Evaluation of How Nursery Pig Performance is Affected by Fermented Corn Protein as a Replacement to Enzymatically Treated Soybean Meal Along With High or Low Branch Chain Amino Acid to Leucine Ratios

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Summary

Two experiments were conducted to determine if fermented corn protein can serve as a replacement to enzymatically treated soybean meal and what the effects may be with high or low branch chain amino acids (BCAA):Leu ratios on nursery pig performance. In Exp. 1, a total of 350 barrows (200 × 400, DNA; initially 13.2 lb) were randomly allotted to 1 of 5 treatments with 5 pigs per pen and 14 replications per treatment. Dietary treatments were arranged in a 2 × 2 + 1 factorial with a control diet or diets with 5 or 10% fermented corn protein or enzymatically treated soybean meal. Pigs were fed phase 1 diets for 10 d followed by phase 2 diets for 21 d. There were no interactions observed throughout the experiment. Overall (d 0 to 31), pigs fed increasing levels of fermented corn protein had decreased (linear, $P \leq 0.026$) BW, ADG, and ADFI with no differences in F/G, whereas increasing enzymatically treated soybean meal had no effect on growth performance. Pigs fed enzymatically treated soybean meal had improved ($P \leq 0.034$) BW, ADG, and F/G compared to pigs fed fermented corn protein diets, with no effect on ADFI.

In Exp. 2, a total of 350 pigs (241 × 600, DNA; initially 26.7 lb) were used to determine the effects of fermented corn protein with high or low BCAA:Leu ratio on nursery pig growth performance. At weaning, pigs were randomly assigned to pens (5 pigs per pen). On d 24 after weaning (d 0 of the trial), pens of pigs were weighed and then allotted to treatment. Pigs were assigned to 1 of 5 dietary treatments with 14 replications per treatment. Dietary treatments were arranged in a 2 × 2 + 1 factorial. Diets consisted of 10 or 20% fermented corn protein either with high or low BCAA:Leu in addition to a control diet. There was no interaction observed between fermented corn protein concentration and BCAA:Leu. Overall (d 0 to 21), BW, ADG, ADFI, and F/G worsened (linear, $P < 0.001$) as fermented corn protein increased in the diet. High BCAA:Leu improved ($P = 0.023$) F/G compared to low BCAA:Leu with no effect on BW, ADG, and ADFI. In summary, using fermented corn protein to replace enzymat-

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ically treated soybean meal in phase 1 and 2 diets of nursery pigs diminished growth performance. Increasing concentrations of fermented corn protein in phase 3 worsened growth performance and increasing BCAA:Leu only improved the feed efficiency.

Introduction

Removing fibrous components of corn before fermentation provides a high crude protein dried distillers grains with solubles value (40% crude protein). When various components of the fermentation process are added back to high protein dried distillers grains with solubles, it results in a fermented corn protein product with up to 50% crude protein and 2% Lys. Because of its high Lys content, fermented corn protein has the potential to become an excellent replacement for specialty soy protein products, such as enzymatically treated or fermented soybean meal in nursery pig diets.

Corn-based ingredients, such as fermented corn protein, contain relatively high amounts of the branch chain amino acid Leu, which increases the dietary requirement of the other branch chain amino acids Ile and Val.[2] Taking this into account and balancing for the branch chain amino acids appears to improve growth performance of finishing pigs fed diets containing excess Leu.[3] Based on these findings, we believe that growth performance may also be improved in nursery pigs fed diets containing excess Leu (typically corn-byproduct-based diets) by increasing levels of Ile and Val.

Therefore, the objective of these studies was to evaluate fermented corn protein as a replacement for enzymatically treated soybean meal in phase 1 and 2 starter diets, and increasing fermented corn protein concentrations in phase 3 starter diets with or without the inclusion of high levels of Ile and Val.

