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Effects of different pharmacological Zn feeding duration strategies on nursery pig growth performance, fecal dry matter, plasma Zn and Cu concentrations, and final market weight

Joana Magoga[1], Jordan T. Gebhardt[1], Robert D. Goodband, Jason C. Woodworth, Joel M. DeRouchey, Katelyn N. Gaffield, and Mike D. Tokach

Summary

Pharmacological levels of Zn from zinc oxide (ZnO) are commonly used in nursery diets to improve growth performance and reduce post-weaning diarrhea. Although the benefits of this strategy during the early nursery phase are well established, less is known about its long-term effects on finishing performance and market weight, particularly when different pharmacological Zn feeding duration strategies are applied. Therefore, this study evaluated the effects of varying pharmacological Zn feeding duration programs on nursery growth performance, fecal dry matter (DM), plasma Zn and Cu concentrations, and subsequent finishing performance. At weaning, 360 pigs (initially 12.5 ± 0.06 lb) were assigned to one of six dietary treatments in a randomized complete block design, with 12 replicate pens per treatment and five pigs per pen. Dietary treatments were applied across three nursery phases (phase 1, d 0 to 11; phase 2, d 11 to 24; phase 3, d 24 to 45), followed by a common diet (phase 4, d 45 to 55). The six dietary treatments included: 1) no pharmacological Zn, with 110 mg/kg Zn provided in the premix from zinc sulfate in all phases; 2) 3,000 mg/kg Zn in phase 1, then 110 mg/kg for phases 2 and 3; 3) 3,000 mg/kg in phase 1, 2,000 mg/kg in phase 2, then 110 mg/kg in phase 3; 4) 3,000 mg/kg in phase 1, 2,000 mg/kg in phase 2, and 1,000 mg/kg for 7 d in phase 3 followed by 110 mg/kg for the remainder of phase 3; 5) 3,000 mg/kg in phase 1, 2,000 mg/kg in phase 2, and 1,000 mg/kg for 14 d in phase 3 followed by 110 mg/kg for the remainder of phase 3, and 6) 3,000 mg/kg in phase 1, 2,000 mg/kg in phase 2, and 1,000 mg/kg throughout phase 3. In phase 4, all pigs received a common diet containing 110 mg/kg of Zn. Pigs were subsequently followed through the finishing period (d 55 to market) and fed a common diet containing 110, 92, and 73 mg/kg of added Zn across finishing phases 1, 2, 3, and 4, respectively. During nursery phase 1, pigs fed pharmacological Zn had greater ADG ($P < 0.001$), ADFI ($P = 0.005$), and better F/G ($P = 0.008$) compared with pigs fed no pharmacological Zn. In phase 2, ADG differed among treatments ($P = 0.005$), with pigs previously fed 3,000 mg/kg

[1] Department of Diagnostic Medicine/Pathobiology, College of Veterinary Medicine, Kansas State University.

Zn and lowered to 110 mg/kg showing decreased performance. No treatment differences were observed during phase 3 or the common nursery period. Body weight was greater ($P < 0.05$) at d 11 and 24 and tended to be greater ($P < 0.10$) at d 31 and 38 for pigs maintained on high Zn levels; however, there was no evidence for differences on d 55. Overall nursery performance (d 0 to 55) was not affected by treatment. Plasma Zn concentration was influenced by treatment over time ($P < 0.001$), reflecting the duration of pharmacological Zn supplementation, whereas plasma Cu concentration was not affected by treatment. Fecal DM was improved in pigs receiving pharmacological Zn during the first nursery phase ($P = 0.002$). During the finishing period, no differences were observed in ADG, ADFI, F/G, or final market weight among previously fed treatments, indicating no carryover effects of nursery pharmacological Zn feeding duration strategy on subsequent growth performance. In conclusion, pharmacological Zn supplementation enhanced growth performance and fecal DM during the early nursery phase; however, these benefits do not persist after removing pharmacological Zn levels from the diet, having no detectable carryover effects on finishing growth performance when pigs were subsequently fed common diets.

