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Feeding protein supplements in alfalfa hay-based lactation diets improves nutrient utilization, lactational performance, and feed efficiency of dairy cows[1]

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ABSTRACT

Due to the increasing cost of soybean meal and concerns of excess N being excreted into the environment, new protein supplements have been developed. Two products that have shown potential in increasing N utilization efficiency are slow-release urea (SRU; Optigen; Alltech Inc., Nicholasville, KY) and ruminal-escape protein derived from yeast (YMP; DEMP; Alltech Inc.). The objective of this study was to assess the effects of feeding these 2 supplements in alfalfa hay-based [45.7% of forage dietary dry matter (DM)] dairy diets on nutrient utilization, feed efficiency, and lactational performance of dairy cows. Twelve multiparous dairy cows were used in a triple 4 × 4 Latin square design with one square consisting of ruminally cannulated cows. Treatments included (1) control, (2) SRU-supplemented total mixed ration (SRUT), (3) YMP-supplemented total mixed ration (YMPT), and (4) SRU- and YMP-supplemented total mixed ration (SYT). The control consisted only of a mixture of soybean meal and canola meal in a 50:50 ratio. The SRU and the YMP were supplemented at 0.49 and 1.15% DM, respectively. The experiment consisted of 4 periods lasting 28 d each (21 d of adaptation and 7 d of sampling). Cows fed YMPT and SYT had decreased intake of DM, and all supplemented treatments had lower crude protein intake compared with those fed the control. Milk yield tended to have the greatest increase in YMPT compared with the control (41.1 vs. 39.7 kg/d) as well as a tendency for increased milk fat and protein yields. Feed efficiencies based on yields of milk, 3.5% fat-corrected milk, and energy-corrected milk increased at 10 to 16% due to protein supplementation. Cows fed protein supplements partitioned less energy toward body weight gain, but tended to partition more energy toward milk production. Efficiency of use of feed N to milk N increased by feeding SRUT and YMPT, and milk N-to-manure N ratio increased with YMPT. Overall results from this experiment indicate that replacing the mixture of soybean meal and canola meal with SRU and YMP in alfalfa hay-based dairy diets can be a good approach to improve nutrient utilization efficiencies in lactating dairy cows.
Key words: alfalfa hay-based dairy diet, lactational performance, protein supplement

INTRODUCTION

Feeding high-forage diets to lactating dairy cows provides many benefits, including increased digestibility as well as decreasing the risk of ruminal acidosis when compared with high-concentrate diets (Broderick, 2003). The Intermountain West (i.e., Utah, Idaho, Wyoming, Montana, and parts of Arizona and Nevada) is unique in that typical lactation dairy diets contain relatively greater alfalfa hay (**AH**) compared with the Midwestern United States; baled AH commonly provides 50 to 75% of the dietary forage with total forage levels averaging 45 to 55% of dietary DM (Holt et al., 2010). With optimal growing conditions, it is not uncommon to feed high-quality AH with at least 21.3 and 38.3% of DM as CP and NDF, on average, respectively (Holt et al., 2013). Although feeding AH provides CP and enough forage NDF to support potential milk production, its CP is extensively broken down in the rumen by microbes, resulting in less-than-optimal microbial CP (**MCP**) synthesis, increased energy costs to convert ruminal NH_3-N to urea, and excess N excretion into the environment (Holt, 2013). Because of the poor utilization of CP in alfalfa-based diets by the animal (Castillo et al., 2001), a need exists to discover strategies to improve nutrient utilization, including feed N in lactation rations, especially in the Intermountain West region.

Microbial protein is the main source of protein for dairy cows, providing 50 to 80% of total absorbable protein with higher concentrations of Met and Lys, the 2 most limiting AA for milk production (NRC, 2001).

