Kansas Agricultural Experiment Station Research Reports

Volume 11
Issue 7 *Swine Day*

Article 15

2025

Determining the Dose-Response Effects of a Modified Corn Protein Product in Nursery Pig Diets

Paula Giacomini
Kansas State University

Jason C. Woodworth
Kansas State University, jwoodworth@k-state.edu

Katelyn N. Gaffield
Kansas State University, gaffield@k-state.edu

See next page for additional authors

Recommended Citation

Giacomini, Paula; Woodworth, Jason C.; Gaffield, Katelyn N.; Tokach, Mike D.; DeRouchey, Joel M.; Gebhardt, Jordan T.; Goodband, Robert D.; Mertz, Keith; and Patience, John F. (2025) "Determining the Dose-Response Effects of a Modified Corn Protein Product in Nursery Pig Diets," *Kansas Agricultural Experiment Station Research Reports*: Vol. 11: Iss. 7. https://doi.org/10.4148/2378-5977.8749

Determining the Dose-Response Effects of a Modified Corn Protein Product in Nursery Pig Diets

Authors

Paula Giacomini, Jason C. Woodworth, Katelyn N. Gaffield, Mike D. Tokach, Joel M. DeRouchey, Jordan T. Gebhardt, Robert D. Goodband, Keith Mertz, and John F. Patience

K-STATE Research and Extension

SWINE DAY 2025

KANSAS STATE UNIVERSITY SWINE INDUSTRY DAY 2025

Determining the Dose-Response Effects of a Modified Corn Protein Product in Nursery Pig Diets

Paula Giacomini, Jason C. Woodworth, Katelyn N. Gaffield, Mike D. Tokach, Joel M. DeRouchey, Jordan T. Gebhardt, Robert D. Goodband, Keith Mertz,[1] and John F. Patience[2]

Summary

This experiment was conducted to determine the dose-response effects of a modified corn protein product (MCP; Cargill Starches, Sweeteners, & Texturizers, Blair, Nebraska) on growth performance, fecal dry matter, removals and mortalities, and apparent total tract digestibility (ATTD) of energy in nursery pigs. A total of 320 weanling pigs (DNA 600 × 241; initially 12.5 lb) were used in a 42-d growth study. Pigs were weaned at approximately 18 d of age, randomly allotted to pens in light (10.8 lb) or heavy (14.5 lb) weight blocks, and then pens were allotted to one of four dietary treatments in a completely randomized block design. There were five pigs per pen and 16 pens per treatment across two barns. Dietary treatments consisted of 0, 7.5, 10.0, and 12.5% MCP in phase 1 and 0, 2.5, 5.0, and 7.0 % MCP in phase 2. Modified corn protein replaced enzymatically treated soybean meal, conventional soybean meal and feed-grade amino acids in the control diet. Treatment diets were balanced for amino acids and minerals, but not energy, and fed in two dietary phases from d 0 to 10 and d 10 to 24, respectively, followed by a common phase 3 corn-SBM-based diet that did not contain MCP and was fed for the remainder of the trial. The percentage of pigs that lost weight on d 3 increased (linear, $P = 0.045$) as MCP increased. From d 0 to 10, ADG and d 10 BW decreased (quadratic, $P < 0.05$) and F/G worsened (linear, $P = 0.002$) as MCP increased, with the largest difference occurring when MCP increased from 10.0 to 12.5% of the diet. From d 10 to 24, ADG (quadratic, $P = 0.086$) and ADFI (quadratic, $P = 0.023$) increased then decreased as MCP increased, with the best performance observed at 2.5% MCP. Day 24 BW tended to decrease (linear, $P = 0.064$) as MCP increased. From d 24 to 42 when all pigs were fed a common diet, no differences in performance were observed. Overall, there were no ADG or ADFI effects observed, but pigs fed increasing MCP had poorer (linear, $P = 0.042$) F/G. Fecal DM was not affected by dietary treatment on d 10, but increased then decreased on d 20 (quadratic, $P = 0.016$) as MCP increased, with the greatest DM observed in pigs fed 5% MCP. In summary, increasing MCP in early nursery diets reduced ADG and worsened F/G. However, in phase 2, when added MCP was reduced, ADG and ADFI, as well as fecal DM, increased then decreased with increasing MCP. For the overall

[1] Cargill Starches, Sweeteners, & Texturizers, Blair, Nebraska.
[2] Oxford Nutrition Consulting, LLC, Ames, IA.

study, increasing MCP had no effects on ADG or ADFI, but worsened F/G, which might reflect the lower dietary ME and NE as MCP increased.

