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Effects of Various Modified Corn Protein Inclusion Rates on Nursery Pig Growth Performance[1]

Rafe Q. Royall, Ty H. Kim, Jason C. Woodworth, Mike D. Tokach, Joel M. DeRouchey, Jordan T. Gebhardt,[2] Robert D. Goodband, Keith Mertz,[3] and John F. Patience[4]

Summary

This experiment was conducted to determine the optimum feeding strategy of a modified corn protein product (MCP; P4000; Cargill Starches, Sweeteners, & Texturizers, Blair, NE) on growth performance and fecal dry matter of nursery pigs. A total of 360 barrows (DNA 200 × 400; initially 12.0 ± 0.14 lb) were used in a 42-d growth trial. Pigs were weaned at approximately 21 d of age, randomly allotted to pens in 1 of 2 weight blocks based on initial BW (initially 10.8 and 13.2 lb), and then allotted to 1 of 6 dietary treatments in a completely randomized design. There were 5 pigs per pen and 12 pens per treatment across 2 barns. Dietary treatments were corn-soybean meal-based and arranged in a 2 × 3 factorial with 2 levels of MCP in phase 1 (10 or 12%) and 3 inclusion rates of MCP in phase 2 (4, 6, or 8%). Treatment diets were formulated in two dietary phases and fed from d 0 to 10 and d 10 to 23, respectively, with a common phase 3 diet that did not contain any MCP fed for the remainder of the study. A tendency was observed for a 3-way interaction for weight block × phase 1 diet × phase 2 diet ($P = 0.064$) on d 42 BW. This interaction was a result of feeding increasing levels of MCP quadratically increasing, then decreasing, BW of lightweight pigs, regardless of phase 1 inclusion. However, in heavyweight pigs, increasing MCP in phase 2 diets quadratically decreased, then increased, BW of pigs fed 10% MCP in phase 1, while increasing MCP in phase 2 linearly decreased BW in heavyweight pigs fed 12% MCP in phase 1. Additionally, during the common period (d 23 to 42) there was a 3-way interaction ($P = 0.038$) for ADG, in which lightweight pigs previously fed 10 and 8% MCP (phase 1 and 2, respectively) had decreased ADG, while feeding increasing MCP in phase 2 to lightweight pigs fed 12% MCP in phase 1 quadratically increased, then decreased, common period ADG. However, for heavyweight pigs the previous MCP feeding strategies did not affect ADG during the common period. During phase 1 (d 0 to 10) pigs fed 10% MCP had greater ($P = 0.032$) ADFI than those fed 12% MCP, resulting in a tendency ($P = 0.065$) for greater ADG. Throughout the experiment (d 0

[1] The authors appreciate Cargill Starches, Sweeteners, & Texturizers (Blair, NE) for providing financial and technical assistance for this study.

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to 42) feeding 10% MCP in phase 1 tended ($P = 0.077$) to increase ADG. During phase 2 (d 10 to 23) feeding increasing levels of MCP quadratically improved, then worsened ($P = 0.018$) feed efficiency, leading to a tendency for a quadratic effect ($P = 0.066$) on feed efficiency throughout the treatment period. There were no 2- or 3-way interactions observed ($P > 0.10$) on fecal dry matter. Nevertheless, pigs fed 12% MCP had greater ($P = 0.024$) fecal dry matter at d 10 compared to those fed 10% MCP. However, the inverse was true on d 23, in which pigs fed phase 1 diets with 10% MCP had greater ($P = 0.016$) fecal dry matter compared to those fed 12% MCP. In summary, feeding 10% MCP in phase 1 tended to improve BW, ADFI, and ADG compared to a 12% MCP level. Moreover, 6% MCP during phase 2 appeared to have a positive impact on feed efficiency during the treatment period but did not impact overall feed efficiency.

Introduction

Highly digestible protein sources are commonly utilized in commercial nursery diets to aid the transition of weanling pigs in the nursery. These protein sources provide easily digestible amino acid profiles while minimizing the anti-nutritional factors commonly associated with traditional soybean meal. Corn-derived protein sources from the wet corn-milling process have recently entered the marketplace as potential alternative protein sources. However, relatively little data are available to describe the effects of feeding varying levels of these products on pig performance. Therefore, the objective of this study was to determine the optimum feeding strategy of a modified corn protein product (MCP) on growth performance and fecal dry matter of nursery pigs.

Procedures

The Kansas State University Animal Care and Use Committee approved the protocol used in this experiment. The experiment was conducted at the Kansas State University Segregated Early Weaning Research Facility in Manhattan, KS. Each pen contained a 4-hole, dry self-feeder, and bowl waterer for *ad libitum* access to feed and water.

