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Effects of Increasing Dietary Level of ValoproWin in Low ABC-4 Diets on Nursery Pig Performance and Fecal Dry Matter

Julian Arroyave, Mike D. Tokach, Jason C. Woodworth, Joel M. DeRouchey, Robert D. Goodband, Katelyn N. Gaffield, Jordan T. Gebhardt,[1] David Guillou,[2] Noëmie Lemoine,[2] and Jim Bryte[2]

Summary
A total of 360 pigs (initially 13.9 ± 0.58 lb) were used to evaluate the effect of increasing ValoproWin (VLPW) in low acid-binding capacity-4 (ABC-4) diets on nursery performance and fecal dry matter (DM). ValoproWin is a fiber ingredient that contains a purified source of coarse indigestible fiber, oat hulls, and yeast autolysate. At weaning, pigs were randomly assigned within six body weight (BW) blocks to one of the six dietary treatments in a generalized randomized block design. There were five pigs per pen and 12 pens per treatment. Experimental diets were fed for 24 d, and then pigs were fed a common diet for 18 d. The control treatment was a low ABC-4 diet formulated to 200 and 250 meq/kg from d 0 to 10 (phase 1) and d 10 to 24 (phase 2), respectively. ValoproWin was added to the control diet at 1.75, 2.50, 3.75, and 5.00% without making any nutritional adjustments. A positive control, high ABC-4 treatment with pharmacological levels of Zn (3,000 and 2,000 ppm of Zn from ZnO in phases 1 and 2, respectively) was used, yielding ABC-4 values of 487 and 470 meq/kg in phases 1 and 2, respectively. As VLPW increased, BW on d 10 (linear, $P = 0.033$) and 24 (quadratic, $P = 0.049$) decreased, with a marginal reduction (quadratic, $P = 0.082$) in d 42 BW. For the experimental period (d 0 to 24), ADG decreased (quadratic, $P = 0.029$) as VLPW increased. No response ($P > 0.10$) to VLPW was observed for ADFI. As a result, feed efficiency worsened (quadratic, $P = 0.006$) as VLPW increased. The formulation strategy (low vs. high ABC-4 diets) did not affect ($P > 0.10$) BW or ADG. However, low ABC-4 diets reduced ($P = 0.028$) ADFI and improved ($P = 0.012$) feed efficiency during the experimental period. Overall, increasing VLPW tended to decrease (quadratic, $P = 0.067$) ADG with the lowest ADG at 2.50% VLPW, with performance returning to control levels at 5%. No responses ($P > 0.10$) were observed for ADFI, with feed efficiency responding (quadratic, $P = 0.098$) similarly to ADG. No differences ($P > 0.10$) between low and high ABC-4 diets were observed for any performance criteria. On d 10 and 24, fecal DM increased (linear, $P < 0.005$) with increasing VLPW. Pigs fed low ABC-4 diets had improved ($P = 0.039$) fecal DM on d 10; however, no

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differences were observed on d 24. The amount of manure observed on the body on d 9 decreased (linear, $P = 0.011$) as VLPW increased; however, no responses ($P > 0.10$) were observed on d 24. A marginal interaction ($P = 0.058$) was observed between sampling day and formulation strategy, where on both days, pigs fed high ABC-4 diets were cleaner; however, on d 24, the differences between both formation strategies were greater than d 9. In conclusion, increasing VLPW linearly increased fecal DM on d 10 and 24, and pig cleanliness on d 9, with overall ADG and feed efficiency responding in a quadratic manner. Low ABC-4 diets improved d 10 fecal DM and feed efficiency during the experimental period; however, no differences were observed for overall performance and d 24 fecal DM. High ABC-4 diets reduced the amount of visible manure observed on the body on d 9 and 23.

Introduction

Post-weaning diarrhea is a significant economic burden for the swine industry, leading to low growth rate, dehydration, reduced nutrient digestibility, and, in severe cases, death.[3] Various nutritional strategies have been evaluated to reduce the incidence of post-weaning diarrhea, including the use of pharmacological levels of Zn (from ZnO), low crude protein diets, ABC-4 capacity of the diet, and the use of fiber. However, mixed results have been observed, suggesting that the response to these nutritional strategies is affected by factors not controlled during the experiment.

