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Ethyl-cellulose rumen-protected methionine enhances performance during the periparturient period and early lactation in Holstein dairy cows

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ABSTRACT

The onset of lactation in dairy cows is characterized by severe negative energy and protein balance. Increasing Met availability during this time may improve milk production, hepatic lipid metabolism, and immune function. The aim of this study was to evaluate the effect of feeding ethyl-cellulose rumen-protected methionine (RPM; Mepron, Evonik Nutrition and Care GmbH, Hanau-Wolfgang, Germany) on the performance of dairy cows during prepartum and early-lactation periods. Sixty multiparous Holstein cows were used in a block design and assigned to either a control or an ethyl-cellulose RPM diet. Ethyl-cellulose RPM was supplied from −28 to 60 d relative to parturition at a rate of 0.09% and 0.10% of dry matter during the prepartum and postpartum periods, respectively. That rate ensured that the ratio of Lys to Met in metabolizable protein was close to 2.8:1. Cows fed ethyl-cellulose RPM had dry matter intakes (DMI) that were 1.2 kg/d greater during the prepartum period and consequently had overall greater cumulative DMI than cows in the control group. Compared with controls, during the fresh period (1–30 d in milk; DIM) feeding ethyl-cellulose RPM increased DMI by 1.7 kg/d, milk yield by 4.1 kg/d, fat yield by 0.17 kg/d, milk protein yield by 0.20 kg/d, 3.5% fat-corrected milk by 4.3 kg/d, and energy-corrected milk by 4.4 kg/d. Although ethyl-cellulose RPM supplementation increased milk protein content by 0.16 percentage units compared with the control during the fresh period, no differences were observed for milk fat, lactose, and milk urea nitrogen concentration. During the high-producing period (31–60 DIM), cows fed ethyl-cellulose RPM increased DMI and milk yield by 1.45 and 4.4 kg/d, respectively. Ethyl-cellulose RPM also increased fat yield by 0.19 kg/d, milk protein yield by 0.17 kg/d, 3.5% fat-corrected milk by 4.7 kg/d, and energy-corrected milk by 4.8 kg/d compared with controls. Ethyl-cellulose RPM supplementation reduced plasma fatty acids in the fresh period and decreased γ-glutamyl transferase, indicating better liver function. In conclusion, when lysine was adequate, feeding ethyl-cellulose RPM to achieve a ratio close to 2.8:1 in metabolizable protein improved dairy cow performance from parturition through 60 DIM. The greater milk production was, at least in part, driven by the greater voluntary DMI and better liver function.

Key words: methionine, milk protein, postpartum, transition period

INTRODUCTION

Despite the prodigious output of research on nutrition and physiology of dairy cows, the transition period remains a challenging phase during which metabolic disorders continue to occur at economically significant rates (Overton and Waldron, 2004). During the transition period cows experience several stressful events, including regrouping, dietary changes, parturition, and the onset of lactation (Sun et al., 2016). Following parturition, cows enter a period of negative energy and protein balance because they cannot consume enough DM to support the requirements for lactation (NRC, 2001). Although extensive research has been conducted focusing on reducing negative energy balance, less emphasis has been put on overcoming protein and indispensable AA imbalances. Previous research suggests that increasing RUP during late gestation improves subsequent lactation performance (Huyler et al., 1999; Greenfield et al., 2000). The RUP fraction is important as a source of EAA for the mammary gland and other

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tissues, such as liver and skeletal muscle (Osorio et al., 2013). Therefore, an adequate profile and amount of EAA in RUP is crucial for a successful transition into and maintenance of an optimal lactation.

