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Lactation performance of dairy cows fed yeast-derived microbial protein in low- and high-forage diets

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ABSTRACT

The objective of this study was to investigate the effect of substituting soybean meal products with yeast-derived microbial protein (YMP) on lactation performance in diets containing 2 forage-to-concentrate ratios. Sixteen Holstein cows (4 primiparous and 12 multiparous) were randomly assigned to multiple 4 × 4 Latin squares with a 2 × 2 factorial arrangement of treatments. Diets contained low (LF; 45% of diet DM) or high forage (HF; 65% of diet DM) and YMP at 0 (NYMP) or 2.25% (WYMP) of the diet. The forage mix consisted of 67% corn silage and 33% alfalfa hay on a DM basis. No interactions of forage and YMP were noted for any of the production parameters measured. Feed efficiency (energy-corrected milk/dry matter intake) was greater for cows fed NYMP compared with WYMP. Regardless of the addition of YMP, cows fed LF had greater dry matter intake and produced more milk than cows fed HF. In addition, cows fed LF produced more energy-corrected milk than those fed HF. Milk fat percentage was lower in cows fed LF compared with HF, whereas fat yield was similar between forage concentrations. Fat yield tended to decrease with feeding YMP. Interactions of forage and YMP were observed for propionate concentration, acetate and propionate proportion, and acetate-to-propionate ratio. A tendency for an interaction of forage and YMP was also noted for ruminal pH. Cows fed HF diets had greater ruminal ammonia and butyrate concentrations, as well as proportion of butyrate. Arterial concentrations of Ile, Leu, Met, Thr, and Val were greater in cows fed LF. Cows fed NYMP had greater arterial concentrations of Ile, Lys, Trp, and Val than cows fed WYMP. Substitution of soybean proteins with YMP did not improve performance or feed efficiency of high-producing dairy cows regardless of the forage-to-concentrate ratio of the diet.

Key words: yeast-derived microbial protein, forage-to-concentrate ratio, milk production, dairy cows

INTRODUCTION

Feed prices are the largest milk production expense, accounting for 53% of total costs in 2014 (USDA-ERS, 2015). Dairy cow diets should be formulated to meet the MP requirements for milk production by feeding a diet balanced for RDP and RUP that also promotes high N efficiency (Agle et al., 2010). Microbial CP (**MCP**) has a superior AA profile compared with that in commercial feed ingredients (Clark et al., 1992). The AA requirements of high-producing dairy cows cannot be met by MCP alone. Feeding additional dietary RDP may result in diminishing returns of MCP when ruminal ammonia N exceeds microbial requirements (Satter and Slyter, 1974). Maintaining adequate RDP in the diet allows for a high-quality source of RUP to be included to improve the quantity of AA reaching the small intestine and support maximum milk protein concentration and yield (Santos et al., 1998; Kalscheur et al., 2006).

New technologies are being developed to find alternative protein supplements to replace traditional feeds, such as soybean meal, fishmeal, and animal protein sources (Seo et al., 2008). These technologies include slow-release urea (Taylor-Edwards et al., 2009), rumen-protected AA (Ordway et al., 2009), oilseeds, oilseed meals that have been chemically or heat-treated (NRC, 2001), and peptides (Gilbert et al., 2008), all of which can improve the total amount as well as the AA profile of the MP reaching the small intestine for absorption (NRC, 2001).

Yeast-derived microbial protein (**YMP**) is a by-product of yeast fermentation with an AA profile that closely resembles the composition of ruminal microbial protein (Sabbia et al., 2012). Previous studies have shown YMP to be an effective replacement for vegetable proteins in dairy cow diets (Sabbia et al., 2012; Neal et al., 2014).

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Inclusion of YMP in diets with a forage-to-concentrate ratio of 60:40 led to no differences in milk production or ECM/DMI; however, milk production was maintained as dietary YMP concentrations increased from 1.14 to 3.41% of dietary DM (Sabbia et al., 2012). Neal et al. (2014) conducted a similar study with YMP fed at 1.15% of diet DM and found a tendency for increased milk production and ECM/DMI.

