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Corn silage hybrid type and quality of alfalfa hay affect dietary nitrogen utilization by early lactating dairy cows[1]

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ABSTRACT

This experiment was conducted to determine the effects of corn silage (CS) hybrids and quality of alfalfa hay (AH) in high-forage dairy diets on N utilization, ruminal fermentation, and lactational performance by early-lactating dairy cows. Eight multiparous Holstein cows were used in a duplicated 4 × 4 Latin square experiment with a 2 × 2 factorial arrangement of dietary treatments. The 8 cows (average days in milk = 23 ± 11.2) were surgically fitted with ruminal cannula, and the 2 squares were conducted simultaneously. Within square, cows were randomly assigned to a sequence of 4 diets: conventional CS (CCS) or brown midrib CS (BMR) was combined with fair-quality AH [FAH: 46.7% neutral detergent fiber (NDF) and 18.4% crude protein (CP)] or high-quality AH (HAH: 39.2% NDF and 20.7% CP) to form 4 treatments: CCS with FAH, CCS with HAH, BMR with FAH, and BMR with HAH. Diets were isonitrogenous across treatments, averaging 15.9% CP. Each period lasted a total of 21 d, with 14 d for treatment adaptation and 7 d for data collection and sampling. Intake of DM and milk yield did not differ in response to CS hybrids or AH quality. Although feeding BMR-based diets decreased urinary N output by 24%, it did not affect fecal N output. Feeding HAH decreased urinary N output by 15% but increased fecal N output by 20%. Nitrogen efficiency [milk N (g/d)/intake N (g/d)] tended to increase for BMR treatments. Ruminal ammonia-N concentration was lower for cows fed BMR-based diets than for those fed CCS-based diets but was not affected by quality of AH. Feeding BMR-based diets or HAH decreased milk urea N concentration by 23 or 15%, respectively, compared with CCS-based diets or FAH. Total volatile fatty acid concentration increased with HAH but was not influenced by CS hybrids. Feeding BMR-based diets decreased urinary N-to-fecal N ratio (UN:FN), and it was further reduced by feeding HAH. Although cows fed the BMR-based diets tended to increase milk N-to-manure N ratio, the quality of AH did not affect the ratio. The lower ratio of UN:FN with a higher ratio of milk N-to-manure N ratio for the BMR-based diets indicates that feeding BMR may reduce manure ammonia-N by reducing excretion of urinary N and increasing secretion of milk N per unit of manure N excreted.
Key words: dairy cow, brown midrib corn silage, alfalfa hay, nitrogen excretion

INTRODUCTION

A major emphasis has been placed on feeding less dietary CP to high-producing dairy cattle for 2 primary reasons. One is to improve profitability by increasing the efficiency of converting feed N intake to milk N output while maintaining overall milk production. The other is that feeding diets lower in CP decreases the excretion of N to the environment and consequently lowers ammonia (NH_3) emissions (Weiss, 2004). Olmos Colmenero and Broderick (2006) reported that diets containing 16.5% CP were sufficient for maximizing production of milk and milk protein in dairy cows with minimal N excretion to the environment compared with diets with higher CP concentration. It is well established that, as the CP concentration of the diet increases, the amount of protein degraded in the rumen also increases (Olmos Colmenero and Broderick, 2006). Losses of dietary N can be reduced by decreasing protein degradation in the rumen or by increasing N use by ruminal microorganisms. Under typical dairy cattle feeding conditions, manipulation of RDP or the efficiency of N use in the rumen is the most effective strategy to reduce N losses (Tamminga, 1996).

Various chemical and physical dietary factors can affect ruminal fermentation and, consequently, N efficiency and milk production. Overall intake of N influences the amount of N excreted via manure, whereas types of carbohydrate and forage have greater effects on the route (fecal or urinary) of excretion (Wattiaux and Karg, 2004). The 2 most common forages fed to