The use of insoluble fiber (resistant to fermentation) is recommended in post-weaning diets as it increases the passage rate, prevents harmful bacterial growth, and improves intestinal morphology and microbial balance in the intestine.[4] Multiple studies have concluded that the use of insoluble fiber in pigs challenged with *E. coli* decreased the incidence of diarrhea due to the reduced ability of *E. coli* to adhere to the small intestine.[5] However, there is little agreement on how fiber affects pig performance. Some studies have observed no significant changes or even a reduction in growth performance when fiber is added to the diet, while others have observed improvements in performance. The discrepancies in the results are not well understood, but they seem to depend on the composition of the basal diet, as well as the chemical and physical characteristics of the fiber source.

ValoproWin (VLPW; MiXscience, Bruz, France) is a fiber ingredient for nursery pigs that contains a purified source of coarse indigestible fiber, oat hulls, and yeast autolysate. A previous study conducted at Kansas State University suggested that the use of 2.50% of VLPW in the first two phases for weaned pigs led to an improvement of fecal dry matter ($P < 0.05$), but no responses were observed in growth performance. However,

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[3] G. F. Silva, B. A. N. Silva, D. Sanglard, R. L. Domingos, M. F. Gonçalves, H. M. C. Cardoso, L. A. Cardoso, T. S. B. Pereira, B. C. A. Maia, S. K. Brito, L. T. S. Martins, A. L. Miranda, L. A. Haupenthal, S. Hirtenlehner, and M. L. T. Abreu. 2023. Performance and gut permeability of post-weaned piglets are influenced by different sources of lignocellulose fiber. Livest. Sci. 274:105274. doi:10.1016/j.livsci.2023.105274.

[4] K. L. Batson, A. C. Neujahr, T. Burkey, S. C. Fernando, M. D. Tokach, J. C. Woodworth, J. M. DeRouchey, R. D. Goodband, J. T. Gebhardt, and H. I. Calderón. 2021. Effect of fiber source and crude protein level on nursery pig performance and fecal microbial communities. J. Anim. Sci. 99(12):skab343. doi:10.1093/jas/skab343.

[5] Li, Q., E. R. Burrough, N. K. Gabler, C. L. Loving, O. Sahin, S. A. Gould, and J. F. Patience. 2019. A soluble and highly fermentable dietary fiber with carbohydrases improved gut barrier integrity markers and growth performance in F18 ETEC challenged pigs. J. Anim. Sci. 97:2139–2153. doi:10.1093/jas/skz093.

studies conducted in Europe have shown that VLPW can improve feed intake and gut function, particularly in diets that do not contain ZnO.

The previous study's lack of response could be related to the inclusion rate of VLPW used, possibly because the amount of fiber was not great enough to increase total fiber intake. Therefore, the objective of this study was to evaluate the effect of increasing VLPW on nursery pig performance and fecal dry matter.

Material and Methods

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment. The experiment was conducted in two barns located at the Kansas State University Segregate Early Weaning (SEW) facility in Manhattan, KS. Each pen (4 × 5 ft) was equipped with a six-hole dry feeder and a cup drinker to provide *ad libitum* access to feed and water.

Animals and diets

A total of 360 pigs (Line 200 × 400, DNA, Columbus, NE) initially, 13.9 ± 0.58 lb were used in a 42-d study. The pigs were weaned at approximately 21 d of age and divided into six body weight (BW) categories. The pigs were then randomly assigned to pens within the BW categories, and pens were allotted to one of six dietary treatments. Each pen had five pigs, and there were 12 pens per treatment. The two identical barns had an equal representation of dietary treatments and BW categories.

Pigs were fed experimental diets for the first two dietary phases, lasting 10 and 14 d, respectively. From d 24 to 42 of the experiment, all pigs were fed a common phase 3 diet. All dietary treatments were manufactured at the Kansas State University O.H. Kruse Feed Technology Innovation Center in Manhattan, KS. The first two phases were pelleted, and the common phase 3 diet was in meal form.

Dietary treatments included a low ABC-4 diet with incremental levels of VLPW (0, 1.75, 2.50, 3.75, or 5.00% of the diet), as well as a positive control diet without VLPW, where the ABC-4 capacity of the diet was not controlled and pharmacological levels of Zn from ZnO were added during phases 1 and 2 (Table 1). The VLPW was added at the expense of the complete diet without other modifications in formulation.

