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Effects of Increasing Zinc from Two Different Sources on Nursery Pig Performance

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Effects of Increasing Zinc from Two Different Sources on Nursery Pig Performance

Abstract

A total of 360 weanling pigs (Line 400 × 200; DNA Genetics, Columbus, NE, initially 13.0 lb) were used in a 28-d trial to evaluate the effects of Zn source and level on nursery pig growth performance. Each treatment had 8 replicate pens with 5 pigs per pen. The 9 dietary treatments were arranged as 2 × 4 + 1 factorial and consisted of a control diet that contained 110 ppm Zn from $ZnSO_4$ from the trace mineral premix or the control diet with 390, 890, 1,890, or 2,890 ppm added Zn from either TBZC (Intellibond Z; Micronutrients, Indianapolis, IN) or ZnO. This provided diets with a total of 500, 1,000, 2,000, or 3,000 ppm added Zn. Diets were fed in 3 phases from d 0 to 7, 7 to 21, and 21 to 28 with the first phase fed in pellet form and the others as meal. No Zn source by level interactions or Zn source differences were observed throughout this 28-d study. Overall, from d 0 to 28, increasing Zn increased (linear, $P \leq 0.05$) ADG, ADFI, and d 28 BW. On d 28, fecal samples were collected from 3 pigs in each of the 8 pens per treatment and analyzed for DM content. There was a tendency ($P = 0.08$) for a Zn source by level interaction. As Zn from TBZC increased, fecal DM decreased, but for pigs fed increased Zn from ZnO there was no difference in fecal DM. In conclusion, up to 3,000 ppm Zn improved ADG and ADFI with no effect on F/G. There were no differences among pigs fed the different Zn sources, suggesting that either Zn source is effective at improving weanling pig growth performance.

Keywords

growth performance, nursery pig, zinc

Cover Page Footnote

Appreciation is expressed to Micronutrients (Indianapolis, IN) for partial financial support and for donating the specialty zinc source.

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Effects of Increasing Zinc from Two Different Sources on Nursery Pig Performance[1]

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Summary

A total of 360 weanling pigs (Line 400 × 200; DNA Genetics, Columbus, NE, initially 13.0 lb) were used in a 28-d trial to evaluate the effects of Zn source and level on nursery pig growth performance. Each treatment had 8 replicate pens with 5 pigs per pen. The 9 dietary treatments were arranged as 2 × 4 + 1 factorial and consisted of a control diet that contained 110 ppm Zn from $ZnSO_4$ from the trace mineral premix or the control diet with 390, 890, 1,890, or 2,890 ppm added Zn from either TBZC (Intellibond Z; Micronutrients, Indianapolis, IN) or ZnO. This provided diets with a total of 500, 1,000, 2,000, or 3,000 ppm added Zn. Diets were fed in 3 phases from d 0 to 7, 7 to 21, and 21 to 28 with the first phase fed in pellet form and the others as meal. No Zn source by level interactions or Zn source differences were observed throughout this 28-d study. Overall, from d 0 to 28, increasing Zn increased (linear, $P \leq 0.05$) ADG, ADFI, and d 28 BW. On d 28, fecal samples were collected from 3 pigs in each of the 8 pens per treatment and analyzed for DM content. There was a tendency ($P = 0.08$) for a Zn source by level interaction. As Zn from TBZC increased, fecal DM decreased, but for pigs fed increased Zn from ZnO there was no difference in fecal DM. In conclusion, up to 3,000 ppm Zn improved ADG and ADFI with no effect on F/G. There were no differences among pigs fed the different Zn sources, suggesting that either Zn source is effective at improving weanling pig growth performance.

Key words: growth performance, nursery pig, zinc

Introduction

Zinc is a trace mineral essential for optimal protein and energy metabolism. In addition to meeting the basal requirement, research has shown that pharmacological levels (3,000 ppm) of dietary Zn from ZnO for the first 2 to 4 wk after weaning can increase growth rate. However, these high levels of dietary Zn are also associated with increased

[1] Appreciation is expressed to Micronutrients (Indianapolis, IN) for partial financial support and for donating the specialty Zinc source.

