Zinc oxide does not alter ex vivo intestinal integrity or active nutrient transport in nursery pigs

C.M. De Mille[1], E.T. Helm[1], E.R. Burrough[2], and N.K. Gabler[1]
[1]Department of Animal Science, [2]Department of Veterinary Diagnostic and Production Animal Medicine, Iowa State University, Ames, IA 50011

Background and Objectives

Pharmacological concentrations of zinc (**Zn**, 2,000-3,000 ppm) in the form of zinc oxide are commonly fed to nursery pigs to improve growth [1] and reduce post-weaning diarrhea [2]. However, the mode of action for this improved growth performance remains elusive. Therefore, the objective of this study was to evaluate the effect of pharmacological ZnO on performance and intestinal function of recently weaned pigs. We hypothesized that improved growth is related to improved intestinal integrity and active nutrient absorption.

Materials and Methods

To test this hypothesis, two experiments were conducted. In experiment 1, 22 newly weaned pigs (4.37 ± 0.21 kg BW) were randomly assigned either a control diet (NC) or NC + zinc oxide (**ZnO)** at 3,000 ppm for 7 d followed by 2,000 ppm for 14 d (n= 11 pigs/treatment. Pig performance (ADG, ADFI, and FE) was determined weekly for 21 days. In experiment 2, 24 weaned pigs (5.45 ± 0.23 kg BW) were randomly assigned to a NC diet or NC + zinc oxide containing 3,000 ppm for 14 d followed by 2,000 ppm for 7 d. At d 2, 7, and 21, 4 pigs per treatment were euthanized for tissue collection. Freshly isolated ileum and colon tissues were placed in modified Ussing chamber for *ex vivo* evaluation of intestinal integrity (transepithelial resistance [TER] and mucosal to serosal flux of 4 kDa Dextran [FD4]). Ileal segments were also evaluated for active glucose and glutamine transport. For both experiments, the MIXED procedure of SAS was used to determine the main effect of diet (Expt. 1) and the diet by day interaction (Expt.2).

Results

In Expt. 1, there were no differences in ADG, ADFI, or G:F for the first 7 d post weaning. However, ZnO pigs had increased ADG from d 7-21 (0.31 vs, 0.23 kg/d, $P = 0.05$). This resulted in a tendency for overall 21 d ADG to be increased by 38% due to ZnO ($P = 0.09$). There were no differences in ADFI or G:F for phase 1, 2, or overall. To understand how ZnO augments growth, a serial slaughter study was conducted (Expt. 2). There were no diet by time interactions for any *ex vivo* markers of intestinal integrity or nutrient transport. Pharmacological zinc did not alter ileum or colon TER and FD4, or ileum glucose and glutamine transport ($P > 0.05$). There was an effect of time on ileal TER where TERs were decreased at d 7 compared to d 2 and d 21 ($P = 0.007$) as well as a time effect on both glucose and glutamine transport with a greater response at d 7 compared to d 2 and d 21 ($P \leq 0.001$).

Conclusion and Discussion

In early weaned pigs, ZnO improved ADG in phase 2, but not immediately post-weaning. These data are in agreement with Hu et al. [3] in which ADG increased with ZnO . However, contrary to our hypothesis, the growth promoting effect of ZnO was not associated with improved intestinal integrity or active nutrient transport. Altogether, these results suggest that the ZnO growth promoting mode of action is less targeted towards the intestinal epithelium and may be associated with changes in immune or metabolic processes, altered microbiota, or post-absorptive metabolism.

References

1. Sales, J., *Effects of pharmacological concentrations of dietary zinc oxide on growth of post-weaning pigs: a meta-analysis.* Biol Trace Elem Res, 2013. **152**(3): p. 343-9.
2. Poulsen HD. Zinc oxide for weanling piglets. Acta Agric Scand Sect A, Animal Sci 415 1995;45:159-167.
3. Hu, C.H., et al., *Effects of zinc oxide supported on zeolite on growth performance, intestinal microflora and permeability, and cytokines expression of weaned pigs.* Animal Feed Science and Technology, 2013. **181**: p. 65-71.