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Evaluating the effects of pelleting, corn dried distillers grains with solubles source, and supplementing sodium metabisulfite in nursery pig diets contaminated with deoxynivalenol

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Evaluating the Effects of Pelleting, Corn Dried Distillers Grains with Solubles Source, and Supplementing Sodium Metabisulfite in Nursery Pig Diets Contaminated with Deoxynivalenol[1]

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Summary

A total of 360 barrows (PIC 1050, initially 24.7 lb ± 0.3 lb BW and 35 d of age) were used in a 28-d trial examining the effects of pelleting, pelleting dried distillers grains with solubles (DDGS), and supplementing sodium metabisulfite[4] (SMB) in diets containing deoxynivalenol (DON) on nursery pig performance. Pigs were allotted to 1 of 10 treatments with 7 replications per treatment (pens) and 5 pigs per pen. Naturally contaminated DDGS were used to incorporate DON at desired concentrations. Ingredients were tested for mycotoxins by the North Dakota State University Veterinary Diagnostic Laboratory (NDSU; Fargo, ND) and served as the basis for diet formulation. The 5 experimental diets were fed in meal and pellet form: (1) positive control, (2) negative control (NC, 5.3 ppm DON), (3) NC with 0.5% SMB, (4) pelleted and reground DDGS (5.3 ppm DON), and (5) pelleted and reground DDGS with 2.5% SMB (final diet contained 0.5% SMB). Experimental diets were fed from d 0 to 21 with a common diet fed from d 21 to 28 to evaluate performance after DON was removed. Due to the variability of DON assays when levels exceed 8 ppm, final diets were lower in DON than predicted from analysis of the DDGS. As a result, expected reductions in performance due to DON were not as significant as anticipated, and may have affected results. From d 0 to 21, pigs fed diets with high-DON levels had decreased ($P < 0.03$) ADG, but the reduction in ADG was only 4%. Pelleting high-DON diets decreased ($P < 0.04$) ADFI and improved ($P < 0.02$) F/G compared with diets fed in meal form; however, pelleting DDGS prior to manufacturing final diets had no effect on growth performance. Supplementing SMB tended ($P < 0.08$) to decrease ADFI, and had no effect on ADG or F/G.

Our results indicate that pelleting high-DON nursery pig diets can recover some reduction in feed intake by improving F/G. Although pelleting DDGS and supplementing SMB did not improve performance in DON-contaminated diets, further studies are needed to verify these results.

Key words: deoxynivalenol, pelleting, sodium metabisulfite, vomitoxin, nursery pig

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[1] Appreciation is expressed to Hubbard Feeds (Mankato, MN) for supplying the DDGS used in this study.

[2] Hubbard Feeds, Mankato, MN.

[3] Department of Diagnostic Medicine/Pathobiology, College of Veterinary Medicine, Kansas State University.

[4] Sodium metabisulfite, ($Na_2S_2O_5$), Samirian Chemicals, Campbell, CA; 100% by weight.

Introduction

Mycotoxins produced by the *Fusarium* species present significant challenges globally because weather conditions at the time of cereal flowering ultimately control toxin production. Of the *Fusarium* toxins, deoxynivalenol (DON, also known as vomitoxin) is of particular importance, because it can be found in toxicologically relevant concentrations that negatively affect farm animal species. Among the most sensitive species are pigs, with concentrations above 1 ppm eliciting a decrease in feed intake and higher levels causing subclinical immune suppression, feed refusal, and vomiting. During so-called *Fusarium* years, such as 2009, when DON levels cause significant problems, swine producers struggled to find ways to incorporate DON-contaminated feedstuffs into swine diets. Dried distillers grains with solubles produced from DON-contaminated corn also presents considerable problems because mycotoxins become 2 to 3 times more concentrated in the DDGS than in the original corn source.