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Zn concentrations in swine waste. Typically, ZnO is the preferred Zn source added to achieve these growth-promotional benefits because it is consistent in response and low cost. However, ZnO also exhibits poorer bioavailability compared to other Zn sources, which contributes to excess Zn excretion. Zinc hydroxychloride (Intellibond Z®, TBZC, Micronutrients Indianapolis, IN) is a more bioavailable Zn source than ZnO (Zhang et al, 2006)[3]. However, little research has been conducted to compare performance of pigs fed either Zn from ZnO or TBZC. The objective of this study was to compare the effects of different levels of Zn from TBZC and ZnO on the growth performance of nursery pigs.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol for this experiment. The study was conducted at the Kansas State University Segregated Early Weaning Facility in Manhattan, KS. The facility has two identical barns that are completely enclosed, environmentally controlled, and mechanically ventilated. Treatments were equally represented in each barn. Each pen was equipped with a 4-hole stainless steel dry self-feeder and a cup waterer for ad libitum access to feed and water. Pens (4 × 4 ft) had wire-mesh floors and deep pits for manure storage.

A total of 360 weanling pigs (Line 400 × 200; DNA Genetics, Columbus, NE, initially 13.0 lb BW) were used in a 28-d trial. Each treatment had 8 replicate pens with 5 pigs per pen. The 9 dietary treatments were arranged as Control + 2 × 4 factorial and where the control diet contained 110 ppm Zn from $ZnSO_4$ included in the trace mineral premix or the control diet plus 390, 890, 1,890, or 2,890 ppm added Zn from either TBZC (Intellibond Z; Micronutrients, Indianapolis, IN) or ZnO. This provided diets with a total of 500, 1,000, 2,000, or 3,000 ppm added Zn for each source. Diets (Table 1) were fed in 3 phases from d 0 to 7, 7 to 21, and 21 to 28 with the first phase fed in pellet form and the others as meal. Diets were manufactured at the O.H. Kruse Feed Mill at Kansas State University, Manhattan, KS. Pig weight and feed disappearance were measured on d 0, 7, 14, 21, and 28 of the trial to determine ADG, ADFI, and F/G. Multiple samples of each diet were collected, blended and subsampled, and submitted for Zn and proximate analysis (Table 2; Ward Laboratories, Inc., Kearney, NE).

On d 28 of the study, feces were collected to determine fecal DM. Feces were collected from 3 pigs per pen, combined, and then subsampled to create 1 representative sample per pen. Fecal samples were then frozen at -20°C until they were analyzed for DM (Undersander et al, 1993)[4].

Data were analyzed as a randomized complete block design using PROC MIXED in SAS (SAS Institute, Inc., Cary, NC) with pen as the experimental unit. Barn was used as a blocking factor, and barn was included in the model as a random effect. Source × level interactions were evaluated using contrasts. The effects of increasing Zn level within source and main effects of Zn level were determined by linear and quadratic

[3] Zhang, B., and Guo, Y. 2006. Beneficial effects of tetrabasic zinc chloride for weanling piglets and the bioavailability of zinc in tetrabasic form relative to ZnO. Animal Feed Science and Technology, Volume 135, Issues 1–2, 15 May 2007, pp 75-85.
[4] Undersander, D., D. R. Mertens, and N. Thiex. 1993. Forage analysis procedures. National Forage Testing Association, Omaha, NE.

polynomial contrasts. Contrast coefficients were determined for unequally spaced treatments using the IML procedure of SAS. Results from the experiment were considered significant at $P < 0.05$ and a tendency between $P > 0.05$ and $P \leq 0.10$.

Results and Discussion

The chemical analyses of the experimental diets were similar to those calculated from diet formulation (Table 2).