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dairy cows in the United States are alfalfa and corn silage (**CS**); they complement each other by providing available N and fermentable energy for microbial CP synthesis in the rumen, respectively. In general, alfalfa is low in fiber and high in CP, and it degrades rapidly and extensively in the rumen compared with other forages (Martin et al., 2004). Efficiency of N use in alfalfa silage-based diets is relatively low (Castillo et al., 2001) because of the high concentration of RDP (Nagel and Broderick, 1992). Due to the fermentation process, alfalfa silage contains more NPN than alfalfa hay (**AH**; 52 vs. 10%, respectively; Martin et al., 2004). Conversely, CS is rich in starch and thus provides a key source of fermentable energy to the rumen microbial population. Corn silage made from brown midrib hybrids typically has higher OM degraded in the rumen and increases flow of microbial N to the small intestines, without affecting total-tract apparent digestibility (Oba and Allen, 2000). Because of lower feed intake but higher milk production in early lactation, nutrient utilization by dairy cows is particularly critical in this lactation phase to achieve potential production of dairy cows with a reduction in nutrient excretion. Thus, the current lactation study was performed to investigate our hypothesis that feeding dairy cows in early lactation a 16% CP diet with fair-quality AH (**FAH**) in brown midrib CS (**BMR**)-based diets would maintain milk production, reduce urinary N excretion, and improve N efficiency compared with those fed high-quality AH (**HAH**) in conventional CS (**CCS**)- or BMR-based diets. We envisioned that overall effects of the combinations of main dairy forages could demonstrate a significant contribution of forages to nutrient utilization and management and might be used to formulate optimal dairy rations with relatively high forage concentrations to improve environmental performance of lactating 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 (approved protocol number: 1436). The study was conducted at the Caine Dairy Research Center, Utah State University (Wellsville) from February to June 2011.

Cows, Experimental Design, and Diets

Eight multiparous lactating Holstein cows surgically fitted with ruminal cannula were used. Days in milk averaged 23 ± 11.2 at the start of the experiment. Average BW was 639 ± 53.6 kg at the beginning of the experiment and 649 ± 42.2 kg at the end of the experiment.

The design of the experiment was a double 4 × 4 Latin square. Within each square, cows were randomly assigned to a sequence of 4 diets during each of the four 21-d periods (14 d of treatment adaptation and 7 d of data collection and sampling). A 2 × 2 factorial arrangement was used: CCS or BMR was combined with FAH (46.7% NDF and 18.4% CP) or HAH (39.2% NDF and 20.7% CP; Table 1) to form 4 treatments: CCS with FAH, CCS with HAH, BMR with FAH, and BMR with HAH (Table 2). Diets were isonitrogenous across treatments, averaging 15.9% CP. Diets are typical of high-producing dairy cows in the Intermountain West (i.e., Utah, Idaho, Wyoming, Montana, and parts of Arizona and Nevada) with 42% of the forage DM coming from AH.

Two CS hybrids, brown midrib corn hybrid (Mycogen F2F569, Mycogen Seeds, Indianapolis, IN) and conventional corn hybrid (DeKalb DKC61-72, Monsanto Com-

Table 1. Chemical composition (means ± SD) of forages (n = 4 sample replicates)

Item, % of DM	Forage[1]			
	CCS	BMR	FAH	HAH
DM, %	28.5 ± 1.96	27.5 ± 1.30	90.4 ± 0.85	93.8 ± 0.86
OM	94.7 ± 0.31	93.3 ± 0.42	89.4 ± 0.70	89.1 ± 0.32
CP	8.40 ± 0.419	8.30 ± 0.369	18.4 ± 0.27	20.7 ± 1.49
NDF	44.8 ± 2.45	52.2 ± 2.60	46.7 ± 3.04	39.2 ± 3.02
IVNDFD,[2] %	62.2 ± 2.96	71.4 ± 1.59	37.9 ± 4.43	46.7 ± 3.99
ADF	25.0 ± 1.36	28.4 ± 1.38	32.6 ± 1.60	28.5 ± 3.09
Ether extract	2.71 ± 0.132	2.22 ± 0.231	1.63 ± 0.112	2.20 ± 0.113
ADL	2.97 ± 0.28	2.94 ± 0.13	6.08 ± 0.52	5.02 ± 1.0
NFC[3]	38.8	30.6	22.7	27.0

[1]CCS = conventional corn silage; BMR = brown midrib corn silage; FAH = fair-quality alfalfa hay; HAH = high-quality alfalfa hay.

[2]IVNDFD = in vitro NDF degradability measured at 30 h of incubation.

[3]NFC = 100 – CP – NDF – ether extract – ash.