The use of adsorbent feed additives to bind mycotoxins in the digestive tract has shown promise for some mycotoxins, but their efficacy against DON has until now proven ineffective. Other detoxification approaches involve using chemical and/or physical treatments of contaminated feedstuffs before feeding. Young et al. (1987)[5] demonstrated that in an autoclave, aqueous sodium bisulfite converted DON to a 10-sulfonate adduct (DON-S), which reduced the toxicity of DON-contaminated corn when fed to pigs and subsequent feed intake matched the level of the control group. A recent study (see "Evaluating the Effects of Pelleting Deoxynivalenol-Contaminated Dried Distillers Grains with Solubles in the Presence of Sodium Metabisulfite on Analyzed DON Levels," p. 90) at Kansas State University attempted to mimic these processing conditions in both an autoclave environment as well as in a commercial pellet mill. Deoxynivalenol levels in contaminated DDGS were significantly reduced after pelleting in the presence of sodium metabisulfite (SMB).

Although pelleting with SMB appears to detoxify contaminated DDGS, whether these methods are able to detoxify DON levels in final diets after incorporation of additional ingredients is uncertain. Furthermore, the effects of pelleting DON-contaminated diets in the presence SMB on nursery pig performance are unknown. The goal of this study was to ascertain the influence of both SMB and pelleting DDGS or complete diets containing DON on nursery pig performance. Additionally, this study aimed to determine whether an interaction exists between pelleting and sodium metabisulfite in both DDGS and final diets that are contaminated with DON.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment. The study was conducted at the K-State Segregated Early Weaning Research Facility in Manhattan, KS.

A total of 360 barrows (PIC 1050, initially 24.7 lb ± 0.3 lb BW and 35 d of age) were used in a 28-d growth trial. Pigs were allotted to pens by initial weight, and pens were assigned to 1 of 10 treatments in a 2 × 2 × 2 + 2 randomized complete block design,

[5] Young, J. C., H. L. Trenholm, D. W. Friend, and D. B. Prelusky. 1987. Detoxification of deoxynivalenol with sodium bisulfite and evaluation of the effects when pure mycotoxin or contaminated corn was treated and given to pigs. J. Agric. Food Chem. 35:259-261.

with location in the barn serving as the blocking factor. Each treatment comprised 7 replications (pens) with 5 pigs per pen, and each pen (4 ft by 4 ft) contained a 4-hole dry self-feeder and 1-cup waterer to provide ad libitum access to feed and water.

To naturally incorporate DON at desired concentrations, both a clean and a contaminated source of DDGS were supplied by Hubbard Feeds (Mankato, MN) to incorporate DDGS into the test diets at equivalent levels. Base corn and the two sources of DDGS were tested for mycotoxin content at NDSU (Table 1) prior to diet manufacturing. These results were used in diet formulation. Diets were manufactured at the K-State Grain Science Feed Mill. Due to the release of sulfur dioxide gas during pelleting of SMB, all personnel were required to wear respirators and safety goggles to prevent eye or lung damage from the gas. For diets requiring DDGS to be pelleted (7 through 10), the DDGS were pelleted prior to diet manufacturing and re-ground through a hammer mill to ensure no particle segregation at the feeder. Diets requiring the addition of SMB were homogenized for 4 min in a paddle mixer prior to and 3 min after SMB addition to eliminate any discrepancies in initial DON level. For both DDGS and final diets, the pellet conditioner was adjusted to a conditioning temperature of 180°F and a retention time of 30 sec. Pellets were cooled prior to sampling, then reground if in pellet form, and 10 subsamples were collected and compiled to make a composite sample that was shipped to NDSU for a full mycotoxin analysis.