Introduction

Zinc (Zn) is an essential trace mineral involved in numerous physiological functions, including enzyme activity, protection against pathogens, immune response, and maintenance of intestinal integrity[2]. Although the Zn requirement for nursery pigs is estimated at approximately 100 mg/kg of the diet (NRC, 2012)[3], pharmacological levels of Zn, typically supplied as zinc oxide (ZnO), are commonly used in swine production during the first three weeks post-weaning at concentrations ranging from 2,000 to 3,000 mg/kg of diet. The modes of action causing the beneficial effects of pharmacological Zn are not fully understood; however, proposed mechanisms include mitigation of reduced intestinal integrity and increased permeability, as well as modulation of gut microbiota[4].

Previous research has demonstrated that the beneficial effects of pharmacological Zn are most pronounced during the early post-weaning period, controlling post-weaning diarrhea, and improving growth performance due to a higher nutrient utilization and water retention by young pigs[5]. However, the optimal duration of pharmacological Zn feeding remains unclear, and limited information is available regarding the effects of different pharmacological Zn feeding duration strategies on subsequent nursery and long-term growth to market performance. Therefore, the objective of this study was to evaluate the effects of different pharmacological Zn feeding duration programs during the nursery phase on growth performance, fecal dry matter, and plasma Zn concentrations, as well as subsequent growth performance during the finishing period.

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[3] NRC. 2012. Nutrient requirements of swine. 11th rev. ed. Natl. Acad. Press, Washington, DC.
[4] Hu, C., J. Song, Y. Li, Z. Luan, and K. Zhu. 2013. Diosmectite-zinc oxide composite improves intestinal barrier function, modulates expression of proinflammatory cytokines and tight junction protein in early weaned pigs. Br. J. Nutr. 110:681–688. doi:10.1017/S0007114512005508.
[5] De Mille, C. M., E. R. Burrough, B. J. Kerr, W. P. Schweer, and N. K. Gabler. 2022. Dietary pharmacological zinc and copper enhances voluntary feed intake of nursery pigs. Front. Anim. Sci. 3:874284. doi:10.3389/fanim.2022.874284.

Procedures

The protocol for this experiment was approved by the Kansas State University Institutional Animal Care and Use Committee. The study was conducted at the Kansas State University Swine Teaching and Research Center in Manhattan, KS. All diets were manufactured at the Kansas State University O.H. Kruse Feed Technology Innovation Center, Manhattan, KS.

Animals and diets

A total of 360 weanling pigs (Line 241 × 600, DNA, Columbus, NE), with an initial weight of 12.5 ± 0.06 lb, were used in a 154-d study (55 d in the nursery and 99 d in finishing). Pigs were weaned at approximately 19 d of age and divided into two body weight (BW) categories: light or heavy. Within the BW categories, pigs were randomly assigned to pens, and pens were allotted to one of six dietary treatments. Each treatment consisted of 12 replicate pens in the nursery, with five pigs per pen. Each pen (4 × 5 ft) was equipped with a 6-hole dry feeder and a nipple drinker to provide ad libitum access to feed and water.

The nursery dietary program consisted of four feeding phases (Table 1): phase 1, from d 0 to 11; phase 2, from d 11 to 24; phase 3, from d 24 to 45, followed by a common phase 4 diet from d 45 to 55. Phase 1 was provided in pellet form and phases 2, 3, and 4 in mash form, and all diets were formulated to meet or exceed the nutrient requirements recommended by the NRC (2012). All diets contained 110 mg/kg of added Zn from $ZnSO_4$ via the trace mineral premix. When pharmacological levels of Zn were fed, additional Zn was provided as ZnO.

Six treatments were designed to evaluate different pharmacological Zn programs: 1) no pharmacological Zn, with 110 mg/kg Zn provided in the premix from zinc sulfate in all phases; 2) 3,000 mg/kg Zn in phase 1, then 110 mg/kg for phases 2 and 3; 3) 3,000 mg/kg in phase 1, 2,000 mg/kg in phase 2, then 110 mg/kg in phase 3; 4) 3,000 mg/kg in phase 1, 2,000 mg/kg in phase 2, and 1,000 mg/kg for 7 d in phase 3 followed by 110 mg/kg for the remainder of phase 3; 5) 3,000 mg/kg in phase 1, 2,000 mg/kg in phase 2, and 1,000 mg/kg for 14 d in phase 3 followed by 110 mg/kg for the remainder of phase 3; and 6) 3,000 mg/kg in phase 1, 2,000 mg/kg in phase 2, and 1,000 mg/kg throughout phase 3. Thus, pharmacological Zn feeding durations were 0,11, 24, 31, 38, and 45 d for treatments 1 through 6, respectively.

