Kansas Agricultural Experiment Station Research Reports

Volume 0
Issue 10 *Swine Day (1968-2014)*

Article 764

1998

Effects of added zinc from zinc sulfate or zinc sulfate/zinc oxide combinations on weanling pig growth performance

J C. Woodworth

P R. O'Quinn

R E. Musser

See next page for additional authors

Recommended Citation

Woodworth, J C.; O'Quinn, P R.; Musser, R E.; Moser, S A.; Fakler, T M.; Tokach, Michael D.; Nelssen, Jim L.; and Goodband, Robert D. (1998) "Effects of added zinc from zinc sulfate or zinc sulfate/zinc oxide combinations on weanling pig growth performance," *Kansas Agricultural Experiment Station Research Reports*: Vol. 0: Iss. 10. https://doi.org/10.4148/2378-5977.6604

Abstract

Three hundred and sixty early-weaned pigs were fed either a control diet containing no added Zn; diets containing added Zn (100, 200, or 400 ppm) from zinc sulfate or a combination of zinc sulfate and zinc oxide (50:50 ratio); or a diet containing 3,000 ppm of added Zn from zinc oxide. No additive effects on growth performance were observed with combinations of zinc sulfate and zinc oxide. Increasing levels of zinc sulfate or increasing the combination of zinc sulfate and zinc oxide had no effect on growth performance. Average daily gain and ADFI were highest for pigs fed diets containing 3,000 ppm of Zn from zinc oxide, which is similar to results of previous research at Kansas State University. To achieve maximum growth performance, 3,000 ppm of Zn from zinc oxide should be added to diets of weanling pigs.; Swine Day, Manhattan, KS, November 19, 1998

Keywords

Swine day, 1998; Kansas Agricultural Experiment Station contribution; no. 99-120-S; Report of progress (Kansas State University. Agricultural Experiment Station and Cooperative Extension Service); 819; Swine; Early-weaned pigs; Growth; Zinc

Authors

J C. Woodworth, P R. O'Quinn, R E. Musser, S A. Moser, T M. Fakler, Michael D. Tokach, Jim L. Nelssen, and Robert D. Goodband

EFFECTS OF ADDED ZINC FROM ZINC SULFATE OR ZINC SULFATE/ZINC OXIDE COMBINATIONS ON WEANLING PIG GROWTH PERFORMANCE [1]

J. C. Woodworth, M. D. Tokach [2],
J. L. Nelssen, R. D. Goodband, P. R. O'Quinn,
R. E. Musser, S. A. Moser, and T. M. Fakler [3]

Summary

Three hundred and sixty early-weaned pigs were fed either a control diet containing no added Zn; diets containing added Zn (100, 200, or 400 ppm) from zinc sulfate or a combination of zinc sulfate and zinc oxide (50:50 ratio); or a diet containing 3,000 ppm of added Zn from zinc oxide. No additive effects on growth performance were observed with combinations of zinc sulfate and zinc oxide. Increasing levels of zinc sulfate or increasing the combination of zinc sulfate and zinc oxide had no effect on growth performance. Average daily gain and ADFI were highest for pigs fed diets containing 3,000 ppm of Zn from zinc oxide, which is similar to results of previous research at Kansas State University. To achieve maximum growth performance, 3,000 ppm of Zn from zinc oxide should be added to diets of weanling pigs.

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

Introduction

A previous study 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 of Zn (zinc oxide) from the trace mineral premix. Although pigs fed diets containing zinc sulfate and AvailaZn had numerically lower ADG and ADFI compared to pigs fed high levels of zinc oxide, all pigs showed improvements in growth performance over those fed the diets containing no additional Zn. It was unclear if the growth response to added zinc sulfate was a true additive growth response to two different inorganic Zn sources (zinc oxide and zinc sulfate) or just a response to higher total Zn concentrations. The objective of this trial was to clarify this response.

Procedures

A total of 360 weanling pigs (initially 12.1 lb and 18 d of age; Genetipork) was used in a 34 d growth assay to determine the influence of added Zn from zinc sulfate or zinc sulfate and zinc oxide combinations on early-weaned pig growth performance. Pigs were blocked by initial weight and allotted randomly to each of eight dietary treatments. Each treatment had five pigs per pen and nine replications (pens) per treatment.

All experimental diets were fed in meal form. Diets fed from d 0 to 5 were formulated to contain 1.70% lysine, .48% methionine, .90% Ca, and .80% P (Table 1).

