

## Effects of Different Corn Protein Sources and Level on Nursery Pig Growth Performance and Feed Efficiency

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### Summary

This experiment was conducted to determine the effects of 3 corn protein sources added at the expense of other specialty protein sources or corn on nursery pig growth performance and feed efficiency (F/G), and economic return. A total of 315 pigs (241 × 600; DNA, Columbus, NE; initially 12.1 lb) were used in a 35-d growth trial. There were 5 pigs per pen and 9 replicates per treatment. The treatments were structured as a randomized complete block design and arranged in a 3×2+1 factorial with main effects of corn protein source (CP1, CP2, and CP3; Cargill Inc., Blair, NE) and level (5 or 10%) plus a control diet. Treatment diets were fed in 2 phases (phase 1: d 0 to 7; phase 2: d 7 to 21) with a common diet fed from d 21 to 35. In phase 1, protein sources were added at the expense of fish meal in the 5% inclusion diets and replaced both fish meal and enzymatically treated soybean meal (HP300) for the 10% inclusion diets. In phase 2, protein sources were added at the expense of fish meal in the 5% inclusion diets, and both fish meal and corn in the 10% inclusion diets. All diets were fed in pellet form throughout the trial. In the treatment period (d 0 to 21), increasing corn protein sources decreased (linear,  $P < 0.05$ ) average daily gain (ADG) and average daily feed intake (ADFI). Feed efficiency worsened (linear,  $P < 0.05$ ) when pigs were fed increasing CP1 or CP2 and tended to worsen (linear,  $P < 0.10$ ) when fed increasing CP3. The growth performance was poorest when the 10% level of the corn protein sources were fed with the 5% level of CP2 or CP3, eliciting similar performance to the control-fed pigs. Pigs fed CP1 had decreased ( $P < 0.05$ ) ADG and ADFI compared to those fed CP2 or CP3. The poorer growth performance of pigs fed CP1 resulted in lower d 21 body weight (BW) ( $P < 0.05$ ) compared to those fed CP2 or CP3. There was no evidence of any difference between pigs fed CP2 and CP3 on all growth performance criteria throughout the treatment period. In the common period (d 21 to 35), compensatory growth and feed intake were observed, but final BW was still lower when pigs were fed diets with any of the corn protein sources compared to pigs fed the control diet. In summary, increasing amounts of these three corn protein sources, at the expense of specialty protein sources such as fish meal, decreased growth performance in nursery

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pigs; however, the magnitude of the impact differed between corn protein sources and level with 5% inclusion of CP2 and CP3 eliciting similar performance to the control. Additional research should be conducted to further compare corn protein sources and help identify why some sources influence performance differently than others.

### Introduction

Protein sources, such as fish meal and enzymatically treated soybean meal, are relatively expensive, but beneficial feed ingredients in nursery pig diets. Therefore, using alternative protein sources to replace fish meal or enzymatically treated soybean meal without compromising growth performance might improve economic return. The corn processing industry removes starch from the corn kernel to produce concentrated starches, sweeteners, and texturizers. The remaining corn fraction is a corn protein product that contains high crude protein (>69% CP, as-fed). However, little data are available to determine the impact on nursery pig performance. Therefore, this study was designed to determine the effects on growth performance of weaned pigs fed diets containing 5 or 10% of three different corn protein sources.

### Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocols used in this experiment conducted at the Kansas State University Swine Teaching and Research Center in Manhattan, KS. Each pen (4 × 4 ft) was equipped with a 4-hole dry self-feeder, and a nipple waterer to provide *ad libitum* access to feed and water.

A total of 315 pigs (241 × 600; DNA, Columbus, NE; initially 12.1 lb) were weaned at approximately 21 d of age and placed in pens of 5 pigs each based on initial BW and gender. Pens of pigs were then randomly allotted to treatment in a randomized complete block design with BW as the blocking factor with 9 replicate pens per treatment. The treatments were structured as a randomized complete block design and arranged in a 3×2+1 factorial with main effects of corn protein source (CP1, CP2, and CP3; Cargill Inc., Blair, NE) and level (5 or 10%) and a control diet similar to that fed in commercial production (Table 1). Treatment diets were fed for 7 d in phase 1 followed by a 14-d feeding period in phase 2. In phase 1, corn protein sources were added at the expense of fish meal in the 5% inclusion diets, and both fish meal and enzymatically treated soybean meal (HP300) were added in the 10% inclusion diets. In phase 2, corn protein sources were added at the expense of fish meal in the 5% inclusion diets, and both fish meal and corn in the 10% inclusion diets. Nutrient loading values for the 3 corn protein sources were obtained from proximate analysis and previous digestibility studies that determined the standardized ileal digestibility (SID) AA and P coefficients, while the loading values for the other ingredients were provided by the supplier or obtained from the NRC.<sup>4</sup> For phase 3, all pigs were fed a common corn, soybean meal-based diet for 14 d. Diets were fed in pellet form in all three phases. Pen weights and feed disappearance were measured on d 0, 7, 14, 21, 27, and 35 to determine ADG, ADFI, and F/G.

