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Nitrogen utilization, nutrient digestibility, and excretion of purine derivatives in dairy cattle consuming rations containing corn milling co-products

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ABSTRACT

The objectives of this experiment were to determine the effects of feeding a combination of modified wet distillers grains with solubles (WDGS) and wet corn gluten feed (WCGF) on nutrient digestion, purine derivative excretion, and N utilization. Multiparous (n = 20) and primiparous (n = 20) cows were arranged in a replicated 5 × 5 Latin square with 21-d periods. Animals were fed one of 5 treatment diets during each period: 1) 0% co-products (control); 2) 15% WDGS (15WDGS); 3) 15% WCGF (15WCGF); 4) 7.5% WDGS and 7.5% WCGF (15MIX); and 5) 15% WDGS and 15% WCGF (30MIX; dry matter basis). A portion of forages, corn, and soy-based protein was replaced with WDGS, or WCGF, or both. Dry matter intake was greater for 15WDGS (25.1 kg/d) and 30MIX (25.5 kg/d) than for control (22.4 kg/d), 15WCGF (23.2 kg/d), or 15MIX (23.5 kg/d). Dry matter digestibility was greatest for 15WCGF and 30MIX (63.6 and 64.1%, respectively) and least for 15WDGS (59.8%), and neutral detergent fiber and N digestibility were greatest for 30MIX (50.7 and 68.6%, respectively) and lowest for 15WDGS (41.3 and 61.5%, respectively). Excretion of purine derivatives in urine was greater for co-product treatment diets than for control. Fecal N was greatest for 15WDGS compared with other treatment diets (311.0 vs. 263.3 g/d), whereas urinary N was greatest for 30MIX (330.0 g/d), intermediate for 15WCGF and 15MIX (319.3 and 320.5 g/d, respectively), and lowest for control and 15WDGS (308.5 and 312.2 g/d, respectively). Manure N (fecal + urinary N) was greatest for 15WDGS, intermediate for 15MIX and 30MIX, and lowest for control and 15WCGF. Treatment diets did not differ in 4% fat-corrected milk production. Compared with the ration containing WDGS, the ration with a 30% mixture of WDGS and WCGF improved nutrient digestibility and N utilization with reduced manure N excretion and increased N retention. Thus, it appears feeding WDGS and WCGF in combination reduces some of the negative effects of feeding WDGS alone.
Key words: corn milling co-product, digestibility, nitrogen utilization, purine derivative

INTRODUCTION

Wet distillers grains with solubles (**WDGS**) is a co-product of the dry milling process and includes the bran, germ, oil, and gluten from the corn grain (Bothast and Schlicher, 2005). Wet corn gluten feed (**WCGF**) is a product of the wet milling process and includes the bran and steep (Bothast and Schlicher, 2005). Both feedstuffs contain highly digestible corn fiber and are high in CP (30 and 23% of DM for WDGS and WCGF, respectively; Kelzer, 2008). Because the corn oil is not fractionated out during dry milling, WDGS contains a higher concentration of ether extract (**EE**) compared with WCGF (14.2 vs. 5.1% of DM; Kelzer, 2008). Ivan et al. (2004) demonstrated that the concentration of RUP in WCGF (5% of CP) was lower than WDGS (43% of CP). Although many dairy nutritionists routinely include corn milling co-products such as WDGS or WCGF in rations for lactating dairy cows, inclusion levels of these products are often low (<10% of DM). Rations high in EE, specifically unsaturated fat found in WDGS (Kelzer, 2008), may negatively affect NDF digestibility (Oldick and Firkins, 2000) and may cause milk fat depression (Harvatine and Allen, 2006). In addition, replacing feedstuffs low in CP, such as corn grain or silage, with co-products high in CP may result in rations that are higher in CP, potentially increasing N excretion (Broderick, 2003; Groff and Wu, 2005). Adding WCGF to a ration with WDGS may result in a ration with lower EE and more RDP, potentially allowing for greater total inclusion of co-products. Consequently, dairy producers may be able to increase energy intake and minimize N excretion by cows by taking advantage of complementary nutritional properties of WDGS and WCGF while reducing inputs of corn, soy-based protein, and forages.

Nutritional methods that maximize the supply of MP should attempt to manipulate RUP and microbial CP (**MCP**) synthesis (NRC, 2001). Digestibility of RUP

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contained in WDGS has also been shown to be high (93.1% of CP; Kelzer, 2008). The digestible fiber from the co-products may supply the ruminal microbes with readily fermentable energy and may promote MCP synthesis (Calsamiglia et al., 2008). Microbial protein has an AA profile that is a close match to the animal's requirements and is believed to be highly digestible (Clark et al., 1992; NRC, 2001). The objectives of this experiment were to explore the potential of complementary effects of including both WDGS and WCGF in rations for lactating dairy cows and to determine the effects of feeding high levels of corn milling co-products on nutrient digestibility, N utilization, purine derivative excretion, and production.