The amount of forage concentration in the diet influences passage rate of the liquid digesta, with increased liquid passage rate occurring with increased concentrations of forages (Colucci et al., 1982; Ledoux et al., 1985; Jacques et al., 1989; Colucci et al., 1990; Allen, 1996). We hypothesized that YMP flows with the liquid phase in the rumen, allowing for increased absorption of AA in the small intestine. The amount of AA available for absorption may be further increased when YMP is fed as part of high-forage diets that promote greater liquid passage rate, resulting in better lactation performance. Therefore, the objectives of our study were to evaluate the effect of feeding YMP in partial substitution of soybean meal and mechanically extracted soybean meal in diets formulated with varying forage-to-concentrate ratios on DMI, milk production, and components, as well as blood and rumen measures of high-producing dairy cows.

MATERIALS AND METHODS

Animals and Diets

This experiment was conducted at the Dairy Research and Training Facility at South Dakota State University (Brookings). All procedures were approved by the South Dakota Institutional Animal Care and Use Committee. Sixteen Holstein dairy cows (12 multiparous and 4 primiparous) averaging 88 ± 18 DIM at the beginning of the experiment were used in a 4 × 4 Latin square design with a 2 × 2 factorial arrangement of treatments with four 28-d periods. Cows were blocked by parity and milk production with 1 square consisting of 4 ruminally cannulated, multiparous cows. Treatment diets were formulated with YMP (**WYMP**; 2.25% of diet DM) or without YMP (**NYMP**; DEMP; Alltech Inc., Nicholasville, KY) and at 2 forage-to-concentrate ratios, 45:55 (low forage, **LF**) and 65:35 (high forage, **HF**). Within each forage-to-concentrate ratio, the forage mix consisted of 67% corn silage and 33% alfalfa hay on a DM basis. Yeast-derived microbial protein partially replaced soybean meal, soyhulls, and mechanically extracted soybean meal in LF and HF diets (Table 1). One unit of YMP replaced 0.37, 0.44, and 0.19 U of soybean meal, mechanically extracted soybean meal, and soyhulls, respectively, to maintain constant CP, RDP, and RUP across treatments as estimated by the NRC (2001). Diets were formulated to be isonitrogenous and isoenergetic (16.2% CP and 1.57 Mcal/kg of NE_L, respectively).

Forages were premixed in a vertical mixer and blended with concentrates in a Calan Data Ranger (American Calan Inc., Northwood, NH). Cows were individually fed for ad libitum intake once daily (0800 h) using Calan Broadbent individual animal feeders (American Calan Inc.). Orts were weighed once daily and feed offered adjusted for 10% orts. Week 1 and 2 of each period were used for acclimation to diets, and wk 3 and 4 were for data collection. Cows had unlimited access to water and feed during the day, except during milking. All cows received rbST (Posilac; Monsanto, St. Louis, MO) every 14 d according to existing farm protocol.

Measurements and Sampling

Feed intakes and orts for individual cows were recorded once daily. Dry matter concentration of corn silage and alfalfa hay was determined weekly for 24 h at 105°C, and diets adjusted to maintain a constant forage-to-concentrate ratio throughout the experiment.

Samples of alfalfa hay, corn silage, concentrate mixes, and TMR of each treatment were collected twice during wk 3 and 4 of each period, frozen, and stored at −20°C until analysis. Samples of individual ingredients were collected from the feed mill each time that the concentrate mixes were prepared. At the end of the study individual feed ingredients were then equally composited by weight into one sample. Additional TMR treatment samples were taken once during wk 3 and 4 to determine particle size and physically effective fiber.

Ruminal fluid was sampled from cannulated cows on d 27 of each period at 0, 2, 4, 6, 8, 10, 12, 16, and 24 h after feeding. Approximately 50 mL of rumen fluid were collected from 5 separate locations (cranial and caudal mat, cranial sac, ventral sac, and caudal blind sac). Samples were immediately measured for pH, and 2 aliquots (10 mL) were acidified with either 200 μL of 50% (vol/vol) sulfuric acid or 2 mL of 25% (wt/vol) metaphosphoric acid and stored at −20°C for later analyses of ammonia and VFA, respectively.

Blood samples were collected from all cows on 2 consecutive days during wk 4 of each period by venipuncture of the coccygeal artery (arterial blood) approximately 3 h after feeding. Blood was drawn into 10-mL vacutainer tubes containing lithium heparin for AA and plasma urea N, and a 7-mL vacutainer tube containing sodium fluoride and potassium oxa-