J. Dairy Sci. 101:1–11
https://doi.org/10.3168/jds.2018-14528

Effects of corn feeding reduced-fat distillers grains with or without monensin on nitrogen, phosphorus, and sulfur utilization and excretion in dairy cows

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ABSTRACT

This study investigated effects of high inclusion of reduced-fat corn distillers grains with solubles (RFDG) with or without monensin on utilization and excretion of dietary N, P, and S. The experiment was conducted for 11 wk (2-wk diet adaptation, 9-wk experimental period of data collection) with 36 Holstein cows in a randomized complete block design. Cows were blocked by parity, days in milk, and milk yield and assigned to the following diets: (1) a control diet (CON); (2) CON with RFDG included at 28.8% (dry matter basis) by replacing soybean meal, soyhulls, and supplemental fat and phosphorus (DG); and (3) DG with monensin (Rumensin; Elanco Animal Health, Greenfield, IN) supplemented at a rate of 20 mg/kg of DM offered (DGMon). Contrasts were used to compare CON versus DG and DG versus DGMon. Inclusion of RFDG at 28.8% of dietary DM replacing mainly soybean meal did not change crude protein content (17.6% on a DM basis) but decreased rumen-degradable protein and increased rumen-undegradable protein. In addition, the DG diets increased P (0.48 vs. 0.36%) and S concentrations (0.41 vs. 0.21%; DM basis) compared with the CON diet. As a result, DG versus CON decreased plasma and milk urea N concentrations and urinary N excretion. However, the increase in P concentration when feeding the DG versus CON diet to lactating cows increased P intake, plasma P concentration, and urinary and fecal P excretion without affecting milk P secretion. Intake of S was greater for cows fed the DG versus CON diet, resulting in greater plasma total S and sulfate concentration and urinary and fecal S excretion. However, milk S secretion was not affected by DG compared with CON. Monensin supplementation to the DG diet did not affect N intake, utilization, and excretion except that apparent N digestibility was lower compared with DG. In addition, feeding the DGMon diet did not affect P and S utilization and excretion compared with DG. The study suggests that inclusion of high RFDG in a ration by replacing mainly soybean meal altered N, P, and S utilization and excretion, but monensin supplementation to a high-RFDG diet, overall, had minimal effects on N, P, and S utilization and excretion in lactating dairy cows.
Key words: reduced-fat distillers grains, monensin, dairy cows

INTRODUCTION

Ethanol production continues to increase, resulting in increased production of corn dried distillers grain with solubles (**DDGS**; Renewable Fuels Association, 2017), which has been widely used as an animal feed. More recently, DDGS with less fat content, reduced-fat DDGS (**RFDG**), has increased in availability and can be used as an animal feed. According to multiple studies with dairy cows, up to 30% (DM basis) RFDG can be included in dairy rations without negatively affecting DMI, milk yield, and milk composition (Mjoun et al., 2010b; Castillo-Lopez et al., 2014; Ramirez-Ramirez et al., 2016). However, due to the high concentration of certain nutrients in RFDG, such as RUP, P, and S, feeding a diet with high RFDG may cause environmental concerns by increasing the excretion of those nutrients. However, studies about utilization and excretion of N, P, and S when dairy cows are fed high-RFDG diets are scarce (N) or not available (P and S).

An in situ and in vitro study by Mjoun et al. (2010a) indicated that intestinal digestibility and total digestible (i.e., RDP plus digested RUP) is less for RFDG compared with soybean meal (**SBM**); therefore, N utilization for milk and urinary N excretion could decrease and fecal N excretion increase when feeding RFDG versus SBM. Furthermore, the concentration of P and S in SBM is about 0.7 and 0.4%, respectively (NRC, 2001), whereas the P and S content of RFDG is 0.8 to 0.9% and 0.7 to 1.2%, respectively (DuFour, 2017). Therefore, increased dietary inclusion of RFDG can increase dietary P and S content, resulting in increased excretion of P and S. Inclusion of RFDG at about 30% of diet DM increased dietary P content from 0.36 to

Received February 1, 2018.
Accepted April 17, 2018.
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0.52% (Castillo-Lopez et al., 2014) and S content from 0.25 to 0.53% (Ramirez-Ramirez et al., 2016). Manure with high P concentration has potential for P losses (e.g., runoff) when the manure is applied to the field (Hanrahan et al., 2009). Manure with high S concentration can negatively affect public perception and human and animal health (e.g., odor and toxicity of S-containing gas to animals and humans; Guidotti, 2010). Due to increased dietary S content with high-RFDG diets, S excretion can increase, potentially resulting in increased hydrogen sulfide (H_2S) emissions from manure, especially when manure is mixed and pumped out (Andriamanohiarisoamanana et al., 2015). However, excretion of P and S has been rarely considered when the inclusion rate of RFDG in a ration is determined.