There were no Zn source × level interactions observed throughout this 28-d study (Tables 3 and 4), nor were there any differences due to Zn source. From d 0 to 7, 7 to 14, 14 to 21, and from d 0 to 28, increasing Zn increased (linear, $P \leq 0.05$) ADG and ADFI. From d 0 to 7, increasing Zn from ZnO tended to increase (linear, $P = 0.060$) ADG and increased (linear, $P = 0.022$) ADFI, while increasing Zn from TBZC tended to improve (linear, $P = 0.074$) F/G. From d 7 to 14, increasing Zn from TBZC increased (linear, $P \leq 0.05$) ADG and ADFI, and pigs fed increasing Zn from ZnO tended to have increased (linear, $P = 0.087$) ADFI. From d 14 to 21, increasing Zn from either TBZC or ZnO increased (linear, $P \leq 0.05$) ADG, ADFI, and d 21 BW. From d 21 to 28, ADG was not influenced by Zn level; however, pigs fed increasing Zn from either Zn source had increased (linear, $P = 0.030$) ADFI, resulting in poorer (quadratic, $P = 0.041$) F/G. Overall, from d 0 to 28, increasing Zn from TBZC increased (linear, $P \leq 0.05$) ADG, ADFI, and d 28 BW, and pigs fed increasing Zn from ZnO had increased (linear, $P = 0.017$) ADFI and tended to have increased (linear, $P \geq 0.10$) ADG and d 28 BW.

For fecal DM (Tables 5 and 6) on d 28, there was a tendency ($P = 0.081$) for a Zn source × level interaction. As Zn from TBZC increased, fecal DM decreased, but for pigs fed increased Zn from ZnO, there were no differences in fecal DM. Despite this interaction, fecal DM decreased (linear, $P = 0.004$) with increasing Zn.

Overall, these data confirm the growth-promoting benefits of including 3,000 ppm of Zn in diets fed to weanling pigs. This study also illustrates feeding duration is critical when feeding high Zn levels since F/G was poorest for the highest Zn treatment d 21 to 28. There were no differences among pigs fed the different Zn sources, suggesting that either Zn source is effective at improving weanling pig growth performance.

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

Item	Phase 1	Phase 2	Phase 3
Ingredient, %			
Corn	36.55	52.74	63.28
Soybean meal (47.5% CP)	20.01	30.12	32.89
Spray-dried whey	25.00	10.00	---
Blood plasma	4.00	---	---
Dried distillers grains with solubles	5.00	---	---
Fish meal	3.75	4.00	---
Choice white grease	3.00	---	---
Monocalcium phosphate	0.93	1.03	1.60
Limestone	0.60	0.88	0.95
Salt	0.30	0.30	0.35
L-Lysine-HCl	0.23	0.28	0.30
DL-methionine	0.13	0.14	0.12
L-threonine	0.08	0.12	0.12
Vitamin premix	0.25	0.25	0.25
Trace mineral premix	0.15	0.15	0.15
Choline chloride 60%	0.04	---	---
Zinc source[2]	---	---	---
TOTAL	100.00	100.00	100.00
Calculated analysis			
Standardized ileal digestible (SID) amino acids, %			
Lys	1.40	1.35	1.22
Ile:lys	59	62	63
Leu:lys	125	123	129
Met:lys	32	35	33
Met & cys:lys	57	57	57
Thr:lys	63	63	63
Trp:lys	18.8	18.1	18.7
Val:lys	69	67	68
Total lys, %	1.57	1.51	1.37
ME, kcal/lb	1,578	1,492	1,477
NE, kcal/lb	1,182	1,098	1,087
SID Lys:ME, g/Mcal	4.02	4.10	3.75
CP, %	22.6	22.8	21.3
Ca, %	0.90	0.90	0.80
P, %	0.73	0.76	0.74
Available P, %	0.52	0.47	0.42

[1] Experimental diets were fed in 3 phases with phase 1, 2, and 3 fed from day 0-7, 7-21, and 21-28 respectively. All diets contained 110 ppm of Zn from $ZnSO_4$ from the trace mineral premix.