Animals and diets

A total of 360 barrows (DNA 200 × 400; initially 12.0 ± 0.14 lb) were used in a 42-d growth trial (June 20, 2022 – August 1, 2022). Pigs were weaned at approximately 21 d of age, randomly allotted to pens in 1 of 2 weight blocks based on initial BW (initially 10.8 and 13.2 lb), and then allotted to 1 of 6 dietary treatments in a completely randomized design. There were 5 pigs per pen and 12 pens per treatment across 2 barns. Pigs were provided *ad libitum* access to water and to feed in meal form in all phases. The experimental diets for phases 1 and 2 were manufactured at the Kansas State University Poultry Unit in Manhattan, KS, while the common phase 3 diet was manufactured at Hubbard Feeds in Beloit, KS.

Dietary treatments were corn-soybean meal-based and arranged in a 2 × 3 factorial with 2 levels of MCP in phase 1 (10 or 12%) and 3 levels of MCP in phase 2 (4, 6, or 8%). Modified corn protein was added to the diet at the expense of soybean meal, and synthetic amino acids were utilized to balance ratios of other AAs to Lys, which were maintained well above requirement estimates to ensure that there were no limiting amino acids. Individual pigs were weighed and feed disappearance was recorded on d 0, 7, 10, 17, 23, and 42 to determine ADG, ADFI, and feed efficiency.

Fecal samples were collected on d 10 and 24 to determine fecal dry matter percentage from the same three randomly selected pigs from each pen. After collection, fecal samples were dried at 131°F in a forced air oven for 48 h and the ratio of dried to wet fecal weight determined the fecal dry matter. Fecal samples were maintained separately for each pig and the average of the three samples from each pen was then used for statistical analysis.

A daily temperature log was kept and is displayed in Figure 1. Temperatures were recorded at 7:00 a.m. (± 1 h), and the high and low temperatures were logged for each 24 h period. An average of each of these temperatures was taken across the 2 barns in this study.

Statistical analysis

Experimental data were analyzed using R Studio (Version 3.5.2, R Core Team, Vienna, Austria) with pen serving as the experimental unit in a completely randomized design. Treatment, body weight block, and the associated interaction served as fixed effects within the statistical model, with barn serving as a random effect. Differences between treatments were determined using estimated marginal means. When treatment was a significant source of variation, differences were determined by the preplanned pairwise comparisons using the Tukey-Krumer multiplicity adjustment to control for type I error. Results were considered significant when $P \leq 0.05$ and marginally significant when $0.05 < P \leq 0.10$.

Results and Discussion

A tendency was observed for a 3-way interaction for weight block × phase 1 diet × phase 2 diet ($P = 0.064$) on d 42 BW (Table 2). This interaction was a result of feeding increasing levels of MCP quadratically increasing, then decreasing, BW of lightweight pigs, regardless of phase 1 inclusion. However, in heavyweight pigs, increasing MCP in phase 2 diets quadratically decreased, then increased, BW of pigs fed 10% MCP in phase 1, while increasing MCP in phase 2 linearly decreased BW in heavyweight pigs fed 12% MCP in phase 1.

Additionally, during the common period (d 23 to 42), there was a 3-way interaction ($P = 0.038$) for ADG, in which lightweight pigs previously fed 10 and 8% MCP (phase 1 and 2, respectively) had decreased ADG, while feeding increasing levels of MCP in phase 2 to lightweight pigs fed 12% MCP in phase 1 quadratically increased, then decreased common period ADG. However, previous MCP feeding strategies for heavyweight pigs did not affect ADG during the common period. There were no other 2- or 3-way interactions observed ($P > 0.10$; Tables 2 and 3).

Increasing MCP levels in phase 1 decreased ($P = 0.028$) d 7 BW and tended to decrease BW ($P \leq 0.09$) at d 10 and 23. Moreover, during phase 1 (d 0 to 10), pigs fed 10% MCP had greater ($P = 0.032$) ADFI than those fed 12% MCP, resulting in a tendency ($P = 0.065$) for greater ADG. In addition, during the common period (d 23 to 42), pigs previously fed 10% MCP in phase 1 tended ($P = 0.087$) to have greater ADFI. Throughout the experiment (d 0 to 42), feeding 10% MCP in phase 1 tended ($P = 0.077$) to increase ADG.

Increasing MCP levels in phase 2 did not significantly affect ($P > 0.10$) BW, ADG, or ADFI. During phase 2 (d 10 to 23), feeding increasing MCP levels quadratically improved, then worsened ($P = 0.018$) feed efficiency, leading to a tendency for a similar quadratic effect ($P = 0.066$) on feed efficiency throughout the entire treatment feeding period (d 0 to 23). However, similar effects were not seen during the common period or the overall experiment ($P > 0.10$).