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<sup>4</sup> National Research Council. 2012. Nutrient Requirements of Swine: Eleventh Revised Edition. Washington, DC: The National Academies Press. <https://doi.org/10.17226/13298>.

Phase 1 and 2 diets were manufactured at Cargill-Provimi, Brookville, OH. The phase 3 common diet was manufactured at Hubbard Feeds, Beloit, KS. All diets met or exceeded the NRC<sup>4</sup> nutrient requirement estimates. Diet samples were collected and thoroughly mixed within treatment before analysis for dry matter and crude protein (Kansas State University Swine Laboratory, Manhattan, KS).

Data were analyzed as a randomized complete block design for one-way ANOVA using the lmer function from the lme4 package in R program (version 3.5.2)<sup>5</sup> with pen considered the experimental unit, initial BW as blocking factor, and treatment as a fixed effect. Interactive and main effects of corn protein source (CP1, CP2, and CP3) and level (5 vs. 10%) were tested in addition to predetermined contrasts that compared the corn protein sources to each other, as well as the linear and quadratic response within corn protein source considering the control treatment as an inclusion level of “0.” All results were considered significant at  $P \leq 0.05$  and marginally significant between  $P > 0.05$  and  $P \leq 0.10$ .

### Results and Discussion

From d 0 to 7, there was no evidence of differences among 5 vs. 10% inclusions or among corn protein sources for any of the response criteria tested (Table 4 and 5). Pigs fed diets with CP1 tended to have poorer ( $P < 0.10$ ) ADG and ADFI compared to those fed CP2. Pigs fed diets with CP2 tended to have poorer ( $P < 0.10$ ) ADG and F/G as the level of CP2 increased.

From d 7 to 21 and the overall treatment period (d 0 to 21), there was no evidence for corn protein level  $\times$  source interactions. Pigs fed 5% of any corn protein source had better ( $P < 0.05$ ) ADG and F/G compared to those fed 10% corn protein source. Pigs fed CP1 tended to have lower ( $P = 0.070$ ) ADG and had lower ( $P < 0.05$ ) ADFI from d 7 to 21 and had lower ( $P < 0.05$ ) ADG and ADFI from d 0 to 21 compared to pigs fed diets with CP2. From d 7 to 21 and 0 to 21, pigs fed CP1 had lower ( $P < 0.05$ ) ADG and ADFI compared to those fed CP3. There was no difference in performance observed during the treatment period between pigs fed CP2 and CP3. From d 7 to 21 and 0 to 21, increasing CP1 or CP2 worsened (linear,  $P < 0.05$ ) ADG, ADFI, and F/G. From d 7 to 21 and 0 to 21 increasing CP3 worsened (linear,  $P < 0.05$ ) ADG and ADFI, and tended to make F/G poorer (linear,  $P < 0.10$ ). Day 21 BW was lower (linear,  $P < 0.05$ ) when pigs were fed increasing levels of any corn protein source, and pigs fed CP1 had lower ( $P < 0.05$ ) d 21 BW compared to CP2 or CP3. The responses observed to the 10% inclusion of corn protein sources were more severe than the 5% inclusion with 5% inclusion of CP2 and CP3 having performance similar to the controls.

