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Zinc Oxide, With or Without Carbadox, Stimulates Performance in Nursery Pigs

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Summary and Implications

As part of a cooperative research study with several other Midwest universities, two experiments were conducted to evaluate the effects of high concentrations of zinc from zinc oxide in nursery diets. In the first experiment, the effects of adding various pharmacological concentrations of zinc as zinc oxide were tested. In the second experiment, the effects of both zinc and(or) carbadox additions to diets for weanling pigs were evaluated. Feeding pharmacological concentrations (2,000 to 3,000 mg/kg) of supplemental zinc from zinc oxide stimulated voluntary feed intake and weight gain of nursery pigs, but additive responses to carbadox (55 mg/kg) were not observed. In this experiment, supplementing weanling pigs diets with carbadox had no effect on growth performance. Based on this study, zinc oxide is more cost-effective than carbadox for promoting growth in weanling pigs.

Introduction

Zinc is one of the trace minerals routinely supplemented to swine diets to meet pigs nutritional requirements. Recently, several researchers have reported pharmacological concentrations of zinc (Zn) as zinc oxide (ZnO) improved growth performance during the nursery phase. In addition, carbadox is commonly added to nursery pig diets to promote growth and control certain pathogenic organisms. The objectives of our studies were to evaluate the effects of various concentrations of Zn as ZnO, as well as the potential interactive or additive effects of Zn and carbadox on weanling pig performance. Although these experiments were part of a larger research project involving several Midwest universities, only the Nebraska results are described in this report.

Methods

Experiment 1.

A total of 300 segregated, early weaned (SEW) pigs (170 barrows and 130 gilts) that were 9 to 13 days of age and weighed 8.6 pounds were used in a 28-day growth trial. Pigs were blocked on the basis of farrowing date and allotted to one of five treatments (0, 500, 1,000, 2,000 and 3,000 mg/kg of Zn as ZnO) with 20 pigs per pen and three replications (pens) per treatment. The Phase 1 diets were fed from week zero to two, followed by the Phase 2 diets from week two to four.

Experiment 2.

The purpose of the second experiment, which used 240 pigs, was to determine whether pharmacological concentrations of Zn have an additive effect when fed in combination with carbadox. The 120 barrows and 120 gilts used in the 28-day growth trial had an average initial weight of 15.5 pounds. Pigs were weaned from 19 to 26 days of age and assigned to blocks based on farrowing date. Within each of the two blocks, pigs were randomly assigned to treatments with 20 pigs per pen and two replications (pens) per treatment. Treatments were arranged in a 2 × 3 factorial with main effects of added Zn (0, 1,500, or 3,000 mg/kg) and carbadox (0 or 55 mg/kg). The Phase 1 diets were fed from week zero to one, then the Phase 2 diets from week two to four.

Table 1. Composition and nutrient analysis of the basal diets in Experiment 1 (as-fed basis)[a].

Item	Phase 1	Phase 2
Ingredient, percent		
Corn	40.64	54.19
Soybean meal (46.5% CP)	19.00	19.50
Whey, dried	20.00	20.00
Plasma, spray-dried	6.00	—
Lactose	10.00	—
Blood meal, spray-dried		2.00
Corn oil	1.00	1.00
L-lysine.HC1	.15	.15
DL-methionine	.11	.06
Dicalcium phosphate	1.45	1.45
Salt and trace mineral[b]	.45	.45
Vitamin premix	1.00	1.00
Aureomycin-50	.20	.20
Nutrient content		
Crude protein, %	19.90	18.20
Lysine, %	1.39	1.20
Calcium, %	.80	.80
Phosphorus, %	.75	.70
Zinc, mg/g	129.00	132.00
Copper, mg/kg	18.60	19.30
Iron, mg/kg	188.00	248.00

[a]Composition of the basal diets. The other four diets in each phase contained additions of 500, 1,000, 2,000 and 3,000 mg/kg zinc from zinc oxide.
[b]Supplied the following amounts of trace elements in milligrams per kilogram of complete diet: Cu (as $CUSO_4$•$5H_2O$) 10; I (as $Ca(IO_3)_2$), .2; Mn (as MnO), 20; Se (as Na_2SeO_3), .3; and Zn (as ZnO), 100.
[c]Supplied the following amounts of vitamins per kilogram of complete diet: retinyl acetate, 4,400 IU; cholecalciferol, 550 IU; *all-rac-α*-tocopheryl acetate, 22 IU; menadione (as menadione sodium bisulfite complex), 3.3 mg; riboflavin, 5.5 mg; niacin, 33 mg; *d*-pantothenic acid (as *d*-calcium pantothenate), 22 mg; cyanocobalamin, 22µg; and choline (as choline chloride), 110 mg.
[d]Calculated.