Initially, all pigs were fed a commercial SEW diet with a budget of 2 lb/pig followed by a commercial transition diet for the first 7 d postweaning. From d 7 to 14 postweaning, Phase 2 diets were fed. Starting on d 14 (d 0 of the experiment), the 10 experimental treatments (Table 2) were fed to the pigs. Apart from DON and SMB content, diets were formulated to be identical in nutrient composition, and all diets contained a total of 20% DDGS. Based on the initial mycotoxin analysis of base ingredients, 5 experimental diets were fed in meal and pellet form. These included: (1) positive control (PC), (2) negative control (NC, 5.3 ppm DON), (3) NC with 0.5% SMB, (4) pelleted DDGS (5.3 ppm DON), and (5) pelleted DDGS with 2.5% SMB (final diet contained 0.5% SMB). Experimental diets were fed from d 0 to 21. A common diet (<0.5 ppm DON) was fed in meal form from d 21 to 28 to evaluate the change in performance immediately after removing DON from the diet. Average daily gain, ADFI, and F/G were determined by weighing pigs and measuring feed disappearance on d 3, 7, 14, 21, and 28 of the trial.

Results were analyzed as a randomized complete block design with a 3-way factorial treatment structure by using the PROC MIXED procedure of SAS (SAS Institute, Inc., Cary, NC) with pen as the experimental unit. Treatment means were separated using the LSMEANS statement and CONTRAST statements in SAS. Two-way interactions between final diet form and DON level were evaluated in positive and negative control treatments. Two- and three-way interactions within high-DON treatments compared final diet form, pelleting DDGS prior to final diets, and SMB inclusion. Means were considered significant at $P < 0.05$ and trends at $P < 0.10$.

Results and Discussion

The DON analyses of the basal ingredients and test diets are shown in Table 2. Deoxynivalenol values for contaminated DDGS sample varied from 26.5 ppm, the basis

of diet formulation, to analyzed levels of 9.7 and 17.9 ppm when analysis was performed again after diet manufacturing. The variation in DON assay results is because the test is designed to analyze samples accurately at 8 ppm or below. When DON levels exceed 8 ppm, samples must be diluted and re-analyzed at laboratory level to quantify actual levels; therefore, at levels exceeding 8 ppm, the variability of results can be significantly greater, as seen in the 3 samples of contaminated DDGS sent for analysis (Table 1). Because of variability in initial mycotoxin analyses, incorporating a high enough level of DON during formulation to generate a true DON response is critical in future studies evaluating strategies to improve growth performance in high-DON containing diets.

When contaminated DDGS were pelleted with SMB individually or only in the final diet, analyzed DON levels were reduced from initial concentrations, which supports observations of detoxification by Young et al. (1987), and the conversion of DON to a DON-S form undetected by standard DON assays. However, test diets without SMB formulated to be 5.3 ppm were analyzed at levels between 3.0 and 3.3 ppm, raising concerns about the extent of expected performance reduction in pigs fed NC diets. Diets 7 and 8, where DDGS was pelleted without SMB prior to final diet manufacturing, also had slightly lower analyzed DON levels, indicating that pelleting alone may somewhat detoxify DON, but not to the extent of pelleting with SMB.

The growth performance of nursery pigs fed the 10 dietary treatments is shown in Table 3. Statistical analysis also revealed no 2-way interactions between DON level and pelleting in PC and NC diets. No 2- or 3-way interactions occurred within high-DON diets, so they are not reported in Table 3. The PC and NC diets were compared to assess the direct effect of DON and pelleting. High-DON levels decreased ($P < 0.01$) ADFI and tended ($P < 0.06$) to decrease ADG between d 0 and 21; however, the DON effect was not as large as expected at only 4% reduction, likely due to the lower than formulated DON levels in NC diets. The common diet period (d 21 to 28) did not affect ADG or ADFI in pigs previously fed high-DON diets, although pigs fed PC diets had better ($P < 0.03$) F/G in this subsequent period. In previous studies, pigs previously fed high-DON diets experienced compensatory performance during the common diet period with higher ADFI and ADG than pigs fed PC diets. The lack of compensatory growth is another indication that DON levels in NC diets did not produce reductions in performance expected in pigs fed high DON levels. Overall (d 0 to 28), pigs fed NC diets had lower ($P < 0.03$) ADG, but ADFI and F/G did not differ. Feeding high-DON diets reduced ($P < 0.04$) pig BW at d 21 and BW remained lower ($P < 0.02$) at d 28 than pigs fed PC diets.