Materials and Methods

The Kansas State University Institutional Animal Care and Use Committee approved the protocols used in both experiments. Exp. 1 was conducted at the Kansas State University Segregated Early Weaning facility in Manhattan, KS. Exp. 2 was conducted at the Kansas State University Swine Teaching and Research Center. In both experiments, each pen was equipped with a 4-hole, dry self-feeder and a nipple waterer to provide *ad libitum* access to feed and water.

Animals and diets

In Exp. 1, 350 barrows (200 × 400, DNA; initially 13.2 lb) were used in a 31-d phase 1 and 2 trial. Pigs were weaned at approximately 21-d of age and placed in pens of 5 pigs each based on initial weight. At weaning pigs were randomly allotted to 1 of 5 dietary treatments with 14 replications per treatment. Dietary treatments were arranged in a 2 × 2 + 1 factorial with main effects of fermented corn protein (5 or 10%) or enzymatically treated soybean meal (5 or 10%). A control diet consisted of a standard corn-soybean meal diet with no fermented corn protein or enzymatically treated soybean meal.

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[2] Cemin, H. S., M. D. Tokach, J. C. Woodworth, S. S. Dritz, J. M. DeRouchey, and R. D. Goodband. 2019c. Branched-chain amino acids interactions in growing pig diets. Trans. Anim. Sci. 3:1246-1253. https://doi.org/10.1093/tas/txz087.

[3] Kerkaert, H. R., H. S. Cemin, J. C. Woodworth, J. M. DeRouchey, S. S. Dritz, M. D. Tokach, R. D. Goodband, K. D. Haydon, C. Hastad, and Z. Post. 2020. Improving Performance of Finishing Pigs with Added Valine, Isoleucine, and Tryptophan: Validating a Meta-Analysis Model. Kansas Agricultural Experiment Station Research Reports: Vol. 6: Iss. 10. https://doi.org/10.4148/2378-5977.7999.

The concentrations of fermented corn protein and enzymatically treated soybean meal in the diet were consistent in phase 1 and 2. Diets (Table 2 and 3) were formulated to contain 1.40% (phase 1) and 1.35% (phase 2) standardized ileal digestible (SID) Lys and met or exceeded nutrient requirements established by the NRC (2012).[4] Treatment diets were fed for 10 d in phase 1 (d 0 to 10) and 21 d in phase 2 (d 10 to 31). The experimental diets were manufactured in pellet form at Provimi North America in Lewisburg, OH. Individual pig weights and feed disappearance were measured on d 10, 17, 24, and 31 to determine ADG, ADFI, and F/G.

In Exp. 2, 350 pigs (241 × 600, DNA; initially 26.7 lb) were used in a 21-d phase 3 trial. Pigs were weaned at approximately 21 d of age and placed in pens of 5 pigs each based on initial weight and gender. On d 24 after weaning (d 0 of the trial), pens of pigs were weighed and then allotted to 1 of 5 dietary treatments with 14 replications per treatment. Dietary treatments were arranged in a 2 × 2 + 1 factorial with main effects of fermented corn protein (10 or 20%) and BCAA:Leu (high or low). The control diet was a standard corn-soybean meal diet with no added fermented corn protein. Diets were manufactured in pellet form at Provimi North American in Lewisburg, OH, with a high or low BCAA:Leu. The 10 and 20% fermented corn protein diets were similar in decreasing amounts of soybean meal, but with or without the addition of the branch chain amino acids Ile and Val. The diets (Table 4) were formulated to contain 1.30% SID Lys and met or exceeded nutrient requirements established by the NRC.[4] Experimental diets were fed for 21 d (d 0 to 21) in phase 3 of the nursery program. Individual pig weights and feed disappearance were measured on d 10 and 21 to determine ADG, ADFI, and F/G.