During the nursery period, pigs and feeders were weighed on d 0, 11, 17, 24, 31, 38, 45, and 55 to determine average daily gain (ADG), average daily feed intake (ADFI), and feed efficiency (F/G). To assess fecal dry matter (DM), fecal samples were collected via rectal stimulation from the same three pigs per pen on d 11, 24 and 45 of the study. Samples were stored at 39.2°F (4°C) until fecal DM analysis was conducted. Samples were dried in a forced-air oven at 131°F (55°C) for 48 h to determine fecal DM. Additionally, on d 0, 11, 24, and 45, blood samples were collected via jugular venipuncture into 10-mL vacutainer tubes. Plasma was obtained by centrifugation, and samples were stored at −112°F (−80°C) until determination of plasma Zn and copper (Cu) concentration.

A total of 341 pigs were subsequently followed during the finishing phase to evaluate carryover effects of nursery dietary treatments until market. Finishing pens were formed by combining one pen from the light BW block and one pen from the heavy BW block

belonging to the same nursery treatment, resulting in groups of 8 to 10 pigs per pen. In total, 36 finishing pens were formed, providing six replicate pens per nursery treatment. A common diet was fed throughout the finishing period. Pigs and feeders were weighed every 14 d to determine ADG, ADFI, and F/G. During the finishing phase, pigs were simultaneously enrolled in a separate study evaluating a medication program consisting of either a control diet or a diet containing chlortetracycline (Aureomycin 100, 4 lb/ton; Phibro Animal Health Corporation, Teaneck, NJ) and tiamulin (Denagard 10, 3.5 lb/ton; Elanco, Indianapolis, IN). The medication treatments were balanced within the nursery dietary treatments. Finishing diets were corn-soybean meal-based containing 110 mg/kg Zn for phase 1 (d 55 to 69) and 2 (d 69 to 88), 92 mg/kg Zn for phase 3 (d 88 to 125), and 73 mg/kg Zn for phase 4 (d 125 to 154).

Statistical analysis

In the nursery phase, data were analyzed as a generalized randomized block design using RStudio (Version 4.0.2, R Core Team, Vienna, Austria) with the lmer function from the lme4 package. The pen served as the experimental unit for all analyses.

Nursery growth performance data were analyzed with Zn treatment and BW block included as fixed effects. Fecal DM and plasma Zn and Cu concentrations were analyzed as repeated measures. For fecal DM, the model included treatment, day of collection, and their interaction as fixed effects, with block included as a fixed effect. Pen was included as a random effect to account for subsampling, and pig was included as a random effect to account for repeated measures over time. For plasma Zn and Cu concentration, the model included treatment, day, their interactions, and block as fixed effects.

For the finishing phase growth performance, the model included nursery treatment and medication treatment as fixed effects to account for the concurrent medication program applied during finishing.

Contrast coefficients were used to test low versus high Zn inclusion levels within each dietary phase. Pairwise comparisons among treatments were performed using Tukey multiple comparison adjustment. Treatment differences were considered statistically significant at $P \leq 0.05$ and marginally significant at $0.05 < P \leq 0.10$.

Results and Discussion

During phase 1 (d 0 to 11), pigs fed pharmacological Zn had greater ADG ($P < 0.001$), ADFI ($P = 0.005$), and improved F/G ($P = 0.008$), and were 1.2 lb heavier ($P = 0.002$) on d 11 than pigs not receiving pharmacological Zn (Table 2). In phase 2 (d 11 to 24), ADG differed among treatments ($P = 0.005$), with pigs fed no pharmacological Zn showing greater ADG than pigs that received pharmacological Zn for only 11 d, while pigs fed pharmacological Zn for 24 d were intermediate. The ADFI tended to differ among treatments ($P = 0.065$), with pigs fed pharmacological levels of Zn for only 11 d numerically having lower ADFI in phase 2 compared with pigs fed no pharmacological Zn or those fed pharmacological Zn for 24 d; however, F/G was not affected by treatment. Body weight on d 24 differed among treatments ($P = 0.036$). Pigs receiving pharmacological Zn for 24 d were 1.5 lb heavier than those receiving it for only 11 d, whereas pigs not receiving pharmacological Zn were intermediate.

