INFLUENCE OF ADDED ZINC FROM ZINC OXIDE ON STARTER PIG PERFORMANCE [1]

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Summary

Three hundred and sixty early-weaned barrows were fed diets containing increasing levels of added Zn from zinc oxide (0, 50, 100, 200, 400, 800, 1,600, 2,400, and 3,200 ppm). From d 11 to 21, growth performance improved with up to 100 ppm of added Zn but was not improved further until pigs were fed 3,200 ppm of added Zn. From d 21 to 36, pigs fed 100 ppm of Zn had the best growth performance. These results suggest that a pig's basal Zn requirement is met with 100 ppm of added Zn from zinc oxide, but adding 3,200 ppm Zn in early starter diets results in further growth promotion. For these reasons, 3,200 ppm Zn from zinc oxide should be added to diets fed from weaning (8 to 10 lb) until 15 lb and a reduced amount in subsequent diets.

(Key Words: Early-Weaned Pigs, Growth, Zinc.)

Introduction

Previous research at Kansas State University compared the effects of added Zn from zinc sulfate or a zinc amino acid complex (AvailaZn) to a diet containing no additional Zn and a diet containing 3,000 ppm of Zn from zinc oxide. All diets contained 165 ppm Zn (zinc oxide) from the trace mineral premix. Although pigs fed the zinc sulfate and AvailaZn diets had numerically lower ADG and ADFI compared to pigs fed the diet containing 3,000 ppm of Zn, all pigs showed improvements in growth performance over those fed the diet containing 165 ppm of Zn from zinc oxide. These responses indicated that the pig's requirement for Zn may be higher than previously estimated and that even higher concentrations of added Zn above this requirement also may have a growth promotional effect.

The results of this trial lead us to question the basal Zn requirement of the young pig and whether the response to high levels of zinc oxide is a true growth promotional effect or simply a measure of meeting the pig's Zn requirement. Therefore, we chose to titrate a wide range of dietary Zn concentrations to determine the effect on pig growth performance. Zinc oxide was chosen as the Zn source because of its consistent effect of growth promotion.

Procedures

A total of 360 weanling barrows (initially 8.6 lb and 12 ± 2 d of age; Newsham Hybrids) was used in a 36-d growth trial. Pigs were blocked by initial weight and allotted

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randomly to each of nine dietary treatments. Each treatment had five pigs per pen and eight replications (pens) per treatment.

All experimental diets were fed in meal form. Diets fed from d 0 to 5 after weaning were formulated to contain 1.70% lysine, .48% methionine, .90% Ca, and .80% P (Table 1). Diets fed from d 5 to 11 were formulated to contain 1.55% lysine, .44% methionine, .90% Ca, and .80% P. Diets fed from d 11 to 21 were formulated to contain 1.40% lysine, .39% methionine, .85% Ca, and .75% P. Diets fed from d 21 to 36 were formulated to contain 1.30% lysine, .36% methionine, .75% Ca, and .70% P. Zinc oxide replaced cornstarch in the control to form the experimental treatments. The nine dietary treatments consisted of a control diet containing no added Zn or the control diet with increasing levels of Zn from zinc oxide (50, 100, 200, 400, 800, 1,600, 2,400, and 3,200 ppm of Zn). The trace mineral premix had no added Zn. The zinc oxide used in this experiment was analyzed, and Zn concentration was determined to be 72%. Pigs were fed the same experimental Zn concentrations throughout the 36-d study.

Pigs were weighed and feed disappearance was determined on d 0, 5, 11, 21, and 36 to calculate ADG, ADFI, and F/G. Feed samples were collected and analyzed for Zn concentration. Two pigs per pen were selected randomly and bled on d 21 and 36 to determine serum Zn levels. Serum Zn values (Table 4) represent the treatment means of pooled samples from the two pigs per pen. Red blood cells also were analyzed for Zn concentration on d 36 to determine if a correlation exists between serum and red blood cell Zn concentrations. The red blood cells could not be pooled for analysis; thus, the values (Table 4) represent the means of two pigs bled per pen.

Data were analyzed in a randomized complete block design with pen as the experimental unit. Pigs were blocked on the basis of initial weight, and analysis of variance was performed using the GLM procedure of SAS. Linear, quadratic, and cubic polynomial contrasts were used to determine the effects of increasing dietary Zn.