There were no 2- or 3-way interactions observed ($P > 0.10$) on fecal dry matter. Nevertheless, pigs fed 12% MCP had greater ($P = 0.024$) fecal dry matter at d 10 compared to those fed a 10% inclusion. However, the inverse was true on d 23, in which pigs fed phase 1 diets with a 10% inclusion rate had greater ($P = 0.016$) fecal dry matter compared to those fed 12% MCP.

As expected, pigs in the heavyweight block had significantly greater ($P < 0.001$) BW at each weighing event (d 0, 7, 10, 17, 23, and 42; Table 5). Additionally, there was a tendency for heavyweight pigs to have greater ($P < 0.100$) ADG during Phase 2 and during the common period, resulting in significantly greater ($P = 0.043$) ADG throughout the experiment (d 0 to 42). However, weight block did not significantly impact the proportion of pigs that lost weight from d 0 to 7, or fecal DM, % at d 10 or 24 ($P > 0.100$).

From d 0 to 10, there was a weight block × Phase 1 MCP level interaction ($P = 0.013$; Table 5) for feed efficiency, in which feeding 12% MCP improved feed efficiency in lightweight pigs, but reduced feed efficiency in heavyweight pigs. Despite this, in the overall experiment (d 0 to 42) there was a tendency for a weight block × Phase 1 MCP level interaction ($P < 0.100$) on ADG and feed efficiency, in which increasing MCP in lightweight pigs did not impact performance but it tended to reduce the performance of heavyweight pigs. There were no observed weight block × Phase 2 MCP level interactions observed (linear and quadratic $P < 0.100$).

In summary, feeding 10% MCP in phase 1 tended to improve BW, ADFI, and ADG compared to a 12% inclusion rate. Moreover, a 6% inclusion rate during phase 2 appeared to have a positive impact on feed efficiency during the treatment period but did not impact overall feed efficiency.

Table 1. Composition of phase 1, 2, and 3 diets (as-fed basis)[1]

	Dietary treatment					
	Phase 1		Phase 2			Phase 3
Item	10% MCP[2]	12% MCP[2]	4% MCP[2]	6% MCP[2]	8% MCP[2]	Common
Ingredient, %						
Corn	41.08	41.81	55.89	56.63	57.41	64.76
Soybean meal, 46.5% CP[2]	16.51	13.74	25.18	22.41	19.63	28.35
Modified corn protein[3]	10.00	12.00	4.00	6.00	8.00	---
Spray-dried bovine plasma	2.50	2.50	---	---	---	---
Spray-dried whey powder	12.50	12.50	10.00	10.00	10.00	---
Whey permeate	11.25	11.25	---	---	---	---
Corn oil	3.00	3.00	1.00	1.00	1.00	---
Limestone	0.80	0.83	0.90	0.93	0.95	0.75
Monocalcium phosphate, 21% P	0.45	0.43	0.75	0.73	0.68	0.85
Salt	0.20	0.20	0.50	0.50	0.50	0.60
L-Lys HCl	0.32	0.32	0.45	0.45	0.45	0.55
DL-Met	0.16	0.16	0.20	0.19	0.18	0.21
L-Thr	0.21	0.21	0.23	0.24	0.24	0.23
L-Trp	0.07	0.08	0.06	0.07	0.09	0.05
L-Val	0.12	0.12	0.15	0.16	0.16	0.16
L-Ile	0.07	0.08	0.05	0.06	0.07	---
Zinc oxide[4]	0.39	0.39	0.25	0.25	0.25	---
Vitamin premix with phytase[5]	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
Total	100	100	100	100	100	100

continued

Table 1. Composition of phase 1, 2, and 3 diets (as-fed basis)[1]

	Dietary treatment					
	Phase 1		Phase 2			Phase 3
Item	10% MCP[2]	12% MCP[2]	4% MCP[2]	6% MCP[2]	8% MCP[2]	Common
Calculated analysis						
SID AA, %						
Lys, %	1.40	1.40	1.35	1.35	1.35	1.30
Ile:Lys	59	59	59	59	59	53
Leu:Lys	143	149	126	132	138	111
Met:Lys	33	33	36	36	36	36
Met and Cys:Lys	58	58	58	58	58	56
Thr:Lys	65	65	65	65	65	63
Trp:Lys	19.4	19.4	19.5	19.5	19.5	19.3
Val:Lys	72	72	72	72	72	69
NE, kcal/lb	1,207	1,211	1,133	1,137	1,141	1,170
SID Lys:NE, g/Mcal	5.26	5.25	5.41	5.39	5.37	5.04
CP, %	21.9	21.9	21.1	21.1	21.1	19.8
Ca, %	0.64	0.63	0.71	0.71	0.70	0.62
STTD P, %	0.54	0.54	0.50	0.50	0.50	0.44
Analyzed Ca:analyzed P	1.10	1.10	1.20	1.20	1.20	1.13
Na, %	0.54	0.57	0.38	0.41	0.43	0.27
Cl, %	0.68	0.69	0.57	0.57	0.58	0.251

[1]Phase 1 diets were fed to pigs from approximately 12 to 15 lb. Phase 2 diets were fed to pigs from approximately 15 to 24 lb. Phase 3 was fed to pigs from approximately 24 to 38.5 lb.
[2]CP = crude protein.
[3]Modified corn protein, Cargill Starches, Sweeteners, & Texturizers, Blair, NE.
[4]Zinc oxide was included in the diet to provide 3,000 and 2,000 ppm of Zn in phase 1 and 2, respectively.
[5]Ronozyme 2700 (DSM Nutritional Products) provided an assumed 0.13% release of STTD P with 453 FYT/lb inclusion in the final diet.

