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Effects of decreasing metabolizable protein and rumen-undegradable protein on milk production and composition and blood metabolites of Holstein dairy cows in early lactation

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ABSTRACT

This study was conducted to evaluate the effects of decreasing dietary protein and rumen-undegradable protein (RUP) on production performance, nitrogen retention, and nutrient digestibility in high-producing Holstein cows in early lactation. Twelve multiparous Holstein lactating cows (2 lactations; 50 ± 7 d in milk; 47 kg/d of milk production) were used in a Latin square design with 4 treatments and 3 replicates (cows). Treatments 1 to 4 consisted of diets containing 18, 17.2, 16.4, and 15.6% crude protein (CP), respectively, with the 18% CP diet considered the control group. Rumen-degradable protein levels were constant across the treatments (approximately 10.9% on a dry matter basis), whereas RUP was gradually decreased. All diets were calculated to supply a postruminal Lys:Met ratio of about 3:1. Dietary CP had no significant effects on milk production or milk composition. In fact, 16.4% dietary CP compared with 18% dietary CP led to higher milk production; however, this effect was not significant. Feed intake was higher for 16.4% CP than for 18% CP (25.7 vs. 24.3 kg/d). Control cows had greater CP and RUP intakes, which resulted in higher concentrations of plasma urea nitrogen and milk urea nitrogen; cows receiving 16.4 and 15.6% CP, respectively, exhibited lower concentrations of milk urea nitrogen (15.2 and 15.1 vs. 17.3 mg/dL). The control diet had a significant effect on predicted urinary N. Higher CP digestibility was recorded for 18% CP compared with the other diets. Decreasing CP and RUP to 15.6 and 4.6% of dietary dry matter, respectively, had no negative effects on milk production or composition when the amounts of Lys and Met and the Lys:Met ratio were balanced. Furthermore, decreasing CP and RUP to 16.4 and 5.4%, respectively, increased dry matter intake.

Key words: crude protein, milk production, blood metabolite, rumen-protected methionine

INTRODUCTION

Dairy cows utilize dietary CP (N × 6.25) with greater efficiency than other ruminants but still excrete about 2 to 3 times more N in manure than in milk (Broderick, 2003), which results in increased milk production costs and environmental concerns related to N pollution. However, several studies have reported no improvement in milk and protein production when dietary CP is increased from 16.1 to 16.7% to 18.4–18.9% (Cunningham et al., 1996; Broderick, 2003; Leonardi et al., 2003). It is well established that the amount of protein degraded in the rumen increases with increasing CP content of the diet. If RDP exceeds microbial needs, then large amounts of NH_3 are produced, absorbed into the blood, converted into urea in the liver, and excreted in the urine. In the manure, urinary urea can be rapidly hydrolyzed to NH_3 and lost by volatilization into the environment (Muck, 1982). Overfeeding CP also reduces profit margins because of the relatively high cost of protein supplements and the poor efficiency of N use by dairy cows fed high-protein diets (Broderick, 2003).

The main function of dietary CP is to supply dairy cows with MP in the form of absorbed AA to meet their requirements for maintenance and production (Broderick, 2003; Schwab et al., 2007). Hence, dairy cow rations should ideally be balanced for AA rather than for protein (Broderick, 2003; Schwab et al., 2007). The goal in protein nutrition should be optimizing N utilization efficiency, which means minimizing total N intake while meeting the requirements for milk protein synthesis and, thereby, reducing feeding costs and N excretion into the environment. As requirements have not been clearly established for all AA, the best alternative is to balance for MP with the right proportions for at least the 2 AA whose requirements are better known; namely, Lys and Met. To meet the requirements for MP without an excess of N, rations must also be balanced for undegradable (RUP) and degradable (RDP) rumen protein.

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Ruminally synthesized microbial CP (**MCP**), RUP, and, to a much lesser extent, endogenous CP contribute to the passage of MP to the small intestine (NRC, 2001). Metabolizable protein is defined as true protein digested postruminally and AA absorbed by the intestine. If the dietary protein is well balanced, the efficiency of dietary to milk protein conversion will be more than 30% but when the dietary CP is imbalanced, it will be decreased to 23% and most of the consumed protein changes to urea (Broderick, 2006; Schwab et al., 2007). In high-producing cows, MCP supplies a lesser portion of the required protein, and significant amounts of the dietary protein must, therefore, escape ruminal degradation to meet protein needs (Broderick, 2006). However, it has been demonstrated that overfeeding of RUP due to imbalanced AA profile reduces the efficiency of MP utilization for milk protein synthesis. The nutritive value of MP for dairy cows is determined by its profile of essential AA (Broderick, 2006).

