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Effect of Zinc Source Fed at Nutritional Levels on Finishing Pig Growth Performance and Carcass Characteristics

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Summary

A total of 2,363 pigs (PIC 337 × 1050; initially 59.3 ± 1.35 lb) were used in a 122-d study to compare the effects of four different Zn sources on growth performance and carcass characteristics of finishing pigs raised under commercial conditions. Pigs were housed in mixed-sex pens with 26 or 27 pigs per pen and 22 pens per treatment. The four dietary treatments were arranged in a randomized complete block design and consisted of four Zn sources, all added at 100 mg of Zn/kg of diet. The Zn sources included ZnSO4, two sources of Zn hydroxychloride (source A = Hydroxy Zn, SAM Nutrition, Bloomington, MN; source B = Intellibond Z, Selko, Indianapolis, IN), and a chelated Zn source (B-Traxim 2C Zn-260, Pancosma, Rolle, Switzerland). The Zn source was added to diets in four separate vitamin-trace mineral premixes and was the only source of added Zn in the diet. Corn-soybean meal-DDGS (20% in phases 1 to 3 and none in phase 4) based diets fed in meal form were used in a four-phase feeding program. All diets were formulated to meet or exceed NRC (2012) requirement estimates within each phase. When the average weight of pigs in the barn was approximately 240 lb, the three heaviest pigs per pen were marketed, with remaining pigs marketed approximately 25 d later. On the last day of the experiment, pigs were weighed, tattooed on a pen basis, and sent to a commercial packing plant to determine carcass yield and characteristics. No differences ($P > 0.10$) between Zn sources were observed for growth performance, mortality, removals, total removals and mortality, HCW, carcass yield, and loin depth. A marginal Zn source response was observed for backfat depth ($P = 0.095$) and percentage lean ($P = 0.072$), mainly driven by pigs fed Zn hydroxychloride source B having numerically higher backfat and lower percentage lean compared to pigs fed all other Zn sources. However, no means separation was observed. In conclusion, the Zn sources used in this experiment did not significantly affect finishing pig growth performance or carcass characteristics, except for a marginal difference between Zn sources for backfat and percentage lean.

Introduction

Zinc (Zn) is an important micromineral playing a key role in various physiological processes, including protein synthesis, immune function, and cellular proliferation

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and differentiation.[2] The NRC (2012) requirement estimates for Zn in growing and finishing pigs increase with increasing weight, beginning at 90 mg/d for pigs weighing 55 lb and up to 139 mg/d for pigs weighing 298 lb.[3]

Due to increasing environmental and public health concerns regarding Zn use in swine diets,[4] the interest in more bioavailable Zn sources has increased. However, there remains uncertainty as to whether these alternative Zn sources provide any benefits in terms of performance or carcass characteristics. Zinc hydroxychloride (ZnHyd), produced through the reaction between Zn, water, and hydrochloric acid,[5] along with amino acid-chelated Zn, are among the most common Zn alternatives, potentially offering greater Zn availability with reduced environmental impact compared to Zn sulfate ($ZnSO_4$).

The responses in growth performance and carcass characteristics are variable when comparing ZnHyd, and chelated Zn to $ZnSO_4$. Therefore, the objective of this study was to evaluate the effects of four different Zn sources on growth performance and carcass characteristics in finishing pigs raised under commercial conditions.

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 independent barns at a commercial research site operated by Hord Farms West in Pipestone, MN. The barns were naturally ventilated and doble-curtain-sided with totally slatted floors. Each pen (9.83 × 18.33 ft) was equipped with a five-hole dry feeder and a cup waterer to provide *ad libitum* access to feed and water.

