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The influence of pelleting and supplementing sodium metabisulfite ($Na_2S_2O_5$) on nursery pigs fed diets contaminated with deoxynivalenol☆

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ABSTRACT

Four experiments were conducted to ascertain the effects of hydrothermal treatment and sodium metabisulfite (SMB) on deoxynivalenol (DON)-contaminated corn dried distillers grains with solubles (DDGS). Experiment 1 evaluated SMB and heat (autoclaving) on high-DON DDGS (20.6 mg/kg). Six levels of SMB were tested: 0.0% (control), 0.5%, 1%, 2.5%, 5%, and 5% with 100 mL/kg distilled water. Autoclaving after 1 h at 121 °C alone elicited a 9.8% reduction in DON, whereas an 82% reduction was achieved when 5% SMB was added before autoclaving. Experiment 2 tested pelleting high-DON DDGS with SMB. Four batches of DDGS (20.5 mg/kg DON) were tested: 0 (control), 1.0, 2.5, and 5.0% SMB. Pelleted samples were collected at conditioning temperatures of 66 and 82 °C and retention times of 30 and 60 s within temperature. Pelleting conditions had no effect on DON levels, but as SMB inclusion increased in pelleted DDGS, DON levels were reduced (quadratic; $P < 0.001$). Experiments 3 and 4 evaluated pelleting and SMB on nursery pig growth. Both trials were arranged in a $2 \times 3 + 1$ factorial with 5 replicate pens per treatment. In Exp. 3, 987 pigs (13.0 ± 0.2 kg) were used with main effects of (1) diet form: meal or pellet and (2) SMB level: Negative Control (NC), NC + 0.25% SMB, or NC + 0.50% SMB. Negative Control diets were formulated to contain 3 mg/kg DON. Treatment 7 was a Positive Control (PC; <0.5 mg/kg DON) fed in meal form. Pigs fed high-DON diets had reduced ($P < 0.001$) ADG and ADFI, but pelleting improved ($P < 0.001$) ADG and G:F. Adding SMB increased (linear; $P < 0.03$) ADG and tended to increase ($P < 0.10$) ADFI. In Exp. 4, 1180 pigs (11.1 ± 0.32 kg) were used with main effects of (1) diet form: meal or pellet and (2) DDGS source: PC (<0.5 mg/kg DON), NC (5 mg/kg DON), or NC + DDGS pelleted and crumbled before mixing into the final diet. In meal form, treatment 7 included 2.5% SMB prior to pelleting DDGS (final diet contained 0.77% SMB). Overall, a 2-way interaction ($P < 0.04$) was observed within NC diets where pelleting the final diet improved G:F by a greater margin in high-DON diets than when the DDGS was pelleted, crumbled, and re-pelleted. DON reduced ($P < 0.002$) ADG and ADFI, and pelleting the diet improved ($P < 0.01$) ADG and G:F. Including SMB prior to pelleting DON-contaminated DDGS increased ($P < 0.01$) ADG and ADFI. Using SMB combined with thermal processing can mitigate DON effects in diets for nursery pigs.

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1. Introduction

Deoxynivalenol (DON), also known as vomitoxin, is produced by fungi of the *Fusarium* genus and is one of the key contaminants of cereal grains because it often occurs at levels high enough to cause adverse effects in farm animals. Among livestock species, pigs are the most sensitive, primarily because DON is rapidly absorbed and poorly metabolized (Etienne and Waché, 2008). The most obvious effect in pigs is reduced feed intake, which may be attributed to irritation of stomach mucosa (Rotter et al., 1994; Trenholm et al., 1994) and changes in brain transmitters (Prelusky, 1993; Swamy et al., 2002).

Levels of DON that elicit negative effects on growth (>1 mg/kg; Dänicke et al., 2001) are relatively common. Ethanol by-products are especially concerning because DON levels are approximately 3 times more concentrated in corn dried distillers grains with solubles (DDGS) than in the corn source. Because DON cannot be consistently removed, many types of detoxification have been evaluated. The majority of these treatments are either ineffective (Friend et al., 1984; Dänicke et al., 2004; Döll et al., 2005) or impractical in large-scale production (He et al., 1993; Li et al., 2011).