Methionine and lysine have been most often identified as the 2 most limiting AA in lactating dairy cows (Schwab et al., 2007). This is largely because of their low concentrations in dietary protein compared with their concentrations in milk and ruminally synthesized MCP. NRC (2001) recommends concentrations of 7.2 and 2.4%, respectively, for Lys and Met in MP for maximal use of MP for milk protein production. It is difficult to achieve these concentrations in practice; hence, the practical concentrations of 6.6 and 2.2% recommended for Lys and Met in MP (Schwab et al., 2003). These can be generally achieved by using a combination of high-Lys protein supplements (e.g., blood, fish, and soybean meals) or a rumen-protected Met (**RPM**) product that not only limits RUP intake to the required levels but also maintains constant RDP and fermentable carbohydrate levels to fix the MCP produced (Schwab et al., 2007). If an RPM product is not available or cannot be used, a blend of RUP supplements will be required to achieve the desired ratio of 3:1 for Lys:Met in MP, which will then lower the concentrations of both Lys and Met in MP (Schwab et al., 2003). The objective of the present study was to investigate the effects of reduced dietary CP and RUP levels on production performance, blood metabolites, nutrient digestibility, and N utilization in high-producing Holstein cows in early lactation when RDP is kept constant and Lys:Met is balanced.

MATERIALS AND METHODS

Cows and Experimental Diets

This study was conducted using 12 high-producing multiparous Holstein cows (second parity, 50 ± 7 DIM, and milk production of 47 ± 4 kg/d). Cows were randomly assigned to 1 of 4 diet sequences in a complete 4 × 4 Latin square design with 4 treatments and 3 squares. Before feeding the cows, all feed ingredients were analyzed for chemical composition (Table 1). The cows were then fed a balanced TMR formulated according to the NRC (2001) model (Table 2). The duration of each experimental period was 21 d, with 16 d for diet adaptation and 5 d for data collection. Cows were held in separator stalls for the duration of the experiment, had free access to water, and were weighed at the beginning (d 1) and end of each period (d 21). The daily CP requirement of large-breed cows (BW of 680 kg at 90 DIM) for 45 kg/d with minimal BW change as predicted by the NRC (2001) model was 17.9%. The cows fed a diet containing 18% CP were used as the control group. Dietary treatments were treatment 1, a TMR containing 18% CP (7% RUP based on DM), treatment 2, a TMR that contained 17.2% CP (6.2% RUP based on DM), treatment 3, a TMR containing 16.4% CP (5.4% RUP based on DM), and treatment 4, a TMR that contained 15.6% CP (4.6% RUP based on DM). The RDP level was kept constant across the diets (almost 11% on a DM basis), and a part of RUP was replaced with corn silage and alfalfa to maintain fixed levels of microbial protein in all diets. Fat powder (Palmak, Gujarat, India) was supplemented so that the diets had the same amount of NE_L (Tables 2 and 3). Decreasing dietary RUP gradually led to declining amounts of MP, especially from RUP sources. Predicted microbial protein synthesis remained invariable due to the constant level of RDP supplemented with urea (Table 3). Ruminally protected methionine (Mepron, Degussa Corp., Kennesaw, GA) was used to meet the requirements (59 g/d in MP) based on the NRC (2001) model (Table 3). All diets were formulated to contain a postruminally available Lys:Met ratio of approximately 3:1, as recommended by Clark et al. (1992) and the Mepron dairy ration evaluator (version 2.1, 1999; Degussa Huls Corp., Bannockburn, IL).

Sample Collection and Analysis

The experimental diets were fed as TMR twice daily at approximately 0800 and 1600 h. The feed offered was adjusted daily to yield 5 to 10% orts. Samples of individual feeds and orts (about 0.5 kg) were taken daily and stored at −20°C. Weekly composite samples from feeds and orts were dried at 60°C for 48 h, and the as-fed composition of the diets was adjusted every week. Weekly feed composites were ground through a 1-mm screen (Wiley mill, Arthur H. Thomas, Philadelphia, PA) and analyzed for DM at 105°C (AOAC, 1980), ash (AOAC International, 2000; method 942.05), NDF (Van Soest et al., 1991), CP (AOAC International,