K·STATE Research and Extension

Swine Day 2017

KANSAS STATE UNIVERSITY SWINE INDUSTRY DAY 2017

Effects of Increasing Zinc, Using Zn Hydroxychloride, on Growth Performance, Carcass Characteristics, and Economic Return of Pigs Housed in a Commercial Environment[1]

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Summary

A total of 2,430 pigs (PIC 337 × 1050; initially 66.3 lb BW) were used in a 113-d growth trial to determine the effects of increasing Zn on growth performance and carcass characteristics of finishing pigs. Two barns were used for a total of 18 pens per treatment with 27 pigs per pen. Pigs were allotted by average initial BW and assigned to 1 of 5 dietary treatments consisting of 50, 87.5, 125, 162.5, or 200 ppm added Zn from Zn hydroxychloride (Intellibond Z, Micronutrients, Indianapolis, IN). Experimental diets were fed from d 0 to 113 in 5 phases and contained a trace mineral premix that did not contain any added Zn.

Overall (d 0 to 113), there were marginally significant quadratic responses in ADFI ($P = 0.073$) and F/G ($P = 0.067$), with the lowest ADFI and best F/G observed when 87.5 and 125 ppm of Zn were fed, respectively. There was no evidence for differences in carcass characteristics ($P > 0.10$). Regarding economic effects, there was a marginally significant ($P = 0.075$) quadratic response in feed cost per pig and feed cost per pound of gain ($P = 0.088$). The lowest feed cost per pig and feed cost per pound of gain were observed when 87.5 and 125 ppm of Zn was fed, respectively.

In conclusion, there were no improvements in ADG when feeding beyond 50 ppm added Zn; however, feeding 125 ppm Zn resulted in the best F/G.

Introduction

The addition of Zn to diets is a common practice in the swine industry. Several supplemental Zn sources are commercially available and have been extensively researched since the 1990s. The beneficial effects of added Zn for nursery pigs are well described;

[1] Appreciation is expressed to Micronutrients (Indianapolis, IN) for financial support and New Horizon Farms (Pipestone, MN) for providing research facilities.

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however, data are lacking regarding the impact of added Zn on performance and carcass characteristics of grow-finishing pigs. Recently, a study conducted by Carpenter et al.[3] compared increasing levels (50, 100, and 150) ppm of added Zn from two sources ($ZnSO_4$ and Zn hydroxychloride) in finishing pigs. They observed no effect of Zn source on growth performance. However, pigs fed diets with 100 ppm added Zn had greater ADG and final BW. Carcass yield increased linearly when pigs were fed diets with increasing Zn, and those fed Zn hydroxychloride had heavier HCW than those fed $ZnSO_4$. Although growth performance was maximized with 100 ppm added Zn, the linear response in carcass yield might suggest an even greater requirement estimate to maximize carcass characteristics. Moreover, the improved carcass weight observed in pigs fed diets containing Zn hydroxychloride warrants further investigation. Thus, the objective of this study was to determine the impact of increasing Zn from Zn hydroxychloride on growth performance and carcass composition of pigs housed in a commercial environment.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment. The study was conducted at a commercial research facility in southwestern Minnesota. The barns were naturally ventilated and double-curtain-sided. Each pen was equipped with a 5-hole stainless steel dry self-feeder and a bowl waterer for ad libitum access to feed and water.

A total of 2,430 pigs (PIC 337 × 1050; initial BW of 66.3 ± 1.55 lb) were used in a 113-d growth trial. Two identical barns were used in this trial for a total of 18 pens per treatment with 27 pigs per pen. Daily feed additions to each pen were accomplished using a robotic feeding system (FeedPro; Feedlogic Corp., Wilmar, MN) able to record feed amounts for individual pens.

Pens were randomly assigned to dietary treatment within weight blocks. The 5 dietary treatments consisted of 50, 87.5, 125, 162.5, and 200 ppm added Zn from Zn hydroxychloride (Intellibond Z, Micronutrients, Indianapolis, IN). A trace mineral premix without any added Zn was used for all experimental diets. Dietary treatments (Table 1) were offered in 5 phases.