Low ABC-4 diets were formulated to 200 and 250 meq/kg for d 0 to 10 (phase 1) and d 10 to 24 (phase 2), respectively. Crystalline lactose and further processed soybean meal (ME-PRO, Aquatech, Brookings, SD) served as lactose and protein concentrate sources, with fumaric and formic acid used to decrease the ABC-4 value. For the high-ABC-4 diets, 3,000 and 2,000 ppm of Zn from ZnO were included in phases 1 and 2, respectively, while crystalline lactose and enzymatically-treated soybean meal (HP300, Hamlet Protein, Findlay, OH) were used as lactose and specialty soy sources, yielding ABC-4 values of 487 and 470 meq/kg for phases 1 and 2, respectively.

For low ABC-4 diet preparation, a large batch of basal phases 1 and 2 diets were mixed and placed in separate bins. A portion of this basal diet was then blended with VLPW to create the experimental diets, without adjusting the nutrient levels; thus, nutrient concentrations decreased as VLPW increased.

Pigs and feeders were weighed on d 10, 24, and 42 to determine ADG, ADFI, and F/G. Fecal samples were collected via rectal palpation from the same three pigs per pen on d 10 and 24 of the study. These samples were stored at 39.2°F (4°C) until fecal dry matter

(DM) analysis was conducted. The samples were dried in a forced-air oven for 48 h at 151°F (55°C) for determination of fecal dry matter. On d 9 and 23, the pigs from each pen were recorded for approximately 30 sec and each pig was scored for the manure on the body by two observers, following the methodology recommended by the Welfare Quality project.[6] Briefly, the body of the pig is divided into five sections, and each section received a score that ranged from 0 to 2, where 0 = clean (less than 10% of the area covered with feces), 1 = dirty (more than 10 but less than 50% covered with feces), and 2 = very dirty (50% or more of the body covered with feces).

Statistical analysis

Data were analyzed as a generalized randomized block design. The lmer function was used from the lme4 package in RStudio [Version 4.0.2 (2020-06-22), R Core Team, R Foundation for Statistical Computing, Vienna, Austria] with pen serving as the experimental unit. For performance data, the model utilized treatment as a fixed effect and BW block nested within barn and barn as random effects. For fecal dry matter, data were analyzed as repeated measures, considering the two sampling days; in addition to the parameters previously mentioned, the model incorporated the pen as a random effect to account for the subsampling associated with multiple individual pigs analyzed from each pen.

The linear and quadratic effects of increasing VLPW on performance and fecal dry matter were evaluated for the first five treatments. Contrast coefficients were established based on VLPW concentration. Specific contrasts were performed to compare the low- and high-ABC-4 diets with no added VLPW.

Manure body scores were initially analyzed as a categorical outcome with a generalized linear mixed model; however, the statistical model did not converge. As a result, data were grouped on a pen basis, using the average score of both evaluators and the sum of all the scores for the different pig sections, and analyzed as a continuous response, considering dietary treatment, day, and their interaction as fixed effects and the BW block nested within barn and barn as random effects. Results were considered significant at $P \le 0.05$ and marginally significant at $P \le 0.10$.

Results and Discussion

The crude protein, NDF, and ADF of experimental diets were consistent with formulated values considering analytical variation (Table 2).

Body weight (BW) at d 10 (linear, $P = 0.033$) and 24 (quadratic, $P = 0.049$) decreased as VLPW increased. On d 24, there was no change between 0 and 1.75% VLPW followed by a reduction in BW at 2.50 and 3.75%, with BW returning to the control levels at 5.0% inclusion. A marginal quadratic response ($P = 0.082$) to increasing the VLPW was observed on d 42, where BW decreased as VLPW increased from 0 to 3.75% in phases 1 and 2 and then increased to values similar to the control treatments at 5.00% VLPW. No differences ($P > 0.10$) were observed between pigs fed the low and high ABC-4 diets for BW at any time throughout the study.

For phase 1 (d 0 to 10), pigs fed increasing VLPW had decreased ADG (linear, $P = 0.019$). There were no differences from increasing VLPW for ADFI ($P > 0.10$).

[6] Welfare Quality. 2009. Welfare Quality Assessment Protocol for Pigs (Sows and Piglets, Growing and Finishing Pigs). Welfare Quality Consortium, Lelystad, Netherlands. Available at: https://www.welfarequalitynetwork.net/media/1018/pig_protocol.pdf.

