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Effects of Varying the Acid-Binding Capacity-4 in Diets Utilizing Specialty Soy Products with or without Pharmacological Levels of Zinc on Nursery Pig Performance

Ethan B. Stas, Alan J. Warner,[1] Chad W. Hastad,[1] Mike D. Tokach, Jason C. Woodworth, Joel M. DeRouchey, Robert D. Goodband, and Jordan T. Gebhardt[2]

Summary

A total of 1,057 pigs (PIC TR4 × [Fast LW × PIC L02]; initially 13.7 lb) were used to evaluate the effects of acid-binding capacity-4 (ABC-4) with or without pharmacological levels of Zn on nursery pig performance. At weaning, pigs were allotted to 1 of 4 dietary treatments based on initial weight. There were 22 pigs per pen and 12 replications per treatment. Dietary treatments were arranged in a 2 × 2 factorial consisting of a low and high ABC-4 level with or without pharmacological levels of Zn provided by ZnO. The low ABC-4 diets contained 13.0 and 10.75% novel soy protein concentrate (AX3 Digest; Protekta; Plainfield, IN) in phase 1 and 2, respectively. The high ABC-4 diets contained 15.85 and 13.15% enzymatically treated soybean meal (HP 300; Hamlet Protein; Findlay, OH) in phase 1 and 2, respectively, replacing the soy protein concentrate on an SID Lys basis. The low ABC-4 diets without ZnO were formulated to 150 and 200 meq in phase 1 and 2, respectively. Replacing novel soy protein concentrate with enzymatically treated soybean meal increased the ABC-4 of the diet by approximately 104 to 127 meq/kg. Diets with added ZnO increased the ABC-4 of the diet by approximately 60 to 65 meq/kg. Pigs were fed experimental diets during phase 1 (d 0 to 7) and phase 2 (d 7 to 21). Following phase 2, pigs were placed on a common diet for an additional 21 d (d 21 to 42). During the experimental period, ABC-4 × ZnO interactions were observed ($P \leq 0.026$) where pigs fed a low ABC-4 diet had improved ($P < 0.05$) ADG and F/G when ZnO was not present, but no differences ($P > 0.10$) were observed based on ABC-4 level when ZnO was added. Overall, there was an ABC-4 × ZnO interaction ($P = 0.002$) observed where pigs fed a high ABC-4 had increased ($P < 0.05$) removals and mortalities when ZnO was not present, and no differences ($P > 0.10$) due to ABC-4 level were observed when ZnO was added. For economics, there was an ABC-4 × ZnO interaction ($P \leq 0.039$) where pigs fed low ABC-4 diets had increased ($P < 0.05$) gain value, feed cost, and IOFC when ZnO was not present, and no differences ($P > 0.10$) due to ABC-4 level were observed when

[1] Appreciation is expressed to New Fashion Pork, Jackson, MN, for their technical support and expertise in conducting this experiment.

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ZnO was added. In summary, a low ABC-4 diet can improve growth performance, reduce the instance of removals and mortalities, and improve economics in nursery pigs when ZnO is not present in the diet.

Introduction

Poor acidification of the stomach in weaned pigs can be attributed to the high acid-binding capacity of feed ingredients. Acid-binding capacity-4 (ABC-4) is the amount of acid required to lower an ingredient or diet to a stable pH of 4. Avoiding high ABC-4 ingredients and incorporating low ABC-4 ingredients in the diets of newly weaned pigs can maintain a low stomach pH and improve nutrient utilization.[3]

Specialty protein sources are often used in early nursery diets as a partial replacement to soybean meal because of soy's antinutritional factors. However, the ABC-4 of specialty soy products can vary depending on how the soy protein is processed. A recent study reported a novel soy protein concentrate was found to have an ABC-4 of -13 meq/kg, while enzymatically treated soybean meal had an ABC-4 of 753 meq/kg, thus influencing the overall diets ABC-4 value.[4] Incorporating a specialty protein source with a low ABC-4 in early nursery diets may improve the health status and performance of newly weaned pigs.

The inclusion of pharmacological levels of Zn has been shown to reduce diarrhea and improve performance of nursery pigs.[5] Even though ZnO has a high ABC-4, it is likely the beneficial antimicrobial properties outweigh the potential negative effects of increased ABC-4 of the diet. However, there are growing concerns with use of ZnO at pharmacological levels. A diet formulated with a low ABC-4 may improve gut health and subsequent performance of early nursery pigs and provide some of the same benefits as pharmacological levels of Zn.