Animals and diets

Two groups of pigs (a total of 2,363 pigs; Line 337 × 1050, PIC, Hendersonville, TN) initially 59.3 ± 1.35 lb were used in a 122-d study. There were 26 or 27 mixed-sex pigs per pen and 22 pens per treatment allotted in a randomized complete block design. Dietary treatments consisted of four Zn sources: zinc sulfate ($ZnSO_4$), two sources of Zn hydroxychloride (Hydroxy Zn, SAM Nutrition, Bloomington, MN and Intellibond Z, Selko, Indianapolis, IN), and a chelated Zn (B-Traxim 2C Zn-260, Pancosma, Rolle, Switzerland). All Zn sources provided 100 mg/kg of Zn to the final diet in all phases.

Diets were fed in meal form in four phases: phase 1 fed from 59 to 110 lb, phase 2 fed from 110 to 165 lb, phase 3 fed from 165 to 220 lb, and phase 4 fed from 220 to marketing. All diets were manufactured at the Hord Farms Feed Mill in Pipestone, MN, and were formulated to meet or exceed NRC requirement estimates for growing-finishing pigs for their respective weight ranges (Table 1).

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[2] Kambe, T., T. Tsuji, A. Hashimoto, and N. Itsumura. 2015. The Physiological, Biochemical, and Molecular Roles of Zinc Transporters in Zinc Homeostasis and Metabolism. Physiol. Rev. 95:749–784. doi:10.1152/physrev.00035.2014.

[3] NRC. 2012. Nutrient Requirements of Swine (11th Ed.). National Academies Press, Washington, D.C. Available from: http://www.nap.edu/catalog/13298.

[4] Duan, M., J. Gu, X. Wang, Y. Li, R. Zhang, T. Hu, and B. Zhou. 2019. Factors that affect the occurrence and distribution of antibiotic resistance genes in soils from livestock and poultry farms. Ecotoxicol. Environ. Saf 180: 114-122. doi:10.1016/j.ecoenv.2019.05.005.

[5] Leisure, N. J., C. C. Jackson, M. Huang, T. B. Moore, and F. A. Steward. 2014. Micronutrient supplement. US Pat. No. 8,802,180 B2.

Pig weights (on a pen basis) and feed disappearance were determined approximately every 14 d to determine ADG, ADFI, and F/G. Mortality and pigs that were removed from pens due to health problems or slow growth were weighed, and their weight was added to the gain during the period when they were removed.

When the average weight of pigs in the barn was approximately 240 lb, the heaviest three pigs per pen (visually selected) were weighed and marketed. The remaining pigs were fed for approximately 25 d before they were marketed. On the last day of the trial, final pen weights were obtained, and pigs were tattooed with a pen identification number and transported to a U.S. Department of Agriculture-inspected packing plant (JBS Swift, Worthington, MN) for carcass data collection. Carcass measurements included HCW, loin depth, backfat depth, and percentage lean. The percentage lean calculations were obtained from a proprietary equation used by the packer. Carcass yield was calculated by dividing the pen average HCW by the pen average final live weight obtained at the farm.

Statistical analysis

Data were analyzed as a randomized complete 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 as the experimental unit. For performance data, the model utilized dietary treatment as a fixed effect and the BW block nested within barn as a random effect. Additionally, the proportion of barrows within each pen was used as a covariate.

For carcass yield, data were analyzed on a pen basis using the same fixed and random effects as the analysis of growth performance data. For carcass composition (backfat depth, loin depth, and percentage lean), data were analyzed using individual carcasses as the observational unit and the model included treatment as a fixed effect, pen and weight block within barn as random effects, and hot carcass weight as a covariate.

Mortality and removals were analyzed using a binomial distribution. The proportion of dead or removed pigs over the initial pigs placed per pen was used as the response variable. Results were considered significant with $P \leq 0.05$ and marginally significant with $P \leq 0.10$.

Results and Discussion

The mineral concentration of experimental diets was consistent with formulated values considering analytical variation (Table 2).