As a result, F/G worsened (quadratic, $P = 0.029$) as dietary VLPW increased, with the poorest F/G observed at 3.75% VLPW. There were no differences ($P > 0.10$) in ADG and ADFI between pigs fed the low and high ABC-4 diets. However, low ABC-4 diets improved feed efficiency ($P = 0.006$).

For phase 2 (d 10 to 24), no response ($P > 0.10$) to increasing VLPW was observed for ADG and ADFI. A quadratic response ($P = 0.012$) was observed for F/G, with the poorest F/G values when fed at 1.75 and 2.50% followed by an improvement between 3.75 and 5.00%. There were no differences ($P = 0.348$) between low and high ABC-4 diets for ADG. Pigs fed low ABC-4 diets had lower ADFI ($P = 0.025$) than pigs fed high ABC-4 diets. As a result, low ABC-4 diets tended ($P = 0.075$) to improve feed efficiency.

For the experimental period (d 0 to 24), there was a quadratic response ($P = 0.029$) to increasing VLPW for ADG, with the lowest ADG observed at 2.50 and 3.75%, followed by an increase at 5.00%. No response ($P > 0.10$) to increasing VLPW was observed for ADFI. As a result, a quadratic response ($P = 0.006$) was observed for F/G, with F/G becoming poorer as VLPW increased from 0 to 2.50% followed by an improvement between 3.75 and 5.00%. There were no differences ($P = 0.621$) between low and high ABC-4 diets for ADG. However, pigs fed the low ABC-4 control had decreased ADFI ($P = 0.028$) and improved ($P = 0.012$) F/G compared to pigs fed the high ABC-4 diets.

For the common period (d 24 to 42), no response ($P > 0.10$) to VLPW levels previously fed from d 0 to 24 was observed for ADG and ADFI. However, feed efficiency tended (linear, $P = 0.09$) to improve as VLPW increased in phase 1 and 2 diets. No differences ($P > 0.10$) between low and high ABC-4 level fed in previous diets were observed for any of the performance criteria.

Overall (d 0 to 42), increasing VLPW during the experimental period (d 0 to 24), tended to decrease ADG (quadratic, $P = 0.067$), with the lowest ADG observed in pigs fed 2.50% and returned to the control values at 5.0%. No responses ($P > 0.10$) were observed for ADFI, resulting in a marginally quadratic response ($P = 0.098$) for F/G, where the F/G worsened as VLPW increased from 0 and 2.50%, followed by an improvement at 3.75 and 5.00%. No differences ($P > 0.10$) between low and high ABC-4 diets were observed for any performance criteria.

On d 10 and 24, fecal DM increased (linear, $P < 0.005$) with increasing VLPW. Pigs fed low ABC-4 diets had improved ($P = 0.039$) fecal DM on d 10; however, no differences between formulation strategies were observed on d 24.

For body manure score, a linear improvement ($P = 0.011$) was observed on d 9 as VLPW increased; however, no responses ($P > 0.10$) were observed on d 24. A marginal interaction ($P = 0.058$) was observed between sampling day and formulation strategy, where on both days, the pigs fed high ABC-4 diets containing ZnO were cleaner; however, on d 24, the differences between both formation strategies were greater than on d 9.

In conclusion, as VLPW increased during the first two phases, d 10 and 24 fecal dry matter linearly increased and d 9 manure scores improved with a quadratic response for the overall ADG and feed efficiency observed. Low ABC-4 diets improved d 10 fecal DM and feed efficiency during the experimental period; however, no differences between formulation strategies were observed for overall performance and d 24 fecal DM. However, high ABC-4 diets with ZnO improved the body cleanliness scores on d 9 and 23.

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Table 1. Diet composition (as-fed)[1]