Table 2. Interactive effects of initial body weight block and MCP level[1,2]

Weight block:	Light						Heavy										
Phase 1 MCP:[3]	10%			12%			10%			12%				*P* =			
Phase 2 MCP:[3]	4%	6%	8%	4%	6%	8%	4%	6%	8%	4%	6%	8%	SEM	Block × P1 ×P2	Phase 1 10 vs. 12%	Phase 2 Linear	Phase 2 Quadratic
Body weight, lb																	
d 0	10.7	10.8	10.7	10.8	10.7	10.8	13.2	13.2	13.1	13.2	13.2	13.2	0.14	---	0.844	---	---
d 7	12.3	11.8	12.3	12.0	11.8	12.0	14.6	14.8	14.7	14.4	14.1	14.4	0.43	---	0.028	---	---
d 10	13.6	13.0	13.7	13.3	13.2	13.6	16.3	16.2	16.3	16.0	15.4	15.6	0.63	0.516	0.056	---	---
d 17	17.8	17.8	17.2	17.7	17.2	17.5	20.7	20.8	21.4	20.8	20.0	20.2	0.52	0.606	0.166	0.537	0.363
d 23	22.7	22.8	21.7	22.6	22.2	22.1	26.4	25.9	26.5	25.5	24.8	25.3	0.66	0.446	0.090	0.329	0.642
d 42	37.0	37.7	34.8	36.1	36.8	35.5	41.9	40.8	42.3	39.9	39.1	35.5	1.26	0.064	0.014	0.308	0.699
Phase 1 (d 0 to 10)																	
ADG, lb	0.29	0.21	0.30	0.25	0.23	0.28	0.32	0.30	0.32	0.28	0.23	0.25	0.053	---	0.065	---	---
ADFI, lb	0.35	0.25	0.34	0.29	0.27	0.30	0.36	0.34	0.36	0.33	0.30	0.32	0.047	---	0.032	---	---
G:F	0.79	0.75	0.87	0.85	0.89	0.93	0.89	0.87	0.88	0.83	0.76	0.77	0.073	---	0.954	---	---
F/G[4]	1.26	1.34	1.15	1.17	1.13	1.08	1.12	1.15	1.14	1.20	1.32	1.30	---	---	0.954	---	---
Phase 2 (d 10 to 23)																	
ADG, lb	0.67	0.73	0.62	0.70	0.69	0.66	0.76	0.75	0.76	0.74	0.70	0.74	0.062	0.354	0.567	0.350	0.590
ADFI, lb	0.90	0.91	0.83	0.91	0.85	0.90	0.99	0.97	1.00	1.00	0.91	0.94	0.066	0.786	0.525	0.347	0.424
G:F	0.76	0.81	0.74	0.77	0.81	0.74	0.77	0.77	0.76	0.73	0.77	0.74	0.033	0.208	0.994	0.961	0.018
F/G[4]	1.32	1.23	1.35	1.31	1.23	1.35	1.29	1.30	1.32	1.37	1.30	1.35	---	0.208	0.994	0.961	0.018
Treatment period (d 0 to 23)																	
ADG, lb	0.50	0.49	0.48	0.50	0.49	0.49	0.57	0.55	0.57	0.54	0.50	0.53	0.034	0.619	0.307	0.623	0.449
ADFI, lb	0.65	0.60	0.62	0.63	0.60	0.64	0.71	0.70	0.72	0.71	0.64	0.67	0.041	0.893	0.325	0.520	0.120
G:F	0.77	0.79	0.77	0.78	0.83	0.78	0.80	0.81	0.79	0.76	0.77	0.79	0.023	0.200	0.845	0.712	0.066
F/G[4]	1.30	1.26	1.30	1.29	1.20	1.28	1.25	1.24	1.26	1.32	1.30	1.26	---	0.200	0.845	0.712	0.066

continued

Table 2. Interactive effects of initial body weight block and MCP level[1,2]