For growth performance, mortality, removals, total removals, HCW, carcass yield, and loin depth, no differences ($P > 0.10$) were observed between pigs fed the different Zn sources. A marginal Zn source response was observed for backfat depth ($P = 0.095$) and percentage lean ($P = 0.072$). Although no means separation among treatments was detected, pigs fed Zn hydroxychloride source B had numerically greater backfat depth and lower percentage lean than pigs fed the other Zn sources.

In conclusion, the Zn sources used in this experiment did not significantly affect finishing growth performance, mortality, removals, HCW, carcass yield, and loin depth. However, a marginal difference between Zn sources was observed for backfat depth and percentage lean.

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The authors wish to thank Hord Farms West (Pipestone, MN) for providing technical support and expertise in conducting this trial and SAM Nutrition (Bloomington, MN) for providing partial financial support.

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

Items	Phase 1	Phase 2	Phase 3	Phase 4
Corn	57.94	63.20	68.13	85.60
Soybean meal	19.10	14.00	9.35	12.20
Corn DDGS[2]	20.00	20.00	20.00	---
Limestone, ground	1.27	1.23	1.16	0.82
Monocalcium phosphate	0.21	0.20	0.06	0.23
Salt	0.35	0.35	0.35	0.35
Liquid lysine 55%	0.67	0.63	0.60	0.44
DL-Methionine	0.05	0.03	0.00	0.03
Thr[3]	0.13	0.10	0.08	0.09
L-Tryptophan	0.03	0.04	0.03	0.02
Phytase[4]	0.04	0.04	0.04	0.04
VTM premix[5]	0.20	0.20	0.20	0.20
Total	100	100	100	100
Calculated analysis				
SID amino acids				
Lys, %	1.10	0.95	0.82	0.72
Ile:Lys	59	60	60	60
Leu:Lys	147	158	170	153
Met:Lys	31	31	31	31
Met & Cys:Lys	57	59	60	59
Thr:Lys	62	62	62	62
Trp:Lys	19	19	19	19
Val:Lys	69	71	73	70
Lys:NE, g/Mcal	4.58	3.90	3.32	2.82
NE, kcal/lb	1,090	1,104	1,119	1,160
Crude protein, %	20.1	18.1	16.2	13.3
Calcium, %	0.61	0.58	0.52	0.43
STTD P, %	0.39	0.37	0.33	0.28

[1] Phases 1, 2, 3, and 4 were formulated to be fed from 59 to 110, 110 to 165, 165 to 220, and 220 lb to marketing, respectively.
[2] DDGS = dried distillers grains with solubles.
[3] Optiphos 2500 (Huvepharma Inc. Peachtree City, GA) provided 1,000 FTU/lb of diet with an assumed release of 0.12% STTD P.
[4] Dietary treatments were based on a vitamin-trace mineral premix that contained either zinc sulfate, one of two sources of Zn hydroxychloride, or a chelated Zn source.

Table 2. Analyzed composition (As- fed)[1]

	Zn, ppm	Ca, %	Mg, %	K, %	Cu, ppm	Fe, ppm	Mn, ppm	S, %
Premix								
$ZnSO_4$	60,291	9.37	0.15	0.26	75,585	62,088	16,542	---
Zn hydroxychloride, A[2]	49,346	9.00	0.13	0.20	70,891	59,584	17,074	---
Zn hydroxychloride, B[2]	51,394	9.23	0.14	0.22	74,934	60,001	13,268	---
Chelated Zn	63,389	8.72	0.13	0.23	76,427	61,893	17,342	---
Complete diets								
Phase 1								
$ZnSO_4$	181	0.72	0.19	0.55	164	188	54	0.13
Zn hydroxychloride, A	128	0.65	0.19	0.49	97	171	48	0.13
Zn hydroxychloride, B	152	0.67	0.19	0.45	153	206	48	0.13
Chelated Zn	199	0.80	0.19	0.45	162	220	53	0.14
Phase 2								
$ZnSO_4$	103	0.60	0.18	0.39	104	157	45	0.11
Zn hydroxychloride, A	208	0.46	0.14	0.26	128	171	50	0.08
Zn hydroxychloride, B	259	0.48	0.14	0.28	123	289	49	0.08
Chelated Zn	129	0.54	0.18	0.37	132	178	46	0.11
Phase 3								
$ZnSO_4$	260	0.63	0.18	0.34	121	178	47	0.10
Zn hydroxychloride, A	178	0.57	0.18	0.30	127	144	44	0.10
Zn hydroxychloride, B	208	0.52	0.18	0.32	95	159	42	0.10
Chelated Zn	134	0.54	0.18	0.29	143	150	45	0.10
Phase 4								
$ZnSO_4$	140	0.42	0.13	0.18	122	185	44	0.07
Zn hydroxychloride, A	135	0.46	0.14	0.21	94	155	40	0.07
Zn hydroxychloride, B	137	0.41	0.13	0.21	133	175	39	0.07
Chelated Zn	131	0.42	0.13	0.16	141	186	41	0.07