[2] Experimental diets contained increasing levels of Zn (added at the expense of corn) from either TBZC or ZnO at 390, 890, 1,890, and 2,890 ppm. Inclusive with the addition of 110 ppm of added Zn from $ZnSO_4$ from the trace mineral premix, these diets provided a total of 500, 1,000, 2,000 and 3,000 ppm of Zn.

Table 2. Chemical analysis of experimental diets[1]

	Total added dietary Zn[2], ppm								
	Control	TBZC[3]				ZnO			
Item	0	500	1,000	2,000	3,000	500	1,000	2,000	3,000
d 0 to 7									
DM, %	90.84	90.99	90.51	90.41	90.15	90.25	90.20	90.13	90.18
CP, %	22.70	22.80	21.90	21.60	21.40	21.40	22.20	22.60	22.70
Ca, %	1.02	1.00	1.09	1.10	1.21	1.18	0.96	1.23	1.09
P, %	0.85	0.79	0.81	0.81	0.80	0.78	0.78	0.86	0.82
Zn, ppm	120	528	1,023	2,173	3,596	644	862	2,375	3,050
d 7 to 21									
DM, %	89.53	89.88	89.73	89.37	89.50	89.48	89.80	89.75	89.42
CP, %	23.10	22.40	22.50	22.70	21.70	23.20	23.40	23.20	23.10
Ca, %	0.99	1.00	1.16	1.15	1.11	1.05	0.99	1.17	0.99
P, %	0.78	0.83	0.83	0.79	0.79	0.78	0.83	0.86	0.78
Zn, ppm	212	502	1,278	2,143	3,065	558	742	1,765	2,480
d 21 to 28									
DM, %	88.52	88.64	88.48	88.52	88.58	88.65	88.44	88.61	88.65
CP, %	21.30	21.30	21.00	21.40	21.80	21.50	21.90	21.30	22.70
Ca, %	0.73	0.87	0.84	0.70	0.76	0.82	0.79	0.86	0.77
P, %	0.72	0.78	0.69	0.67	0.73	0.73	0.72	0.78	0.73
Zn, ppm	243	522	1,565	2,030	2,479	725	731	1,547	2,449

[1] Multiple samples of each diet were collected, blended and subsampled, and analyzed (Ward Laboratories, Inc., Kearney, NE).
[2] All diets contained 110 ppm Zn from $ZnSO_4$ provided by the trace mineral premix.
[3] Tetrabasic zinc chloride; IntelliBond® Z (Micronutrients, Indianapolis, IN).

Table 3. Evaluation of different zinc sources and levels on nursery pig performance, (Exp. 2)[1]