In the common period (d 21 to 35), a tendency for an ADG interaction ( $P = 0.056$ ) was observed because pigs previously fed 10% CP1 or CP3 had greater ADG compared to those fed 5% of their corn protein source, but pigs previously fed 5% CP2 had greater ADG than those fed 10% CP2. Feed efficiency was better (linear,  $P < 0.05$ ) for pigs previously fed 10% of any corn protein source compared to those previously fed the 5% level, illustrating a compensatory response to removing the corn protein sources from

<sup>5</sup> R Core Team. 2018. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria. <https://www.R-project.org/>.

the diet. This may suggest a dietary component that may act to reduce intake. Pigs previously fed CP1 tended ( $P < 0.10$ ) to have poorer ADFI, but improved F/G compared to those previously fed CP2, and had poorer ( $P < 0.05$ ) ADFI but tended to have improved ( $P < 0.10$ ) F/G compared to those fed CP3. Pigs previously fed increasing levels of CP1 tended (quadratic,  $P = 0.059$ ) to have decreased then increased ADG and had reduced (linear,  $P < 0.05$ ) ADFI and improved F/G. Pigs previously fed diets with increasing CP2 tended to have reduced (linear,  $P < 0.062$ ) ADFI, and pigs previously fed diets with increasing CP3 tended to have improved (linear,  $P < 0.064$ ) F/G, with both responses being driven by the performance of the 10% inclusion level as the 5% inclusion and the control were the same.

Overall (d 0 to 35), pigs fed CP1 tended to have decreased ( $P < 0.10$ ) ADG and ( $P < 0.05$ ) ADFI, but tended to have improved ( $P < 0.10$ ) F/G compared to those fed CP2, and had decreased ( $P < 0.05$ ) ADG and ADFI but tended to have improved ( $P < 0.10$ ) F/G compared to those fed CP3. Pigs fed increasing CP1 or CP2 had reduced ( $P < 0.05$ ) ADG, ADFI, and d 35 BW, and those fed increasing levels of CP3 tended to have lower ( $P < 0.10$ ) ADFI and d 35 BW. The responses observed were primarily driven by the pigs fed the 10% inclusion level, as the pigs fed 5% had performance similar to that observed with the control pigs.

In summary, increasing amounts of these corn protein sources at the expense of other specialty protein sources decreased growth performance and d 21 BW of weanling pigs. Pigs fed CP1 had poorer performance compared to CP2 and CP3, while CP2 and CP3 elicited similar performance. The performance observed during the post-treatment common feeding period would suggest a compensatory growth and feed intake response, which might indicate the presence of a compound in the corn protein sources that limited intake. The observation that 5% inclusion of CP2 or CP3 resulted in similar performance as the control diet warrants further investigation to determine the optimum level of inclusion that optimizes performance and economics.

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**Table 1. Phase 1 diet composition, (as-fed basis)<sup>1</sup>**

Item	Control	Protein source <sup>2</sup>					
		CP1		CP2		CP3	
		5%	10%	5%	10%	5%	10%
Ingredients, %							
Corn	38.75	37.68	37.58	37.78	37.78	37.79	37.76
Soybean meal	16.14	16.16	16.15	16.17	16.16	16.14	16.15
Fish meal	5.00	--	--	--	--	--	--
Enzymatically treated soybean meal	5.00	5.00	--	5.00	--	5.00	--
CP1	--	5.00	10.00	--	--	--	--
CP2	--	--	--	5.00	10.00	--	--
CP3	--	--	--	--	--	5.00	10.00
Corn DDGS, 7.5% oil	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Dried whey	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Soybean oil	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Calcium carbonate	0.50	0.80	0.78	0.85	0.90	0.85	0.90
Monocalcium phosphate	0.50	1.10	1.20	1.00	0.95	1.00	0.95
Sodium chloride	0.30	0.30	0.30	0.30	0.30	0.30	0.30
L-Lysine-HCl	0.40	0.60	0.75	0.50	0.55	0.51	0.56
DL-Methionine	0.19	0.14	0.06	0.16	0.10	0.17	0.12
L-Threonine	0.17	0.17	0.16	0.18	0.18	0.18	0.19
L-Tryptophan	0.04	0.04	0.05	0.04	0.06	0.05	0.07
L-Valine	0.16	0.13	0.10	0.15	0.15	0.15	0.14
Trace mineral premix	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Vitamin premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Phytase <sup>3</sup>	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Zinc oxide	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

