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Effects of dietary zinc source and concentration on performance of growing-finishing pigs reared with reduced floor space

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ABSTRACT

The objectives of this experiment were to evaluate effects of dietary zinc source (AA complex vs. inorganic) and increasing zinc concentration on growth performance and carcass composition of growing-finishing pigs housed in crowded conditions. Maternal-line barrows and gilts (636 pigs; initial BW = 28.7 kg) were blocked by initial BW and assigned randomly within block to 1 of 5 treatments. Twelve pens were assigned to each treatment over 3 replicate trials. Treatments were (1) control (Con9)—pigs housed in an uncrowded environment (0.73 m^2/pig) and fed diets based on corn, soybean meal, and dried distillers grains with solubles containing 60 mg/kg Zn (phases 1, 2, and 3), and 50 mg/kg Zn (phase 4); (2) crowded (Con11)—pigs housed at 0.60 m^2/pig and fed the same diets as Con9; (3) ZnAA40—same as Con11 + 40 mg/kg Zn from Zn AA complex (Availa-Zn, Zinpro Corp., Eden Prairie, MN); (4) ZnAA80—same as Con11 + 80 mg/kg Zn from Zn AA complex; and (5) inorganic zinc (ZnSO80)—same as Con11 + 80 mg/kg Zn from zinc sulfate monohydrate. Growth characteristics were determined at the end of each dietary phase (28 d). Upon completion of the trial, carcass composition and meat quality were recorded. Overall, crowding decreased ADG ($P < 0.05$, SE = 0.01) for Con11 compared with Con9 pigs (0.91 vs. 0.97 kg). There were no differences in average daily feed intake (2.74, 2.66, 2.62, 2.59, and 2.65 kg; SE = 0.05) or G:F (0.368, 0.356, 0.369, 0.368, and 0.365; SE = 0.006) among Con9, Con11, ZnAA40, ZnAA80, and ZnSO80, respectively. Neither zinc source nor concentration affected fat-free lean percentage, DP, loin muscle area, or backfat depth. Altogether, these data indicate that neither additional AA complexed zinc nor additional inorganic zinc influenced growth performance, carcass composition, or pork quality of pigs housed under crowded conditions.

Key words: crowding, growing-finishing pig, growth performance, zinc

INTRODUCTION

High capital costs of modern environmentally controlled grow-finish barns often encourage pork producers to reduce floor space allowance for individual pigs, which spreads fixed building costs across a larger population of pigs. Reduced floor space allowance, or crowding of pigs, depresses performance of individual pigs (Brumm and NCR-89 Committee on Management of Swine, 1996; Gonyou and Stricklin, 1998; Brumm et al., 2001). Although individual pig performance is depressed with crowding, overall output of the barn (measured as pigs or kilograms of pork) increases with densely stocked pens (Kornegay and Notter, 1984; Powell and Brumm, 1992; Flohr et al., 2016). Efforts to mitigate the crowding-induced depression in individual pig performance by increasing density of dietary energy and AA (Brumm and Miller, 1996) or including an antibiotic in the diet (Moser et al., 1985) have not been successful.

Social stress, resulting from crowding, reduces growth performance and increases aggressive behavior among finishing pigs (Randolph et al., 1981; Turner et al., 2000; Anil et al., 2007). Such aggressive behavior may have negative psychological effects on pigs, which could exacerbate crowding-induced stresses. Li et al. (2017) observed that chronic social stress significantly impairs intestinal function of pigs. Psychological stress in rats causes redistribution of body zinc stores and depressed serum zinc concentration because of reduced absorption of zinc through the small intestinal wall (Tao et al., 2013). Another form of stress caused by excessive exposure to heat also reduces intestinal integrity in growing pigs (Pearce et al., 2013). Amino acid complexes of Zn can ameliorate the negative effects of heat stress on intestinal integrity (Sanz Fernandez et al., 2014). Because supplemental Zn AA complex improves intestinal integrity of stressed pigs, it may potentially mitigate the effects of crowding-induced stress on growth performance.

The objectives of this study were to evaluate the effects of dietary zinc source and concentration on growth perfor-

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mance, carcass composition, and pork quality of growing-finishing pigs housed with reduced floor space allocation. A second objective was to determine the optimal concentration of an AA complexed zinc source that maximizes pig performance.

MATERIALS AND METHODS

Animals, Housing, and Treatments

All procedures in this experiment were approved by the University of Minnesota Institutional Animal Care and Use Committee. This study was conducted at the University of Minnesota's West Central Research and Outreach Center in Morris, Minnesota. There were 3 replicates within the experiment: the first conducted between June and September 2015 and the remaining 2 replicates between October 2015 and January 2016.

