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Effects of Feeding Formate-Treated Alfalfa Silage or Red Clover Silage on the Production of Lactating Dairy Cows[1]

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ABSTRACT

In trial 1, 15 Holsteins were fed 3 total mixed rations (TMR) with 33% neutral detergent fiber in 3 × 3 Latin squares (28-d periods). Two TMR contained (dry matter basis): 40% control alfalfa silage (CAS) or 40% ammonium tetraformate-treated alfalfa silage (TAS), 20% corn silage (CS), 33% high-moisture shelled corn (HMSC), 6% solvent soybean meal (SSBM), and 18% crude protein (CP); the third TMR contained 54% red clover silage (RCS), 6% dried molasses, 33% HMSC, 6% SSBM, and 16.3% CP. Silages differed in nonprotein N (NPN) and acid detergent insoluble N (ADIN; % of total N): 50 and 4% (CAS); 45 and 3% (TAS); 27 and 8% (RCS). Replacing CAS with TAS increased intake, yields of milk, fat-corrected milk, protein, and solids-not-fat, and apparent dry matter and N efficiency. Replacing CAS with RCS increased intake and N efficiency but not milk yield. Replacing CAS or TAS with RCS lowered milk urea N, increased apparent nutrient digestibility, and diverted N excretion from urine to feces. In trial 2, 24 Holsteins (8 ruminally cannulated) were fed 4 TMR in 4 × 4 Latin squares (28-d periods). Diets included the CAS, TAS, and RCS (RCS1) fed in trial 1 plus an immature RCS (RCS2; 29% NPN, 4% ADIN). The CAS, TAS, and RCS2 diets contained 36% HMSC and 3% SSBM and the RCS1 diet contained 31% HMSC and 9% SSBM. All TMR had 50% legume silage, 10% CS, 27% neutral detergent fiber, and 17 to 18% CP. Little difference was observed between cows fed CAS and TAS. Intakes of DM and yields of milk, fat-corrected milk, fat, protein, lactose, and solids-not-fat, and milk fat and protein content were greater on alfalfa silage vs. RCS. Blood urea N, milk urea N, ruminal ammonia, and total urinary N excretion were reduced on RCS, suggesting better N utilization on the lower NPN silage. Apparent N efficiency tended to be higher for cows fed RCS but there was no difference when N efficiency was expressed as kilograms of milk yield per kilogram of total N excreted.
Key words: production, silage, nitrogen utilization, dairy cow

INTRODUCTION

Between 44 and 87% of the CP in alfalfa silage (**AS**) was found to be degraded to NPN in the silo whereas the comparable value for red clover silage (**RCS**) was only 7 to 40% (Papadopoulos and McKersie, 1983; Muck, 1987). Extensive protein degradation in the silo may lead to both reduced DMI and N efficiency in ruminants (Waldo, 1985), raising environmental concerns regarding excess urinary N excretion. Lower NPN in RCS results from the action of polyphenol oxidase, which converts *o*-diphenols, present at high concentration in red clover, into reactive *o*-quinones (Jones et al., 1995c). These compounds react rapidly with both proteases and substrate proteins, reducing the extent of proteolysis in the silage mass (Hatfield and Muck, 1999). Lower proportions of NPN in RCS may account for its better protein utilization than AS when fed as the sole forage to lactating dairy cows (Broderick, 2002). However, production results have been inconsistent with RCS. When RCS replaced AS in the diet, Hoffman et al. (1997) observed increased milk yield and Broderick et al. (2001) found greater apparent total tract digestibility of DM and NDF and better feed efficiency. Conversely, Broderick et al. (2000) reported lower milk yield in 2 out of 3 experiments when cows were fed RCS rather than AS, despite higher energy digestibility. Results from feeding studies comparing these 2 forages have nearly always been confounded by greater CP content in AS.

There is extensive European evidence that formic acid treatment reduces NPN formation in direct-cut grass silages and improves their nutritive value for ruminants (McDonald et al., 1991). Nagel and Broder-

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ick (1992) showed that formic acid treatment of wilted AS decreased NPN formation and substantially improved N utilization when fed to lactating dairy cows. Ammonium tetraformate (**ATF**) is a buffered form of formic acid containing 1 mol of ammonia for every 4 mols of formate. This compound is less corrosive and easier to handle than formic acid and has been shown to reduce proteolysis in direct-cut grass silages (Randby, 2000). It seemed likely that ATF also would be effective for reducing proteolysis in AS.