*continued*

**Table 1. Phase 1 diet composition, (as-fed basis)<sup>1</sup>**

Item	Control	Protein source <sup>2</sup>					
		CP1		CP2		CP3	
		5%	10%	5%	10%	5%	10%
Standardized ileal digestible (SID) amino acids, %							
Lysine	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Isoleucine:lysine	58	61	63	59	60	58	58
Leucine:lysine	116	146	175	138	160	134	152
Methionine:lysine	37	34	32	34	33	35	34
Met and cysteine:lysine	57	57	57	57	57	57	57
Threonine:lysine	64	64	64	64	64	64	64
Tryptophan:lysine	19.0	19.0	19.0	19.0	19.0	19.0	19.0
Valine:lysine	74	74	74	74	74	74	74
Histidine:lysine	33	34	34	33	33	33	32
Net energy, kcal/lb	1,173	1,108	1,055	1,109	1,057	1,109	1,057
Crude protein, %	21.9	22.7	23.8	22.2	22.9	22.2	22.9
Calcium, %	0.80	0.80	0.80	0.80	0.80	0.80	0.80
STTD P, <sup>4</sup> %	0.63	0.63	0.63	0.63	0.63	0.63	0.63
Proximate analysis, % <sup>5</sup>							
Dry matter	89.0	89.5	89.4	89.5	89.1	88.9	88.8
Crude protein	20.8	21.5	23.1	21.3	20.9	21.2	20.2

<sup>1</sup>Phase 1 diets were fed from d 0 to 7.

<sup>2</sup>CP1, CP2, and CP3 were provided by Cargill Inc., Blair, NE.

<sup>3</sup>Ronozyme HiPhos GT 2700 (DSM Nutritional Products, Basel, Switzerland) provided 919 FTU per lb of feed and an expected P release of 0.14%.

<sup>4</sup>STTD P = standardized total tract digestible phosphorus.

<sup>5</sup>A representative sample of each diet was collected from the feeders of each treatment, homogenized, and analyzed for proximate nutrients (Kansas State University Swine Laboratory, Manhattan, KS).

DDGS = distillers dried grains with solubles.

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**Table 2. Phase 2 diet composition, (as-fed basis)<sup>1</sup>**

Item	Control	Protein source <sup>2</sup>					
		CP1		CP2		CP3	
		5%	10%	5%	10%	5%	10%
Ingredients, %							
Corn	47.86	46.86	42.24	46.91	42.51	46.90	42.45
Soybean meal	21.90	21.90	21.88	21.92	21.88	21.90	21.88
Fish meal	5.00	--	--	--	--	--	--
CP1	--	5.00	10.00	--	--	--	--
CP2	--	--	--	5.00	10.00	--	--
CP3	--	--	--	--	--	5.00	10.00
Corn DDGS, 7.5% oil	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Dried whey	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Soybean oil	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Calcium carbonate	0.55	0.83	0.83	0.88	0.93	0.88	0.93
Monocalcium phosphate	0.40	1.00	1.00	0.93	0.80	0.93	0.80
Sodium chloride	0.55	0.55	0.55	0.55	0.55	0.55	0.55
L-Lysine-HCl	0.45	0.65	0.61	0.55	0.41	0.56	0.43
DL-Methionine	0.15	0.10	0.00	0.12	0.00	0.13	0.03
L-Threonine	0.18	0.18	0.09	0.19	0.11	0.19	0.11
L-Tryptophan	0.04	0.05	0.03	0.05	0.03	0.05	0.04
L-Valine	0.14	0.12	0.00	0.14	0.01	0.14	0.01
Trace mineral premix	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Vitamin premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Phytase <sup>3</sup>	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Zinc oxide	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

*continued*

**Table 2. Phase 2 diet composition, (as-fed basis)<sup>1</sup>**

Item	Protein source <sup>2</sup>						
	Control	CP1		CP2		CP3	
		5%	10%	5%	10%	5%	10%
Standardized ileal digestible (SID) amino acids, %							
Lysine	1.35	1.35	1.35	1.35	1.35	1.35	1.35
Isoleucine:lysine	57	60	70	59	67	57	65
Leucine:lysine	123	154	196	146	180	142	172
Methionine:lysine	36	33	32	34	30	34	31
Met and cysteine:lysine	57	57	59	57	57	57	57
Threonine:lysine	64	64	64	64	64	64	64
Tryptophan:lysine	19.0	19.0	19.0	19.0	19.0	19.0	19.0
Valine:lysine	74	74	76	74	74	74	74
Histidine:lysine	36	36	40	36	40	35	39
Net energy, kcal/lb	1,156	1,092	1,030	1,092	1,030	1,093	1,031
Crude protein, %	22.3	23.1	26.3	22.6	25.3	22.6	25.4
Calcium, %	0.72	0.72	0.72	0.72	0.72	0.72	0.72
STTD P, <sup>4</sup> %	0.55	0.55	0.55	0.55	0.55	0.55	0.55
Proximate analysis, % <sup>5</sup>							
Dry matter	88.4	88.9	89.0	88.9	88.6	88.6	88.3
Crude protein	21.1	22.3	26.3	20.5	23.6	20.4	23.4

<sup>1</sup>Phase 2 diets were fed from d 7 to 21.