Representative diet samples were obtained from every fifth bag of manufactured feed. The diet samples were stored at -20°C (-4°F) until they were homogenized, subsampled, and submitted for analysis of crude protein (CP), dry matter (DM), and ether extract (EE) to the University of Missouri Experiment Station Chemical Laboratories (Columbia, MO). A sample of fermented corn protein and enzymatically treated soybean meal were submitted for analysis of amino acid profile, Ca, and P to the University of Missouri Experiment Station Chemical Laboratories (Columbia, MO; Table 1). Standardized ileal digestibility coefficients for the fermented corn protein were derived from Yang et al.[5] A sample of fermented corn protein was submitted to determine the presence of mycotoxins to the North Dakota State University Veterinary Diagnostic Laboratory (Fargo, ND).

Statistical analysis

Data were analyzed as a randomized complete block design using the RStudio environment (Version 1.3.1093, RStudio, Inc., Boston, MA) using R programming language [Version 4.0.2 (2020-06-22), R Core Team, R Foundation for Statistical Computing, Vienna, Austria] with body weight serving as the blocking factor and pen as the experimental unit. Block was included in the model as a random effect. Linear and quadratic main effects of increasing levels of enzymatically treated soybean meal or fermented

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

[5] Yang, Z., A. Palowski, P. E. Urriola, and G. C. Shurson. 2020. Digestible and metabolizable energy content, and standardized ileal digestibility of amino acids in novel corn co-products for swine. J. Anim. Sci. 98 (Suppl. 1; (Abstr.)).

corn protein were tested, as well as any interactions. Differences between treatments were considered significant at $P \leq 0.05$ and marginally significant at $0.05 < P \leq 0.10$.

Results and Discussion

The analyzed DM, CP, and EE (Table 2, 3, and 4) were reasonably consistent compared to formulated values between treatments. For both experiments, the analyzed CP percentage was slightly less than formulated values. As expected, the analyzed fermented corn protein (Table 1) was high in CP and the BCAA:Leu.

Fermented corn protein was found to contain 51 ppb aflatoxin and 16.7 ppm of total fumonisin. All other mycotoxins were below practical quantitation limit.

In Exp. 1 (Table 5), there were no interactions observed between protein source and inclusion level throughout the duration of the experiment.

From d 0 to 10 (phase 1), pigs fed fermented corn protein tended to have decreased ($P = 0.084$) BW compared to pigs fed diets containing enzymatically treated soybean meal. All other growth performance criteria were not significantly different between treatments in phase 1.

From d 10 to 31 (phase 2), pigs fed fermented corn protein had decreased ($P \leq 0.045$) BW and ADG compared to pigs fed enzymatically treated soybean meal. Pigs that were fed increasing levels of fermented corn protein had decreased (linear, $P \leq 0.011$) BW, ADG, and ADFI with no difference in F/G. However, pigs that were fed fermented corn protein regardless of inclusion percentage tended to have decreased (quadratic, $0.051 \leq P \leq 0.079$) BW and ADFI compared to pigs fed the control diet. Pigs fed increasing levels of enzymatically treated soybean meal tended to have decreased (linear, $P = 0.068$) ADFI.

Overall (d 0 to 31), pigs fed enzymatically treated soybean meal had improved ($P \leq 0.034$) BW, ADG, and F/G compared to pigs fed fermented corn protein, with no difference in ADFI. Pigs fed increasing levels of fermented corn protein had decreased (linear, $P \leq 0.026$) BW, ADG, and ADFI, with no difference in F/G. However, pigs that were fed fermented corn protein regardless of inclusion percentage tended to have decreased (quadratic, $0.051 \leq P \leq 0.090$) BW and ADFI.

In Exp. 2 (Table 6), there were no BCAA × fermented corn protein interactions observed throughout the duration of the experiment.

In the first weigh period and overall (d 0 to 21), pigs that were fed fermented corn protein diets with high BCAA:Leu had improved ($P = 0.034$) F/G compared to pigs fed fermented corn protein diets with low BCAA:Leu.

In both weight periods and overall, pigs fed diets containing increasing levels of fermented corn protein had worsened (linear, $P \leq 0.020$) BW, ADG, ADFI, and F/G.