Weight block:	Light						Heavy							*P* =			
Phase 1 MCP:[3]	10%			12%			10%			12%							
Phase 2 MCP:[3]	4%	6%	8%	4%	6%	8%	4%	6%	8%	4%	6%	8%	SEM	Block × P1 ×P2	Phase 1 10 vs. 12%	Phase 2 Linear	Phase 2 Quadratic
Common period (d 23 to 42)																	
ADG, lb	0.76	0.79	0.69	0.71	0.77	0.70	0.82	0.79	0.83	0.76	0.75	0.77	0.048	0.038	0.015	0.505	0.203
ADFI, lb	1.54	1.59	1.45	1.52	1.54	1.42	1.65	1.62	1.67	1.59	1.58	1.59	0.076	0.205	0.087	0.148	0.328
G:F	0.49	0.50	0.48	0.47	0.50	0.50	0.50	0.48	0.50	0.47	0.48	0.48	0.014	0.407	0.152	0.352	0.432
F/G[4]	2.04	2.01	2.09	2.15	2.00	2.02	2.02	2.07	2.01	2.12	2.09	2.07	---	0.407	0.152	0.352	0.432
Overall (d 0 to 42)																	
ADG, lb	0.61	0.62	0.57	0.59	0.62	0.59	0.68	0.66	0.69	0.64	0.61	0.64	0.036	0.205	0.077	0566	0.981
ADFI, lb	1.05	1.03	0.99	1.03	1.02	0.99	1.13	1.12	1.14	1.11	1.06	1.09	0.052	0.761	0.207	0.338	0.698
G:F	0.59	0.60	0.58	0.57	0.61	0.60	0.60	0.59	0.60	0.57	0.58	0.59	0.012	0.173	0.213	0.395	0.286
F/G[4]	1.70	1.67	1.73	1.74	1.65	1.68	1.67	1.69	1.67	1.75	1.74	1.71	---	0.173	0.213	0.395	0.286
BW loss (d 0 to 7), %[5]	26.2	25.4	25.6	24.5	27.3	25.4	25.5	26.3	25.4	26.2	25.7	25.7	1.03	---	0.861	---	---
Fecal DM, %																	
d 10	26.7	25.4	26.7	26.9	28.9	27.0	26.6	27.7	26.1	29.7	27.7	27.5	1.49	0.343	0.024	---	---
d 23	25.8	25.4	24.6	22.1	25.7	23.8	24.4	24.8	24.7	22.6	23.7	24.0	1.11	0.721	0.016	0.388	0.105

[1]A total of 360 barrows (initial BW = 12.0 ± 0.14 lb) were used in a growth performance study with 5 pigs per pen and 4 or 8 replicates per treatment in the light and heavy weight block, respectively.
[2]ADG = average daily gain. ADFI = average daily feed intake. F/G = feed-to-gain ratio.
[3]Modified corn protein (Cargill Starches, Sweeteners, & Texturizers, Blair, NE) was included in the diet at 10 or 12% in Phase 1, and at 4, 6, or 8% in Phase 2.
[4]F/G was calculated by taking the inverse of G:F. Statistics were not run on F/G, therefore no SEM is reported and *P*-values are the same as reported for G:F.
[5]Percentage of individual pigs that lost weight from d 0 to 7 per treatment.

Table 3. Interactive effects of MCP level in Phase 1 and Phase 2[1,2]

Phase 1 MCP:[3]	10%			12%				*P* =	
Phase 2 MCP:[3]	4%	6%	8%	4%	6%	8%	SEM	Phase 1 × Phase 2 Linear	Phase 1 × Phase 2 Quadratic
Body weight, lb									
d 0	12.0	12.0	11.9	12.0	12.0	12.0	0.13	---	---
d 7	13.4	13.3	13.5	13.2	12.9	13.2	0.38	---	---
d 10	15.0	14.6	15.0	14.6	14.3	14.6	0.56	---	---
d 17	19.3	19.3	19.3	19.3	18.6	18.9	0.32	0.537	0.439
d 23	24.5	24.3	24.1	24.1	23.5	23.7	0.40	0.327	0.581
d 42	39.5	39.3	38.6	38.0	38.0	37.8	1.00	0.308	0.909
Phase 1 (d 0 to 10)									
ADG, lb	0.30	0.26	0.31	0.26	0.24	0.26	0.045	---	---
ADFI, lb	0.35	0.30	0.35	0.31	0.29	0.31	0.040	---	---
G:F	0.84	0.81	0.87	0.84	0.82	0.85	0.048	---	---
F/G[4]	1.19	1.23	1.15	1.19	1.22	1.18	---	---	---
Phase 2 (d 10 to 23)									
ADG, lb	0.72	0.74	0.69	0.72	0.70	0.70	0.053	0.350	0.257
ADFI, lb	0.94	0.94	0.92	0.95	0.88	0.92	0.050	0.347	0.258
G:F	0.77	0.79	0.75	0.75	0.79	0.77	0.025	0.961	0.991
F/G[4]	1.30	1.27	1.33	1.33	1.27	1.30	---	0.961	0.991
Treatment period (d 0 to 23)									
ADG, lb	0.53	0.52	0.52	0.52	0.50	0.51	0.022	0.623	0.804
ADFI, lb	0.68	0.65	0.67	0.67	0.62	0.65	0.025	0.520	0.736
G:F	0.78	0.80	0.78	0.77	0.80	0.79	0.015	0.712	0.811
F/G[4]	1.28	1.25	1.28	1.30	1.25	1.27	---	0.712	0.811
Common period (d 23 to 42)									
ADG, lb	0.79	0.79	0.76	0.73	0.76	0.74	0.043	0.505	0.639
ADFI, lb	1.59	1.60	1.56	1.56	1.56	1.51	0.064	0.148	0.939
G:F	0.49	0.49	0.49	0.47	0.49	0.49	0.010	0.352	0.480
F/G[4]	2.04	2.04	2.04	2.13	2.04	2.04	---	0.352	0.480