Introduction

Soybean meal (SBM) has limited use in early nursery diets because of the presence of anti-nutritional factors and allergens that can reduce protein digestibility and pig performance. Therefore, alternative protein sources are often used to reduce the level of conventional SBM in diets but still meet the protein and AA needs of the pig. High-protein corn by-products such as modified corn protein (MCP), can serve as a potential alternative to SBM for use in nursery diets. The MCP in this trial (PX, Cargill Starches, Sweeteners, & Texturizers, Blair, Nebraska) is a next-generation corn protein that has yet to be tested in feeding trials. We hypothesized that the next-generation MCP used in this trial will support growth similar to other specialty soy protein sources fed to pigs and will show benefits in terms of animal health. Therefore, this study was conducted to evaluate the effects of increasing MCP, as a replacement for SBM and specialty protein ingredients, on growth performance, removals and mortality, fecal dry matter, and ATTD of energy in weanling pigs.

Materials and Methods

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment. The experiment was conducted at the Kansas State University Swine Teaching and Research Center in Manhattan, KS. Each pen was equipped with a four-hole, dry self-feeder and nipple waterer to provide *ad libitum* access to feed and water. This trial was conducted from June 14, 2024, to July 26, 2024.

Animals and diets

A total of 320 weanling pigs (241 × 600, DNA; initially 12.5 lb) were used in a 42-d trial in two barns. Pigs were weaned at approximately 18 d of age, randomly allotted to pens in light (10.8 lb) or heavy (14.5 lb) weight blocks. Pens of pigs were then allotted to one of four dietary treatments in a completely randomized block design. There were five pigs per pen and 16 pens per treatment across two barns. Dietary treatments consisted of 0, 7.5, 10.0 or 12.5% MCP in phase 1 and 0, 5.0, 7.5 or 10% MCP in phase 2 (Table 2). Phase 1 diets were fed from d 0 to 10 and phase 2 fed from d 10 to 24, with a common phase 3 diet that did not contain MCP fed for the remainder of the study (Table 3). Modified corn protein was added to the diet at the expense of enzymatically treated soybean meal and conventional soybean meal. Feed-grade amino acids were used to balance ratios of other amino acids to Lys. Diets were balanced for amino acids and minerals but not energy. Non-energy nutrient loading values considered for the MCP were obtained from the supplier (Table 1). The nutrient loading values used for the enzymatically treated soybean meal were provided from the supplier. The nutrient loading values from other ingredients were obtained from the NRC (2012) with the exception of the NE value of SBM, which was considered to be 2,264 kcal/kg and 85% of the NE of corn. Phase 2 diets contained titanium dioxide as an indigestible marker to determine apparent total tract digestibility values (ATTD). Feed was provided in pellet form for phases 1 and 2 and meal form for phase 3 and was manufactured at the O.H. Kruse Feed Technology Innovation Center.

Individual pigs were weighed, and feed disappearance was recorded on d 0, 3, 10, 17, 24, 33, and 42 to determine ADG, ADFI, and F/G. Fecal samples were collected on d 10 and 20 to determine percentage fecal dry matter 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 was used to calculate fecal dry matter.

Feed samples were analyzed for proximate analysis and complete AA profile at the University of Missouri Agricultural Experiment Station Chemical Laboratory, and for calcium and phosphorus at the Kansas State University Soil Laboratory (Table 4). Titanium dioxide concentration in both dried feed and fecal samples were analyzed at the Kansas State University Swine Laboratory and the energy at ATC Scientific analytical testing laboratory (North Little Rock, Arkansas).