	Phase 1		Phase 2		Phase 3
Ingredients, % **ABC-4:**	**Low**	**High**	**Low**	**High**	**---**
Corn	50.56	48.88	55.97	55.26	68.06
Soybean meal	17.34	17.35	25.35	25.35	28.12
Lactose	15.00	---	7.50	---	---
Spray-dried whey powder	---	20.85	---	10.40	---
Spray-dried bovine plasma	3.25	3.25	---	---	---
Corn oil	2.00	2.00	1.00	1.00	---
Calcium carbonate	0.33	0.33	0.48	0.52	0.75
Monocalcium phosphate, 21% P	0.91	0.20	0.97	0.60	0.85
Salt	0.77	0.28	0.80	0.55	0.60
L-Lys-HCl	0.44	0.36	0.49	0.45	0.55
DL-Met	0.24	0.16	0.24	0.19	0.21
L-Thr	0.18	0.14	0.21	0.19	0.23
L-Trp	0.04	0.04	0.05	0.05	0.05
L-Val	0.09	0.07	0.11	0.12	0.16
Trace mineral premix	0.15	0.15	0.15	0.15	0.15
Vitamin premix without phytase	0.25	0.25	0.25	0.25	0.25
Phytase[2]	0.06	0.06	0.06	0.06	0.03
Zinc oxide	---	0.40	---	0.25	---
Microbial enhanced protein[3]	7.50	---	5.50	0.00	---
Specialty soybean meal[4]	---	5.26	---	4.62	---
Fumaric acid[5]	0.50	---	0.50	---	---
Formic acid[6]	0.40	---	0.40	---	---
Total	100.00	100.00	100.00	100.00	100.00

continued

Table 1. Diet composition (as-fed)[1]

		Phase 1		Phase 2		Phase 3
Ingredients, %	**ABC-4:**	**Low**	**High**	**Low**	**High**	**---**
SID amino acids, %						
Lys		1.36	1.36	1.35	1.35	1.3
Ile:Lys		56	57	58	58	53
Leu:Lys		115	118	115	115	113
Met:Lys		37	31	39	35	36
Met & Cys:Lys		56	56	56	56	57
Thr:Lys		63	63	63	63	63
Trp:Lys		20	21	21	21	19
Val:Lys		70	70	70	70	70
His:Lys		36	35	36	36	35
Total Lys, %		1.52	1.51	1.50	1.49	1.44
NE, kcal/lb		1,173	1,184	1,125	1,135	1,111
SID Lys:NE, g/Mcal		5.26	5.21	5.44	5.40	5.31
CP, %		21.05	20.80	21.46	21.24	19.98
Ca, %		0.49	0.49	0.57	0.59	0.64
P, %		0.52	0.52	0.55	0.56	0.56
STTDP, %[7]		0.47	0.46	0.46	0.46	0.43
Crude fat, %		4.14	4.30	3.38	3.50	2.80
Crude fiber, %		2.20	1.87	2.48	2.27	2.44
NDF, %[8]		7.49	6.36	8.25	7.54	8.51
ADF, %[9]		3.10	2.63	3.49	3.20	3.45
Lignin, %[10]		0.42	0.35	0.51	0.46	0.53
Lactose, %		15.00	15.00	7.50	7.50	---

[1] Phases 1, 2, and 3 were fed for 10, 14, and 18 d, respectively. ValoproWin was mixed with the low ABC-4 basal diet at 0.00, 1.75, 2.50, 3.75, and 5.00% of the diet with no other adjustment in the formulation made.
[2] Ronozyme Hiphos 2700 (dsm-firmenich, Parsippany, NJ) provided an estimated release of 0.14% STTD P in phases 1 and 2 (1,486 FTU) and 0.12% STTD P in phase 3 (811 FTU).
[3] ME-Pro (Prairie Aquatech, Brookings, SD).
[4] HP 300 (Hamlet protein, Findlay, OH).
[5] Primary Products Ingredients Americas LLC, Decatur, IL.
[6] pHormasil Na (Hawkins, Roseville, MN).
[7] Standardized total tract digestible phosphorus.
[8] Neutral detergent fiber.
[9] Acid detergent fiber.
[10] Acid detergent lignin.

Table 2. Analyzed composition of experimental diets (as-fed basis)[1,2]

ABC-4:	Low					High
VLPW, %:	0.00	1.75	2.5	3.75	5.00	---
Phase 1						
CP, %[2]	20.61	19.93	19.85	19.55	19.47	19.79
NDF, %[3]	8.06	8.48	9.75	8.69	12.65	6.56
ADF, %	2.22	2.63	2.88	3.64	3.23	2.57
Phase 2						
CP, %	21.05	21.00	20.88	19.66	19.43	21.10
NDF, %	7.63	7.61	7.84	9.88	10.72	5.73
ADF, %	2.22	2.78	3.26	3.17	3.55	2.80

[1] The values represent the mean of two samples. Phase 1 was fed for 10 d and phase 2 for 14 d in pellet form.
[2] Nitrogen was estimated by N combustion, using the Dumas methodology, and then multiplied by a factor of 6.25 to obtain the CP values.
[3] Fiber components were determined using the sequential methodology described by VanSoest, 1988.