Results and Discussion

From d 0 to 11, no differences ($P>.05$, Table 3) were observed; however, pigs fed 100 ppm of added Zn had numerically the highest ADG and best F/G (.32 lb and 1.55, respectively).

From d 11 to 21 after weaning, ADG was increased from 0 to 100 ppm of added Zn and then plateaued before a second increase for pigs fed 3,200 ppm of Zn (cubic, $P<.08$). Average daily feed intake increased (linear, $P<.0001$) with increasing dietary Zn. Feed to gain ratio was not affected ($P>.10$) by added Zn.

From d 21 to 36, no differences ($P>.09$) occurred in ADG; however, pigs fed 100 or 200 ppm of Zn had numerically the highest ADG. Average daily feed intake increased (linear, $P<.0001$) with increasing dietary Zn, and as a result, F/G also became poorer (linear, $P<.004$). From d 21 to 36 pigs fed 100 ppm of Zn had the best F/G.

Cumulative data (d 0 to 36) showed a tendency for ADG to increase (linear, $P<.07$) with increasing Zn. Average daily feed intake also increased (linear, $P<.0001$), with increasing dietary Zn. Feed efficiency became poorer (linear, $P<.04$) with increasing dietary Zn, with pigs fed 100 ppm of Zn having the best F/G.

Analyzed dietary Zn concentrations (Table 2) generally increased with increasing Zn supplementation. However, some analyzed Zn concentrations showed considerable variation from calculated values. These differences could be results of the 20% variation permitted for Zn analysis.

Serum Zn analysis on d 21 showed that Zn concentrations increased (linear, $P<.0001$) with increasing dietary Zn. On d 36, serum Zn concentrations increased for pigs fed 100 ppm of added Zn, then plateaued and increased again for pigs fed

3,200 ppm of Zn (cubic, P<.0006). No statistical differences (P>.10) across treatments were observed in red blood cell Zn concentrations, indicating that serum analysis is a better indicator of Zn status.

In conclusion, our results are similar to those of previous research at Kansas State University, showing maximum growth performance when pigs were fed higher levels (above 3,000 ppm) of Zn from zinc oxide in the early starter diets. Our results suggest 100 ppm of Zn from zinc oxide is sufficient to meet the basal requirement; however, 3,200 ppm of Zn was required for a growth-promotional response. The increased growth performance was not observed in the last phase of our experiment, showing that levels of Zn should be decreased after pigs (initially 8 to 10 lb) are approximately 15 lb.

Table 1. Diet Compositions (As-Fed Basis)

Ingredient, %	Day 0 to 5[a]	Day 5 to 11[b]	Day 11 to 21[c]	Day 21 to 36[d]
Corn	38.69	45.61	51.95	58.72
Dried whey	25.00	20.00	10.00	-
Soybean meal (46.5% CP)	12.18	21.30	28.50	34.39
Spray-dried animal plasma	6.75	2.50	-	-
Select menhaden fish meal	6.00	2.50	-	-
Lactose	5.00	-	-	-
Soy oil	2.00	2.00	3.00	3.00
Spray-dried blood meal	1.75	2.50	2.50	-
Monocalcium phosphate	.69	1.26	1.59	1.48
Limestone	.50	.76	.99	.97
Corn starch[e]	.50	.50	.50	.50
Salt	.25	.30	.30	.35
Vitamin premix	.25	.25	.25	.25
L-Lysine HCl	.15	.15	.15	.15
Trace mineral premix[f]	.15	.15	.15	.15
DL-Methionine	.12	.15	.10	.04
Total	100.00	100.00	100.00	100.00

[a]Diets were formulated to contain 1.70% lysine, .48% methionine, .90% Ca, and .80% P and were fed from d 0 to 5 after weaning.
[b]Diets were formulated to contain 1.55% lysine, .44% methionine, .90% Ca, and .80% P and were fed from d 5 to 11.
[c]Diets were formulated to contain 1.40% lysine, .39% methionine, .85% Ca, and .75% P and were fed from d 10 to 21.
[d]Diets were formulated to contain 1.30% lysine, .36% methionine, .75% Ca, and .70% P and were fed from d 21 to 36.
[e]Zinc oxide replaced corn starch to provide 50, 100, 200, 400, 800, 1,600, 2,400, 3,200 ppm of Zn.
[f]Provided per ton of complete feed: 36 g Mn; 150 g Fe; 15 g Cu; 270 mg I; and 270 mg Se.