From d 0 to 21, comparing final diet form, pelleting PC, and NC diets decreased ($P < 0.01$) ADFI and improved ($P < 0.02$) F/G with no difference in ADG. Pigs previously fed pelleted diets tended ($P < 0.07$) to have decreased ADFI when switched to meal diets during the common diet period, but the switch had no effect on ADG or F/G. Overall, pelleting PC and NC diets decreased ($P < 0.01$) ADFI and improved ($P < 0.02$) F/G compared with meal diets. No differences occurred in pig BW at d 21 or 28 due to pelleting.

Within treatments formulated to contain high levels of DON (diets 3 to 10), the effects of pelleting, pelleting DDGS, and SMB were examined. Pigs fed pelleted diets tended ($P < 0.06$) to have lower ADFI and had improved ($P < 0.01$) F/G than pigs fed meal

diets from d 0 to 21, but there was no difference in ADG. When all pigs were switched to a common meal diet from d 21 to 28, pigs previously fed pelleted diets had increased ($P < 0.03$) ADG compared with those fed meal diets throughout the trial, but ADFI and F/G were similar. Overall, pigs fed pelleted diets had decreased ($P < 0.04$) ADFI but improved ($P < 0.02$) F/G. No differences were measured in pig BW at d 21 or 28.

When evaluating DDGS processing prior to final diet manufacturing, pelleting high-DON DDGS had no effect on ADG, ADFI, F/G, or pig weights in any period. Supplementing SMB to high-DON diets tended ($P < 0.08$) to decrease daily feed intake during the experimental period (d 0 to 21), but ADG and F/G were similar. From d 21 to 28, pigs previously fed SMB had decreased ($P < 0.04$) ADG and tended ($P < 0.10$) to have decreased ADFI, with no difference in F/G. Overall, supplementing 0.5 % SMB to nursery pigs had no effect on ADG, ADFI, F/G, or pig BW.

In summary, obtaining correct DON analysis and providing an adequate level in formulation is crucial to obtain a great enough DON response to adequately test amelioration strategies. In this study, DON levels in negative control diets were approximately 3 ppm, and expected reductions in growth performance were not as great as anticipated; however, pelleting high-DON nursery pig diets can overcome some of the reduction in feed intake by improving F/G. Furthermore, pelleting DDGS prior to diet manufacturing had no effect on performance. Although analyzed DON levels were reduced by supplementing 0.5% SMB, SMB tended to decrease feed intake, which may indicate that the conversion to DON-S is not truly a non-toxic form of DON, or could also indicate palatability issues when including SMB in nursery pig diets. Additional research should be carried out with a greater negative DON response to reinforce these results.

Table 1. Analyzed deoxynivalenol (DON) concentration in diet samples (as-fed basis)[1,2]

Item		Initial	Analyzed
Basal ingredients, ppm			
Ground corn		<0.5	-[3]
Control dried distillers grains with solubles (DDGS)		0.7	0.6
Contaminated DDGS		26.5	9.7, 17.9[4]
Contaminated DDGS, pelleted final diet form		-	7.4
Contaminated DDGS, pelleted prior to final diet		-	3.0
Test diets, ppm		Formulated	Analyzed
1	Positive control, meal	0.0	<0.5
2	Positive control, pellet	0.0	0.5
3	Negative control, meal	5.3	3.2
4	Negative control, pellet	5.3	3.2
5	Negative control, meal [0.5% SMB]	5.3	3.3
6	Negative control, pellet [0.5% SMB]	5.3	0.7
7	Pelleted DDGS, meal	5.3	3.0
8	Pelleted DDGS, pellet	5.3	1.9
9	Pelleted DDGS [2.5% SMB], meal	5.3	2.8
10	Pelleted DDGS [2.5% SMB], pellet	5.3	0.5

