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Evaluation of the potential connection between Distillers Dried Grains with Solubles and manure pit foaming in commercial pork production systems

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Project objectives

The original objectives of the project were:

1. Determine the amount of long-chain fatty acids excreted in the feces between pigs fed DDGS and typical corn-soybean meal diets
2. Determine the amount of long-chain fatty acids excreted in the manure (feces and urine) between pigs fed DDGS and typical corn-soybean meal diets
3. Determine the amount of long-chain fatty acids from DDGS in manure that are necessary to produce foam
4. Determine the effects of diet particle size on foam production and accumulation

Description of work performed

Manure pit foaming on commercial swine farms has been a significant problem in recent years. We hypothesize that dietary changes in fiber fermentability and lipid composition may alter manure chemical composition resulting in a greater risk of manure foaming due to methane production and foam stabilization from undigested lipids in anaerobic manure pits. The objective of this experiment was to measure nutrient excretion and manure foaming capability (MFC) of pigs fed 3 diets differing in the source and amount of neutral detergent fiber (NDF; % DM) and ether extract (EE; % DM) when ground to 2 particle sizes. Two groups of 24 growing gilts (initial BW =119.5 ± 8.9 kg) were placed into metabolism crates and randomly allotted to 1 of 6 diets (4 replicates/treatment/group). Dietary treatments consisted of 1) corn-soybean meal (7.2% NDF, 4.6% EE; CSB), 2) CSB + 35% DDGS (13.7% NDF, 6.2% EE; DDGS), and 3) CSB + 21% soybean hulls (20.0% NDF, 6.8% EE; SBH). Diets were ground to a mean particle size of 374 ± 29 µm (fine) or 631 ± 35 µm (coarse) and fed for 7 weeks. Excretion of DM, NDF, and EE were measured after total feces and urine was collected from d-21 to d-24. Except for d 21 to 24, all other feces and urine were collected and mixed daily and stored in simulated deep pit storage tanks. The MFC of each manure sample was measured in duplicate in the laboratory using a column and injecting nitrogen to stimulate foam production. Data were analyzed using the MIXED procedure of SAS, with individual pig as a random effect and diet composition, particle size, and their interaction as fixed effects. There was a diet composition × particle size interaction for MFC ($P < 0.05$). Greater ($P < 0.05$) MFC was observed for pigs fed coarse SBH compared with fine CSB and SBH, but not for fine or coarse DDGS. There was no diet composition × particle size interaction for excretion of DM, NDF, or EE. Excretion of DM and NDF were greater ($P < 0.05$) in pigs fed DDGS and SBH than in pigs fed CSB. Excretion of EE

was greater ($P < 0.01$) for pigs fed DDGS than CSB or SBH. Excretion of DM, NDF, and EE was greater ($P < 0.05$) for coarse compared to fine diets regardless of the fiber composition. These results indicate that fiber composition in soybean hulls has a greater impact on MFC than the fiber composition in DDGS, and larger diet particle size reduces DM, NDF, and EE digestibility causing increased content in manure and MFC.

Results of technology or process assessed

Physical characteristics of manure, gas production, manure chemical composition, and manure output

Hydrogen sulfide production and manure output measured from manure tanks were greater ($P < 0.05$) for pigs in group 2 than for pigs in group 1. However, there were no differences in manure foam characteristics (MFC or recession time) among pigs of the 2 groups.

There was a diet composition × particle size interaction for MFC and recession time ($P < 0.05$). Greater MFC and recession time were observed for pigs fed coarse SBH compared fine SBH or fine CSB, but not for fine or coarse DDGS. Also, greater MFC and recession time was observed for pigs fed coarse CSB compared with fine CSB.

There was no diet composition × particle size interaction for hydrogen sulfide gas (sulfide probe) and ammonia (NH_4-N). Pigs fed DDGS had greater ($P < 0.01$) hydrogen sulfide gas and ammonia gas production than pigs fed CSB and SBH. Pigs fed coarse particle size diets had greater ($P < 0.01$) ammonia gas production than those fed fine particle size diets.