In summary, the results of Exp. 1 indicate that utilizing fermented corn protein as a replacement for enzymatically treated soybean meal diminishes growth performance in the diets of nursery pigs. The results of Exp. 2 indicate that increasing concentrations of fermented corn protein diminishes growth performance in the diets of nursery pigs and increasing BCAAs can only improve feed efficiency.

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Table 1. Chemical analysis of fermented corn protein and enzymatically treated soybean meal (as-fed basis)[1]

Item, %	Fermented corn protein	Enzymatically treated soybean meal
DM	92.22	93.69
CP	50.28	55.10
Ether extract	7.05	1.04
Crude fiber	7.10	5.55
Ash	2.75	6.73
Ca	0.137	3.30
P	0.552	0.691
Amino acids		
Ala	3.67	2.40
Arg	2.21	3.93
Asp	3.25	6.14
Cys	1.02	0.82
Glu	8.59	9.91
Gly	1.86	2.36
His	1.40	1.44
Ile	2.09	2.71
Leu	6.30	4.31
Lys	1.77	3.18
Met	1.19	0.76
Phe	2.66	2.84
Pro	4.09	2.80
Ser	2.14	2.46
Thr	1.85	2.18
Trp	0.33	0.71
Tyr	2.00	1.92
Val	2.68	2.81

[1] A sample of fermented corn protein and enzymatically treated soybean meal was collected, homogenized, subsampled, and submitted to the University of Missouri Experiment Station Chemical Laboratories (Columbia, MO) for proximate analysis and amino acid profile.

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

		Fermented corn protein,[2] %		Enzymatically treated soybean meal,[3] %	
Item	**Control**	**5**	**10**	**5**	**10**
Ingredients, %					
Corn	36.60	37.15	37.75	37.40	38.20
Soybean meal (46.5% CP)	31.40	25.60	19.80	25.60	19.75
Whey powder	25.00	25.00	25.00	25.00	25.00
Fermented corn protein	---	5.00	10.00	---	---
Enzymatically treated soybean meal	---	---	---	5.00	10.00
Choice white grease	2.50	2.50	2.50	2.50	2.50
Limestone	0.95	1.00	1.05	0.98	0.98
Monocalcium phosphate (21% P)	1.70	1.68	1.65	1.70	1.70
Salt	0.50	0.50	0.50	0.50	0.50
L-Lys HCl	0.35	0.46	0.58	0.35	0.35
DL-Met	0.20	0.19	0.18	0.20	0.20
L-Thr	0.16	0.18	0.20	0.16	0.16
L-Trp	0.02	0.04	0.05	0.02	0.02
L-Val	0.09	0.11	0.12	0.08	0.07
L-Ile	---	0.04	0.08	---	---
Zinc oxide	0.39	0.39	0.39	0.39	0.39
Vitamin-trace mineral premix	0.15	0.15	0.15	0.15	0.15
Total	100	100	100	100	100

continued

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

		Fermented corn protein,[2] %		Enzymatically treated soybean meal,[3] %	
Item	Control	5	10	5	10
SID amino acids, %					
Lys	1.40	1.40	1.40	1.40	1.40
Ile:Lys	62	62	62	63	63
Leu:Lys	110	116	121	111	113
Met:Lys	34	34	34	34	35
Met and Cys:Lys	56	56	56	56	56
Thr:Lys	63	63	63	63	63
Trp:Lys	19.0	19.0	19.0	19.0	19.0
Val:Lys	70	70	70	70	70
His:Lys	33	34	35	33	33
Total Lys, %	1.54	1.56	1.58	1.53	1.53
NE NRC, kcal/lb	1,273	1,268	1,264	1,259	1,244
SID Lys:NE, g/Mcal	4.99	5.01	5.03	5.05	5.11
CP, %	21.5	21.6	21.6	21.6	21.7
Ca, %	0.89	0.89	0.88	0.89	0.90
P, %	0.87	0.86	0.85	0.87	0.87
STTD P, %	0.63	0.63	0.63	0.63	0.63
Analyzed values, %					
DM	89.19	88.65	89.64	88.92	90.33
CP	19.14	17.80	19.31	18.88	18.35
Ether extract	4.18	4.64	4.87	4.42	4.57

[1] Phase 1 diets were fed from approximately 13 to 15 lb.
[2] Fermented corn protein was included at 5 or 10% of the diet.
[3] Enzymatically treated soybean meal was included at 5 or 10% of the diet.