Table 3. Effect of the VLPW level in low ABC-4 diets on performance and fecal dry matter of nursery pigs[1]

ABC-4:	Low					High		P =[3]		
VLPW, %[2]:	0.00	1.75	2.50	3.75	5.00	0.00	SEM	Linear	Quadratic	ABC-4
BW, lb										
d 0	13.9	13.9	13.9	13.9	13.9	13.9	0.58	0.933	0.960	0.893
d 10	17.4	17.3	16.8	17.0	17.0	17.3	0.70	0.033	0.129	0.513
d 24	30.0	29.6	28.5	28.6	29.4	30.0	0.98	0.160	0.049	0.948
d 42	56.2	55.9	54.2	55.1	55.9	55.5	1.43	0.535	0.082	0.494
Period 1 (d 0 to 10)										
ADG, lb	0.35	0.34	0.29	0.31	0.31	0.34	0.019	0.019	0.084	0.441
ADFI, lb	0.38	0.39	0.34	0.36	0.38	0.40	0.018	0.302	0.114	0.311
F/G	1.10	1.15	1.18	1.22	1.20	1.21	0.029	0.003	0.029	0.006
Period 2 (d 10 to 24)										
ADG, lb	0.90	0.88	0.84	0.83	0.89	0.93	0.029	0.379	0.055	0.348
ADFI, lb	1.20	1.23	1.18	1.15	1.19	1.30	0.035	0.291	0.701	0.025
F/G	1.34	1.41	1.41	1.38	1.35	1.40	0.024	0.906	0.012	0.075
Experimental period (d 0 to 24)										
ADG, lb	0.67	0.65	0.61	0.61	0.65	0.68	0.021	0.120	0.029	0.621
ADFI, lb	0.86	0.88	0.83	0.82	0.85	0.93	0.025	0.229	0.439	0.028
F/G	1.29	1.35	1.36	1.34	1.32	1.36	0.019	0.393	0.006	0.012
Period 3 (d 24 to 42)										
ADG, lb	1.46	1.46	1.43	1.47	1.47	1.42	0.031	0.603	0.425	0.322
ADFI, lb	2.33	2.31	2.26	2.30	2.29	2.25	0.050	0.428	0.407	0.149
F/G	1.60	1.58	1.58	1.57	1.55	1.58	0.019	0.090	0.913	0.536
Overall (d 0 to 42)										
ADG, lb	1.01	1.00	0.96	0.98	1.00	1.00	0.022	0.515	0.067	0.666
ADFI, lb	1.49	1.49	1.44	1.46	1.47	1.49	0.032	0.224	0.310	0.961
F/G	1.48	1.49	1.50	1.49	1.47	1.50	0.015	0.430	0.098	0.516
Fecal dry matter, %[4]										
d 10	26.92	25.78	27.92	27.81	29.01	24.32	0.875	0.027	0.464	0.039
d 24	24.41	23.90	26.66	26.44	26.57	23.51	0.875	0.018	0.612	0.466

[1] A total of 360 pigs (Line 200 × 400, DNA, Columbus, NE; initially 13.9 ± 0.58 lb) were used in a 42-d growth study with five pigs per pen and 12 pens per treatment.

[2] VLPW = ValoproWin (MiXscience, Bruz, France), is a fiber source that contains a purified source of coarse indigestible fiber with oat hulls and yeast autolysate.

[3] Linear and quadratic P-values evaluated the effect of VLPW level within the low ABC-4 diets, whereas the ABC-4 P-value compared the low and high ABC-4 diets when VLPW was not added.

[4] The same three pigs per pen were sampled on d 10 and 24. There was a significant effect of sampling day ($P = 0.001$); however, no significant interactions ($P > 0.10$) between day and the linear or quadratic effects of VLPW inclusion were observed.