	Total added dietary Zn[2], ppm										Probability[3,4], $P <$			
	Control	TBZC[5]				ZnO					TBZC[5]		ZnO	
Item	0	500	1,000	2,000	3,000	500	1,000	2,000	3,000	SEM	Linear	Quadratic	Linear	Quadratic
d 0 to 7														
ADG, lb	0.23	0.28	0.25	0.30	0.29	0.25	0.19	0.29	0.29	0.04	0.140	0.585	0.060	0.636
ADFI, lb	0.24	0.30	0.28	0.29	0.28	0.26	0.23	0.30	0.29	0.02	0.367	0.271	0.022	0.912
F/G	1.22	1.09	1.16	0.99	0.98	1.06	1.29	1.07	1.15	0.10	0.074	0.962	0.615	0.649
d 7 to 14														
ADG, lb	0.43	0.44	0.45	0.47	0.51	0.46	0.38	0.49	0.47	0.03	0.049	0.692	0.190	0.569
ADFI, lb	0.58	0.65	0.66	0.67	0.70	0.63	0.56	0.67	0.66	0.05	0.047	0.529	0.087	0.894
F/G	1.36	1.50	1.47	1.43	1.38	1.38	1.51	1.40	1.41	0.10	0.818	0.200	0.812	0.190
d 14 to 21														
ADG, lb	0.86	0.85	0.88	0.86	1.05	0.93	0.85	0.97	1.02	0.06	0.008	0.072	0.018	0.569
ADFI, lb	1.12	1.12	1.15	1.15	1.28	1.28	1.08	1.24	1.33	0.08	0.015	0.307	0.007	0.290
F/G	1.30	1.33	1.32	1.36	1.23	1.40	1.27	1.28	1.31	0.05	0.203	0.095	0.615	0.631
d 21 to 28														
ADG, lb	1.00	0.97	0.98	1.01	1.00	0.95	1.00	1.05	0.95	0.05	0.680	0.846	0.999	0.299
ADFI, lb	1.51	1.49	1.49	1.50	1.67	1.49	1.51	1.62	1.58	0.07	0.030	0.085	0.099	0.822
F/G	1.53	1.54	1.53	1.49	1.67	1.59	1.52	1.54	1.68	0.05	0.092	0.078	0.058	0.130
d 0 to 28														
ADG, lb	0.63	0.63	0.64	0.66	0.71	0.65	0.60	0.70	0.68	0.03	0.030	0.470	0.083	0.990
ADFI, lb	0.86	0.89	0.89	0.90	0.98	0.91	0.84	0.96	0.96	0.03	0.016	0.577	0.017	0.934
F/G	1.38	1.41	1.40	1.37	1.38	1.42	1.40	1.37	1.42	0.03	0.567	0.693	0.756	0.708
BW, lb														
d 0	13.0	13.0	13.2	13.0	13.0	13.0	13.0	13.0	13.0	0.30	0.707	0.418	0.887	0.813
d 7	14.6	15.0	14.9	15.1	15.1	14.7	14.3	15.0	15.0	0.26	0.186	0.401	0.070	0.560
d 14	17.6	18.0	18.0	18.4	18.6	18.0	16.9	18.5	18.3	0.40	0.061	0.781	0.076	0.546
d 21	23.7	24.0	24.2	24.4	26.0	24.5	22.9	25.2	25.6	0.71	0.009	0.415	0.011	0.416
d 28	30.7	30.8	31.0	31.5	33.2	31.1	29.8	32.6	32.2	0.94	0.024	0.433	0.055	0.823

[1]A total of 360 pigs (DNA Genetics Line 400 × 200, initially 13.0 lb) were used with 5 pigs per pen and 8 pens per treatment.

[2]All diets contained 110 ppm Zn from $ZnSO_4$ provided by the trace mineral premix.

[3]Significance was determined by $P \leq 0.05$.

[4]There were no source × level interactions $P \geq 0.10$.

[5]Tetrabasic zinc chloride; IntelliBond® Z, (Micronutrients, Indianapolis, IN).

Table 4. Main effects of different zinc sources and levels on nursery pig performance[1]