Methionine typically is the first-limiting AA for lactating cows (NRC, 2001). Among the various biological functions besides milk protein synthesis for which Met availability is important, some of the most relevant to the transition period include lipoprotein synthesis in liver, antioxidant synthesis, and synthesis of immune-related proteins (e.g., acute-phase proteins; Osorio et al., 2013; Zhou et al., 2016a). Previous studies have observed beneficial effects of rumen-protected Met (**RPM**) on performance (Chen et al., 2011; Osorio et al., 2013) and immunometabolic status (Osorio et al., 2014; Zhou et al., 2016a) of dairy cows during the transition period. However, in those studies the effects of RPM on lactation performance were focused only on the immediate postpartum period up to 30 DIM. Knowledge of the potential effect of nutritional strategies that commence in the last few weeks of the dry period (e.g., the close-up) through peak lactation is essential because each additional kilogram of milk secreted at peak production results in approximately 200 kg more milk during the lactation (Roche et al., 2013). Therefore, determining the effects of RPM supplementation not only during the peripartal period but also through peak lactation is of particular importance.

Different sources of RPM might elicit different responses due to inherent differences in either coating system or effectiveness of the coating system (Patton, 2010). Therefore, our general hypothesis was that feeding ethyl-cellulose RPM starting at 4 wk from expected parturition through 60 DIM would improve overall lactation performance not only during the peripartal period but also through peak lactation. The objective of this study was to evaluate the effect of feeding ethyl-cellulose RPM on the performance of dairy cows during the peripartal and early-lactation periods.

MATERIALS AND METHODS

Animal Housing and Care

The Institutional Animal Care and Use Committee at the University of Illinois (Urbana; protocol no. 14270) approved all experimental procedures. The experiment began on October 25, 2015, and ended on October 10, 2016. All cows were housed in a freestall system equipped with gate system (American Calan Inc., Northwood, NH) during the prepartum period. After parturition, all cows were housed in tiestalls. Cows were fed once daily (1300 h) at 120% of expected intake and milked 3 times daily (at 0600, 1400, and 2200 h). Standard reproduction and health herd checks and breeding practices were maintained during this study.

Design and Treatment Diets

Sixty multiparous Holstein cows from the University of Illinois Dairy Research Farm were used in a randomized complete block design experiment with 30 cows per treatment. Cows were blocked by the expected parturition day, and the blocks were balanced by parity, previous 305-d milk yield, and BCS. The BCS used to block cows was measured at −30 d before parturition using a 1-to-5 scale (1 = thin, 5 = fat) in increments of 0.25. Cows within each block were randomly assigned to 1 of the 2 treatments. Treatment diets were a basal control diet with no Met supplementation or the basal diet plus ethyl-cellulose RPM (Mepron, Evonik Nutrition and Care GmbH, Hanau-Wolfgang, Germany). Ethyl-cellulose RPM was supplied from −28 to 60 d relative to parturition at a rate of 0.09 and 0.10% of the DMI of the previous day during the prepartum and postpartum periods, respectively. These target values were based on recent experiments demonstrating a benefit in terms of production performance and health of supplementing RPM to achieve a Lys:Met ratio close to 2.8:1 during the prepartum and postpartum periods (Osorio et al., 2013; Zhou et al., 2016b). Mepron is a commercial rumen-protected source of DL-Met that resists ruminal degradation through an ethyl-cellulose film coating. Pellets measure 1.8 × 3 mm and contain 85% DL-Met. The intestinal digestibility coefficient and rumen bypass of Mepron is 90% (Schwab, 1995) and 80% (Overton et al., 1996); therefore, the cows received 6.1 g of Met available for absorption/10 g of Mepron. During the far-off period (from −45 to −29 d), all cows received the same diet (1.33 Mcal/kg of DM and 13.9% CP) with no RPM. The basal close-up (from −28 d to parturition), fresh (from 1 to 30 d), and high-production (from 31 to 60 d) diets contained 1.47 Mcal/kg of DM and 15.3% CP, 1.67 Mcal/kg of DM and 17.7% CP, and 1.61 Mcal/kg of DM and 17.4% CP, respectively. Diets were mixed daily in a tumble mixer, and ethyl-cellulose RPM was top dressed on the TMR. The ingredient and nutrient compositions of the diets fed are reported in Tables 1 and 2. All rations were formulated to meet cow predicted requirements according to NRC (2001).

Data and Sample Collection and Analysis

Dry matter of individual feed ingredients and diets was determined weekly and used to adjust the DM of the TMR accordingly. Weekly samples of ingredients and TMR were frozen at −20°C and composited monthly for analysis of CP (AOAC International, 2000;