The objective of this study was to evaluate the effects of varying the ABC-4 diet values by utilizing different specialty soy protein sources with or without pharmacological levels of Zn on nursery pig performance in a commercial environment.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment. The experiment was conducted at a commercial research site owned and operated by New Fashion Pork in Jackson, MN. All diets were manufactured at the New Fashion Pork feed mill located in Estherville, IA.

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[3] Lawlor, P. G., P. B. Lynch, P. J. Caffrey, J. J. O'Reilly, and M. K. O'Connell. 2005. Measurements of the acid-binding capacity of ingredients used in pig diets. Ir. Vet. J. 58, 447-452. doi:10.1186/2046-0481-58-8-447.

[4] Stas, E. B., M. D. Tokach, J. M. DeRouchey, R. D. Goodband, J. C. Woodworth, and J. T. Gebhardt. 2022. Evaluation of the acid binding capacity of ingredients and complete diets commonly used for weanling pigs. *Accepted to* Transl. Anim. Sci.

[5] G. M. Hill, G. L. Cromwell, T. D. Crenshaw, C. R. Dove, R. C. Ewan, D. A. Knabe, A. J. Lewis, G. W. Libal, D. C. Mahan, G. C. Shurson, L. L. Southern, and T. L. Veum. 2000. Growth promotion effects and plasma changes from feeding high dietary concentrations of zinc and copper to weanling pigs (regional study), J. Anim. Sci., 78(4):1010-1016. doi:10.2527/2000.7841010x.

Animals and diets

A total of 1,057 pigs (PIC TR4 × [Fast LW × PIC L02]; initially 13.7 lb) were used in a 42-d study with 22 pigs per pen and 12 replications per treatment. Pens were randomly assigned to treatment and blocked based on initial body weight. Dietary treatments were arranged in a 2 × 2 factorial with low or high ABC-4 levels with or without pharmacological levels of Zn from ZnO. The low ABC-4 diets were formulated with 13.0 and 10.75% novel soy protein concentrate (AX3 Digest; Protekta; Plainfield, IN) in phase 1 and 2, respectively. The high ABC-4 diets were formulated with 15.85 and 13.15% enzymatically treated soybean meal (HP 300; Hamlet Protein; Findlay, OH) in phase 1 and 2, respectively, replacing the novel soy protein concentrate on an SID Lys basis. Novel soy protein concentrate and enzymatically treated soybean meal were measured to have ABC-4 values of -13 and 753 meq/kg, respectively. The low ABC-4 diets without ZnO were formulated to 150 and 200 meq/kg in phase 1 and 2, respectively. Replacing novel soy protein concentrate with enzymatically treated soybean meal increased the ABC-4 of the diet by approximately 104 to 127 meq/kg. Diets with pharmacological levels of Zn contained approximately 2,000 ppm of Zn from ZnO in phases 1 and 2. The ZnO increased the ABC-4 of the diet by approximately 60 to 65 meq/kg. Diets were formulated to contain 1.36% (phase 1) and 1.42% (phase 2) SID Lys and met or exceeded other nutrient requirement estimates established by the NRC.[6] Treatment diets were fed for 7 d in phase 1 (d 0 to 7) and 14 d in phase 2 (d 7 to 21). Following phase 2, all pigs were fed a common diet for an additional 21 d (d 21 to 42). On approximately d 15 of the trial, the research site experienced a significant PRRS health challenge. Pens of pigs were weighed, and feed disappearance was calculated weekly from d 7 to 42 to determine ADG, ADFI, and F/G.

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. Main effects of ABC-4 and added ZnO as well as their interactions were tested using the lmer function. Differences between treatments were considered significant at $P \leq 0.05$ and marginally significant at $0.05 < P \leq 0.10$.

Results and Discussion

All analyzed ABC-4 diet values were less than calculated values. However, analyzed ABC-4 still increased with the inclusion of enzymatically treated soybean meal and ZnO. Analyzed values were on average 8.5 and 37 meq/kg lower than calculated values in diets without ZnO in phase 1 and 2, respectively. Diets with ZnO had analyzed values on average 50 and 68 meq/kg lower than calculated values for phase 1 and 2, respectively. A previous study by Stas et al.[4] also reported lower analyzed ABC-4 diet values compared to calculated ABC-4 diet values and indicated the addition of ZnO contributed to the discrepancy. The pH of the drinking water in the study was measured at 7.37. Therefore, drinking water was near neutral pH and wouldn't be expected to influence the results of the study.