<sup>2</sup>CP1, CP2, and CP3 were provided by Cargill Inc., Blair, NE.

<sup>3</sup>Ronozyme HiPhos GT 2700 (DSM Nutritional Products, Basel, Switzerland) provided 919 FTU per lb of feed and an expected P release of 0.14%.

<sup>4</sup>STTD P = standardized total tract digestible phosphorus.

<sup>5</sup>A representative sample of each diet was collected from the feeders of each treatment, homogenized, and analyzed for proximate nutrients (Kansas State University Swine Laboratory, Manhattan, KS).

DDGS = distillers dried grains with solubles.

**Table 3. Phase 3 common diet composition, (as-fed basis)<sup>1</sup>**

Item	Common diet
Ingredients, %	
Corn	65.47
Soybean meal	28.30
Fat	2.00
Calcium carbonate	0.75
Monocalcium phosphate	1.10
Sodium chloride	0.60
L-Lysine-HCl	0.55
DL-Methionine	0.25
L-Threonine	0.23
L-Tryptophan	0.05
L-Valine	0.16
Trace mineral premix	0.15
Vitamin premix with phytase <sup>2</sup>	0.25
Alltech All-Bind HD <sup>3</sup>	0.15
Total	100.00
SID amino acids, %	
Lysine	1.30
Isoleucine:lysine	53
Leucine:lysine	111
Methionine:lysine	39
Met and cysteine:lysine	60
Threonine:lysine	63
Tryptophan:lysine	19.3
Valine:lysine	70
Histidine:lysine	35
Net energy, kcal/lb	1,152
Crude protein, %	19.9
Calcium, %	0.65
STTD P, <sup>4</sup> %	0.48

<sup>1</sup>Phase 3 common diets were fed from d 21 to 35.

<sup>2</sup>Ronozyme HiPhos GT 2700 (DSM Nutritional Products, Basel, Switzerland) provided 566 FTU per lb of feed and an expected P release of 0.11%.

<sup>3</sup>Alltech, Lexington, KY.

<sup>4</sup>STTD P = standardized total tract digestible phosphorus.

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**Table 4. Effects of 5% or 10% inclusion of 3 corn protein sources on nursery pig growth performance, feed efficiency, and economic return<sup>1</sup>**

Item <sup>3</sup>	Protein source <sup>2</sup>								Probability, <i>P</i> =		
	Control	CP1		CP2		CP3		SEM	Interaction	5 vs. 10%	Source
		5%	10%	5%	10%	5%	10%				
BW, lb											
d 0	12.2	12.1	12.2	12.0	12.2	12.1	12.0	1.59	0.442	0.141	0.407
d 7	13.8	13.4	13.6	13.9	13.6	13.6	13.4	1.65	0.334	0.535	0.280
d 21	24.4	21.9	21.3	23.5	21.7	23.3	22.2	2.59	0.524	0.006	0.044
d 35	42.1	38.8	39.3	41.5	39.0	41.2	40.3	3.92	0.181	0.124	0.095
d 0 to 7											
ADG, lb	0.23	0.18	0.20	0.28	0.21	0.22	0.20	0.026	0.216	0.237	0.170
ADFI, lb	0.27	0.23	0.27	0.30	0.28	0.27	0.25	0.025	0.289	0.944	0.206
F/G	1.22	1.62	1.44	1.08	2.11	1.26	1.32	0.337	0.173	0.271	0.638
d 7 to 21											
ADG, lb	0.76	0.61	0.55	0.68	0.58	0.69	0.62	0.071	0.776	0.003	0.024
ADFI, lb	0.97	0.78	0.75	0.90	0.82	0.89	0.85	0.087	0.670	0.066	0.005
F/G	1.28	1.30	1.39	1.33	1.42	1.30	1.37	0.035	0.918	0.004	0.509
d 0 to 21 (treatment period)											
ADG, lb	0.58	0.47	0.43	0.55	0.46	0.53	0.48	0.051	0.448	0.003	0.025
ADFI, lb	0.74	0.60	0.59	0.70	0.64	0.69	0.65	0.063	0.534	0.122	0.009
F/G	1.27	1.29	1.39	1.28	1.41	1.28	1.35	0.031	0.637	< 0.001	0.635
d 21 to 35 (common period)											
ADG, lb	1.27	1.21	1.29	1.29	1.24	1.25	1.29	0.100	0.056	0.408	0.656
ADFI, lb	1.75	1.62	1.63	1.75	1.64	1.72	1.70	0.130	0.299	0.292	0.072
F/G	1.38	1.33	1.27	1.36	1.33	1.38	1.32	0.025	0.735	0.020	0.135
d 0 to 35											
ADG, lb	0.86	0.76	0.77	0.84	0.77	0.82	0.81	0.069	0.135	0.138	0.103
ADFI, lb	1.14	1.00	1.01	1.12	1.04	1.10	1.07	0.090	0.366	0.176	0.018
F/G	1.33	1.31	1.31	1.33	1.36	1.34	1.33	0.018	0.455	0.779	0.157

