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Utilization of protein in red clover and alfalfa silages by lactating dairy cows and growing lambs

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ABSTRACT

Feeding trials were conducted with lactating cows and growing lambs to quantify effects of replacing dietary alfalfa silage (AS) with red clover silage (RCS) on nutrient utilization. The lactation trial had a 2 × 4 arrangement of treatments: AS or RCS fed with no supplement, rumen-protected Met (RPM), rumen-protected Lys (RPL), or RPM plus RPL. Grass silage was fed at 13% of dry matter (DM) with AS to equalize dietary neutral detergent fiber (NDF) and crude protein contents. All diets contained (DM basis) 5% corn silage and 16% crude protein. Thirty-two multiparous (4 ruminally cannulated) plus 16 primiparous Holstein cows were blocked by parity and days in milk and fed diets as total mixed rations in an incomplete 8 × 8 Latin square trial with four 28-d periods. Production data (over the last 14 d of each period) and digestibility and excretion data (at the end of each period) were analyzed using the MIXED procedure of SAS (SAS Institute Inc., Cary, NC). Although DM intake was 1.2 kg/d greater on AS than RCS, milk yield and body weight gain were not different. However, yields of fat and energy-corrected milk as well as milk content of fat, true protein, and solids-not-fat were greater on AS. Relative to AS, feeding RCS increased milk and energy-corrected milk yield per unit of DM intake, milk lactose content, and apparent N efficiency and reduced milk urea. Relative to AS, apparent digestibility of DM, organic matter, NDF, and acid detergent fiber were greater on RCS, whereas apparent and estimated true N digestibility were lower. Urinary N excretion and ruminal concentrations of ammonia, total AA, and branched-chain volatile fatty acids were reduced on RCS, indicating reduced ruminal protein degradation. Supplementation of RPM increased intake, milk true protein, and solids-not-fat content and tended to increase milk fat content. There were no silage × RPM interactions, suggesting that RPM was equally limiting on both AS and RCS. Supplementation of RPL did not influence any production trait; however, a significant silage × RPL interaction was detected for intake: RPL reduced intake of AS diets but increased intake of RCS diets. Duplicated metabolism trials were conducted with lambs confined to metabolism crates and fed only silage. After adaptation, collections of silage refusals and excreta were made during ad libitum feeding followed by feeding DM restricted to 2% of body weight. Intake of DM was not different when silages were fed ad libitum. Apparent digestibility of DM, organic matter, NDF, and hemicellulose was greater in lambs fed RCS on both ad libitum and restricted intake; however, acid detergent fiber digestibility was only greater at restricted intake. Apparent and estimated true N digestibility was substantially lower, and N retention was reduced, on RCS. Results confirmed greater DM and fiber digestibility in ruminants and N efficiency in cows fed RCS. Specific loss of Lys bioavailability on RCS was not observed. Based on milk composition, Met was the first-limiting AA on both silages; however, Met was not limiting based on production and nutrient efficiency. Depressed true N digestibility suggested impaired intestinal digestibility of rumen-undegraded protein from RCS.

Key words: milk production, alfalfa silage, red clover, silage, nitrogen utilization

INTRODUCTION

Forages such as alfalfa (*Medicago sativa*) are often harvested as silage rather than hay because greater mechanization and speed of harvest reduces risk of weather damage. However, during ensiling, typically more than half of the CP in alfalfa is broken down to small peptides and AA by enzymes released from cell rupture in the foliage (McDonald et al., 1991). Red clover (*Trifolium pratense*) has a polyphenol oxidase

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enzyme (**PPO**) system that forms *o*-quinones from endogenous plant *o*-diphenols; these *o*-quinones react with foliage proteins to substantially reduce their breakdown in both the silo (Lee et al., 2004) and the rumen (Brito et al., 2007). Lower yields, poorer persistency, and slower field drying rates of red clover have limited its widespread use in North America. We have conducted several lactation trials to determine the relative feeding value of alfalfa silage (**AS**) and red clover silage (**RCS**) for dairy cows. A summary from 5 trials showed similar yields of milk and protein, reduced MUN, and 3.5 percentage units greater N efficiency when lactating cows were fed RCS containing one-third less NPN than AS (Broderick, 2002); however, DMI and milk fat yield were higher on AS.