Statistical analysis

The data were analyzed in SAS using repeated measures employing appropriate contrast coefficients to evaluate treatment effects within phases. Additionally, the overall (d 0 to 42) dataset was analyzed independently using a one-way ANOVA to assess the main treatment effects without the influence of the repeated measure's structure. Fecal DM was analyzed on each pig sample individually (three individual samples per pen) and treated as an observational unit within the pen experimental unit. The three fecal DM results were then averaged and reported on an experimental unit basis. For the analysis determining the percentage of pigs that lost weight on d 3 and mortality and removals, a generalized linear mixed model (GLMM) was utilized via the PROC GLIMMIX procedure in SAS, specifying a binomial distribution for the response variable. Treatment and block were included as fixed effects, while barn was modeled as a random effect. Treatment differences were considered significant at $P < 0.05$, and a tendency for significant difference considered at $0.05 < P < 0.10$.

Results and Discussion

Analysis of diets was within formulated nutrient expectations (Table 4). The percentage of pigs that lost weight from d 0 to 3 increased (linear, $P = 0.045$; Table 5) as MCP increased. From d 0 to 10, there was a significant decrease (quadratic, $P < 0.05$) in ADG and d 10 BW, with the greatest decrease observed as MCP increased from 10 to 12.5%. Dietary treatment did not affect ADFI and consequently, F/G worsened (linear, $P = 0.002$) as MCP increased.

From d 10 to 24, ADG (quadratic, $P = 0.086$) and ADFI (quadratic, $P = 0.023$) increased then decreased as MCP increased with the best performance observed in pigs fed 2.5% MCP. Day 24 BW tended to decrease (linear, $P = 0.064$) as MCP increased. There was no effect on F/G from d 10 to 24. From d 24 to 42 when pigs were fed a common diet, no differences in growth performance were observed. Overall, pigs fed increasing MCP in phases 1 and 2 did not affect ADG, ADFI, or final BW, but F/G worsened (linear, $P = 0.042$) as MCP increased.

There were no differences in fecal dry matter observed on d 10. However, fecal dry matter increased then decreased (quadratic, $P = 0.016$) on d 20 as MCP increased, with pigs fed 5% MCP having the greatest fecal dry matter.

In summary, increasing MCP in phase 1 nursery diets reduced ADG and worsened F/G, with the greatest impact on performance occurring when MCP increased from 10.0 to 12.5%. However, in phase 2 when the addition of MCP was decreased, ADG, ADFI, and fecal dry matter increased then decreased with increasing MCP. Overall

F/G worsened as MCP increased, which could be a result of decreased DE, ME, and NE of the diet.

Brand names appearing in this publication are for product identification purposes only. No endorsement is intended, nor is criticism implied of similar products not mentioned. Persons using such products assume responsibility for their use in accordance with current label directions of the manufacturer.

Table 1. Composition of the modified corn protein (as-fed basis)[1,2]

	Supplier provided composition	Analyzed composition
Nutrient, %		
Crude protein	65.10	65.06
Crude fat	2.10	3.04
Crude fiber	1.10	0.80
Ash	7.90	7.70
Phosphorus	0.80	0.88
Calcium	0.01	0.03
NDF	13.60	2.52
ADF	5.20	0.31
Starch	0.30	1.67
Essential AA		
Arg	2.20	2.24
His	1.30	1.37
Ile	2.50	2.60
Leu	10.0	9.75
Lys	5.10	4.58
Met	1.40	1.44
Phe	3.60	3.87
Thr	2.10	2.07
Trp	0.30	0.30
Val	2.90	2.99
Non-essential AA		
Ala	5.60	5.52
Asp	3.70	3.78
Cys	1.90	1.18
Glu	13.90	13.30
Gly	1.90	1.87
Pro	5.80	5.72
Ser	3.20	2.61
Tyr	3.00	3.10

[1]Modified Corn Protein, Cargill Starches, Sweeteners, & Texturizers, Blair, Nebraska.
[2]Samples were analyzed for proximate analysis and complete AA profile at the University of Missouri Agricultural Experiment Station Chemical Laboratory and analyzed for Ca and P at the Kansas State University Soil Laboratory, Department of Agronomy.