Pens of pigs were weighed on d 0, 14, 27, 42, 59, 73, 90, and 113 of the trial to determine ADG, ADFI, and F/G. On d 90, the 3 heaviest pigs in each pen were tattooed with a treatment identification number and transported to a USDA-inspected packing plant (JBS Swift and Company, Worthington, MN) for carcass data collection. On the last day of the trial, final pen weights were taken and the remaining pigs were tattooed with a pen identification number and transported to the same packing plant for carcass data collection. Carcass measurements included HCW, loin depth, backfat, and percentage lean. Percentage lean was calculated from plant proprietary equation. Carcass yield was calculated by taking the pen average HCW divided by the pen average final live weight obtained at the farm.

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[3] Carpenter, C.; Coble, K.; Woodworth, J. C.; DeRouchey, J. M.; Tokach, M. D.; Goodband, R. D.; Dritz, S. S.; and Usry, J. (2016) "Effects of Increasing Zn from Zinc Sulfate or Zinc Hydroxychloride on Finishing Pig Growth Performance, Carcass Characteristics, and Economic Return," *Kansas Agricultural Experiment Station Research Reports*: Vol. 2: Iss. 8. https://doi.org/10.4148/2378-5977.1316

An economic analysis was performed to determine the financial impact of dietary treatments. The base diet cost in phases 1 to 5 was $223.83, $217.39, $210.68, $207.45, and $218.24, respectively. Intellibond Z was valued at $2.95/lb. Total feed cost per pig was calculated by multiplying the ADFI by the feed cost per pound and the number of days in each period, then adding the values of each period. Feed cost per pound of gain was calculated by dividing total feed cost per pig by overall gain. Gain value was obtained by multiplying carcass gain by an assumed value of $70.00 per cwt of carcass. Income over feed cost (IOFC) per pig was calculated by subtracting total feed cost from gain value.

Data were analyzed using the GLIMMIX procedure of SAS version 9.4 (SAS Institute, Inc., Cary, NC) with pen as the experimental unit. The statistical model included dietary treatment as a fixed effect and barn and block nested within barn as random effects. Results were considered significant at $P \le 0.05$ and marginally significant at $0.05 < P \le 0.10$.

Results and Discussion

Chemical analyses of complete diets are presented in Tables 2 and 3. Crude protein, total Ca, and total P levels were similar within dietary phase. The total analyzed Zn concentrations for diets formulated to 50, 87.5, 125, 162.5, and 200 ppm added Zn ranged from 89 to 173, 108 to 121, 134 to 147, 172 to 201, and 183 to 231 ppm, respectively. Of the 25 experimental diets, only 1 was outside the 20% analytical variation limits for Zn.[4]

From d 0 to 42, increasing Zn decreased ADFI (linear, $P = 0.043$; Table 4) with a marginal decrease in ADG (linear, $P = 0.092$). The reduction in ADG elicited a marginal linear decrease in BW ($P = 0.078$).

From d 42 to 113, increasing Zn resulted in quadratic response ($P = 0.042$) in ADFI with intake decreasing, then returning to control values as dietary Zn increased. Pigs fed 87.5 ppm of Zn had the lowest ADFI. As a result of the decreased ADFI, increasing Zn marginally improved F/G (linear, $P = 0.063$).

For overall growth performance (d 0 to 113), there were marginally significant quadratic responses in ADFI ($P = 0.073$) and F/G ($P = 0.067$), with the lowest ADFI observed at 87.5 and the best F/G observed at 125 ppm added Zn. There was no evidence for differences in overall ADG, final BW, HCW, backfat, loin depth, lean percentage, mortality, and removal rate ($P > 0.10$).

Regarding economic effects, there was a marginally significant ($P = 0.075$) quadratic response in feed cost per pig with the lowest cost observed at 87.5 ppm added Zn. There was a marginally significant ($P = 0.088$) effect for a quadratic response in feed cost per pound of gain, with the lowest cost observed at 125 ppm added Zn. There was no evidence for differences in gain value and IOFC ($P > 0.10$).

[4] Association of American Feed Control Officials (AAFCO). 2000. Official Publication. Assoc. Am. Feed Cont. Off., Atlanta, GA.

In summary, increasing added Zn beyond 50 ppm to a basal diet negatively affected ADFI and ADG from d 0 to 42. However, F/G from d 42 to 113 tended to improve with increasing Zn. Overall, 50 ppm added Zn maximized ADG, but feeding 125 ppm Zn resulted in the best F/G with no evidence for differences in carcass characteristics.