[1] Reported total DON levels as a combination of DON and 15-acetyl DON levels.
[2] North Dakota State University Veterinary Diagnostic Laboratory, Fargo, ND. Samples were analyzed using a variety of mass spectrometry, ELISA (enzyme-linked immunosorbent assay), and HPLC (high-pressure liquid chromatography).
[3] (-) indicates sample was not analyzed at this time.
[4] After analyzed at 9.7 ppm, the contaminated DDGS sample was reanalyzed due to the major difference from initial value.

Table 2. Diet composition (as-fed basis)[1]

Item	Positive control	Negative control	Negative control + SMB	Pelleted DDGS[2]	Pelleted DDGS + SMB	Common Phase 3[3]
Ingredient, %						
Corn	48.77	48.77	48.23	48.77	48.23	48.77
Soybean meal (46.5% CP)	27.98	27.98	28.02	27.98	28.02	27.98
Control DDGS (26.3% CP)	20.00	-	-	-	-	20.00
Contaminated DDGS (26.4% CP)	-	20.00	20.00	20.00	-	-
Contaminated DDGS (2.5% SMB)	-	-	-	-	20.50	-
Monocalcium P (21% P)	0.60	0.60	0.60	0.60	0.60	0.60
Limestone	1.20	1.20	1.20	1.20	1.20	1.20
Salt	0.35	0.35	0.35	0.35	0.35	0.35
Copper sulfate	0.05	0.05	0.05	0.05	0.05	0.05
Vitamin premix	0.25	0.25	0.25	0.25	0.25	0.25
Trace mineral premix	0.15	0.15	0.15	0.15	0.15	0.15
L-Lysine HCl	0.40	0.40	0.40	0.40	0.40	0.40
DL-Methionine	0.05	0.05	0.05	0.05	0.05	0.05
L-Threonine	0.08	0.08	0.08	0.08	0.08	0.08
Phytase[4]	0.13	0.13	0.13	0.13	0.13	0.13
Sodium metabisulfite[5]	-	-	0.50	-	-	-
Total	100	100	100	100	100	100

continued

Table 2. Diet composition (as-fed basis)[1]

Item	Positive control	Negative control	Negative control + SMB	Pelleted DDGS[2]	Pelleted DDGS + SMB	Common Phase 3[3]
Calculated composition, %						
Standardized ileal digestible (SID) amino acids, %						
Lysine	1.27	1.27	1.27	1.27	1.27	1.27
Isoleucine:lysine	64	64	64	64	64	64
Leucine:lysine	148	148	148	148	148	148
Methionine:lysine	30	30	30	30	30	30
Met & Cys:lysine	58	58	58	58	58	58
Threonine:lysine	62	62	62	62	62	62
Tryptophan:lysine	17.1	17.1	17.1	17.1	17.1	17.1
Valine:lysine	73	73	73	73	73	73
Total lysine, %	1.44	1.44	1.44	1.44	1.44	1.44
ME, kcal/lb	1,506	1,506	1,506	1,506	1,506	1,506
SID lysine:ME, g/Mcal	3.83	3.83	3.83	3.83	3.83	3.83
CP, %	22.9	22.9	22.9	22.9	22.9	22.9
Ca, %	0.70	0.69	0.69	0.69	0.69	0.70
P, %	0.60	0.61	0.61	0.61	0.61	0.60
Available P, %	0.42	0.43	0.43	0.43	0.43	0.42
Deoxynivalenol, ppm[6]	0.14	5.30	5.30	5.30	5.30	0.14

[1] Diets were fed in meal and pellet form.
[2] Dried distillers grains with solubles.
[3] Common diet was fed from d 21 to 28.
[4] Natuphos 600 (BASF Corporation, Florham Park, NJ).
[5] Sodium metabisulfite, Samirian Chemicals, Campbell, CA; 100% by weight.
[6] Formulated deoxynivalenol (DON) level from control and contaminated DDGS was analyzed at North Dakota State University Veterinary Diagnostic Laboratory prior to diet manufacturing with DON levels of 0.7 and 26.5 ppm, respectively.