Lee et al. (2009) speculated that the PPO reaction mechanism might result in greater reduction in bioavailability of Met rather than Lys in the RUP in RCS. However, Prigent et al. (2008) observed that, among the essential AA, Lys residues were the most reactive to *o*-quinone formed from the *o*-diphenol chlorogenic acid. Relative responsiveness to feeding Met or Lys as rumen-protected AA in cows fed RCS versus AS may indicate which of these essential AA is most affected by the PPO action. Our hypothesis was that PPO activity in RCS would cause greater reduction of Lys rather than Met bioavailability but that increased RUP formation would improve N efficiency. Therefore, the objectives of these experiments were to assess, relative to AS, whether PPO action in RCS caused (1) greater reduction in bioavailability of Met or Lys and (2) a net improvement in N utilization.

MATERIALS AND METHODS

Harvest and Composition of Legume Silages

Alfalfa and red clover were both established in August 2009 at the US Dairy Forage Center farm (Prairie Du Sac, WI) on fields fertilized with P and K according to soil test. Alfalfa silage was harvested from the second cutting on June 25, 2010, using a conventional mower conditioner; wilted for 1 to 2 d to about 40% DM; chopped to a theoretical length of 2.9 cm; and ensiled without additives in a plastic bag (Ag-Bag Systems, St. Nazianz, WI). Red clover silage (cultivar = Arlington) was harvested using the same equipment from the first cutting on May 28 and 29, 2010, and, to obtain additional forage DM, from the second cutting on June 30, 2010; wilted for 2 d to about 40% DM; and ensiled in separate plastic bags (Ag-Bag Systems) for each cutting. Approximately twice as much RCS was harvested on May 28 to 29 as on June 30, 2010. No forage was rained on during any harvest. Samples of forage were collected from every load, dried for 48 h at 60°C, and then analyzed for DM at 105°C, total N by combustion (Leco 2000; Leco Instruments Inc., St. Joseph, MI), and NDF using heat stable α-amylase (Van Soest et al., 1991) and Na_2SO_3 (Hintz et al., 1996). Crude protein (total N × 6.25) and NDF were computed on the basis of 105°C DM. Mean (SD) composition before ensiling of alfalfa was 43.0% (5.5) DM, 21.8% (1.2) CP, and 39.3% (1.4) NDF. Mean compositions before ensiling of red clover were 40.7% (3.2) DM, 17.0% (1.6) CP, and 39.3% (2.0) NDF for the first cutting and 42.0% (2.0) DM, 18.1% (1.9) CP, and 40.0% (1.7) NDF for the second cutting. Prior to silo opening before the lactation trial, AS had been ensiled for 62 d and RCS had been ensiled for 90 d (first cutting) and 57 d (second cutting). At the end of the lactation study, 8 compressed and wrapped rectangular bales (2 from AS, 4 from the first cutting of RCS, and 2 from the second cutting of RCS) containing 592 to 810 kg of as-fed silage were made using the compacting machine described by Digman et al. (2010). These baled silages were stored under cover from December 2010 to April 2011 and then fed in the lamb N metabolism trials described below.

Lactation Trial

Thirty-two multiparous Holstein cows [4 of which were fitted with permanent 10-cm ruminal cannulas (Bar Diamond Inc., Parma, ID); mean (SD) 2.4 (0.7) parity, 111 (35.4) DIM, 50 (4.9) kg of milk/d, and 582 (55) kg of BW] plus 16 primiparous cows [mean (SD) 126 (29.7) DIM, 46 (2.0) kg of milk/d, and 512 (34) kg of BW] were used in the trial. Cows were distributed by DIM and parity to 3 pairs of 2 blocks each (2 pairs of blocks of multiparous cows and 1 pair of blocks of primiparous cows) and randomly assigned to the 2 sets of 8 treatment sequences (design "18", Table 4 in Davis and Hall, 1969). All cows were injected every other week with bST (500 mg of Posilac; Elanco Animal Health, Greenfield, IN) beginning around 60 DIM; injections were synchronized such that animals received a full dose on d 1 followed by subsequent bST doses at 14-d intervals throughout the trial. Cows were housed in tiestalls and had free access to water. The Animal Care and Use Committee of the College of Agricultural and Life Sciences of the University of Wisconsin–Madison approved all procedures involving the animals.

Diets were fed as TMR and contained either AS plus grass silage (4 diets) or RCS (4 diets), corn silage, rolled high-moisture corn, dried finely ground shelled corn, solvent-extracted soybean meal, and a mineral–vitamin supplement. The RCS from cuttings 1 and 2 was mixed into the TMR in DM ratios of 2:1. The grass silage was made from a mixture largely of bluegrass,