---

[1] Appreciation is expressed to Zinpro Corporation, Eden Prairie, MN for parial financial support for this experiment and to Ed Ebert, Norton Pig Company, for supplying the pigs for this experiment, and to Colin Bradley of the London Health Sciences Centre, London, Ontario, Canada for conducting the serum Zn analysis.

[2] Northeast Area Extension Office, Manhattan, KS.

[3] Zinpro Corporation, Eden Prairie, MN.

Diets fed from d 5 to 10 were formulated to contain 1.55% lysine, .44% methionine, .90% Ca, and .80% P. Diets fed from d 10 to 20 were formulated to contain 1.40% lysine, .39% methionine, .85% Ca, and .75% P. Diets fed from d 20 to 34 were formulated to contain 1.30% lysine, .36% methionine, .75% Ca, and .70% P. The eight experimental diets consisted of a negative control diet containing no added Zn; three diets containing added zinc sulfate to provide 100, 200, or 400 ppm of Zn; three diets containing added zinc sulfate and zinc oxide at a 1:1 ratio to achieve total Zn additions of 100, 200, or 400 ppm; and a positive control diet containing 3,000 ppm of added Zn from zinc oxide. Pigs were fed the same experimental Zn concentrations throughout the 34 d study. Zinc sulfate and zinc oxide replaced cornstarch in the negative control diet to form the experimental treatments. The trace mineral premix had no additional Zn.

Pigs were housed in the Kansas State University segregated early-weaning facility. Each pen was 4 × 4 ft and contained one nipple waterer and one self-feeder to provide ad libitum access to feed and water.

Pigs were weighed and feed disappearance was determined on d 0, 5, 10, 20, and 34 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 days 20 and 34 to determine serum Zn concentration. Samples were centrifuged, and the serum from the two pigs in each pen was pooled for analysis. Water samples were collected and analyzed for Zn concentration.

Data were analyzed as a randomized complete block design with pen as the experimental unit. Linear and quadratic values were obtained for increasing levels of zinc sulfate and zinc sulfate/zinc oxide combinations including the negative control. Contrast statements were used to investigate the mean differences between the two controls, 0 and 3,000 ppm of added Zn from zinc oxide, and the other diets as well as comparing the mean differences of diets containing zinc sulfate to diets containing the combination of zinc sulfate and zinc oxide.

Results and Discussion

From d 0 to 10, no difference (linear and quadratic, P>.57) occurred in ADG with increasing zinc sulfate, but pigs fed increasing levels of total Zn from the combination of zinc sulfate and zinc oxide had decreasing (linear, P<.01) ADG. Pigs fed the positive control diet containing 3,000 ppm of Zn from zinc oxide had higher (P<.006) ADG and ADFI compared to pigs fed any other diet. Feed to gain ratio worsened (linear, P<.006) for pigs fed increasing total Zn from combinations of zinc sulfate and zinc oxide, which explains the poorer ADG exhibited by pigs fed the combination of 200 ppm of Zn from zinc sulfate and 200 ppm of Zn from zinc oxide. Pigs fed this diet also had poorer (P<.001) F/G compared to pigs fed 400 ppm of Zn from only zinc sulfate. Pigs fed the diet containing 3,000 ppm of Zn had improved (P<.02) F/G compared to pigs fed diets containing zinc sulfate or diets containing zinc sulfate and zinc oxide but did not differ (P<.14) from pigs fed no additional Zn.

From d 10 to 20, no differences (linear and quadratic, P<.15) occurred in ADG, ADFI, or F/G for pigs fed increasing zinc sulfate or increasing total Zn from combinations of zinc sulfate and zinc oxide. Pigs fed diets containing 3,000 ppm of Zn from zinc oxide had higher (P<.0001) ADG and ADFI compared to pigs in all other treatments. Pigs fed the positive control diet tended to have improved (P<.07) F/G compared to pigs fed all other diets. Average daily gain, ADFI, and F/G was not affected (P>.32) by pigs fed zinc sulfate compared to pigs fed diets containing both zinc sulfate and zinc oxide.