The experiment was conducted in 3 replicate rooms in the same barn, with each room containing 20 pens. Control pens (n = 12) housed 9 pigs to provide 0.73 m^2/pig. Crowded pens (n = 12/treatment; 48 pens total) housed 11 pigs to provide 0.60 m^2/pig. The control pens provided floor space similar to the 0.74 m^2 per pig suggested by the Federation of Animal Science Societies (2010). Each pen with a fully slatted floor over a deep manure collection pit was equipped with a 4-space stainless steel dry feeder and 2 nipple waterers. Therefore, pigs assigned to crowded treatments received less feeder access than pigs assigned to the uncrowded treatment. Pigs had ad libitum access to feed and water throughout the experiment. The barn was heated and mechanically ventilated. Heaters and ventilation fans were controlled by a computerized controller (Expert Series 2; Automated Production Systems, Assumption, IL).

Genetiporc maternal-line barrows and gilts (n = 636) with an initial BW of 28.7 kg were blocked by initial BW and assigned within weight blocks randomly to treatments. The following treatments were imposed: (1) control (**Con9**)—pigs housed in an uncrowded environment (0.73 m^2/pig) and fed diets based on corn and soybean meal; (2) crowded (**Con11**)—pigs housed at 0.60 m^2/pig and fed the same diets as Con9; (3) **ZnAA40**—same as Con11 + 40 mg/kg Zn from Zn AA complex (Availa-Zn, Zinpro Corp., Eden Prairie, MN); (4) **ZnAA80**—same as Con11 + 80 mg/kg Zn from Zn AA complex; and (5) **ZnSO80**—same as Con11 + 80 mg/kg inorganic Zn from zinc sulfate monohydrate. Experimental diets were formulated to satisfy NRC (2012) nutrient requirements (Tables 1–4). The vitamin–trace mineral premix supplied 60 mg/kg Zn in diets for phases 1 to 3 and 50 mg/kg Zn in the phase 4 diet from zinc sulfate monohydrate. Experimental diets were offered to pigs on a time budget over 4 phases. Phases 1, 2, 3, and 4 lasted from d 0 to 27, 28 to 55, 56 to 83, and 84 to 112 of the experiment, respectively. Grower diets (phases 1–3) contained 20% corn dried distillers grains with solubles and the finisher diet (phase 4) contained 10% dried distillers grains with solubles and 9.9 mg/kg ractopamine hydrochloride.

Growth Performance, Pork Quality, and Carcass Measurements

All pigs were identified individually using ear tags. At the end of each dietary phase, pigs were weighed individually and assigned a subjective lameness score modified from Grandin (2010). Functionally, pigs were assessed as they exited the pen and walked or ran down the alley to the livestock scale. All pigs were assigned automatically a score of 1 unless there was evidence that an individual pig showed signs of lameness. If a pig showed signs of lameness, a more critical evaluation was conducted to determine the appropriate score to assign. Pigs considered lame at phase changes were assigned one of the following scores: 2 = slight lameness, may have arched back; 3 = obvious limping, able to keep up with penmates when walking; 4 = not able to keep up with penmates due to lameness; and 5 = barely capable of walking. All feed deliveries to each pen were weighed and recorded. Remaining feed in the feeder on weigh days was weighed to allow calculation of feed disappearance on a pen basis. From these data, ADG, average daily feed intake (**ADFI**), and G:F were calculated. All treatments for ill health and mortalities were recorded. Within 3 d of marketing, final live weight was recorded and a trained technician used real-time ultrasonography (Exago model, Echo Control Medical, Angouleme, France) to capture images of backfat depth (**BF**) and loin muscle cross-sectional area (**LMA**) at the 10th rib for each pig. Images were digitized and depth or area determined using Biosoft Toolbox II for Swine software (Version 2.5.0.6; Biotronics Inc., Ames, IA). Additionally, all pigs were slap-tattooed individually with a unique identifier. One gilt closest to the pen final mean BW was selected and transported to the University of Minnesota, St. Paul campus. After an overnight fast, gilts were slaughtered at the Andrew Boss Laboratory of Meat Science. Carcasses were static chilled at 3 to 4°C and 0 to 5 km/h wind speed for 48 h. After carcass fabrication, the anterior end of one loin from each gilt was faced 48 h postmortem and allowed to bloom for 10 min. A Hunter colorimeter (MiniScanEZ 4500S; Hunter Lab, Reston, VA; 465 illuminate and 10° observer) was used to measure objective color scores. A panel of 5 observers determined subjective color and marbling scores of loins at the anterior loin end as described by NPPC (2000). Two loin chops from each loin were weighed, suspended from a smoke stick using the fish hook method, and covered with a sealed plastic bag for 24 h. Loin chops were then reweighed and the percentage of drip loss was calculated (NPPC, 2000). All other pigs were slaughtered by Hormel Foods (Austin, MN). Hot carcass weight was recorded in both St. Paul and Austin, Minnesota. Dressing percentage was calculated using the following formula: (HCW/final live weight) × 100. Percentage