During the first week of phase 3 (d 24 to 31), treatment did not affect ADG, ADFI, or F/G. Body weight tended to differ at d 31 ($P = 0.066$), with pigs fed pharmacological

Zn for longer durations exhibiting numerically greater BW, but no mean separation was found. However, during the second week of phase 3 (d 31 to 38), treatment influenced growth performance. The ADG differed among treatments ($P = 0.013$), with pigs fed the control diet and those continuing to receive pharmacological Zn for all 38 d having greater ADG than pigs fed pharmacological Zn for 11 or 31 d, whereas pigs fed pharmacological Zn for 24 d were intermediate. Body weight tended to differ at d 38 ($P = 0.080$), with pigs fed pharmacological Zn for longer durations exhibiting numerically greater BW, but no mean separation was found. Average daily feed intake was also affected by treatment ($P = 0.038$), with pigs fed pharmacological Zn for 38 d having greater ADFI than those fed for 11 or 31 d, whereas pigs receiving pharmacological Zn for 0 or 24 d were intermediate. No differences were observed for F/G. During the third week of phase 3 (d 38 to 45), no treatment effects were observed for ADG, ADFI, or F/G. For the overall phase 3 period (d 24 to 45), ADG, d 45 BW, ADFI, and F/G were not affected by pharmacological Zn feeding duration strategy. No effects of the different pharmacological Zn feeding durations were observed for growth performance during the common feeding period (d 45 to 55).

For the overall nursery period (d 0 to 55), ADG, ADFI, and F/G were not influenced by treatment. Similarly, no differences in BW were observed among treatments at d 55. However, a numerical difference in BW remained at d 55, with pigs that were fed pharmacological Zn for 45 d being approximately 2.0 lb and 1.6 lb heavier than pigs that received no pharmacological Zn or pharmacological Zn for 24 d, respectively, the latter being closest to common industry practice.

Fecal DM was affected by treatment and sampling day, with a significant treatment × day interaction ($P = 0.015$; Table 2). On d 11, pigs receiving pharmacological Zn exhibited greater fecal DM compared with pigs fed only nutritional Zn levels ($P = 0.002$), suggesting improved fecal consistency during the first 11 d after weaning. No differences were observed for fecal DM at d 24 and d 45 across the different pharmacological Zn feeding durations.

Plasma Zn concentration was influenced by treatment over time, as demonstrated by a significant treatment × day interaction ($P < 0.001$). Pigs fed pharmacological Zn for 11 d (phase 1) had greater ($P < 0.0001$) plasma Zn concentrations at d 11. At d 24 (phase 2), pigs fed pharmacological Zn for 24 d (phases 1 and 2) had greater plasma Zn concentrations ($P < 0.05$) than pigs that were not fed pharmacological Zn or fed for only 11 d. On d 45, pigs that were fed pharmacological Zn for 45 d had greater ($P < 0.05$) plasma Zn concentrations than those that were fed pharmacological Zn for 0, 11, or 24 d, whereas pigs that were fed pharmacological Zn for 31 or 38 d were intermediate. Plasma Cu concentration was not influenced by treatment or its interaction with day, indicating no effect of pharmacological Zn feeding duration strategies on Cu status over time.

For the finishing period, nursery pharmacological Zn feeding duration did not influence growth performance or BW at any intermediate time point (Table 3). For the overall finishing period (d 55 to 154), pigs had similar ADG, ADFI, and F/G across treatments, indicating that pharmacological Zn feeding duration implemented during the nursery phase did not influence subsequent finishing growth performance. Final BW at market (d 154) was also not affected by nursery Zn treatment.

In conclusion, pharmacological Zn fed during the early nursery period improved growth performance in phase 1 compared with pigs fed only nutritional Zn levels. These benefits were accompanied by improved fecal DM and increased plasma Zn concentrations. Although treatment effects diminished over time, an interesting numerical difference in BW remained at the end of the nursery period, suggesting a potential carryover of early growth advantages. However, this numerical advantage did not persist during the finishing phase, as pigs exhibited similar growth performance and BW throughout finishing, regardless of the duration of pharmacological Zn feeding in the nursery. Overall, these findings indicate that while pharmacological Zn supplementation supports early post-weaning performance and fecal consistency, there are no detectable carryover effects on finishing growth performance when pigs were subsequently fed a common diet.