Monensin is a commonly used feed additive in the dairy industry and has been shown to increase N utilization efficiency (Plaizier et al., 2000; Ruiz et al., 2001; Martineau et al., 2007). Increased apparent absorption and retention of certain minerals, including P, were also observed when monensin was fed to beef cattle and sheep (Starnes et al., 1984; Greene et al., 1986). Furthermore, monensin can alter ruminal S metabolism by altering rumen microbial communities. As an example, monensin supplementation to a diet containing DDGS in beef cattle decreased ruminal H_2S in some (Felix and Loerch, 2011) but not all studies (Felix et al., 2012). Therefore, monensin supplementation to a high-RFDG diet has potential to alter N, P, and S utilization and excretion in dairy cows. Although monensin and RFDG are a widely used feed additive and ingredient for dairy cows, few studies have examined N, P, and S utilization in terms of environmental impacts.

The objectives of our study were to assess the effect of feeding RFDG with or without monensin on N, P, and S utilization and excretion in dairy cattle. Our hypotheses were (1) feeding RFDG decreases urinary N excretion but increases fecal and urinary P and S excretion, and (2) monensin supplementation to a high-RFDG diet will decreases N and P excretion and alter S utilization and excretion.

MATERIALS AND METHODS

Animals and Treatments

Animal care and procedures were approved by The Ohio State University Institutional Animal Care and Use Committee. The cows used were not fed monensin for at least 6 mo before the experiment.

The experiment was carried out at the Ohio Agricultural Research and Development Dairy Center (Wooster, OH). Information about animals, experimental design, and dietary treatments were described in detail in our previous study (Morris et al., 2018). Briefly, 36 (9 primiparous and 27 multiparous) Holstein cows (average ± SD at the beginning of the trial: milk yield = 44.2 ± 8.1 kg/d; DIM = 80 ± 31 d; BW = 675 ± 74 kg) were blocked into groups of 3 (n = 12) by parity, DIM, and milk yield. Cows in each block were randomly allocated to 1 of 3 treatment diets (a randomized complete block design): (1) control diet (**CON**; a typical lactating cow ration; Table 1); (2) the CON with RFDG included at 28.8% of diet DM replacing SBM, soyhulls and supplemental fat (**DG**); and (3) the DG diet with monensin (Rumensin; Elanco Animal Health, Greenfield, IN) supplemented at a rate of 20 mg/kg of DM offered (**DGMon**). For the DG diets (i.e., DG and DGMon), RFDG fully replaced SBM, soyhulls, and supplemental fat and calcium phosphate. All diets were formulated to be isoenergetic and isonitrogenous and to meet or exceed nutrient requirements according to NRC (2001). Supplemental P (i.e., calcium phosphate) was removed from the DG diets to minimize P overfeeding. Although this resulted in a decrease in dietary Ca content in the DG diets (Table 1), Ca supply exceeded NRC (2001) requirements. Further information about dietary composition is available in our previous study (Morris et al., 2018). The experiment consisted of a diet adaptation period for 2 wk and a 9-wk experimental period (wk 1 through 9 refers to the 9-wk experimental period). During the first week of the diet adaptation, the inclusion rate of monensin for DGMon was half of the target rate (i.e., 10 mg/kg of DM) and it was increased to 20 mg/kg of DM at the start of wk 2. Cows were housed in individual tiestalls with free access to water and milked twice a day. All diets were prepared daily and fed as TMR once a day with a target refusal rate of 5%.

Sample Collection

Animals were sampled during wk 1, 5, and 9. During the first 3 d of sampling week, spot fecal and urine samples (from the rectum and by massaging the vulva, respectively) were collected every 9 h, yielding 8 samples representing every 3 h in a 24-h period. Samples were composited on an equal volume basis during collection and frozen (−20°C) between sampling events until later analysis. Urine samples were acidified with 2 *M* HCl to maintain a pH <3.0. During fecal and urine sampling (first 3 d of wk 1, 5, and 9), feeds offered and refused were monitored, sampled, and composited and feed ingredients; refusal samples were collected for the 3 d and composited by week for feeds and by cow and week for refusals (on a weight basis). In addition, individual cows were weighed for 2 consecutive days in wk 1, 5, and 9 (4 to 6 h after feeding). Therefore, feed