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

In phase 1 (d 0 to 7), there was an ABC-4 × ZnO interaction observed ($P = 0.036$) where pigs fed a high ABC-4 diet had increased ($P < 0.05$) ADG and tended to have improved ($P < 0.10$) F/G when ZnO was added but no differences ($P > 0.10$) due to ABC-4 levels when ZnO was not present. There was a main effect observed where pigs fed diets with added ZnO had increased ($P \le 0.012$) BW and ADFI compared to pigs fed diets without ZnO.

In phase 2 (d 7 to 21), there was a tendency for an interaction ($P \le 0.076$) where pigs fed a low ABC-4 diet improved ($P < 0.05$) ADG and F/G when ZnO was not present, but no differences ($P > 0.10$) due to ABC-4 level was observed when ZnO was added. There was a tendency for a main effect observed where pigs fed diets with added ZnO tended to have increased ($P = 0.062$) ADFI compared to pigs fed diets without ZnO.

In the experimental period (d 0 to 21), there was an interaction and tendency for an interaction ($P \le 0.091$) where pigs fed a low ABC-4 diet had improved ($P < 0.05$) ADG and F/G and tended to have improved ($P < 0.10$) ADFI when ZnO was not present, but no differences ($P > 0.10$) due to ABC-4 level when ZnO was added. There was also an interaction and tendency for an interaction ($P \le 0.064$) where pigs fed a high ABC-4 diet had higher ($P < 0.05$) removal and mortality percentage and higher mortalities when ZnO was not present, but no differences ($P > 0.10$) due to ABC-4 level when ZnO was added. There was a main effect observed where pigs fed diets with added ZnO had increased ($P = 0.008$) BW compared to pigs fed diets without ZnO.

In the common period (d 21 to 42), there was an interaction ($P = 0.029$) where pigs previously fed a low ABC-4 diet had numerically higher removal and mortality percentage when ZnO was added, but the opposite was observed when ZnO was not present. There was a main effect observed where pigs previously fed diets without ZnO had improved ($P = 0.036$) F/G compared to pigs previously fed diets with added ZnO.

Overall (d 0 to 42), there was an interaction ($P \le 0.043$) where pigs fed a high ABC-4 diet had increased ($P < 0.05$) mortalities, removal and mortality percentage and tended to have higher removals ($P < 0.10$) when ZnO was not present but no differences ($P > 0.10$) due to ABC-4 level when ZnO was added. For economics, there was an interaction ($P \le 0.039$) where pigs fed low ABC-4 diets had increased ($P < 0.05$) gain value, feed cost, and IOFC when ZnO was not present and no differences ($P > 0.10$) due to ABC-4 level when ZnO was added.

When overall data were analyzed on a pig placed basis, there was an interaction ($P \le 0.040$) where pigs fed a low ABC-4 diet had increased ($P < 0.05$) overall BW and ADG when ZnO was not present but no differences ($P > 0.10$) due to ABC-4 level when ZnO was added. There was a main effect observed where pigs fed diets with added ZnO had increased ($P = 0.047$) ADFI compared to pigs fed diets without ZnO.

In conclusion, pharmacological levels of Zn improved nursery pig performance when diets had high ABC-4 levels. When ZnO is not present in the diet, a low ABC-4 diet can improve gain, feed efficiency, economics, and reduce the instance of morbidity and mortality in health-challenged nursery pigs compared to those fed a diet with a high ABC-4.

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

	No ZnO		Added ZnO[2]	
Item	**Low ABC-4[3]**	**High ABC-4[3]**	**Low ABC-4[3]**	**High ABC-4[3]**
Ingredients, %				
Corn	42.81	39.85	42.51	39.55
Soybean meal (46.8% CP)	18.58	18.58	18.58	18.58
Cereal blend	13.10	13.10	13.10	13.10
Novel soy protein concentrate4	13.00	---	13.00	---
Enzymatically treated soybean meal5	---	15.85	---	15.85
Oat groats	3.75	3.75	3.75	3.75
Crystalline lactose	1.38	1.38	1.38	1.38
Fumaric acid	1.27	1.27	1.27	1.27
Fat blend	2.00	2.00	2.00	2.00
Beef tallow	0.50	0.50	0.50	0.50
Limestone	0.32	0.40	0.32	0.40
Dicalcium phosphate (19% P)	1.40	1.20	1.40	1.20
Salt	0.45	0.63	0.45	0.63
L-Lys	0.42	0.42	0.42	0.42
DL-Met	0.22	0.24	0.22	0.24
L-Thr	0.26	0.28	0.26	0.28
L-Trp	0.07	0.06	0.07	0.06
L-Val	0.06	0.08	0.06	0.08
Copper chloride	0.04	0.04	0.04	0.04
Choline chloride	0.03	0.03	0.03	0.03
Zinc oxide	---	---	0.30	0.30
Custom zinc	0.05	0.05	0.05	0.05
Vitamin E	0.05	0.05	0.05	0.05
Vitamin-trace mineral premix6	0.25	0.25	0.25	0.25
Manganese	0.02	0.02	0.02	0.02
Total	100	100	100	100