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Table 1. Phases 1, 2, 3, and 4 nursery diet composition (as-fed basis)[1,2]

	Phase 1	Phase 2	Phase 3[3]
Ingredient, %			
Corn	48.68	56.66	63.75
Soybean meal, 47.7% CP	16.96	24.00	32.16
Spray-dried bovine plasma	3.00	---	---
Whey powder	5.00	---	---
Whey permeate	14.25	10.00	---
Soy protein concentrate[4]	7.50	5.00	---
Soybean oil	1.00	---	---
Calcium carbonate	0.55	0.70	0.72
Monocalcium phosphate, 21% P	0.98	1.11	0.85
Salt	0.20	0.47	0.60
L-Lys-HCl	0.36	0.48	0.43
DL-Met	0.21	0.24	0.20
L-Thr	0.19	0.23	0.20
L-Trp	0.03	0.05	0.04
L-Val	0.09	0.14	0.10
Trace mineral premix	0.15	0.15	0.15
Vitamin premix	0.25	0.25	0.25
Choline chloride, 60%	0.05	---	---
Phytase[5]	0.06	0.06	0.06
ZnO	+/-	+/-	+/-
TiO_2	0.50	0.50	0.50
Calculated analysis			
SID amino acids, %			
Lys	1.40	1.35	1.30
Ile:Lys	56	56	58
Leu:Lys	115	112	120
Met:Lys	35	38	37
Met and Cys:Lys	58	58	59
Thr:Lys	64	64	65
Trp:Lys	20.1	20.1	20.2
Val:Lys	70	70	70
His:Lys	35	35	38
NE, kcal/lb	1,162	1,117	1,093
SID Lys:NE, g/Mcal	5.47	5.48	5.40
CP, %	21.2	20.7	21.4
Lactose, %	15.0	8.0	---
Ca, %	0.64	0.69	0.64
STTD P, %	0.55	0.52	0.45

[1] Phases 1, 2, and 3 were fed from d 0 to 11, 11 to 24, and 24 to 45, respectively, followed by a common phase 4 diet fed from d 45 to 55.

[2] All diets contained 110 mg/kg of supplemental Zn from $ZnSO_4$ provided through the trace mineral premix. Pharmacological Zn concentrations were achieved by adding ZnO (72% Zn) at the expense of corn to provide total added Zn levels of 3,000 mg/kg (0.40% ZnO) in phase 1, 2,000 mg/kg (0.26% ZnO) in phase 2, and 1,000 mg/kg (0.12% ZnO) in phase 3.

[3] All pigs were fed the phase 3 diet containing 110 mg/kg of Zn during phase 4 (d 45 to 55)

[4] Bunge SPC Pure Pro (Bunge, Chesterfield, MO).

Table 2. Effects of different pharmacological Zn feeding duration strategies on growth performance, fecal DM, and plasma Zn and Cu of nursery pigs[1]

Treatments, added Zn, mg/kg[2]								
Total days fed pharmacological Zn:	0	11	24	31	38	45	SEM	*P*=
Phase 1, d 0 to 11:	110	3,000	3,000	3,000	3,000	3,000		
Phase 2, d 11 to 24:	110	110	2,000	2,000	2,000	2,000		
Phase 3, d 24 to 31:	110	110	110	1,000	1,000	1,000		
Phase 3, d 31 to 38:	110	110	110	110	1,000	1,000		
Phase 3, d 38 to 45:	110	110	110	110	110	1,000		
Phase 4, d 45 to 55	110	110	110	110	110	110		
BW, lb								
d 0	12.5						0.06	
d 11	16.5	17.7					0.34	0.002
d 24	28.5[ab]	28.2[a]	29.7[b]				0.58	0.036
d 31	35.1	35.5	36.3	37.0			0.70	0.066
d 38	45.4	44.2	45.6	45.7	47.1		0.84	0.080
d 45	58.3	56.8	58.7	58.9	59.4	59.5	1.00	0.422
d 55	77.3	75.4	77.7	78.4	78.2	79.3	1.18	0.274
Phase 1, d 0 to 11								
ADG	0.36	0.47					0.028	< 0.001
ADFI	0.44	0.52					0.025	0.005
F/G	1.25	1.10					0.042	0.008
Phase 2, d 11 to 24								
ADG	0.92[a]	0.82[b]	0.90[ab]				0.024	0.005
ADFI	1.33	1.20	1.29				0.038	0.065
F/G	1.44	1.48	1.43				0.026	0.229
Phase 3, d 24 to 31								
ADG	0.93	0.99	0.94	1.04			0.049	0.160
ADFI	1.71	1.76	1.68	1.77			0.051	0.416