<sup>1</sup>A total of 315 pigs (initially 12.1 lb) were used with 5 pigs/pen and 9 replicates/treatment. Treatment diets were fed from d 0 to 21. The common diet was fed to all pigs from d 21 to 35.

<sup>2</sup>CP1, CP2, and CP3 were provided by Cargill Inc., Blair, NE.

<sup>3</sup>BW = body weight. ADG = average daily gain. ADFI = average daily feed intake. F/G = feed-to-gain ratio.

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**Table 5. Additional probability values of nursery pig growth performance, feed efficiency, and economic return<sup>1,2</sup>**

Item <sup>3</sup>	Probability, <i>P</i> =								
	Protein source comparison			CP1		CP2		CP3	
	CP1 vs. CP2	CP1 vs. CP3	CP2 vs. CP3	Linear	Quadratic	Linear	Quadratic	Linear	Quadratic
BW, lb									
d 0	0.365	0.192	0.686	0.812	0.395	0.962	0.049	0.255	0.545
d 7	0.152	0.911	0.186	0.517	0.194	0.517	0.295	0.197	1.000
d 21	0.040	0.024	0.825	< 0.001	0.116	< 0.001	0.509	0.002	0.993
d 35	0.118	0.037	0.588	0.012	0.057	0.007	0.321	0.096	0.977
d 0 to 7									
ADG, lb	0.067	0.559	0.205	0.439	0.278	0.479	0.071	0.330	0.830
ADFI, lb	0.099	0.786	0.165	0.984	0.125	0.824	0.449	0.409	0.771
F/G	0.843	0.483	0.369	0.653	0.488	0.067	0.159	0.834	0.971
d 7 to 21									
ADG, lb	0.070	0.008	0.357	< 0.001	0.201	< 0.001	0.774	0.002	0.991
ADFI, lb	0.009	0.002	0.636	< 0.001	0.051	0.002	0.851	0.017	0.716
F/G	0.476	0.661	0.251	0.024	0.373	0.007	0.607	0.087	0.549
d 0 to 21 (treatment period)									
ADG, lb	0.026	0.013	0.777	< 0.001	0.135	< 0.001	0.342	0.003	0.926
ADFI, lb	0.007	0.007	0.997	< 0.001	0.037	0.010	0.708	0.023	0.822
F/G	0.905	0.449	0.381	0.006	0.319	0.002	0.136	0.053	0.483
d 21 to 35 (common period)									
ADG, lb	0.585	0.364	0.716	0.681	0.059	0.385	0.236	0.525	0.410
ADFI, lb	0.073	0.033	0.718	0.037	0.132	0.062	0.296	0.410	0.832
F/G	0.082	0.085	0.987	0.003	0.864	0.164	0.964	0.064	0.396
d 0 to 35									
ADG, lb	0.094	0.048	0.750	0.010	0.061	0.006	0.236	0.108	0.673
ADFI, lb	0.017	0.011	0.872	0.002	0.056	0.018	0.442	0.100	0.767
F/G	0.062	0.188	0.568	0.267	0.753	0.338	0.416	0.808	0.735

<sup>1</sup>A total of 315 pigs (initially 12.1 lb) were used with 5 pigs/pen and 9 replicates/treatment. Treatment diets were fed from d 0 to 21. The common diet was fed to all pigs from d 21 to 35. The control treatment was used as an inclusion level of "0%" for linear and quadratic analysis.

<sup>2</sup>CP1, CP2, and CP3 were provided by Cargill Inc., Blair, NE.

<sup>3</sup>BW = body weight. ADG = average daily gain. ADFI = average daily feed intake. F/G = feed-to-gain ratio.