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It is important to maintain MCP synthesis by meeting the protein requirement of the cow with the lowest dietary CP input, while still maintaining the best ratio between RDP and RUP to support milk production and optimize N utilization efficiency (Agle et al., 2010). Alfalfa hay alone is unable to meet these requirements and, therefore, must be supplemented with other protein sources. Soybean meal (**SBM**) is a common protein source, but because of its high degradability in the rumen as well as its increasing cost, alternative protein supplements have been developed. Urea is a chemically synthesized NPN that can be used to supplement dietary CP, but is quickly and extensively broken down in the rumen, increasing the ammonia concentration rapidly. Alltech Inc. (Nicholasville, KY) has developed 2 commercial protein supplement products: (1) slow-release urea (**SRU**; Optigen), which is urea coated in vegetable oil, slowing its release of ammonia, and (2) yeast-derived MCP (**YMP**; DEMP) with an AA profile that more closely matches the composition of ruminal MCP and presumably flows with the liquid phase of the rumen, allowing for increased absorption of AA in the small intestine (Sabbia et al., 2012). In a recent study, when SRU was added to high-forage dairy diets consisting of 23.7% corn silage and 27.7% alfalfa silage of total dietary DM where SRU replaced SBM, there was an increase in milk yield compared with a control diet (35.9 vs. 35.4 kg/d; Inostroza et al., 2010). However, when the rumen reaches the point of NH_3-N overflow, adding more RDP will not increase MCP synthesis (Satter and Slyter, 1974). Instead, if a high-quality RUP is supplied, and a sufficient amount of RDP already exists, the amount of AA absorbed in the small intestine can be increased, which supports milk production (Santos et al., 1998; Kalscheur et al., 2006). For example, Sabbia et al. (2012) reported improved milk and TS production when SBM was replaced with YMP in high-forage dairy diets. Therefore, SRU and YMP have great potential to improve nutrient utilization and lactational performance when supplemented in lactation diets consisting of a high concentration of AH. The objective of the current study was to test the hypothesis that adding SRU or YMP, or both, to a high-forage lactation diet consisting of a high dietary concentration of AH would improve N utilization efficiency and enhance the lactational performance of dairy cows.

MATERIALS AND METHODS

The dairy cows used in this study were cared for according to the Live Animal Use in Research Guidelines of the Institutional Animal Care and Use Committee at Utah State University (Logan). The study was conducted at the Caine Dairy Research Center (Wellsville, UT), Utah State University from October 18, 2012, to April 15, 2013.

Cows, Experimental Design, and Diets

Twelve multiparous lactating Holstein cows, 4 of which were surgically fitted with rumen cannula, were used. Cows began the experiment averaging 46 ± 8.1 DIM. Average BW were 717 ± 48.9 and 730 ± 43.2 kg at the beginning and the end of the experiment, respectively.

A 4 × 4 Latin square (replicated 3 times) design was used with one square comprising ruminally cannulated cows. The experiment consisted of 4 periods lasting 28 d each (21 d of treatment adaptation and 7 d of data and sample collection). Within each square, cows were randomly assigned to a sequence of 4 dietary treatments without or with added protein supplements: no supplement as a control, a TMR containing SRU (**SRUT**), a TMR containing YMP (**YMPT**), or a TMR containing SRU and YMP (**SYT**). The SRU was supplemented at 0.49% DM in the SRUT and the SYT in order for cows to consume approximately 127 g/d. The dietary concentration of the SRU was chosen based on a previous lactation study (Inostroza et al., 2010). Slow-release urea has a CP concentration of 256% (41% N × 6.25), which is slightly lower than urea due to the vegetable oil coating of SRU. The YMP was added at 1.15% DM in the YMPT and the SYT treatments in order for cows to consume approximately 299 g/d (Sabbia et al., 2012). The CP concentration of YMP is 44.0% and contains 10.9% Arg, 5.1% His, 11.1% Ile, 17.6% Leu, 16.0% Lys, 3.6% Met, 9.6% Phe, 10.0% Thr, 2.9% Trp, and 13.4% Val of total EAA (Sabbia et al., 2012). As a total of CP, YMP contains approximately 55 to 60% insoluble protein (Tricarico et al., 2011), and is estimated to have a passage rate of 7%/h by NRC (2001). The passage rate for YMP is underestimated by NRC (2001) because YMP has a very similar passage rate to that of the ruminal liquid phase, which can range from 12 (Agle et al., 2010) to 17%/h (Choi et al., 2002). Isonitrogenous conditions between treatments were maintained by replacing the mixture of SBM and canola meal (**SBMCM**) at a ratio of 50:50 with the SRU or the YMP, or both (Table 1), and the SBMCM had 74 and 26% RDP and RUP, respectively, as a percentage of CP. In addition, diets had similar RDP and RUP fractions.

Diets were formulated based on the NRC (2001) recommendations to provide sufficient NE_L, MP, vitamins, and minerals to produce 40 kg of milk/d with 3.5% fat and 3.0% true protein (**TP**). Diets were isonitrogenous and isocaloric (NE_L basis), averaging 16.0% CP and