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

		Fermented corn protein,[2] %		Enzymatically treated soybean meal,[3] %	
Item	**Control**	**5**	**10**	**5**	**10**
Ingredients, %					
Corn	51.85	52.45	53.00	53.60	55.00
Soybean meal (46.5% CP)	31.00	25.20	19.40	25.20	19.35
Whey powder	10.00	10.00	10.00	10.00	10.00
Fermented corn protein	---	5.00	10.00	---	---
Enzymatically treated soybean meal	---	---	---	5.00	10.00
Choice white grease	2.50	2.50	2.50	2.50	2.50
Limestone	1.00	1.05	1.10	1.03	1.03
Monocalcium phosphate (21% P)	1.80	1.78	1.75	1.83	1.83
Salt	0.50	0.50	0.50	0.50	0.50
L-Lys HCl	0.42	0.54	0.65	0.42	0.42
DL-Met	0.19	0.19	0.18	0.20	0.20
L-Thr	0.20	0.22	0.24	0.20	0.20
L-Trp	0.04	0.05	0.06	0.04	0.04
L-Val	0.10	0.12	0.14	0.10	0.09
L-Ile	---	0.06	0.10	0.02	0.02
Zinc oxide	0.25	0.25	0.25	0.25	0.25
Vitamin-trace mineral premix	0.15	0.15	0.15	0.15	0.15
Total	100	100	100	100	100

continued

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

Item	Control	Fermented corn protein,[2] %		Enzymatically treated soybean meal,[3] %	
		5	10	5	10
SID amino acids, %					
Lys	1.35	1.35	1.35	1.35	1.35
Ile:Lys	61	61	61	59	59
Leu:Lys	111	116	121	109	109
Met:Lys	35	35	35	35	35
Met and Cys:Lys	56	56	56	56	55
Thr:Lys	63	63	63	63	63
Trp:Lys	19.0	19.0	19.0	19.0	19.0
Val:Lys	70	70	70	70	70
His:Lys	34	35	36	33	33
Total Lys, %	1.49	1.51	1.53	1.49	1.48
NE NRC, kcal/lb	1,278	1,273	1,268	1,262	1,248
SID Lys:NE, g/Mcal	4.79	4.81	4.83	4.85	4.91
CP, %	21.2	21.1	21.1	20.6	20.6
Ca, %	0.83	0.83	0.83	0.83	0.84
P, %	0.81	0.80	0.79	0.82	0.82
STTD P, %	0.56	0.56	0.56	0.56	0.56
Analyzed values, %					
DM	88.96	89.83	89.12	89.28	89.89
CP	18.08	20.18	19.58	19.31	20.44
Ether extract	4.02	4.40	4.60	4.10	4.20

[1] Phase 2 diets were fed from approximately 15 to 35 lb.
[2] Fermented corn protein was included at 5 or 10% of the diet.
[3] Enzymatically treated soybean meal was included at 5 or 10% of the diet.

Table 4. Phase 3 diet composition, Exp. 2 (as-fed basis)[1]

		Low BCAA:Leu		High BCAA:Leu[3]	
Item Fermented corn protein[2]:	**Control**	**10%**	**20%**	**10%**	**20%**
Ingredients, %					
Corn	63.85	63.80	63.80	63.65	63.50
Soybean meal (46.5% CP)	32.60	22.40	12.20	22.40	12.25
Fermented corn protein	---	10.00	20.00	10.00	20.00
Limestone	0.88	0.95	1.03	0.95	1.03
Monocalcium phosphate (21% P)	0.90	0.85	0.80	0.84	0.78
Salt	0.50	0.50	0.50	0.50	0.50
L-Lys HCl	0.38	0.57	0.75	0.57	0.75
DL-Met	0.16	0.13	0.09	0.13	0.09
L-Thr	0.21	0.22	0.24	0.22	0.24
L-Trp	0.05	0.07	0.09	0.07	0.09
L-Val	0.10	0.11	0.12	0.19	0.28
L-Ile	---	---	---	0.08	0.15
Vitamin premix with phytase[4]	0.25	0.25	0.25	0.25	0.25
Trace mineral premix	0.15	0.15	0.15	0.15	0.15
Total	100	100	100	100	100