Experimental Diets.

All diets were fed in a meal form. The nutritional compositions of these diets are given in Table 1 (Exp. 1) and

(Continued on next page)

Table 2. Composition and nutrient analysis of the basal diets in Experiment 2 (as-fed basis)[a].

Item	Phase 1	Phase 2
Ingredient, percent		
Corn	35.15	47.15
Soybean meal (46.5% CP)	14.00	20.00
Whey, dried	25.00	20.00
Plasma, spray-dried	6.00	—
Soy protein concentrate	4.80	—
Blood meal, spray-dried	1.00	3.50
Lactose	10.00	5.00
Soybean oil	1.00	1.00
L-lysine.HCl	.10	.10
DL-methionine	.05	.05
Dicalcium phosphate	1.10	1.55
Limestone	.45	.30
Salt and trace mineral[b]	.35	.35
Vitamin premix[c]	1.00	1.00
Nutrient content[d]		
Crude protein, %	21.80	19.30
Lysine, %	1.54	1.28
Calcium, %	.94	.94
Phosphorus, %	.71	.71
Zinc, mg/kg	128.00	132.00
Copper, mg/kg	18.80	19.30
Iron, mg/kg	218.00	290.00

[a]Composition of the basal diets. The other five diets in each phase contained additions of zinc (1,500 or 3,000 mg/kg) or carbadox (55 mg/kg).
[b]Supplied the following amounts of trace elements in milligrams per kilogram of complete diet: Cu (as $CuSO_4 \cdot 5H_2O$), 10; I (as $Ca(IO_3)_2$), .2; Mn (as MnO), 20; Se (as Na_2SeO_3), .3; and Zn (as ZnO), 100.
[c]Supplied the following amounts of vitamins per kilogram of complete diet: retinyl acetate, 4,400 IU; cholecalciferol, 550 IU; *all-rac-α*-tocopheryl acetate, 22 IU; menadione (as menadione sodium bisulfite complex), 3.3 mg; riboflavin, 5.5 mg; niacin, 33 mg; *d*-pantothenic acid (as *d*-calcium pantothenate), 22 mg; cyanocobalamin, 22µg; and choline (as choline chloride), 110 mg.
[d]Calculated.

Table 3. Effects of zinc supplementation on growth performance of weanling pigs (Experiment 1).[a].

	Supplemental Zinc Concentration, mg/kg[b]					P-value[d]	
Item[c]	0	500	1,000	2,000	3,000	L	Q
Phase 1 (0 to 2 week)							
ADG, lb/d	.295	.289	.291	.407	.418	< .005	NS
ADFI, lb/d	.496	.469	.479	.558	.560	< .05	NS
ADFI/ADG	1.697	1.637	1.686	1.381	1.351	< .005	NS
Phase 2 (2 to 4 week)							
ADG, lb/d	.551	.665	.706	.840	.833	< .005	< .005
ADFI, lb/d	.855	.971	.989	1.209	1.262	< .005	NS
ADFI/ADG	1.559	1.463	1.404	1.439	1.514	NS	NS
Overall (0 to 4 week)							
ADG, lb/d	.423	.477	.498	.623	.626	< .005	< .01
ADFI, lb/d	.675	.720	.734	.884	.911	< .005	NS
ADFI/ADG	1.597	1.509	1.478	1.416	1.454	< .05	< .05

[a]Data represent means of three pens per treatment (each pen contained 20 pigs, the ratio of barrow:gilt was either 11:9 or 12:8). Four-week experiment: average initial weight 8.57 lb; average final weight 23.39 lb.
[b]Supplemental zinc was provided as zinc oxide.
[c]ADG = average daily gain, ADFI = average daily feed intake.
[d]L = linear effect, Q = quadratic effect, and NS = nonsignificant effect.