From d 20 to 34, ADG, ADFI, and F/G again were not affected (P>.14) by increasing levels of zinc sulfate and increasing levels of total Zn from combined zinc sulfate and zinc oxide. Average daily gain was higher (P<.04) for pigs fed the combination of 50 ppm of Zn from zinc sulfate and 50 ppm of Zn from zinc oxide compared to pigs fed only 100 ppm of Zn from zinc sulfate. Pigs fed the positive control diet had higher (P<.004) ADG than pigs fed diets containing zinc sulfate and tended to have higher (P>.08) ADGs compared to pigs fed diets containing both zinc sulfate and zinc oxide or diets containing no added Zn. Average daily feed intake was higher (P<.001) for pigs fed 3,000 ppm of Zn from zinc oxide compared to all other treatments. Pigs fed diets containing combinations of Zn from zinc sulfate and zinc oxide had higher (P<.05) ADFI than pigs fed diets containing only zinc sulfate. Like ADFI, pigs fed the positive control diet had improved (P<.01) F/G compared to pigs fed any other treatment. Feed efficiency was not different (P>.46) for pigs fed zinc sulfate compared to pigs fed diets containing both zinc sulfate and zinc oxide.

Overall from d 0 to 34, no differences (linear and quadratic, P>.16) in ADG, ADFI, or F/G occurred for pigs fed increasing concentrations of Zn from zinc sulfate or increasing concentrations of total Zn from zinc sulfate and zinc oxide. Pigs fed the diet containing 3,000 ppm of added Zn from zinc oxide had the highest (P<.0009) ADG and ADFI compared to pigs fed all other diets. Pigs fed diets containing only zinc sulfate tended to have higher (P<.09) ADFI compared to pigs fed diets containing both zinc sulfate and zinc oxide but did not differ (P>.24) in ADG and F/G. No differences (P>.08) occurred in F/G between treatments from d 0 to 34.

Feed samples were collected and analyzed for Zn concentrations (Table 2). Zinc concentrations generally increased with increasing additions of Zn. Some variation did occur between calculated and analyzed values. According to AAFCO guidelines, variations of 20% are permitted in Zn analysis. Water samples also were analyzed for Zn concentration and found to contain only 90 ppb Zn, which would not significantly influence growth performance of the pigs.

Serum Zn concentrations at d 20 and 34 (Tables 3 and 4) increased (linear and quadratic, P<.04) with increasing zinc sulfate and increasing total Zn from combinations of zinc sulfate and zinc oxide. Pigs fed the positive control diet containing 3,000 ppm of Zn from zinc oxide had higher (P<.0001) serum Zn concentrations, and pigs fed no additional Zn had lower (P<.05) serum Zn concentrations compared to all pigs in other treatments. No difference (P>.39) occurred in serum Zn concentration for pigs fed only zinc sulfate versus pigs fed both zinc sulfate and zinc oxide.

In conclusion, pigs fed diets containing 3,000 ppm of Zn from zinc oxide had the highest ADG compared to all other treatments. The response in ADG was a result of higher ADFI exhibited by these pigs compared to pigs fed other diets. No consistent differences occurred in ADG, ADFI, or F/G for pigs fed diets containing zinc sulfate compared to pigs fed diets containing both zinc sulfate and zinc oxide. Data from previous trials showed increases in ADG of pigs fed diets containing added Zn versus diets containing no Zn. The lack of response in this trial to basal levels of added Zn could be explained by differences in health status of the pigs and by different genotypes having different Zn requirements. These data suggest that 3,000 ppm of Zn from zinc oxide should be added to diets to maximize weanling pig growth performance.

Table 1. Diet Compositions (As-Fed Basis)

Ingredient, %	Day 0 to 5[a]	Day 5 to 10[b]	Day 10 to 20[c]	Day 20 to 34[d]
Corn	38.69	45.66	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	.70	1.27	1.60	1.48
Limestone	.51	.77	1.0	.97
Cornstarch[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]Zn sources replaced corn starch to provide 100, 200, 400,or 3,000 ppm of added 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 Formulated Diets[a]

		Added Zn (ppm)							
	Zinc Sulfate	0	100	50	200	100	400	200	0
Item	Zinc Oxide	0	0	50	0	100	0	200	3,000
Day 0 to 5									
Zn		38	217	140	189	185	438	374	2,700
Day 5 to 10									
Zn		44	155	93	131	229	178	361	2,440
Day 10 to 20									
Zn		59	117	97	155	253	379	404	2,529
Day 20 to 34									
Zn		230	116	116	165	149	269	234	1,944

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

Table 3. Effects of Added Zinc from Zinc Sulfate or Zinc Sulfate/Zinc Oxide Combinations on Weanling Pig Growth Performance[a]