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

	Modified corn protein, %[2]							
	Phase 1				Phase 2			
Item	**0.0**	**7.5**	**10.0**	**12.5**	**0.0**	**2.5**	**5.0**	**7.5**
Ingredient, %								
Corn	41.40	43.97	44.65	44.81	54.94	55.61	56.50	57.54
Soybean meal	19.99	12.49	11.83	11.80	25.26	23.34	21.26	19.02
Modified corn protein	0.00	7.50	10.00	12.50	0.00	2.50	5.00	7.50
Enzymatically treated SBM[3]	7.50	5.00	2.50	---	3.75	2.50	1.25	---
Blood plasma	2.50	2.50	2.50	2.50	---	---	---	---
Whey powder	12.50	12.50	12.50	12.50	10.00	10.00	10.00	10.00
Whey permeate	11.25	11.25	11.25	11.25	---	---	---	---
Corn oil	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Calcium carbonate	0.68	0.75	0.76	0.78	0.85	0.87	0.88	0.90
Monocalcium phosphate	0.70	0.60	0.58	0.50	0.85	0.83	0.78	0.73
Sodium chloride	0.20	0.20	0.20	0.20	0.55	0.55	0.55	0.55
L-Lys-HCl	0.38	0.28	0.25	0.20	0.49	0.46	0.43	0.40
DL-Met	0.22	0.13	0.10	0.06	0.23	0.20	0.18	0.14
L-Thr	0.19	0.23	0.24	0.25	0.23	0.24	0.26	0.27
L-Trp	0.03	0.08	0.09	0.10	0.06	0.08	0.09	0.11
L-Val	0.11	0.14	0.15	0.14	0.16	0.18	0.18	0.19
L-Ile	0.02	0.07	0.08	0.08	0.03	0.05	0.06	0.07
Trace mineral premix	0.15	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	0.25
Phytase[4]	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Zinc oxide[5]	0.39	0.39	0.39	0.39	0.25	0.25	0.25	0.25
Titanium dioxide	---	---	---	---	0.40	0.40	0.40	0.40

continued

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

	Modified corn protein, %[2]							
	Phase 1				Phase 2			
Item	0.0	7.5	10.0	12.5	0.0	2.5	5.0	7.5
Calculated analysis								
SID AA, %								
Lys, %	1.40	1.40	1.40	1.40	1.35	1.35	1.35	1.35
Ile:Lys	59	59	59	59	59	59	59	59
Leu:Lys	113	141	149	159	112	122	131	140
Met:Lys	35	31	30	29	37	36	35	33
Met and Cys:Lys	58	58	58	58	58	58	58	58
Thr:Lys	65	65	65	65	65	65	65	65
Trp:Lys	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
Val:Lys	72	72	72	72	72	72	72	72
ME, kcal.lb[6]	1,560	1,439	1,403	1,366	1,524	1,481	1,445	1,409
NE, kcal/lb[6]	1,182	1,110	1,086	1,060	1,158	1,133	1,110	1,086
SID Lys:NE, g/Mcal	5.37	5.72	5.85	5.99	5.29	5.40	5.52	5.64
CP, %	21.5	21.6	21.6	21.8	20.7	20.8	20.8	20.8
Ca, %	0.67	0.65	0.64	0.62	0.72	0.72	0.70	0.69
STTD P, %	0.42	0.42	0.42	0.42	0.38	0.38	0.38	0.37
Na, %	0.40	0.52	0.56	0.60	0.35	0.38	0.42	0.46
Cl, %	0.68	0.66	0.65	0.64	0.60	0.59	0.59	0.58

[1]Phase 1 diets were fed to pigs from approximately 12 to 17 lb. Phase 2 diets were fed to pigs from approximately 17 to 29 lb.
[2]Modified Corn Protein, Cargill Starches, Sweeteners, & Texturizers, Blair, Nebraska.
[3]HP 300; Hamlet Protein, Findlay, OH.
[4]Ronozyme 2700 (DSM Nutritional Products) provided an assumed 0.12% release of STTD P with 674 FYT/lb in the final diet.
[5]Zinc oxide was included in the diet to provide 3,000 and 2,000 ppm of Zn in phases 1 and 2, respectively.
[6]Calculated without considering an energy value for the MCP.