continued

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

	No ZnO		Added ZnO[2]	
Item	**Low ABC-4[3]**	**High ABC-4[3]**	**Low ABC-4[3]**	**High ABC-4[3]**
SID amino acids, %				
Lys	1.36	1.36	1.36	1.36
Ile:Lys	61	60	61	60
Leu:Lys	113	108	113	108
Met:Lys	36	37	36	37
Met and Cys:Lys	56	56	56	56
Thr:Lys	66	66	66	66
Trp:Lys	22.3	22.2	22.3	22.2
Val:Lys	70	70	70	70
His:Lys	36	36	36	36
Total Lys, %	1.51	1.52	1.51	1.52
NE, kcal/lb	1,074	1,066	1,070	1,062
SID Lys:NE, g/Mcal	5.75	5.79	5.76	5.81
CP, %	22.5	22.4	22.5	22.4
Ca, %	0.58	0.59	0.58	0.59
P, %	0.61	0.62	0.61	0.62
STTD P, %	0.46	0.46	0.46	0.46
Calculated ABC-4, meq	150	277	215	342
Analyzed ABC-4, meq	143	267	167	290
Difference in ABC-4, meq	7	10	48	52

[1] Phase 1 diets were fed from approximately 13.7 to 14.2 lb.
[2] Diets contained 2,265 ppm Zn from ZnO.
[3] Acid-binding capacity at a pH of 4.
[4] AX3 Digest; Protekta; Plainfield, IN.
[5] HP 300; Hamlet Protein; Findlay, OH.
[6] Vitamin-trace mineral premix contained Optiphos PLUS (Huvepharma Inc.; Peachtree City, GA) which provided an estimated release of 0.12% STTD P with 1,426 FTU/lb.

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

Item	No ZnO		Added ZnO[2]	
	Low ABC-4[3]	High ABC-4[3]	Low ABC-4[3]	High ABC-4[3]
Ingredients, %				
Corn	52.32	49.87	52.04	49.59
Soybean meal (46.8% CP)	22.65	22.65	22.65	22.65
Cereal blend	5.00	5.00	5.00	5.00
Novel soy protein concentrate[4]	10.75	---	10.75	---
Enzymatically treated soybean meal[5]	---	13.15	---	13.15
Crystalline lactose	1.38	1.38	1.38	1.38
Fumaric acid	1.38	1.38	1.38	1.38
Fat blend	2.00	2.00	2.00	2.00
Beef tallow	0.50	0.50	0.50	0.50
Limestone	0.56	0.63	0.56	0.63
Dicalcium phosphate (19% P)	1.30	1.13	1.30	1.13
Salt	0.58	0.70	0.58	0.70
L-Lys	0.49	0.49	0.49	0.49
DL-Met	0.25	0.26	0.25	0.26
L-Thr	0.26	0.27	0.26	0.27
L-Trp	0.08	0.08	0.08	0.08
L-Val	0.13	0.14	0.13	0.14
Copper chloride	0.04	0.04	0.04	0.04
Choline chloride	0.03	0.03	0.03	0.03
Zinc oxide	---	---	0.28	0.28
Custom zinc	0.05	0.05	0.05	0.05
Vitamin E	0.01	0.01	0.01	0.01
Vitamin-trace mineral premix[6]	0.25	0.25	0.25	0.25
Manganese	0.02	0.02	0.02	0.02
Total	100	100	100	100