continued

Table 4. Phase 3 diet composition, Exp. 2 (as-fed basis)[1]

		Low BCAA:Leu		High BCAA:Leu[3]	
Item Fermented corn protein[2]:	**Control**	**10%**	**20%**	**10%**	**20%**
SID amino acids, %					
Lys	1.30	1.30	1.30	1.30	1.30
Ile:Lys	62	58	54	64	65
Leu:Lys	117	131	145	131	145
Met:Lys	34	34	33	34	33
Met and Cys:Lys	57	57	57	57	57
Thr:Lys	65	65	65	65	65
Trp:Lys	20.5	20.5	20.6	20.5	20.6
Val:Lys	74	74	74	80	86
His:Lys	36	40	43	40	43
Total Lys, %	1.45	1.50	1.54	1.50	1.54
NE NRC, kcal/lb	1,243	1,233	1,223	1,235	1,226
SID Lys:NE, g/Mcal	4.74	4.78	4.82	4.78	4.81
CP, %	21.5	22.0	22.6	22.1	22.8
Ca, %	0.68	0.68	0.68	0.68	0.68
P, %	0.59	0.58	0.57	0.58	0.56
STTD P, %	0.46	0.46	0.46	0.46	0.46
Analyzed values, %					
DM	88.23	87.87	88.73	88.44	88.82
CP	17.06	18.30	20.59	19.90	22.28
Ether extract	2.15	3.14	4.09	2.65	3.50

[1] Phase 3 diets were fed from approximately 26 to 55 lb.
[2] Fermented corn protein was included at 10 or 20% of the diet.
[3] Branch chain amino acids were increased with the addition of isoleucine and valine.
[4] Vitamin premix with phytase provided an estimated release of 0.13% STTD P.

Table 5. Interactive effect of protein source and inclusion level on nursery pig performance, Exp. 1[1]

		Fermented corn protein[2]		Enzymatically treated soybean meal[3]			P^5 =				
								Fermented corn protein		Enzymatically treated soybean meal	
Item	Control	5%	10%	5%	10%	SEM	Protein source[4]	Linear	Quad	Linear	Quad
BW, lb											
d 0	13.2	13.2	13.2	13.2	13.2	0.08	0.998	0.968	0.834	0.946	0.979
d 10	15.7	15.4	15.3	15.5	15.8	0.28	0.084	0.230	0.855	0.730	0.386
d 31	36.3	33.9	33.9	35.2	35.2	0.63	0.029	0.004	0.079	0.166	0.417
Phase 1 (d 0 to 10)											
ADG, lb	0.25	0.22	0.20	0.22	0.26	0.026	0.176	0.116	0.823	0.752	0.218
ADFI, lb	0.31	0.28	0.27	0.27	0.31	0.019	0.500	0.104	0.689	0.773	0.116
F/G	1.36	1.38	1.61	1.29	1.32	0.138	0.138	0.170	0.494	0.814	0.731
Phase 2 (d 10 to 31)											
ADG, lb	0.97	0.88	0.89	0.94	0.92	0.023	0.045	0.011	0.103	0.129	0.886
ADFI, lb	1.23	1.12	1.13	1.17	1.16	0.027	0.119	0.010	0.051	0.068	0.464
F/G	1.27	1.27	1.28	1.25	1.27	0.014	0.142	0.620	0.891	0.746	0.262
Overall (d 0 to 31)											
ADG, lb	0.73	0.66	0.66	0.70	0.70	0.020	0.034	0.013	0.150	0.298	0.635
ADFI, lb	0.92	0.84	0.85	0.88	0.88	0.023	0.161	0.026	0.090	0.153	0.412
F/G	1.27	1.28	1.29	1.25	1.25	0.013	0.009	0.140	0.779	0.443	0.452