Table 3. Composition of phase 3 diet (as-fed basis)[1]

Ingredient, %	
Corn	68.04
Soybean meal	28.12
Calcium carbonate	0.75
Monocalcium phosphate	0.85
Sodium chloride	0.60
L-Lys-HCl	0.55
DL-Met	0.21
L-Thr	0.23
L-Trp	0.05
L-Val	0.16
Trace mineral premix	0.15
Vitamin premix	0.25
Phytase[2]	0.06
Calculated analysis	
SID AA, %	
Lys, %	1.30
Ile:Lys	53
Leu:Lys	113
Met:Lys	36
Met and Cys:Lys	57
Thr:Lys	63
Trp:Lys	19.3
Val:Lys	70
ME, kcal.lb[6]	1,493
NE, kcal/lb[6]	1,133
SID Lys:NE, g/Mcal	5.21
CP, %	20.0
Ca, %	0.62
STTD P, %	0.32
Na, %	0.28
Cl, %	0.51

[1]Phase 3 was fed to pigs from approximately 29 to 54 lb.
[2]Ronozyme 2700 (DSM Nutritional Products) provided an assumed 0.12% release of STTD P with 674 FYT/lb in the final diet.

Table 4. Analyzed composition of experimental diets (as-fed basis)[1]

	Modified corn protein, %							
	Phase 1				Phase 2			
	0.0	7.5	10.0	12.5	0	2.5	5.0	7.5
Nutrient, %								
Dry matter	87.65	87.21	87.72	87.45	87.14	86.98	87.71	86.76
Crude protein	20.79	21.19	21.00	21.60	19.98	19.31	19.88	19.88
Crude fat	2.83	3.17	3.02	3.11	3.34	3.30	3.31	3.24
Crude fiber	1.86	1.59	1.37	1.40	2.19	2.01	1.57	1.43
Ash	6.09	6.22	6.23	6.25	5.81	5.98	5.68	5.65
Phosphorus	0.70	0.67	0.58	0.60	0.61	0.55	0.66	0.58
Calcium	0.85	0.90	0.82	0.82	0.99	0.88	0.92	0.97
NDF	4.93	4.70	4.45	3.90	6.04	5.50	5.36	4.66
ADF	2.44	2.40	2.41	2.19	3.16	2.93	2.88	2.74
Starch	31.71	35.16	32.11	33.48	28.98	26.61	30.11	28.78
Titanium	---	---	---	---	0.340	0.353	0.370	0.369
Essential AA								
Arg	1.28	1.15	1.02	1.04	1.25	1.19	1.08	1.03
His	0.56	0.55	0.51	0.53	0.53	0.52	0.48	0.49
Ile	0.93	0.97	0.92	0.97	0.91	0.92	0.89	0.90
Leu	1.76	2.10	2.13	2.41	1.69	1.81	1.85	1.97
Lys	1.53	1.53	1.45	1.55	1.45	1.48	1.37	1.42
Met	0.49	0.47	0.41	0.46	0.50	0.49	0.48	0.47
Phe	1.01	1.06	1.01	1.10	0.96	0.97	0.94	0.96
Thr	1.02	1.08	1.02	1.10	0.95	1.00	0.94	0.93
Trp	0.25	0.26	0.24	0.27	0.25	0.25	0.24	0.25
Val	1.15	1.19	1.15	1.19	1.08	1.09	1.09	1.09
Non-essential AA								
Ala	1.01	1.20	1.22	1.36	0.99	1.05	1.08	1.14
Asp	2.16	1.97	1.75	1.80	2.01	1.93	1.76	1.70
Cys	0.38	0.40	0.38	0.42	0.33	0.33	0.34	0.34
Glu	3.70	3.89	3.72	4.02	3.63	3.66	3.57	3.62
Gly	0.82	0.78	0.71	0.73	0.79	0.77	0.72	0.70
Pro	1.14	1.33	1.34	1.48	1.13	1.19	1.21	1.27
Ser	0.92	0.92	0.87	0.92	0.86	0.85	0.79	0.80
Tyr	0.71	0.76	0.74	0.81	0.68	0.68	0.66	0.69