Two feeding trials were conducted to investigate the effects of silage NPN content on production, ruminal metabolism and nutrient utilization in lactating dairy cows fed AS or RCS as their principal forage. In both trials, ATF was added to alfalfa at ensiling to reduce proteolysis and the RCS that was fed had similar NDF content (and lower CP) compared with the AS. An earlier maturity RCS with comparable CP to the AS also was fed in the second study.

MATERIALS AND METHODS

Harvest and Composition of AS and RCS

Alfalfa silage was harvested from third cutting. Red clover was seeding-year forage and was judged visually to be a pure stand. The first RCS (**RCS1**) was harvested from first cutting when some flowers were present, at a later maturity intended to produce forage with NDF content similar to the AS, as had been done in earlier feeding trials (Broderick et al., 2000, 2001). The second RCS (**RCS2**) was harvested from second cutting when no flowers were present, at an earlier maturity intended to produce forage with CP content similar to the AS. All forages were cut using a conventional mower conditioner and field-wilted to about 40% DM. This DM was attained in 1 d with the AS but tedding plus an additional drying day was required for the 2 RCS. Forages were chopped to a theoretical length of 2.9 cm. The control alfalfa and both red clovers were ensiled without additives. Alternate windrows of alfalfa were harvested either as the control AS (**CAS**) or treated using field application while chopping with ATF (GrasAAT; Norsk Hydro ASA, Porsgrunn, Norway) to reduce NPN formation in the silo (**TAS**). Approximately 7 L of ATF was applied per ton of wet silage based on the weight of silage harvested and the volume of GrasAAT utilized. Three forages (CAS, TAS, and RCS1) were ensiled in upright concrete stave silos; RCS2 was ensiled in a plastic bag (Ag-Bag International Ltd., Warrenton, OR). No forage was rained on during harvest.

Weekly composite samples were prepared for all silages from daily 0.5-kg samples collected during feedout throughout both trials and stored at −20°C until analyzed. At the end of the trials, weekly composites were thawed, water extracts were prepared (Muck, 1987), and extract pH was measured. Extracts were deproteinized (Muck, 1987) and then analyzed for total AA and ammonia (Broderick et al., 2004) using flow-injection (Lachat Quik-Chem 8000 FIA, Lachat Instruments, Milwaukee, WI) and for NPN (Muck, 1987) using a combustion assay (Mitsubishi TN-05 Nitrogen Analyzer; Mitsubishi Chemical Corp., Tokyo, Japan). Thawed weekly composites also were dried at 60°C (48 h), ground through a 1-mm screen (Wiley mill, Arthur H. Thomas, Philadelphia, PA), and analyzed for DM at 105°C, ash, and OM (AOAC, 1980), total N by combustion assay (Leco 2000, Leco Instruments, Inc., St. Joseph, MI), sequentially (Van Soest et al., 1991) for NDF and ADF using heat stable α-amylase and Na_2SO_3 (Hintz et al., 1995), and for neutral detergent insoluble N (**NDIN**) and ADIN. Mean composition data for the silages fed during both trials are in Table 1.

Trial 1

Twelve multiparous (average parity 2.8, SD 1.0) and 3 primiparous Holstein cows averaging (mean ± SD) 33 ± 5 kg of milk/d, 256 ± 48 DIM, and 643 ± 72 kg of BW at the beginning of the trial were blocked into 5 squares by parity and DIM and, within each square, randomly assigned to treatment sequences in replicated 3 × 3 Latin squares. Each experimental period lasted 28 d and consisted of 14 d for diet adaptation and 14 d for data and sample collection. All cows were injected with bST (500 mg of Posilac, Monsanto, St. Louis, MO) beginning on d 1 of the trial and at 14-d intervals thereafter until completion of the study. Cows were housed in tie stalls and had free access to water throughout the experiment. Care and handling of the animals was conducted as outlined by the guidelines of the University of Wisconsin institutional animal care and use committee.

Diets were fed as TMR and were formulated from CAS, rolled corn silage, rolled high-moisture shelled corn (**HMSC**), and solvent-extracted soybean meal (**SSBM**) (diet CAS); TAS, rolled corn silage, HMSC, and SSBM (diet TAS); and RCS1, dried molasses, HMSC, and SSBM (diet RCS). Rolled corn silage was added to the AS diets to equalize NDF; dried molasses was added to the RCS diet to improve intake. Vitamin and mineral supplements also were fed. Table 2 gives the composition and chemical analyses of these 3 diets. Diets were offered once daily at 1000 h, and orts were collected daily at 0900 h. The amount of feed offered to the animals was adjusted daily to yield refusals of about 5 to 10% of intake.

Daily samples of approximately 0.5 kg of silages, HMSC, TMR, and orts were collected, stored at −20°C,