Table 1. Composition of base diets (as-fed basis)[1]

Items	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
Ingredients, %					
Corn	50.39	55.56	58.37	61.77	78.35
Soybean meal (46.5% CP)	17.08	11.95	9.34	5.92	9.64
DDGS[2]	30.00	30.00	30.00	30.00	10.00
Limestone	1.35	1.35	1.25	1.25	1.10
Salt	0.35	0.35	0.35	0.35	0.35
L-Lys HCl	0.50	0.50	0.45	0.45	0.30
DL-Met	0.05	0.02	---	---	0.01
L-Thr	0.06	0.05	0.02	0.04	0.05
L-Trp	0.04	0.04	0.03	0.03	0.02
Mineral-vitamin premix[3]	0.15	0.15	0.15	0.15	0.15
Zn hydroxychloride[4]	+/-	+/-	+/-	+/-	+/-
Calculated analysis					
SID amino acids, %					
Lys	1.03	0.91	0.81	0.73	0.65
Ile:Lys	63	62	64	63	64
Leu:Lys	162	172	186	196	186
Met:Lys	30	29	29	31	30
Met and Cys:Lys	56	56	58	60	60
Thr:Lys	61	61	61	63	66
Trp:Lys	19	19	19	19	19
Val:Lys	71	71	75	76	75
Lys:ME, g/Mcal	3.21	2.83	2.52	2.27	2.00
ME, kcal/lb	1,455	1,457	1,460	1,461	1,476
CP, %	20.0	17.9	16.8	15.4	13.0
Ca, %	0.59	0.56	0.52	0.50	0.46
Available P, %	0.38	0.37	0.36	0.36	0.24

[1] Phases 1, 2, 3, 4, and 5 were fed from 66 to 100 lb, 100 to 140 lb, 140 to 180 lb, 180 to 230 lb, and 230 lb to marketing, respectively.
[2] DDGS = dried distillers grains with solubles.
[3] Provided per lb of diet: 29 ppm Mn from manganese oxide; 76 ppm Fe from iron sulfate; 162 ppm Cu from tri-basic copper chloride; 0.38 ppm I from ethylenediamin dihydroiodide; 0.30 ppm Se from sodium selenite; 2,800 IU vitamin A; 450 IU vitamin D; 180 IU vitamin E; 1.2 mg vitamin K; 8 mg pantothenic acid; 12 mg niacin; 4.0 mg riboflavin; 11 mg vitamin B12.
[4] Intellibond Z (Micronutrients, Indianapolis, IN) was added to achieve 50, 87.5, 125, 167.5, or 200 ppm of Zn to form the experimental treatments.

Table 2. Chemical analysis of phase 1, 2, and 3 diets (as-fed basis)[1]

	Phase 1				
Calculated Zn, ppm	50	87.5	125	162.5	200
DM, %[2]	87.1	87.2	87.2	87.4	87.2
CP, %[2]	21.5	21.2	21.3	21.5	22.3
Ca, %[2]	0.62	0.69	0.64	0.66	0.65
P, %[2]	0.51	0.50	0.51	0.53	0.52
Zn, ppm[3]	99	108	146	172	198
	Phase 2				
DM, %[2]	86.9	86.8	86.4	86.6	86.3
CP, %[2]	19.6	18.9	19.3	19.7	18.9
Ca, %[2]	0.56	0.46	0.61	0.59	0.57
P, %[2]	0.47	0.47	0.47	0.47	0.46
Zn, ppm[3]	93	114	138	177	183
	Phase 3				
DM, %[2]	86.8	86.7	86.8	86.5	86.7
CP, %[2]	19.4	18.6	18.2	18.5	18.7
Ca, %[2]	0.47	0.56	0.54	0.48	0.59
P, %[2]	0.49	0.47	0.49	0.48	0.48
Zn, ppm[3]	173	117	134	184	198

[1] For each treatment, samples were collected from multiple feeders, blended, subsampled, ground, and analyzed (Cumberland Valley Analytical Services, Hagerstown, MD, and Midwest Laboratories Inc., Omaha, NE).
[2] Values represent means from 2 samples at Cumberland Valley Analytical Services, Hagerstown, MD, and 2 samples at Midwest Laboratories Inc., Omaha, NE.
[3] Values represent means from 8 samples at Cumberland Valley Analytical Services, Hagerstown, MD, and 6 samples at Midwest Laboratories Inc., Omaha, NE.