		Added Zn (ppm)							
	Zinc Sulfate	0	100	50	200	100	400	200	0
Item	Zinc Oxide	0	0	50	0	100	0	200	3,000
Day 0 to 10									
ADG, lb		.38	.35	.35	.33	.35	.36	.32	.47
ADFI, lb		.47	.46	.48	.44	.45	.44	.47	.55
F/G		1.29	1.35	1.38	1.38	1.29	1.24	1.51	1.19
Day 10 to 20									
ADG, lb		.68	.68	.72	.69	.68	.66	.68	.88
ADFI, lb		1.01	.99	1.05	.95	.96	.94	.97	1.25
F/G		1.55	1.49	1.45	1.39	1.42	1.44	1.43	1.42
Day 20 to 34									
ADG, lb		1.20	1.15	1.25	1.19	1.20	1.13	1.16	1.28
ADFI, lb		1.88	1.91	2.03	1.87	1.97	1.83	1.92	2.23
F/G		1.56	1.66	1.62	1.57	1.63	1.62	1.66	1.75
Day 0 to 34									
ADG, lb		.81	.77	.83	.79	.80	.80	.77	.92
ADFI, lb		1.21	1.22	1.28	1.18	1.23	1.21	1.21	1.44
F/G		1.51	1.57	1.54	1.50	1.53	1.51	1.58	1.57
Day 20 Serum[b]									
Zn, mg/L		.41	.77	.88	.94	.88	.88	.91	1.74
Day 34 Serum[b]									
Zn, mg/L		.93	.97	1.09	1.16	1.13	1.11	1.16	1.78

[a]A total of 360 weanling pigs (initially 12.1 lb and 18 d of age), five pigs per pen and nine pens per treatment.
[b]Values represent treatment means of pooled samples from two pigs per pen.

Table 4. Statistical Analysis of Mean Values (P <)

	Zinc Sulfate		Combination			Contrasts[a]								
Item	Lin.	Quad.	Lin.	Quad.	CV	1	2	3	4	5	6	7	8	9
Day 0 to 10														
ADG, lb	.41	.28	.01	.89	15.3	.001	.93	.45	.37	.11	.10	.0001	.0001	.96
ADFI, lb	.09	.79	.74	.44	11.9	.006	.65	.72	.11	.16	.70	.0001	.0003	.16
F/G	.76	.19	.006	.21	11.0	.14	.64	.24	.001	.53	.09	.02	.0007	.12
Day 10 to 20														
ADG, lb	.75	.85	.79	.77	14.7	.0001	.31	.88	.66	.82	.75	.0001	.0001	.45
ADFI, lb	.22	.75	.21	.95	11.4	.0001	.32	.85	.58	.26	.67	.0001	.0001	.32
F/G	.15	.16	.18	.27	10.2	.07	.61	.70	.84	.07	.05	.66	.75	.86
Day 20 to 34														
ADG, lb	.25	.92	.24	.34	8.6	.13	.04	.72	.56	.27	.89	.004	.08	.08
ADFI, lb	.57	.74	.95	.21	9.7	.0002	.20	.26	.32	.96	.18	.0001	.001	.05
F/G	.54	.69	.14	.62	6.7	.0006	.47	.25	.40	.20	.08	.003	.01	.46
Day 0 to 34														
ADG, lb	.49	.78	.16	.45	8.4	.0009	.09	.74	.93	.32	.86	.0001	.0001	.26
ADFI, lb	.47	.99	.73	.38	9.1	.0001	.21	.37	.43	.64	.45	.0001	.0001	.09
F/G	.73	.77	.19	.95	4.9	.12	.50	.35	.08	.60	.17	.17	.59	.24
Day 20 Serum														
Zn, mg/L	.0001	.0001	.0001	.0001	19.86	.0001	.21	.51	.79	.0001	.0001	.0001	.0001	.62
Day 34 Serum														
Zn, mg/L	.007	.097	.0007	.04	16.73	.0001	.20	.74	.59	.05	.01	.0001	.0001	.39

[a]Contrasts were 1) neg control vs pos control, 2) 100 vs 50/50, 3) 200 vs 100/100, 4) 400 vs 200/200, 5) neg control vs zinc sulfate, 6) neg control vs combination, 7) pos control vs zinc sulfate, 8) pos control vs combination, and 9) zinc sulfate vs combination.