continued

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

	No ZnO		Added ZnO[2]	
Item	**Low ABC-4[3]**	**High ABC-4[3]**	**Low ABC-4[3]**	**High ABC-4[3]**
SID amino acids, %				
Lys	1.42	1.42	1.42	1.42
Ile:Lys	58	57	58	57
Leu:Lys	109	106	109	105
Met:Lys	37	37	37	37
Met and Cys:Lys	56	56	56	56
Thr:Lys	63	63	63	63
Trp:Lys	22.3	22.2	22.3	22.2
Val:Lys	71	71	71	71
His:Lys	34	34	34	34
Total Lys, %	1.57	1.58	1.57	1.58
NE, kcal/lb	1,114	1,108	1,111	1,104
SID Lys:NE, g/Mcal	5.78	5.82	5.80	5.84
CP, %	22.7	22.6	22.7	22.6
Ca, %	0.64	0.64	0.64	0.64
P, %	0.61	0.61	0.61	0.61
STTD P, %	0.46	0.46	0.46	0.46
Calculated ABC-4, meq	200	304	261	365
Analyzed ABC-4, meq	170	260	197	293
Difference in ABC-4, meq	30	44	64	72

[1] Phase 1 diets were fed from approximately 14.2 to 20.6 lb.
[2] Diets contained 2,121 ppm Zn from ZnO.
[3] Acid-binding capacity at a pH of 4.
[4] AX3 Digest; Protekta; Plainfield, IN.
[5] HP 300; Hamlet Protein; Findlay, OH.
[6] Vitamin-trace mineral premix contained Optiphos PLUS (Huvepharma Inc.; Peachtree City, GA) which provided an estimated release of 0.12% STTD P with 1,426 FTU/lb.

Table 3. Interactive effects of acid-binding capacity-4 (ABC-4) with or without ZnO on nursery pig performance in a commercial environment[1]

	No ZnO		Added ZnO[2]			$P =$		
Item:	Low ABC-4[3]	High ABC-4[3]	Low ABC-4[3]	High ABC-4[3]	SEM	ABC-4 × ZnO	ABC-4	ZnO
BW, lb								
d 0	13.6	13.7	13.7	13.7	0.23	0.096	0.775	0.324
d 7	14.0	14.0	14.3	14.6	0.24	0.303	0.228	<0.001
d 21	20.4	19.7	21.0	21.3	0.45	0.230	0.642	0.008
d 42	38.7	39.2	39.3	39.2	0.63	0.617	0.747	0.623
d 42 per pig placed[4]	31.8	28.1	31.6	33.4	1.32	0.040	0.466	0.050
Day 0 to 7 (Phase 1)								
ADG, lb	0.05	0.03	0.09	0.13	0.015	0.036	0.415	<0.001
ADFI, lb	0.16	0.16	0.18	0.19	0.009	0.461	0.671	0.012
G:F	0.32	0.16	0.46	0.70	0.093	0.036	0.634	0.001
F/G[5]	3.14	6.13	2.18	1.42	---	0.036	0.634	0.001
Day 7 to 21 (Phase 2)								
ADG, lb	0.42	0.32	0.43	0.43	0.029	0.063	0.106	0.043
ADFI, lb	0.59	0.51	0.60	0.61	0.027	0.102	0.223	0.062
G:F	0.70	0.61	0.71	0.71	0.026	0.076	0.070	0.045
F/G[5]	1.42	1.65	1.41	1.41	---	0.076	0.070	0.045
Day 0 to 21 (Experimental period)								
ADG, lb	0.29	0.22	0.31	0.33	0.021	0.026	0.175	0.004
ADFI, lb	0.44	0.39	0.45	0.46	0.019	0.091	0.247	0.027
G:F	0.66	0.54	0.68	0.71	0.029	0.017	0.166	0.003
F/G[5]	1.53	1.84	1.48	1.41	---	0.017	0.166	0.003
Day 21 to 42 (Common period)								
ADG, lb	0.83	0.87	0.82	0.82	0.024	0.306	0.409	0.218
ADFI, lb	1.15	1.20	1.17	1.17	0.026	0.397	0.299	0.830
G:F	0.72	0.73	0.70	0.70	0.010	0.408	0.827	0.036
F/G[5]	1.40	1.38	1.42	1.43	---	0.408	0.827	0.036
Day 0 to 42 (Overall)								
ADG, lb	0.54	0.51	0.55	0.56	0.019	0.152	0.563	0.124
ADFI, lb	0.78	0.75	0.78	0.80	0.019	0.202	0.788	0.106
G:F	0.70	0.67	0.70	0.70	0.012	0.192	0.367	0.308
F/G[5]	1.43	1.49	1.44	1.43	---	0.192	0.367	0.308
Day 0 to 42 (Overall) per pig placed								
ADG, lb[6]	0.44	0.35	0.43	0.47	0.030	0.024	0.394	0.080
ADFI, lb[7]	0.68	0.64	0.72	0.71	0.027	0.640	0.307	0.047
G:F	0.64	0.58	0.59	0.67	0.063	0.240	0.835	0.789
F/G[5]	1.56	1.72	1.70	1.49	---	0.240	0.835	0.789