There was no diet composition × particle size interaction for manure output, manure tank temperature, and manure pH. Pigs fed SBH had lower manure pH than CSB ($P < 0.05$) and DDGS ($P < 0.01$). Pigs fed coarse particle size diets had lower ($P < 0.05$) manure pH than pigs fed fine particle size diets.

There was no diet composition × particle size interaction for concentration of N, C, or S in manure. Pigs fed diets with DDGS had greater ($P < 0.01$) manure concentration of N and C compared with pigs fed SBM and SBH, while manure from pigs fed SBM had less ($P < 0.01$) concentration of N and C than pigs fed SBH. Pigs fed coarse particle size diets had greater ($P < 0.01$) N and C concentrations in manure than pigs fed fine particle size diets. Pigs fed SBH had less ($P < 0.01$) S concentration in manure than those fed CSB and DDGS.

Energy balance of diets

Gross energy content among diet samples varied from 4,278 to 4,519 kcal/kg DM. There was no diet composition × particle size interaction for DE and ME. Feeding the fine particle size diets resulted in greater ($P < 0.01$) DE and ME content than feeding coarse particle size diets.

EE and NDF excretion and digestibility

Pigs in group 1 had higher ($P < 0.05$) DM, EE and NDF intake than pigs in group 2. There was no diet composition × particle size interaction for DM intake, feces excretion and digestibility. Pigs fed CSB had less DM excretion in feces and greater DM digestibility than DDGS ($P < 0.01$ and $P < 0.01$, respectively) and SBH ($P < 0.05$ and $P < 0.01$, respectively). Pigs fed fine particle size diets had less DM excretion in feces and greater DM digestibility than ($P < 0.01$) those fed coarse particle size diets.

There was no diet composition × particle size interaction for EE intake and feces excretion. Pigs fed CSB had less ($P < 0.01$) EE intake than those fed DDGS and SBH. Pigs fed DDGS had greater ($P < 0.01$) EE excretion in feces than those fed CSB and SBH. Pigs fed fine particle size diets had less ($P < 0.01$) EE excretion in feces than those fed coarse particle size diets. There was a diet composition × particle size interaction for EE digestibility ($P < 0.05$). Greater EE digestibility was observed for pigs fed fine CSB and fine SBH compared with coarse CSB, coarse DDGS and coarse SBH. Also, less EE digestibility was observed for pigs fed coarse CSB compared with fine DDGS and coarse SBH.

There was no diet composition × particle size interaction for NDF intake, feces excretion and digestibility. However, pigs fed SBH had greatest ($P < 0.01$) NDF intake compared with those fed CSB and DDGS, while pigs fed CSB had the least ($P < 0.01$) NDF intake compared with those fed DDGS and SBH. Pigs fed fine particle size diets had less NDF feces excretion and greater NDF digestibility ($P < 0.05$) than those fed coarse diets.

N, C and S excretion and balance

Pigs in group 1 had higher ($P < 0.05$) N, C, and S intake than pigs in group 2. There was no diet composition × particle size interaction for N intake, feces excretion, digestibility, urine excretion and net N utilization. Pigs fed DDGS had greater ($P < 0.01$) N intake than those fed SBH, while pigs fed CSB had less ($P < 0.01$) N excretion in feces than those fed DDGS and SBH. Pigs fed SBH had less N digestibility and urine excretion than pigs fed CSB ($P < 0.01$ and $P < 0.01$, respectively) and DDGS ($P < 0.05$ and $P < 0.01$, respectively). Pigs fed fine particle size diets had less ($P < 0.05$) N excretion in feces and greater N digestibility ($P < 0.01$) than those fed the coarse diets.