Table 3. Effect of pelleting, dried distillers grains with solubles (DDGS) source, and sodium metabisulfite (SMB) on growth performance of nursery pigs fed deoxynivalenol (DON)-contaminated diets[1]

DON level[2]	< 0.5 ppm		5.3 ppm									Probability, $P <$[3]				
	Positive control		Negative control		NC[4] + SMB[5]		Pellet DDGS		Pellet DDGS + SMB[6]			PC vs. NC[4]		High-DON Diets		
Diet form	M	P	M	P	M	P	M	P	M	P	SEM	DON	Pellet vs. meal	Pellet vs. meal	Pelleted DDGS	SMB
d 0 to 21																
ADG, lb	1.36	1.32	1.29	1.26	1.25	1.29	1.30	1.32	1.27	1.31	0.033	0.06	0.30	0.44	0.25	0.54
ADFI, lb	2.12	1.96	1.96	1.88	1.89	1.84	1.99	1.94	1.94	1.89	0.042	0.01	0.01	0.06	0.13	0.08
F/G	1.56	1.48	1.52	1.49	1.52	1.43	1.53	1.47	1.53	1.44	0.022	0.41	0.02	0.01	0.92	0.13
d 21 to 28[7]																
ADG, lb	1.77	1.75	1.72	1.68	1.84	1.75	1.76	1.73	1.86	1.72	0.053	0.20	0.61	0.03	0.55	0.04
ADFI, lb	3.69	3.44	3.76	3.61	3.92	3.81	3.61	3.71	3.82	3.66	0.114	0.29	0.07	0.29	0.33	0.10
F/G	2.09	1.97	2.19	2.15	2.13	2.19	2.07	2.15	2.05	2.13	0.062	0.03	0.19	0.32	0.13	0.74
d 0 to 28																
ADG, lb	1.46	1.43	1.40	1.37	1.40	1.40	1.42	1.42	1.41	1.42	0.028	0.03	0.25	0.84	0.21	0.78
ADFI, lb	2.51	2.33	2.41	2.31	2.39	2.33	2.39	2.38	2.40	2.33	0.420	0.16	0.01	0.04	0.66	0.72
F/G	1.72	1.63	1.72	1.69	1.72	1.66	1.69	1.67	1.70	1.65	0.025	0.18	0.02	0.02	0.21	0.43
BW, lb																
d 0	24.6	24.9	24.7	24.7	24.9	24.9	24.7	24.7	24.5	24.5	0.29	0.95	0.22	0.82	0.06	0.78
d 21	53.3	53.0	51.9	51.3	51.1	52.5	52.1	52.9	51.4	52.0	0.73	0.04	0.55	0.29	0.40	0.58
d 28	65.6	65.3	63.9	63.1	64.0	64.7	64.4	65.0	64.5	64.1	0.87	0.02	0.48	0.96	0.34	0.72

[1] A total of 360 barrows (initial BW of 24.7 lb ± 0.3 lb BW and 35 d of age), with 5 pigs per pen and 7 replicates per treatment.
[2] Formulated deoxynivalenol (DON) levels of <0.5 and 5.3 ppm total DON. Analyzed DON levels are shown in Table 2.
[3] All interactions were excluded from the table due to lack of significance.
[4] NC, negative control; PC, positive control.
[5] Treatments contained a final level of 0.5% SMB added during final diet manufacturing.
[6] Treatments had 2.5% SMB added prior to pelleting DDGS; final SMB level of 0.5%.
[7] A common diet was fed from d 21 to 28.