90 (0.86)	0.92 (0.88)	0.94 (0.90)	0.89 (0.88)
Leu	1.74 (1.75)	1.78 (1.78)	1.79 (1.80)	1.82 (1.82)	1.71 (1.80)
Lys	1.50 (1.46)	1.49 (1.46)	1.47 (1.47)	1.45 (1.47)	1.36 (1.46)
Met	0.49 (0.53)	0.47 (0.52)	0.47 (0.51)	0.44 (0.50)	0.44 (0.50)
Met. + Cys.	0.79 (0.85)	0.80 (0.84)	0.81 (0.84)	0.78 (0.83)	0.77 (0.83)
Thr	0.94 (0.96)	0.93 (0.95)	0.96 (0.94)	0.89 (0.93)	0.87 (0.94)
Trp	0.28 (0.30)	0.28 (0.29)	0.25 (0.29)	0.28 (0.29)	0.26 (0.29)
Val	1.06 (1.03)	1.04 (1.02)	1.02 (1.01)	1.00 (1.01)	0.98 (1.01)
Phe	0.97 (0.95)	1.01 (0.98)	1.02 (1.00)	1.04 (1.03)	0.99 (1.01)
Free Lys	0.33 (0.45)	0.28 (0.45)	0.27 (0.45)	0.28 (0.45)	0.24 (0.45)

[1] Complete diet samples were obtained from each dietary treatment during the study and composited. Samples of diets were then submitted to Ward Laboratories, Inc. (Kearney, NE) for analysis.

[2] HP 300 (Hamlet Protein, Findlay, OH).

[3] Total amino acid analysis of diets were analyzed in duplicate by Ajinomoto Heartland, Inc. (Chicago, IL). Values in parentheses indicate formulated values.

[4] Flowdex (Hanson Research, Chatsworth, CA) flowability index represents smallest diameter disk in which 50 grams of sample flows on three consecutive attempts.

Table 5. Laboratory analysis of phase 3 common diet[1]

Item, %	Common diet
DM	87.86
CP	18.7
Ca	0.74
P	0.60
Ether extract	5.0

[1] A complete diet sample was obtained during the study and composited. A composite sample was then submitted to Ward Laboratories, Inc. (Kearney, NE) for analysis.

Table 6. Effect of feeding increasing HP 300 on nursery pig performance[1,2]

		HP 300 replacing SBM and FM					Probability, $P <$		
							HP 300		FM control vs. HP 300 replacing FM
Item	Fish meal control	Low	Medium	High	HP 300 replacing FM	SEM	Linear	Quadratic	
BW, lb									
d 0	11.3	11.2	11.3	11.3	11.3	0.16	0.974	0.941	0.959
d 7	11.9	11.7	12.0	12.0	11.9	0.17	0.183	0.168	0.995
d 22	22.2	21.5	21.2	21.1	21.7	0.40	0.008	0.274	0.175
d 43	46.3	45.4	45.0	44.7	45.3	0.63	0.043	0.577	0.155
d 0 to 7									
ADG, lb	0.10	0.07	0.10	0.11	0.10	0.011	0.134	0.122	0.950
ADFI, lb	0.44	0.42	0.41	0.45	0.44	0.009	0.774	0.001	0.696
F/G	4.90	7.13	4.19	4.95	5.18	0.809	0.444	0.371	0.813
d 7 to 22									
ADG, lb	0.67	0.63	0.60	0.59	0.63	0.020	0.002	0.328	0.115
ADFI, lb	0.88	0.87	0.84	0.81	0.86	0.017	0.001	0.599	0.359
F/G	1.34	1.40	1.41	1.37	1.38	0.026	0.402	0.073	0.297
d 0 to 22									
ADG, lb	0.48	0.44	0.44	0.44	0.46	0.015	0.020	0.162	0.135
ADFI, lb	0.74	0.72	0.70	0.69	0.72	0.012	0.001	0.632	0.276
F/G	1.56	1.65	1.61	1.60	1.61	0.033	0.529	0.128	0.309

continued

Table 6, *continued*. Effect of feeding increasing HP 300 on nursery pig performance[1,2]

							Probability, $P <$		
		HP 300 replacing SBM and FM					HP 300		FM control vs. HP 300 replacing FM
Item	Fish meal control	Low	Medium	High	HP 300 replacing FM	SEM	Liner	Quadratic	
BW, lb									
d 22 to 43									
ADG, lb	1.14	1.14	1.12	1.12	1.12	0.021	0.426	0.942	0.474
ADFI, lb	1.63	1.60	1.59	1.59	1.59	0.032	0.298	0.580	0.268
F/G	1.43	1.40	1.42	1.42	1.42	0.009	0.437	0.075	0.235
d 0 to 43									
ADG, lb	0.80	0.78	0.77	0.77	0.77	0.014	0.120	0.444	0.248
ADFI, lb	1.17	1.14	1.13	1.13	1.14	0.018	0.071	0.460	0.243
F/G	1.47	1.47	1.47	1.47	1.47	0.007	0.943	0.944	0.856
Economics, $/pig									
Feed cost	4.77	4.64	4.46	4.42	4.31	0.074	0.001	0.456	0.001
Feed cost/lb gain[3]	0.140	0.139	0.135	0.134	0.130	0.0022	0.033	0.903	0.021
Total revenue/pig[4,5]	21.58	21.07	20.77	20.82	20.98	0.382	0.120	0.444	0.248
IOFC[6]	16.82	16.43	16.31	16.40	16.67	0.348	0.366	0.487	0.752

[1] A total of 1,215 pigs (PIC 327 × 1050; initial BW 11.3 lb) with 27 pigs per pen and 9 replications per treatment were used in a 42-d growth trial. Experimental diets were fed in 2 phases (d 0 to 7 and 7 to 22) with a common diet fed from d 22 to 43.

[2] The diet with the highest inclusion of HP 300 was formulated and 2 intermediate diets (low and medium HP 300) were then created to have an equal stepwise increase in HP 300 with the HP 300 included at the expense of soybean meal and fish meal. A fifth treatment (HP 300–replacing fish meal) was included to solely replace fish meal.

[3] Feed cost/lb gain = total feed cost divided by total gain per pig.

[4] One lb of live weight gain was considered to be worth $0.63.

[5] Total revenue/pig = total gain/pig × $0.63.

[6] Income over feed cost = total revenue/pig – feed cost/pig.