	Zn Source				Added Zn[2], ppm					Zn Probability[3], $P <$		
Item	Control	TBZC[4]	ZnO	SEM	500	1,000	2,000	3,000	SEM	TBZC vs ZnO	Zn Level Linear	Zn Level Quadratic
d 0 to 7												
ADG, lb	0.23	0.28	0.25	0.02	0.27	0.22	0.30	0.29	0.03	0.210	0.038	0.964
ADFI, lb	0.24	0.29	0.27	0.01	0.28	0.25	0.29	0.29	0.02	0.312	0.047	0.537
F/G	1.22	1.06	1.14	0.07	1.07	1.23	1.03	1.06	0.08	0.163	0.109	0.756
d 7 to 14												
ADG, lb	0.43	0.47	0.45	0.02	0.45	0.41	0.48	0.49	0.02	0.458	0.042	0.549
ADFI, lb	0.58	0.67	0.63	0.04	0.64	0.61	0.67	0.68	0.04	0.181	0.022	0.635
F/G	1.36	1.44	1.43	0.08	1.44	1.49	1.41	1.40	0.08	0.538	0.987	0.124
d 14 to 21												
ADG, lb	0.86	0.91	0.94	0.04	0.89	0.86	0.91	1.03	0.05	0.346	0.002	0.141
ADFI, lb	1.12	1.18	1.23	0.06	1.20	1.11	1.19	1.31	0.07	0.122	0.002	0.198
F/G	1.30	1.31	1.32	0.02	1.36	1.30	1.32	1.27	0.03	0.884	0.349	0.462
d 21 to 28												
ADG, lb	1.00	0.99	0.99	0.02	0.96	0.99	1.03	0.98	0.03	0.915	0.798	0.598
ADFI, lb	1.51	1.54	1.55	0.05	1.49	1.50	1.56	1.63	0.06	0.717	0.018	0.348
F/G	1.53	1.56	1.58	0.03	1.57	1.52	1.52	1.68	0.04	0.510	0.024	0.041
d 0 to 28												
ADG, lb	0.63	0.66	0.66	0.01	0.64	0.62	0.68	0.69	0.02	0.820	0.016	0.659
ADFI, lb	0.86	0.91	0.92	0.02	0.90	0.87	0.93	0.97	0.03	0.896	0.003	0.690
F/G	1.38	1.39	1.40	0.01	1.41	1.40	1.37	1.40	0.02	0.529	0.820	0.975
BW, lb												
d 0	13.0	13.1	13.0	0.29	13.0	13.1	13.0	13.0	0.29	0.343	0.747	0.721
d 7	14.6	15.0	14.8	0.17	14.9	14.6	15.1	15.0	0.20	0.138	0.052	0.872
d 14	17.6	18.3	17.9	0.20	18.0	17.5	18.4	18.5	0.28	0.202	0.024	0.839
d 21	23.7	24.6	24.5	0.47	24.2	23.5	24.8	25.8	0.56	0.796	0.001	0.313
d 28	30.7	31.6	31.4	0.60	30.9	30.4	32.0	32.7	0.73	0.762	0.010	0.531

[1] A total of 360 pigs (DNA Genetics Line 400 × 200, initially 13.0 lb) were used with 5 pigs per pen, 32 pens for source, and 16 pens for dose per treatment.
[2] All diets contained 110 ppm Zn from $ZnSO_4$ provided by the trace mineral premix.
[3] Significance was determined by $P \leq 0.05$.
[4] Tetrabasic zinc chloride; IntelliBond® Z, (Micronutrients, Indianapolis, IN).

Table 5. Evaluation of zinc sources and levels on nursery pig fecal DM (Exp. 2)[1]

		Added dietary Zn[2], ppm									Probability, $P <$					
	Control	TBZC[3]				ZnO					Source × level		TBZC[5]		ZnO	
Item	0	500	1,000	2,000	3,000	500	1,000	2,000	3,000	SEM	Linear	Quadratic	Linear	Quadratic	Linear	Quadratic
Fecal, DM	27.9	29.8	27.4	27.6	24.2	27.6	28.0	27.9	25.9	0.93	0.081	0.568	0.001	0.087	0.179	0.294

[1] A total of 216 samples were collected on d 28 of the study with 3 samples per pen and 8 pens per treatment.
[2] All diets contained an additional 110 ppm Zn from $ZnSO_4$ provided by the trace mineral premix.
[3] Tetrabasic zinc chloride; IntelliBond® Z, (Micronutrients, Indianapolis, IN).

Table 6. Main effects of zinc sources on nursery pig fecal DM (Exp. 2)[1]

	Zn Source				Added dietary Zn[2], ppm					Probability, $P <$		
Item	Control	TBZC[3]	ZnO	SEM	500	1,000	2,000	3,000	SEM	TBZC vs ZnO	Linear	Quadratic
Fecal, DM	27.9	27.3	27.3	0.46	28.7	27.7	27.7	25.1	0.66	0.134	0.004	0.087

[1] A total of 216 samples were collected on d 28 of the study with 3 samples per pen, 32 pens for source, and 16 pens for dose per treatment.
[2] All diets contained an additional 110 ppm Zn from $ZnSO_4$ provided by the trace mineral premix.
[3] Tetrabasic zinc chloride; IntelliBond® Z, (Micronutrients, Indianapolis, IN).