Table 2. Analyzed Zinc Concentrations (ppm) of Diets

	Zinc from Zinc Oxide, ppm								
Item	0	50	100	200	400	800	1,600	2,400	3,200
Day 0 to 5									
Zn	47	164	174	226	437	899	1,600	2,271	3,118
Day 5 to 11									
Zn	140	174	218	346	539	1,021	1,881	3,021	3,756
Day 11 to 21									
Zn	63	84	145	234	260	1,064	1,848	3,224	4,151
Day 21 to 36									
Zn	80	106	137	219	478	787	1,529	2,321	3,399

[a]Values (as-fed basis) represent analysis of one sample per diet for each time period.

Table 3. Influence of Added Zinc from Zinc Oxide on Starter Pig Performance[a]

	Zinc from Zinc Oxide, ppm										P <		
Item	0	50	100	200	400	800	1,600	2,400	3,200	CV	linear	quadratic	cubic
Day 0 to 11													
ADG, lb	.25	.24	.32	.29	.26	.27	.26	.26	.29	20.36	.74	.43	.38
ADFI, lb	.40	.43	.49	.45	.45	.44	.43	.44	.46	16.48	.66	.72	.35
F/G	1.64	1.82	1.55	1.56	1.75	1.74	1.69	1.77	1.61	16.86	.92	.28	.75
Day 11 to 21													
ADG, lb	.55	.54	.62	.61	.59	.58	.59	.60	.72	12.35	.0002	.03	.08
ADFI, lb	.96	.94	1.03	1.04	1.05	.97	1.05	1.11	1.21	9.72	.0001	.13	.41
F/G	1.77	1.76	1.71	1.73	1.81	1.71	1.79	1.84	1.68	10.18	.98	.25	.22
Day 0 to 21													
ADG, lb	.39	.38	.46	.44	.41	.41	.42	.42	.49	13.56	.01	.10	.16
ADFI, lb	.66	.67	.75	.73	.73	.69	.72	.76	.81	10.60	.0005	.30	.38
F/G	1.71	1.77	1.65	1.67	1.78	1.72	1.75	1.79	1.66	9.63	.90	.15	.39
Day 21 to 36													
ADG, lb	.94	1.05	1.14	1.14	1.11	1.07	1.13	1.11	1.08	9.86	.30	.09	.36
ADFI, lb	1.55	1.65	1.73	1.79	1.75	1.71	1.82	1.86	1.84	7.67	.0001	.11	.57
F/G	1.66	1.56	1.52	1.58	1.59	1.60	1.62	1.67	1.71	7.34	.004	.49	.56
Day 0 to 36													
ADG, lb	.62	.66	.74	.73	.70	.69	.71	.70	.74	10.00	.07	.89	.20
ADFI, lb	1.03	1.08	1.16	1.17	1.16	1.11	1.18	1.21	1.24	7.90	.0001	.79	.41
F/G	1.67	1.63	1.56	1.61	1.65	1.63	1.66	1.72	1.69	6.76	.04	.79	.35

[a]A total of 360 weanling pigs (initially 8.6 lb and 12 ± 2 d of age), five pigs per pen and 8 pens per treatment.

Table 4. Influence of Added Zinc from Zinc Oxide on Serum and Red Blood Cell Zinc Concentration[a]

	Zn from Zinc Oxide, ppm									P <		
Item	0	50	100	200	400	800	1,600	2,400	3,200	linear	quadratic	cubic
Day 21 Serum Zn, mg/L	.69	.77	.93	.99	.92	.95	1.19	1.81	2.46	.0001	.0001	.49
Day 36 Serum Zn, mg/L	.46	.77	1.00	1.01	1.03	1.11	1.17	1.62	2.17	.0001	.04	.0006
Day 36 RBC Zn, mg/L	7.32	7.32	7.55	7.21	7.45	7.13	7.38	6.78	7.48	.61	.37	.35

[a]Serum values represent treatment means of pooled values of two pigs per pen. Red blood cell (RBC) values represent treatment means of two pigs per pen.