There was no diet composition × particle size interaction for C intake, feces excretion, digestibility and urine excretion. Pigs fed CSB had less C excretion in feces and greater C digestibility ($P < 0.01$) than pigs fed DDGS and SBH. Pigs fed SBH had less ($P < 0.01$) C urine excretion than those fed CSB and DDGS. Pigs fed fine particle size diets had less C excretion in feces and greater C digestibility than ($P < 0.01$) those fed the coarse diets.

There was no diet composition × particle size interaction for S intake, feces excretion, digestibility and net S utilization. Pigs fed DDGS had greater S

intake and less net S utilization than those fed CSB ($P < 0.01$ and $P < 0.05$, respectively) and SBH ($P < 0.01$ and $P < 0.01$, respectively). Pigs fed CSB had less S excretion in feces than those fed DDGS ($P < 0.05$) and SBH ($P < 0.01$). Pigs fed SBH had less S digestibility than pigs fed CSB ($P < 0.01$) and DDGS ($P < 0.05$). There was a diet composition × particle size interaction for S urine excretion ($P < 0.01$), where greater S excretion in urine was observed for pigs fed fine DDGS compared with fine CSB, coarse CSB, fine SBH and coarse SBH. Also, less S urine excretion was observed for pigs fed fine SBH compared with those fed fine CSB, coarse CSB and coarse DDGS.

Benefit to Minnesota economic development

Manure pit foaming has been a significant problem in the Minnesota and U.S. pork industry in recent years, causing health and safety concerns for barn workers and pigs. Methane gas produced from anaerobic manure pits has led to barn explosions and flash fires. Hydrogen sulfide trapped in manure foam can rise to lethal levels within minutes of being released. In addition, foaming manure reduces cleanliness of pens and reduces manure storage volume. Some pork producers, veterinarians, and agricultural advisors have suggested that including corn dried distillers grains with solubles (DDGS) is the cause of manure foaming. Prior to conducting this study, there were no data to support or refute this claim. Therefore, the impact of the results of this study affects both the pork and ethanol industries.

Our results indicate that feeding diets containing DDGS is not the primary cause of manure foaming in commercial swine facilities. Fiber digestibility and excretion of swine diets appears to have a greater effect on manure foaming than lipid digestion and excretion, but the overall amount of dry matter excretion has the greatest effect on manure foaming. Therefore, diet formulation and manufacturing (i.e. reduce diet particle size) strategies that maximize dry matter digestibility and minimize excretion will minimize manure foaming potential.

Marketing

We have presented the results from this study to industry nutritionists at the Midwest Section of the American Society of Animal Science meeting, and will be submitting a manuscript for publication in the Journal of Animal Science. This information has also been published on our University of Minnesota Swine Extension website. We are collaborating with Dr. Brian Kerr (USDA-ARS, Ames, IA) to conduct a follow-up study to better understand the role of lipid and fiber on manure foaming.

Conclusions

Feeding the coarsely ground SBH diet to finishing pigs increased MFC, but feeding coarse and fine DDGS diets did not increase MFC. Diet fiber composition may have greater effect on MFC than diet lipid composition. Dry matter excretion was a significant factor that contributed to MFC. There was no clear association observed between N, C, S balance and MFC. These results suggest that diet formulation strategies to maximize dry matter digestibility (e.g. reducing diet particle size) and reduce dry matter excretion, along with minimizing the amount coarsely ground SBH in diets will decrease manure foaming propensity in anaerobic manure pit in pig barns.

Future needs/plans

We are collaborating with Dr. Brian Kerr (USDA-ARS, Ames, IA) to conduct a follow-up study to better understand the role of lipid and fiber on manure foaming. In addition, we developed a research proposal (submitted to the Minnesota Pork Board) to evaluate a promising feed additive (commercially available *Bacillus spp.* direct-fed microbial) on improving fiber digestibility and reducing manure foaming capability, but this project was not selected for funding. We plan to continue to explore funding sources to allow us to evaluate nutritional approaches for reducing manure foaming in commercial pork production facilities.