Table 4. Effects of carbadox and zinc supplementation on growth performance of weanling pigs (Experiment 2).[a].

	Treatment[b]						Effect of zinc	
Carbadox, mg/kg:	0	0	0	55	55	55	P-value[d]	
Item[c] Zinc: mg/kg:	0	1,500	3,000	0	1,500	3,000	L	Q
Phase 1 (0 to 1 week)								
ADG, lb/d	.278	.266	.323	.297	.223	.261	NS	NS
ADFI, lb/d	.386	.357	.416	.398	.334	.362	NS	< .05
ADFI/ADG	1.650	1.765	1.322	1.478	1.771	1.764	NS	NS
Phase 2 (1 to 4 week)								
ADG, lb/d	.841	.911	.989	.834	1.012	.951	NS	NS
ADFI, lb/d	1.209	1.371	1.499	1.210	1.449	< .005	NS	
ADFI/ADG	1.441	1.509	1.516	1.451	1.411	1.530	NS	NS
Overall (0 to 4 week)								
ADG, lb/d	.701	.750	.823	.699	.815	.779	NS	NS
ADFI, lb/d	1.003	1.118	1.229	1.007	1.155	1.177	< .005	NS
ADFI/ADG	1.432	1.489	1.494	1.438	1.420	1.526	NS	NS

[a]Data represent means of two pens per treatment (each pen contained 10 barrows and 10 gilts). Four-week experiment: average initial weight 15.48 lb; average final weight 36.82 lb.
[b]Supplemental zinc was provided as zinc oxide.
[c]ADG = average daily gain, ADFI = average daily feed intake.
[d]L = linear effect, Q = quadratic effect, and NS = nonsignificant effect. No effects of carbadox were observed.

Table 2 (Exp. 2). Zinc oxide and/or carbadox replaced corn in the diets. Within each phase, dietary crude protein, lysine, methionine, Ca and P were kept constant.

Management.

In both experiments, pigs were housed in environmentally controlled nurseries and were allowed ad libitum access to feed and water. Weight gain and feed intake were measured weekly to determined average daily gain (ADG), average daily feed intake (ADFI) and feed efficiency (ADFI/ADG).

Results and Discussion

Experiment 1.

From week zero to two after weaning, increasing Zn concentration linearly increased ADG and ADFI and decreased ADFI/ADG (Table 3). From week two to four, increasing ZnO improved ADG up to the 2,000 mg/kg treatment. Average daily feed intake increased slightly as Zn increased from 2,000 to 3,000 mg/kg. For the overall experiment (week zero to four), increasing Zn increased ADG and ADFI and decreased ADFI/ADG. However, most of the improvement of ADG and ADFI/ADG was achieved with 2,000 mg/kg Zn, with little or no further improvement as Zn concentration in creased from 2,000 to 3,000 mg/kg. These results suggest pharmacological concentrations of Zn from ZnO are beneficial in the diets of SEW pigs. It was apparent the weight gain responses resulted primarily from increased voluntary feed intake. The mechanism for the feed intake response was not determined in this experiment, however, other reports suggest such improvements may be due to more healthy gut tissue and improved nutrient absorption.

Experiment 2.

In this experiment, no additive effect of Zn and carbadox was found (Table 4). Carbadox had no effect on ADG, ADFI and ADFI/ADG during Phase 1, Phase 2 or the overall experiment. This contrasts with results from previously reported studies. On the other hand, Zn increased ADFI in both the first and second phases and the overall experiment. Although the increase in ADG as Zn concentration increased was not statistically significant in this experiment, supplementation with 1,500 and 3,000 mg/kg of Zn increased ADG by 15 and 16 percent in phase 2, and by 12 and 14 percent in the overall experiment. The nonsignificant effect of Zn on ADG was probably because there were only two replications per treatment in this experiment. The results of the second experiment agree with the results of the first experiment. Feeding pharmacological concentrations of Zn stimulated voluntary feed intake and weight gain of pigs during the nursery phase.

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