[1]Feed samples by treatment were collected weekly and analyzed for mineral content in duplicate at the K-State Research and Extension Soil Testing Lab. A composite sample from each premix was analyzed in triplicate at Cumberland Valley Analytical Services, Inc.
[2]Source A: Hydroxy Zn, SAM Nutrition, Bloomington, MN. Source B: Intellibond Z, Selko, Indianapolis, IN.

Table 3. Effect of Zn source on finishing pig performance and carcass characteristics[1]

	Zn Source					
		Zn hydroxychloride[2]				
Item	$ZnSO_4$	Source A	Source B	Chelated Zn[3]	SEM	*P* =
BW, lb						
d 0	59.2	59.3	59.2	59.3	1.35	0.985
d 42	144.1	143.2	143.2	143.4	2.77	0.493
d 120	292.3	291.0	290.3	293.8	2.39	0.187
Grower period, (d 0 to 42)						
ADG, lb	2.00	1.99	1.98	1.98	0.039	0.673
ADFI, lb	4.16	4.19	4.17	4.17	0.125	0.849
F/G	2.08	2.10	2.10	2.10	0.025	0.144
Finishing period, (d 42 to 120)						
ADG, lb	1.90	1.90	1.89	1.92	0.024	0.634
ADFI, lb	5.76	5.76	5.77	5.80	0.045	0.782
F/G	3.04	3.04	3.06	3.04	0.036	0.713
Overall, (d 0 to 120)						
ADG, lb	1.96	1.96	1.95	1.97	0.012	0.706
ADFI, lb	5.11	5.12	5.12	5.14	0.046	0.878
F/G	2.61	2.62	2.62	2.61	0.016	0.671
Mortality and removals						
Mortality, %	1.89	2.24	1.89	1.55	0.614	0.900
Removals, %	4.69	4.68	4.67	5.71	1.013	0.800
Total, %	6.46	6.80	6.45	7.16	1.092	0.999
Carcass characteristics						
HCW, lb	217.5	215.3	216.0	218.0	1.73	0.397
Carcass yield, %	74.4	73.8	74.2	74.1	0.37	0.615
Backfat depth, in[4]	0.64	0.64	0.67	0.66	0.011	0.095
Loin depth, in[4]	2.75	2.75	2.73	2.75	0.014	0.612
Lean, %[4]	57.36	57.31	56.78	57.09	0.183	0.072

[1]A total of 2,363 pigs (PIC 337 × 1050, Hendersonville, TN) initially 59.3 ± 1.35 lb were used in a 120-d study. There were 26 or 27 pigs per pen and 22 pens per treatment.
[2]Source A: Hydroxy Zn, SAM Nutrition, Bloomington, MN. Source B: Intellibond Z, Selko, Indianapolis, IN.
[3]B-Traxim 2C Zn-260, Pancosma, Rolle, Switzerland
[4]Adjusted using HCW as a covariate.