Table 3. Chemical analysis of phase 4 and 5 diets (as-fed basis)[1]

	Phase 4				
Calculated Zn, ppm	50	87.5	125	162.5	200
DM, %[2]	86.3	86.4	86.6	86.4	86.6
CP, %[2]	16.9	17.1	16.8	16.0	17.2
Ca, %[2]	0.33	0.46	0.43	0.57	0.48
P, %[2]	0.45	0.45	0.45	0.44	0.45
Zn, ppm[3]	89	116	147	201	208
	Phase 5				
DM, %[2]	85.5	86.4	85.3	85.7	85.8
CP, %[2]	12.9	13.4	13.3	12.9	13.0
Ca, %[2]	0.53	0.65	0.50	0.62	0.61
P, %[2]	0.32	0.35	0.33	0.34	0.32
Zn, ppm[3]	94	121	147	190	231

[1] For each treatment, samples were collected from multiple feeders, blended, subsampled, ground, and analyzed (Cumberland Valley Analytical Services, Hagerstown, MD, and Midwest Laboratories Inc., Omaha, NE).
[2] Values represent means from 2 samples at Cumberland Valley Analytical Services, Hagerstown, MD, and 2 samples at Midwest Laboratories Inc., Omaha, NE.
[3] Values represent means from 8 samples at Cumberland Valley Analytical Services, Hagerstown, MD, and 6 samples at Midwest Laboratories Inc., Omaha, NE.

Table 4. Effects of increasing added dietary Zn hydroxychloride on finishing pig growth performance, carcass characteristics, and economics[1,2]

							Probability, *P* <	
Added Zn, ppm:	50	87.5	125	162.5	200	SEM	Linear	Quadratic
BW, lb								
d 0	66.4	66.3	66.3	66.3	66.4	1.553	0.947	0.895
d 42	151.3	149.0	149.2	150.0	148.0	2.382	0.078	0.752
d 113	291.4	286.0	288.0	290.4	288.5	5.510	0.830	0.314
d 0 to 42								
ADG, lb	2.09	2.03	2.04	2.06	2.01	0.043	0.092	0.674
ADFI, lb	4.44	4.28	4.28	4.31	4.26	0.081	0.043	0.227
F/G	2.12	2.11	2.10	2.09	2.11	0.033	0.512	0.243
d 42 to 113								
ADG, lb	2.06	2.01	2.06	2.06	2.07	0.051	0.208	0.407
ADFI, lb	6.47	6.29	6.35	6.38	6.41	0.084	0.868	0.042
F/G	3.15	3.13	3.08	3.10	3.10	0.044	0.063	0.154
d 0 to 113								
ADG, lb	2.07	2.02	2.06	2.06	2.05	0.047	0.887	0.494
ADFI, lb	5.69	5.52	5.56	5.59	5.58	0.071	0.317	0.073
F/G	2.75	2.74	2.70	2.71	2.73	0.034	0.140	0.067
Removals, %								
Mortality	1.0	1.0	0.8	0.4	0.6	0.463	0.251	0.862
Removals	1.7	1.9	2.9	2.9	2.9	0.759	0.141	0.613
Total	2.8	2.9	3.7	3.3	3.5	0.880	0.317	0.559
Carcass characteristics								
HCW, lb	213.2	209.1	210.0	212.5	211.1	3.969	0.852	0.140
Yield, %	73.3	73.1	72.9	73.2	73.2	0.179	0.702	0.151
Backfat, in.[3]	0.69	0.69	0.68	0.69	0.68	0.025	0.536	0.947
Loin depth, in.[3]	2.70	2.72	2.68	2.72	2.70	0.046	0.817	0.767
Lean, %[3]	56.4	56.5	56.5	56.4	56.6	0.509	0.470	0.851
Economics, $/pig								
Feed cost	67.64	65.77	66.33	66.77	66.89	1.413	0.773	0.075
Feed cost/lb gain[4]	0.289	0.288	0.285	0.287	0.289	0.003	0.778	0.088
Gain value[5]	114.36	111.51	112.18	113.91	112.96	2.316	0.887	0.156
IOFC[6]	46.73	46.12	46.66	47.14	46.07	3.265	0.859	0.637

[1] A total of 2,430 pigs (PIC 337 × 1050; initial BW = 66 lb) were used with 27 pigs per pen and a total of 18 replications per treatment.
[2] Intellibond Z (zinc hydroxychloride; Micronutrients, Indianapolis, IN).
[3] Adjusted for HCW.
[4] Feed cost/lb gain = total feed cost ÷ total gain per pig.
[5] Gain value = (HCW × $0.70) – (d 0 BW × 0.75 × $0.70).
[6] Income over feed cost = gain value – feed cost.