F/G	1.87	1.81	1.80	1.74			0.063	0.279
Phase 3, d 31 to 38								
ADG	1.47[a]	1.24[b]	1.34[ab]	1.27[b]	1.43[a]		0.057	0.013
ADFI	2.02[ab]	1.85[b]	1.98[ab]	1.85[b]	2.05[a]		0.065	0.038
F/G	1.38	1.50	1.49	1.48	1.44		0.037	0.107
Phase 3, d 38 to 45								
ADG	1.85	1.79	1.82	1.81	1.76	1.77	0.057	0.885
ADFI	2.63	2.51	2.57	2.63	2.47	2.60	0.074	0.570
F/G	1.42	1.41	1.42	1.45	1.41	1.47	0.028	0.450
Phase 3, d 24 to 45								
ADG	1.42	1.34	1.36	1.36	1.42	1.41	0.031	0.355
ADFI	2.12	2.04	2.07	2.08	2.10	2.14	0.048	0.736
F/G	1.50	1.53	1.52	1.53	1.48	1.52	0.019	0.327
Common period, d 45 to 55								
ADG	1.90	1.86	1.90	1.95	1.89	1.98	0.037	0.224
ADFI	3.23	3.18	3.22	3.31	3.17	3.26	0.070	0.730
F/G	1.70	1.72	1.70	1.70	1.68	1.65	0.031	0.708
Overall nursery, d 0 to 55								
ADG	1.16	1.13	1.16	1.17	1.19	1.20	0.023	0.435
ADFI	1.78	1.73	1.76	1.80	1.78	1.80	0.038	0.832
F/G	1.53	1.53	1.51	1.53	1.50	1.50	0.014	0.312
Fecal DM, %[3]								
d 11	14.7	17.5					0.806	0.002
d 24	19.8	19.0	19.9				0.795	0.636
d 45	25.4	22.4	24.3	23.7	24.0	25.1	0.796	0.106
Plasma Zn concentration, mg/L[4]								
d 0	1.06						0.060	
d 11	0.65	1.98					0.171	< 0.0001
d 24	0.72[a]	0.83[a]	1.29[b]				0.087	< 0.0001
d 45	0.81[a]	0.87[a]	0.88[a]	0.93[ab]	0.94[ab]	1.09[b]	0.047	0.001
Plasma Cu concentration, mg/L								
d 0	1.92						0.078	
d 11	1.15	1.21					0.078	0.457
d 24	1.40	1.40	1.32				0.078	0.454
d 45	1.83	1.81	1.75	1.82	1.88	1.91	0.078	0.783

[a,b,c] Differ, $P < 0.05$.

[1] A total of 360 weaned pigs (initially 12.5 ± 0.06 lb) were used in a nursery trial to determine the effect of six different pharmacological Zn feeding duration strategies on growth performance. Treatments were assigned in a randomized block design with 5 pigs per pen and 12 replications per treatment. Treatment diets were fed during phase 1 (d 0 to 11), phase 2 (d 11 to 24), and phase 3 (d 24 to 45), followed by a common diet in phase 4 (d 45 to 55).

[2] The nursery diets contained 110 mg/kg of Zn from $ZnSO_4$ and ZnO (72%) was used to increase the Zn level to 3,000 mg/kg in phase 1, 2,000 mg/kg in phase 2, and 1,000 mg/kg in phase 3.

[3] Treatment × day interaction ($P = 0.015$).

[4] Treatment × day interaction ($P < 0.001$).