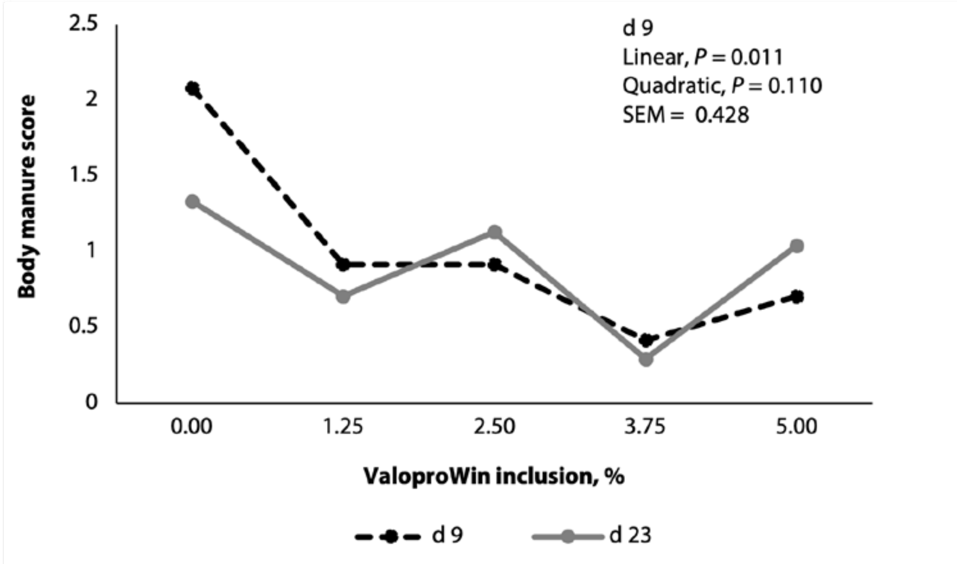

Figure 1. Effect of increasing VLPW on body manure scores on d 9 and 23. Manure scoring followed the methodology recommended by the Welfare Quality project, dividing the pig's body into five sections, each scored on a scale from 0 to 2. Scores were assigned as: 0 = clean (less than 10% of the area covered with feces), 1 = dirty (10–50% covered with feces), and 2 = very dirty (50% or more covered with feces). For this analysis, data were averaged on a pen basis and analyzed as continuous data. On d 23 no linear or quadratic effects were observed (P > 0.10).

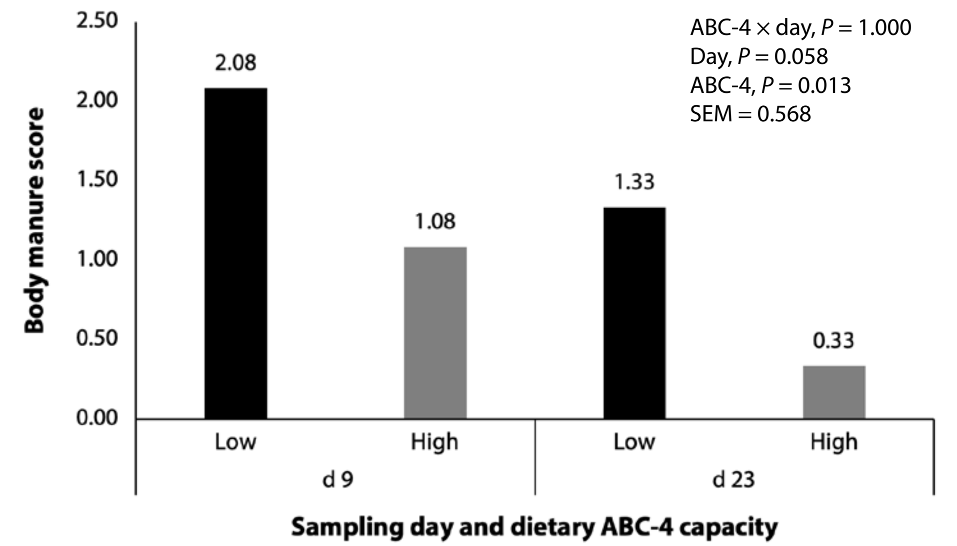

Figure 2. Effect of the ABC-4 dietary capacity on body manure scores on d 9 and 23. Manure scoring followed the methodology recommended by the Welfare Quality project, dividing the pig's body into five sections, each scored on a scale from 0 to 2. Scores were assigned as follows: 0 = Clean (less than 10% of the area covered with feces), 1 = Dirty (10–50% covered with feces), and 2 = Very dirty (50% or more covered with feces). For this analysis, data were averaged on a pen basis and analyzed as continuous data. *ABC-4 P-value compares the low and high ABC-4 diets without the inclusion of VLPW.