Other studies have shown more promising results. Young et al. (1987), for instance, showed that DON is converted to a 10-sulfonate adduct (DON-S) in the presence of sodium bisulfite and heat (autoclave); the resulting DON-S is non-toxic when fed to pigs. Research by Dänicke et al. (2005) reported similar DON-transformation using sodium metabisulfite (SMB) and hydrothermal treatment with a laboratory conditioner. We hypothesized that pelleting, particularly conditioning, could detoxify DON-contaminated feedstuffs. Using DON-contaminated DDGS, the aims of this study were to evaluate: (1) the ability of SMB to transform DON using an autoclave, (2) pelleting under varying conditions with SMB for reducing DON, and (3) the effects of pelleting either DDGS or final diets with SMB on nursery pig performance.

2. Material and methods

2.1. General

All experimental procedures and animal care were approved by the Kansas State Institutional Animal Care and Use Committee. Corn DDGS were provided by Hubbard Feeds (Mankato, MN), and the uncontaminated (POET Bio-refining, Bingham Lake, MN) and naturally DON-contaminated (POET Bio-refining, North Manchester, IN) DDGS originated from the same plants across all four experiments.

2.2. Experiment 1

The objective of this pilot study was to verify that DON levels in naturally DON-contaminated DDGS can be reduced using SMB (Samirian Chemical, Campbell, CA) in an autoclave. All samples used in this study were prepared at the Kansas State University Swine Nutrition Laboratory, with the samples autoclaved at the K-State Food Science Laboratory. Samples were prepared from a previously identified, uniform source of DDGS with a known DON concentration of 20.6 mg/kg. The DDGS were homogenized thoroughly prior to sample preparation to eliminate variation in DON content across samples.

This experiment used 6 treatments with DDGS containing either: (1) No SMB (control), (2) 0.5% SMB, (3) 1.0% SMB, (4) 2.5% SMB, (5) 5.0% SMB, or (6) 5.0% SMB with 100 mL/kg distilled water added to evaluate the role of water in the potential change in DON. Each treatment had a final weight of 500 g per sample except treatment 6 (550 g with water). Samples were split into two replicates and placed in covered aluminum trays but were not sealed airtight to allow steam interaction and gas release during the autoclave process. Samples were autoclaved at 121 °C for 60 min. After autoclaving, samples were dried in a 55 °C drying oven to convert to a DM basis before replicates were sent for a full 17-component mycotoxin analysis at the North Dakota State University Veterinary Diagnostic Laboratory (NDSU; Fargo, ND). Analyzed mycotoxin levels were adjusted by the proportion of DDGS in the original sample, then converted to an as-fed basis. Because replications were combined for mycotoxin analysis in Exp. 1, statistical analysis could not be conducted for this pilot study.

2.3. Experiment 2

The objective of this experiment was to evaluate the extent of DON reduction due to SMB when DDGS were pelleted under varying conditions. This experiment was conducted at the Kansas State University Grain Sciences and Industry Feed Mill. All personnel involved were required to wear respirators and safety goggles during the pelleting process, because sodium metabisulfite releases sulfur dioxide gas in the presence of heat and moisture and can irritate the eyes and respiratory tract.

Treatments comprised of 205-kg batches of DDGS after the addition of SMB. The DDGS were sourced from naturally DON-contaminated DDGS (averaging 20.6 ± 0.5 mg/kg). Four DDGS treatments contained either: (1) 0.0% (control), (2) 1.0% SMB, (3) 2.5% SMB, or (4) 5.0% SMB. Prior to the addition of SMB, each batch was mixed for 4 min in a paddle mixer (Forberg 500 L double-shaft) to homogenize the DDGS and eliminate any variation in initial DON concentration. After adding SMB, each batch was mixed for an additional 3 min before pelleting. The pellet mill (CPM Master Model 1000HD; Crawfordsville, IN) was set to a production rate of 454 kg/h to control conditioning temperature and retention time for each batch of DDGS. Within each treatment, the pellet conditioner was adjusted to conditioning temperatures of 66 and 82 °C and retention times of 30 and 60 s for each temperature, and 2-kg samples were collected at each temperature × retention time combination.