Table 3. Effects of different pharmacological Zn feeding duration strategies fed during the nursery phase on subsequent finishing pig growth performance[1]

	Treatments, added Zn, mg/kg[2]							
	A	B	C	D	E	F		
Phase 1, d 0 to 11:	110	3,000	3,000	3,000	3,000	3,000		
Phase 2, d 11 to 24:	110	110	2,000	2,000	2,000	2,000		
Phase 3, d 24 to 31:	110	110	110	1,000	1,000	1,000		
Phase 3, d 31 to 38:	110	110	110	110	1,000	1,000		
Phase 3, d 38 to 45:	110	110	110	110	110	1,000		
Phase 4, d 45 to 55:	110	110	110	110	110	110		
Finishing, d 55 to 154:	Common diet						SEM	*P*=
BW, lb								
d 55	77.4	75.6	77.9	78.6	77.7	79.0	1.13	0.274
d 69	109.5	107.9	108.0	109.2	109.6	110.4	1.68	0.895
d 83	141.1	139.0	139.8	140.2	140.8	142.4	1.60	0.747
d 97	172.7	171.6	171.1	171.0	172.5	173.8	1.95	0.896
d 119	230.1	229.3	228.6	228.0	228.4	230.3	2.26	0.966
d 140[3]	284.4	280.9	282.0	278.9	280.2	281.8	2.91	0.841
d 154	321.4	318.8	319.0	315.2	316.6	317.5	3.22	0.808
Avg. market wt.	319.2	317.0	318.2	313.8	316.0	316.8	3.34	0.905
d 55 to 69								
ADG	2.29	2.31	2.15	2.18	2.28	2.23	0.066	0.499
ADFI	4.12	4.11	3.97	4.00	4.08	4.12	0.096	0.808
F/G	1.80	1.79	1.85	1.83	1.80	1.86	0.027	0.363
d 69 to 83								
ADG	2.26	2.22	2.27	2.22	2.23	2.29	0.040	0.790
ADFI	4.52	4.57	4.54	4.68	4.56	4.68	0.092	0.707
F/G	2.01	2.06	2.00	2.11	2.04	2.05	0.035	0.285
d 83 to 97								
ADG	2.27	2.33	2.23	2.19	2.26	2.25	0.060	0.704
ADFI	5.21	5.13	5.06	5.10	5.14	5.22	0.113	0.902
F/G	2.31	2.20	2.28	2.33	2.27	2.33	0.061	0.721
d 97 to 119								
ADG	2.61	2.61	2.57	2.59	2.53	2.57	0.045	0.788
ADFI	6.58	6.52	6.51	6.42	6.50	6.48	0.110	0.944
F/G	2.52	2.50	2.53	2.48	2.57	2.53	0.045	0.797
d 119 to 140								
ADG	2.64	2.54	2.62	2.56	2.59	2.58	0.052	0.799
ADFI	7.83	7.56	7.79	7.63	7.61	7.74	0.138	0.694
F/G	2.97	2.98	2.98	2.99	2.94	3.01	0.053	0.979
d 140 to 154								
ADG	2.65	2.71	2.65	2.59	2.60	2.56	0.064	0.645

ADFI	8.30	8.10	8.21	8.15	8.15	8.15	0.141	0.938
F/G	3.15	3.00	3.11	3.15	3.14	3.20	0.068	0.407
Overall finishing, d 55 to 154								
ADG	2.47	2.47	2.43	2.41	2.43	2.43	0.029	0.715
ADFI	6.22	6.11	6.11	6.11	6.12	6.18	0.090	0.931
F/G	2.51	2.48	2.51	2.53	2.52	2.54	0.022	0.372

[1] A total of 360 weaned pigs (initially 12.5 ± 0.06 lb) were used in a nursery trial to determine the effect of six different pharmacological Zn feeding duration strategies on growth performance. Treatments were assigned in a randomized block design with 5 pigs per pen and 12 replications per treatment. Treatment diets were fed during phase 1 (d 0 to 11), phase 2 (d 11 to 24), and phase 3 (d 24 to 45), followed by a common diet in phase 4 (d 45 to 55). A total of 341 pigs were subsequently followed during the finishing phase and were placed in groups of 8 to 10 pigs according to their original nursery treatments. During the finishing phase, pigs were fed a common diet throughout the entire period.

[2] The nursery diets contained 110 mg/kg of Zn from $ZnSO_4$ and ZnO (72%) was used to increase the Zn level to 3,000 mg/kg in phase 1, 2,000 mg/kg in phase 2, and 1,000 mg/kg in phase 3.

[3] On d 126 of the trial, 25 pigs were topped. The strategy was to reduce pens to a consistent number of pigs remaining per pen (8 to 9 pigs), removing a maximum of one pig per pen, while balancing the number of pigs topped across treatments and blocks.