MATERIALS AND METHODS

Animals and Experimental Treatment Diets

Twenty primiparous and 20 multiparous Holsteins averaging (mean ± SD) 631 ± 87 kg of BW and 93 ± 29 DIM were used in this experiment. Animals were blocked by parity and production and assigned to 1 of 8 replicated 5 × 5 Latin squares with 21-d periods. Animals consumed one of 5 treatment diets during each period. Treatment diets were: 1) 0% co-products (control); 2) 15% of DM WDGS (**15WDGS**); 3) 15% of DM WCGF (**15WCGF**); 4) 7.5% of DM WDGS and 7.5% of DM WCGF (**15MIX**); and 5) 15% of DM WDGS and 15% of DM WCGF (**30MIX**). Ration ingredient composition is shown in Table 1. Weekly loads of WDGS were received from Platte Valley Fuel Ethanol LLC (Central City, NE) and loads of WCGF (Sweet Bran) were received from Cargill Inc. (Blair, NE) and stored in commodity bays. The WDGS used in this experiment was a modified WDGS composed of dry and partially dry distillers grains with solubles, with higher DM than commonly observed for WDGS (Schingoethe et al., 1999). Rations were formulated to be similar in CP, ME, and MP based on the Cornell-Penn-Miner model (Boston et al., 2000). The control ration was formulated to be similar to a dairy diet fed in the Great Plains of the United States. This ration did not contain any corn milling co-products and largely comprised corn silage, alfalfa silage and hay, ground corn, and soybean meal. Given the high concentration of NDF and CP contained in WDGS and WCGF, they largely replaced the alfalfa silage and hay as well as soybean meal and bypass soy. A portion of ground corn was also replaced. Urea was removed from all treatment diets containing co-products. Because of the high fat content of WDGS, tallow was removed from treatment diets containing WDGS. Additional brome hay was added to treatment diets with co-products to achieve similar CP to control and to increase the concentration of effective fiber.

Cows were milked twice daily at 0730 and 1930 h. Cows were housed in a tie-stall barn and fed once daily for 105% ad libitum intake. All experimental animals were treated with bST (Posilac, Monsanto Co., St. Louis, MO) on d 1 and every 14 d thereafter for the duration of the experiment. All procedures were approved by the University of Nebraska–Lincoln Animal Care and Use Committee.

Sample Collection and Analysis

BW, BCS, and Milk Composition. Body weight and BCS (1 to 5 scale) were measured on d 19 and 20 of each period. Body condition score was measured by a single trained individual. The scoring method used was similar to Wildman et al. (1982) but differed slightly because it was reported to the quarter point. Milk production was measured daily and milk samples were collected during 4 consecutive milkings on d 19 and 20 and were preserved using 2-bromo-2-nitropropane-1,3 diol. Daily DMI and milk yield were averaged for d 14 to 20 of each period. Milk samples were analyzed by Heart of America DHIA (Manhattan, KS) for fat, true protein, and MUN (AOAC, 2000) using a B2000 Infrared Analyzer (Bentley Instruments, Chaska, MN).

Feed, Urine, and Fecal Samples. Total mixed rations and feedstuffs were sampled on d 19 and 20 of each period. The Penn State Particle Separator was used to measure particle size of TMR as described by Heinrichs and Kononoff (2002). Feed samples were dried for 48 h at 55°C in a forced air oven, ground to pass through a 1-mm screen (Wiley Mill, Arthur A. Thomas Co., Philadelphia, PA), and composited by sample for each period. Feed samples were analyzed for DM and ash (AOAC, 2000), N (Leco, FP-528, Leco Corp, St. Joseph, MI), and ADF and NDF (Ankom Fiber Analyzer, Ankom Technology, Fairport, NY). Heat-stable α-amylase (no. A3306, Sigma Chemical Co., St. Louis, MO) was included in the NDF procedure (0.5 mL/0.50 g of sample). Additionally, TMR were analyzed for starch (Megazyme Total Starch Assay, Bray, Ireland) and EE (AOAC, 2000).

Fecal and urine samples were collected for all cows at 0600 and 1800 h on d 17 to 20 of each period. Feces were sampled from the rectum and urine was sampled during urination with stimulation. Fecal samples were composited for individual cows in each period, dried at 55°C in a forced-air oven, and ground to pass through a 1-mm screen. Ground samples were analyzed for DM, N, ash, NDF, ADF, and EE using the same procedures described for feed. Urine was acidified to pH <4 using 5 *M* HCl and frozen (−20°C). Urine samples were