[1] Samples were analyzed for proximate analysis and complete AA profile at the University of Missouri Agricultural Experiment Station Chemical Laboratory and analyzed for Ca and P in the Kansas State University Soil Laboratory, Department of Agronomy.

Table 5. Effect of increasing modified corn protein on nursery pig performance[1]

	Modified corn protein, %						
Phase 1:	**0.0**	**7.5**	**10.0**	**12.5**			
Phase 2:	**0.0**	**2.5**	**5.0**	**7.5**		***P* =**	
Phase 3:	**0.0**	**0.0**	**0.0**	**0.0**	**SEM**	**Linear**	**Quadratic**
Pigs losing weight d 3, %[2]	20.3	26.8	28.1	36.6[#]	15.59	0.045	0.587
Initial BW, lb							
d 0	12.47	12.46	12.46	12.47	---	---	---
d 10	16.94	16.80	16.62	16.11[*]	0.248	0.001	0.039
d 24	29.10	29.27	29.07	27.82[#]	0.518	0.064	0.147
d 42	54.15	54.03	54.01	53.05	0.858	0.401	0.587
d 0 to 10 (Phase 1)[3]							
ADG, lb	0.45	0.43	0.42	0.36[*]	0.015	0.001	0.026
ADFI, lb	0.47	0.47	0.48	0.43	0.018	0.194	0.160
F/G	1.07	1.09	1.15	1.20[*]	0.029	0.002	0.109
d 10 to 24 (Phase 2)							
ADG, lb	0.86	0.89	0.89	0.84	0.024	0.500	0.086
ADFI, lb	1.17	1.25	1.22	1.15	0.032	0.443	0.023
F/G	1.37	1.41	1.38	1.37	0.026	0.853	0.447
d 24 to 42 (Phase 3)							
ADG, lb	1.39	1.38	1.39	1.40	0.027	0.830	0.496
ADFI, lb	1.97	1.96	2.00	1.99	0.043	0.531	0.940
F/G	1.41	1.43	1.45	1.42	0.013	0.241	0.164
d 0 to 42 (Overall)[4]							
ADG, lb	0.99	0.99	0.99	0.97	0.016	0.420	0.387
ADFI, lb	1.34	1.37	1.38	1.34	0.027	0.873	0.212
F/G	1.36	1.38	1.39[#]	1.39	0.012	0.042	0.285
Fecal DM, %[5]							
d 10	18.24	18.45	18.13	17.35	0.915	0.574	0.467
d 20	17.70	18.54	20.14	17.43	0.786	0.824	0.016

[*#] Indicates that treatment differs from control treatment including 0% modified corn protein for all dietary phases using a Dunnett multiple comparison test (*, $P < 0.05$; #, $P < 0.10$). All Dunnett tests were performed within dietary phase or overall and not considering repeated measures analysis.

[1]A total of 320 weanling pigs (DNA 241 × 600, initially 12.5 lb) approximately 18 days of age were used in a 42-d experiment with five pigs per pen and 16 pens per treatment.

[2]Percentage of pigs that had a lower BW on d 3 than on d 0.

[3]All phases were analyzed as a repeated measure using the appropriate contrast coefficients corresponding to each phase. An interaction between modified corn protein and phase was observed for ADG (linear, $P = 0.024$), ADFI (quadratic, $P = 0.045$), and F/G (linear, $P = 0.003$).

[4]Overall data were analyzed independently of the repeated measures as a one-way ANOVA.

[5]Feces from three pigs from each pen were weighed and dried to determine fecal dry matter. Treatment × day, $P = 0.386$; Treatment, $P = 0.250$; Day, $P = 0.454$.