continued

Table 3. Interactive effects of MCP level in Phase 1 and Phase 2[1,2]

Phase 1 MCP:[3]	10%			12%				*P* =	
Phase 2 MCP:[3]	4%	6%	8%	4%	6%	8%	SEM	Phase 1 × Phase 2 Linear	Phase 1 × Phase 2 Quadratic
Overall (d 0 to 42)									
ADG, lb	0.65	0.64	0.63	0.61	0.61	0.61	0.029	0.566	0.928
ADFI, lb	1.09	1.07	1.07	1.07	1.04	1.04	0.040	0.338	0.857
G:F	0.59	0.59	0.59	0.57	0.59	0.59	0.008	0.395	0.611
F/G[4]	1.69	1.68	1.70	1.75	1.69	1.69	---	0.395	0.611
BW loss (d 0 to 7), %[5]	25.9	25.8	25.5	25.3	26.5	25.6	1.03	---	---
Fecal DM, %									
d 10	26.6	26.5	26.4	28.3	28.3	27.2	1.49	0.389	0.719
d 23	25.1	25.1	24.6	22.4	24.7	23.9	1.11	0.388	0.224

[1]A total of 360 barrows (initial BW = 12.0 ± 0.14 lb) were used in a growth performance study with 5 pigs per pen and 4 or 8 replicates per treatment in the light and heavy weight block, respectively.
[2]ADG = average daily gain. ADFI = average daily feed intake. F/G = feed-to-gain ratio.
[3]Modified corn protein (Cargill Starches, Sweeteners, & Texturizers, Blair, NE) was included in the diet at 10 or 12% in Phase 1, and at 4, 6, or 8% in Phase 2.
[4]F/G was calculated by taking the inverse of G:F. Statistics were not run on F/G, therefore no SEM is reported and *P*-values are the same as reported for G:F.
[5]Percentage of individual pigs that lost weight from d 0 to 7 per treatment.

Table 4. Main effects of MCP level in Phase 1 and Phase 2[1,2]

Dietary phase:	Phase 1				Phase 2				*P* =	
Dietary MCP, %:[3]	10	12	SEM	*P* =	4	6	8	SEM	Linear	Quadratic
Body weight, lb										
d 0	12.0	12.0	0.14	0.844	12.0	12.0	12.0	0.13	---	---
d 7	13.4	13.1	0.43	0.028	13.3	13.1	13.3	0.39	---	---
d 10	14.9	14.5	0.63	0.056	14.8	14.5	14.8	0.58	---	---
d 17	19.3	18.9	0.52	0.166	19.3	18.9	19.1	0.37	0.537	0.363
d 23	24.3	23.8	0.66	0.090	24.3	23.9	23.9	0.47	0.329	0.642
d 42	39.1	37.9	1.26	0.014	38.7	38.6	38.1	1.05	0.308	0.699
Phase 1 (d 0 to 10)										
ADG, lb	0.29	0.26	0.053	0.065	0.28	0.25	0.28	0.047	---	---
ADFI, lb	0.33	0.30	0.047	0.032	0.33	0.29	0.33	0.042	---	---
G:F	0.84	0.84	0.073	0.954	0.84	0.81	0.86	0.054	---	---
F/G[4]	1.19	1.19	---	0.954	1.19	1.23	1.16	---	---	---
Phase 2 (d 10 to 23)										
ADG, lb	0.72	0.70	0.062	0.567	0.72	0.72	0.69	0.055	0.350	0.590
ADFI, lb	0.93	0.92	0.066	0.525	0.95	0.91	0.92	0.053	0.347	0.424
G:F	0.77	0.77	0.033	0.994	0.76	0.79	0.76	0.027	0.961	0.018
F/G[4]	1.30	1.30	---	0.994	1.32	1.27	1.32	---	0.961	0.018
Treatment period (d 0 to 23)										
ADG, lb	0.52	0.51	0.034	0.307	0.53	0.51	0.52	0.025	0.623	0.449
ADFI, lb	0.67	0.65	0.041	0.325	0.68	0.63	0.66	0.029	0.520	0.120
G:F	0.79	0.79	0.023	0.845	0.79	0.80	0.78	0.017	0.712	0.066
F/G[4]	1.27	1.27	---	0.845	1.27	1.25	1.28	---	0.712	0.066
Common period (d 23 to 42)										
ADG, lb	0.78	0.74	0.048	0.015	0.76	0.77	0.75	0.044	0.505	0.203
ADFI, lb	1.58	1.54	0.076	0.087	1.58	1.58	1.53	0.067	0.148	0.328
G:F	0.49	0.48	0.014	0.152	0.48	0.49	0.49	0.011	0.352	0.432
F/G[4]	2.04	2.08	---	0.152	2.08	2.04	2.04	---	0.352	0.432