continued

Table 3. Interactive effects of acid-binding capacity-4 (ABC-4) with or without ZnO on nursery pig performance in a commercial environment[1]

	No ZnO		Added ZnO[2]			*P* =		
Item:	Low ABC-4[3]	High ABC-4[3]	Low ABC-4[3]	High ABC-4[3]	SEM	ABC-4 × ZnO	ABC-4	ZnO
Day 0 to 21 (Experimental period)[8]								
Removals, %[9]	3.3	6.2	3.4	3.0	1.55	0.239	0.417	0.285
Mortality, %[10]	5.5	11.2	7.3	6.6	2.23	0.064	0.167	0.557
Removals and mortality, %	9.0	17.7	11.0	9.8	2.49	0.025	0.102	0.241
Day 21 to 42 (Common period)								
Removals, %[9]	2.3	4.5	2.6	0.0	1.47	0.999	0.999	0.999
Mortality, %[10]	5.9	7.5	7.2	5.5	1.87	0.301	0.950	0.822
Removals and mortality, %	8.1	12.0	9.8	5.4	2.37	0.029	0.690	0.175
Day 0 to 42 (Overall)								
Removals, %[9]	5.3	9.9	5.7	3.0	1.92	0.021	0.986	0.037
Mortality, %[10]	11.1	17.8	14.0	11.7	2.46	0.043	0.354	0.554
Removals and mortality, %	16.5	27.7	19.7	14.8	2.88	0.002	0.327	0.076
Economics, $/pig placed								
Gain value[11]	15.01	11.94	14.78	16.28	1.089	0.035	0.457	0.057
Feed cost	5.55	4.93	5.63	5.87	0.202	0.034	0.333	0.013
Feed cost/lb of gain[12]	0.31	1.58	0.33	0.30	0.597	0.262	0.285	0.276
IOFC[13]	9.46	7.00	9.14	10.41	0.908	0.039	0.496	0.082

[1] A total of 1,057 pigs (initial BW of 13.7 ± 0.79 lb) were used in a 42-d nursery trial. A total of 4 dietary treatments were arranged in a 2 × 2 factorial design consisting of low or high ABC-4 of the diet with or without the presence of ZnO. There were 22 pigs per pen and 12 replications per treatment.
[2] Diets contained 2,265 and 2,121 ppm of Zn from ZnO in phase 1 and 2, respectively.
[3] The low ABC-4 diets were formulated with a novel soy protein concentrate (AX3 Digest; Protekta; Plainfield, IN) and the high ABC-4 diets were formulated with enzymatically treated soybean meal (HP 300; Hamlet Protein; Findlay, OH). The low ABC-4 diet without ZnO was formulated to a value of 150 and 200 meq in phase 1 and 2, respectively. The addition of ZnO increased the ABC-4 of the diet by approximately 60 to 65 meq. Replacing novel soy protein concentrate with enzymatically treated soybean meal increased the ABC-4 of the diet by 104 to 127 meq.
[4] BW per pig placed = final ending weight ÷ pigs placed.
[5] F/G was calculated from G:F by taking the inverse, therefore the *P*-values are the same and there are no reported SEM.
[6] ADG per pig placed = (final ending weight – initial weight) ÷ (Pigs initially placed × days of trial).
[7] ADFI per pig placed = (total feed intake) ÷ (Pigs initially placed × days of trial).
[8] The research site experienced a significant PRRS health challenge on approximately d 15 of the trial.
[9] Percentage of pigs that were removed into a hospital pen and lived until d 42. Does not include pigs that were removed and died/euthanized in hospital pen.
[10] Percentage of pigs that died/euthanized in original pen or hospital pen after being removed.
[11] Gain value = total gain per pen × assumed yield (0.75) × lean hog price (1.10).
[12] Feed cost per lb of gain = total feed cost per pen ÷ total gain per pen.
[13] Income over feed cost = gain value – feed cost.