[1] A total of 350 pigs (initial BW of 13.2 ± 0.08 lb) were used in a 31-d nursery trial with 5 pigs per pen and 14 pens per treatment. Pigs were weaned at approximately 21 d of age and allotted to treatment in a randomized complete block design. Dietary treatments were arranged in a 2 × 2 + 1 factorial with main effects on protein source and inclusion level.
[2] Fermented corn protein was included at 0, 5, or 10% of the diet.
[3] Enzymatically treated soybean meal was included at 0, 5, or 10% of the diet.
[4] Comparison of fermented corn protein and enzymatically treated soybean meal, excluding the control.
[5] There were no significant protein source × inclusion level interactions observed ($P > 0.05$). Linear and quadratic analysis within protein source considered the control diet representing an inclusion level of 0%.

Table 6. Interactive effect of fermented corn protein and BCAAs on nursery pig performance, Exp. 2[1]

BCAA:Leu[2]:		Low		High			P^4 =			
Fermented corn protein[3]:	Control	10%	20%	10%	20%	SEM	BCAA	Fermented corn protein	Linear	Quad
BW, lb										
d 0	26.8	26.6	26.5	26.8	26.7	3.41	0.691	0.912	0.810	0.967
d 10	39.5	37.8	36.3	38.9	36.0	4.65	0.607	0.007	0.001	0.438
d 21	58.9	55.4	50.9	56.4	51.0	5.44	0.554	< 0.001	< 0.001	0.303
d 0 to 10										
ADG, lb	1.27	1.10	0.91	1.22	0.93	0.119	0.071	< 0.001	< 0.001	0.075
ADFI, lb	1.75	1.72	1.62	1.74	1.58	0.164	0.873	0.014	0.020	0.266
F/G	1.38	1.58	1.79	1.44	1.74	0.046	0.034	< 0.001	< 0.001	0.126
d 10 to 21										
ADG, lb	1.76	1.60	1.40	1.59	1.37	0.093	0.621	< 0.001	< 0.001	0.667
ADFI, lb	2.61	2.43	2.32	2.43	2.19	0.179	0.242	0.004	< 0.001	0.877
F/G	1.48	1.53	1.66	1.53	1.61	0.034	0.360	< 0.001	< 0.001	0.251
Overall (d 0 to 21)										
ADG, lb	1.53	1.36	1.17	1.41	1.16	0.104	0.449	< 0.001	< 0.001	0.197
ADFI, lb	2.20	2.09	1.99	2.10	1.90	0.172	0.410	0.002	< 0.001	0.670
F/G	1.44	1.54	1.70	1.49	1.65	0.023	0.023	< 0.001	< 0.001	0.068

[1]A total of 324 pigs (initial BW of 26.7 ± 3.41 lb) were weaned at approximately 21 d of age and placed in pens of 5 pigs each based on initial weight and gender. On d 24 after weaning (d 0 of the trial), pens of pigs were weighed and then allotted to 1 of 5 dietary treatments with 14 replications per treatment. Dietary treatments were arranged in a 2 × 2 + 1 factorial with main effects of fermented corn protein (10 or 20%) and BCAA:Leu (high or low).

[2] Branch chain amino acids.

[3]Fermented corn protein was included at 0, 10, or 20% of the diet.

[4]The BCAA and fermented corn protein columns compare the low and high BCAA:Leu formulation and the 10/20% inclusion of fermented corn protein and do not include the control treatment. The Linear and Quad columns include the control (0%), 10, and 20% fermented corn protein averaged across low/high BCAA:Leu. There were no significant BCAA × fermented corn protein interactions observed ($P > 0.05$).