continued

Table 4. Main effects of MCP level in Phase 1 and Phase 2[1,2]

Dietary phase:	Phase 1				Phase 2				*P* =	
Dietary MCP, %:[3]	10	12	SEM	*P* =	4	6	8	SEM	Linear	Quadratic
Overall (d 0 to 42)										
ADG, lb	0.64	0.61	0.036	0.077	0.63	0.63	0.62	0.030	0566	0.981
ADFI, lb	1.08	1.05	0.052	0.207	1.08	1.06	1.05	0.043	0.338	0.698
G:F	0.59	0.58	0.012	0.213	0.58	0.59	0.59	0.009	0.395	0.286
F/G[4]	1.69	1.72	---	0.213	1.72	1.69	1.69	---	0.395	0.286
BW loss (d 0 to 7), %[5]	25.8	25.7	1.03	0.861	---	---	---	---	---	---
Fecal DM, %										
d 10	26.5	28.0	1.49	0.024	27.5	27.4	26.8	1.21	---	---
d 23	25.0	23.7	1.11	0.016	23.7	24.9	24.3	0.83	0.388	0.105

[1]A total of 360 barrows (initial BW = 12.0 ± 0.14 lb) were used in a growth performance study with 5 pigs per pen and 4 or 8 replicates per treatment in the light and heavy weight block, respectively.
[2]ADG = average daily gain. ADFI = average daily feed intake. F/G = feed-to-gain ratio.
[3]Modified corn protein (Cargill Starches, Sweeteners, & Texturizers, Blair, NE) was included in the diet at 10 or 12% in Phase 1, and at 4, 6, or 8% in Phase 2.
[4]F/G was calculated by taking the inverse of G:F. Statistics were not run on F/G, therefore no SEM is reported and *P*-values are the same as reported for G:F.
[5]Percentage of individual pigs that lost weight from d 0 to 7 per phase 1 MCP inclusion level.

Table 5. Interactive effects of initial body weight block and MCP level[1,2]

Weight block:	Light		Heavy			*P* =	Weight block:	Light			Heavy				*P* =	
Phase 1 MCP:[3]	10%	12%	10%	12%	SEM	Block × Phase 1	Phase 2 MCP:[3]	4%	6%	8%	4%	6%	8%	SEM	Block × Phase 2 Linear	Block × Phase 2 Quadratic
Body weight, lb																
d 0	10.7	10.8	13.2	13.2	0.15	0.801		10.8	10.8	10.8	13.2	13.2	13.2	0.15	---	---
d 7	12.1	11.9	14.7	14.3	0.43	0.539		12.1	11.8	12.2	14.5	14.4	14.5	0.43	---	---
d 10	13.4	13.4	16.3	15.7	0.63	0.147		13.4	13.1	13.7	16.1	15.8	16.0	0.63	---	---
d 17	17.5	17.5	21.0	20.3	0.52	0.318		17.8	17.5	17.4	20.8	20.4	20.9	0.52	0.202	0.681
d 23	22.4	22.3	26.3	25.2	0.66	0.135		22.7	22.5	21.9	26.0	25.4	25.9	0.66	0.581	0.622
d 42	36.5	36.1	41.7	39.6	1.26	0.097		36.6	37.3	35.2	40.9	40.0	39.6	1.26	0.432	0.519
Phase 1 (d 0 to 10)																
ADG, lb	0.27	0.26	0.31	0.25	0.053	0.126		0.27	0.23	0.29	0.30	0.27	0.29	0.053	---	---
ADFI, lb	0.31	0.29	0.35	0.32	0.047	0.667		0.32	0.26	0.32	0.35	0.32	0.34	0.047	---	---
G:F	0.80	0.89	0.88	0.79	0.073	0.013		0.82	0.82	0.90	0.86	0.82	0.83	0.073	---	---
F/G[4]	1.25	1.12	1.14	1.27	---	0.013		1.22	1.22	1.11	1.16	1.22	1.20	---	---	---
Phase 2 (d 10 to 23)																
ADG, lb	0.67	0.68	0.76	0.73	0.062	0.320		0.69	0.71	0.64	0.75	0.73	0.75	0.062	0.901	0.559
ADFI, lb	0.88	0.89	0.99	0.95	0.066	0.412		0.90	0.88	0.87	1.00	0.94	0.97	0.066	0.331	0.648
G:F	0.77	0.77	.77	0.77	0.033	0.811		0.77	0.81	0.74	0.75	0.77	0.76	0.033	0.187	0.843
F/G[4]	1.30	1.30	1.30	1.30	---	0.811		1.30	1.23	1.35	1.33	1.30	1.32	---	0.187	0.843
Treatment period (d 0 to 23)																
ADG, lb	0.49	0.50	0.57	0.52	0.034	0.117		0.50	0.49	0.49	0.55	0.52	0.55	0.034	0.724	0.643
ADFI, lb	0.62	0.62	0.71	0.67	0.041	0.375		0.64	0.60	0.63	0.71	0.67	0.70	0.041	0.397	0.730
G:F	0.78	0.80	0.79	0.77	0.023	0.108		0.78	0.82	0.78	0.78	0.78	0.79	0.023	0.346	0.633
F/G[4]	1.28	1.25	1.27	1.30	---	0.108		1.28	1.22	1.28	1.28	1.28	1.27	---	0.346	0.633

continued

Table 5. Interactive effects of initial body weight block and MCP level[1,2]

Weight block:	Light		Heavy			*P* =
Phase 1 MCP:[3]	10%	12%	10%	12%	SEM	Block × Phase 1
Common period (d 23 to 42)						
ADG, lb	0.75	0.73	0.81	0.76	0.048	0.225
ADFI, lb	1.53	1.49	1.65	1.59	0.076	0.596
G:F	0.49	0.49	0.49	0.48	0.014	0.313
F/G[4]	2.04	2.04	2.04	2.08	---	0.313
Overall (d 0 to 42)						
ADG, lb	0.60	0.60	0.68	0.63	0.036	0.084
ADFI, lb	1.02	1.01	1.13	1.09	0.052	0.401
G:F	0.59	0.59	0.60	0.58	0.012	0.061
F/G[4]	1.69	1.69	1.67	1.72	---	0.061
BW loss (d 0 to 7), %[5]	25.7	25.7	25.7	25.9	1.20	0.878
Fecal DM, %						
d 10	26.2	27.6	26.8	28.3	1.49	0.945
d 23	25.3	23.9	24.6	23.4	1.11	0.827

Weight block:	Light			Heavy				*P* =	
Phase 2 MCP:[3]	4%	6%	8%	4%	6%	8%	SEM	Block × Phase 2 Linear	Block × Phase 2 Quadratic
Common period (d 23 to 42)									
ADG, lb	0.74	0.78	0.70	0.79	0.77	0.80	0.048	0.446	0.565
ADFI, lb	1.53	1.57	1.44	1.62	1.60	1.63	0.076	0.914	0.670
G:F	0.48	0.50	0.49	0.49	0.48	0.49	0.014	0.291	0.788
F/G[4]	2.08	2.00	2.04	2.04	2.08	2.04	---	0.291	0.788
Overall (d 0 to 42)									
ADG, lb	0.60	0.62	0.58	0.66	0.64	0.67	0.036	0.560	0.855
ADFI, lb	1.04	1.03	0.99	1.12	1.09	1.12	0.052	0.633	0.840
G:F	0.58	0.61	0.59	0.59	0.59	0.60	0.012	0.662	0.969
F/G[4]	1.72	1.64	1.69	1.69	1.69	1.67	---	0.622	0.969
BW loss (d 0 to 7), %[5]	---	---	---	---	---	---	---	---	---
Fecal DM, %									
d 10	26.8	27.2	26.8	28.2	27.7	26.8	1.49	---	---
d 23	24.0	25.6	24.2	23.5	24.3	24.4	1.11	0.518	0.300

[1]A total of 360 barrows (initial BW = 12.0 ± 0.14 lb) were used in a growth performance study with 5 pigs per pen and 4 or 8 replicates per treatment in the light and heavy weight block, respectively.
[2]ADG = average daily gain. ADFI = average daily feed intake. F/G = feed-to-gain ratio.
[3]Modified corn protein (Cargill Starches, Sweeteners, & Texturizers, Blair, NE) was included in the diet at 10 or 12% in Phase 1, and at 4, 6, or 8% in Phase 2.
[4]F/G was calculated by taking the inverse of G:F. Statistics were not run on F/G, therefore no SEM is reported and *P*-values are the same as reported for G:F.
[5]Percentage of individual pigs that lost weight from d 0 to 7 per treatment.