J. Dairy Sci. 98:1–11
http://dx.doi.org/10.3168/jds.2015-9348

Effects of feeding birdsfoot trefoil hay on neutral detergent fiber digestion, nitrogen utilization efficiency, and lactational performance by dairy cows[1]

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ABSTRACT

This experiment was conducted to determine effects of feeding birdsfoot trefoil hay-based diets in comparison with an alfalfa hay-based diet on N utilization efficiency, ruminal fermentation, and lactational performance by mid-lactation dairy cows. Nine multiparous lactating Holstein cows (131 ± 22.6 d in milk), 3 of which were rumen fistulated, were fed 3 experimental diets in a replicated 3 × 3 Latin square design with 3 periods of 14 d of adaptation and 7 d of data and sample collection. Within squares, cows were randomly assigned to diets as follows: alfalfa hay-based diet (AHT), alfalfa and birdsfoot trefoil hay-based diet (ABT), and birdsfoot trefoil hay-based diet (BT). Intakes of dry matter and crude protein were similar across treatments, whereas ABT and BT diets resulted in decreased fiber intake compared with AHT. Feeding BT tended to increase neutral detergent fiber digestibility compared with AHT and ABT. Milk yield tended to increase for cows consuming ABT or BT diets. Milk true protein concentration and yield were greater for cows consuming ABT relative to those fed AHT. Concentration of total volatile fatty acids tended to increase by cows fed BT compared with those fed AHT and ABT. Feeding birdsfoot trefoil hay in a total mixed ration resulted in a tendency to decrease acetate proportion, but it tended to increase propionate proportion, leading to a tendency to decrease acetate-to-propionate ratio. Whereas concentration of ammonia-N was similar across treatments, cows offered BT exhibited greater microbial protein yield relative to those fed AHT and ABT. Cows offered birdsfoot trefoil hay diets secreted more milk N than AHT, resulting in improved N utilization efficiency for milk N. The positive effects due to feeding birdsfoot trefoil hay were attributed to enhanced neutral detergent fiber digestion, and thus it could replace alfalfa hay in high-forage dairy diets while improving N utilization efficiencies and maintaining lactational performance compared with alfalfa hay.
Key words: alfalfa hay, birdsfoot trefoil hay, lactating dairy cows, nitrogen utilization efficiency

INTRODUCTION

Forage quality affects feed intake and energy density, lactational performance, cow health, and feed cost. Dairy producers in the western United States use alfalfa (*Medicago sativa* L.) hay for most of the forage portion in dairy diets. Alfalfa is a very palatable legume that is high in CP and low in fiber, and thus feeding alfalfa can maximize intake and production of milk by dairy cattle (Martin and Mertens, 2005). However, the protein in alfalfa is extensively degraded to ammonia in the rumen, resulting in excess N waste excretion. Birdsfoot trefoil (*Lotus corniculatus* L.) is a nonbloating forage legume that is similar to alfalfa in feeding value, and consequently it has a potential to be fed as a main forage to dairy cows with its unique cell wall digestion characteristics as well as condensed tannins (**CT**; Williams et al., 2011). Within a legume family, evidence exists that lignification has less effect on digestibility in birdsfoot trefoil than alfalfa. At the early bloom stage, Tomlin et al. (1965) demonstrated birdsfoot trefoil cellulose to be digested more rapidly than alfalfa cellulose, despite similar lignin concentrations. McGraw and Marten (1986) reported greater digestibility of birdsfoot trefoil stems than alfalfa stems. Whereas Mowat et al. (1969) found a highly negative correlation ($R^2 = 0.78$) between cell wall lignin concentration and in vitro cell wall digestibility in alfalfa, birdsfoot trefoil cell wall digestibility was not correlated with lignin concentration ($R^2 = 0.13$). Greater cell wall digestibility in birdsfoot trefoil may lead to an increase in DMI by lactating dairy cows (Allen, 2000). In addition, feeding birdsfoot trefoil has been reported to improve N utilization by ruminants due to CT in birdsfoot trefoil (Barry and McNabb, 1999; Min et al., 2003). Moderate concentrations of CT (2.0–4.0% DM) bind protein by hydrogen bonding at near neutral pH (i.e., pH 6.0–7.0) in the

Received January 15, 2015.
Accepted July 12, 2015.
[1]Approved as Journal Paper Number 8812 of the Utah Agricultural Experiment Station, Utah State University, Logan.
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rumen to form CT-protein complexes, but dissociate and release bound protein at pH <3.5 in the abomasum (Barry et al., 2001). Using continuous culture, we previously reported that ammonia-N (NH_3-N) concentration and flow were reduced when replacing alfalfa hay with birdsfoot trefoil hay in dairy TMR (Williams et al., 2011). This in vitro result suggests that incorporating birdsfoot trefoil hay as a CT-containing legume forage into dairy TMR can have a potential to improve environmental performance of dairy operations through a reduction in N excretion. Though feeding birdsfoot trefoil hay has potential benefits over alfalfa hay, establishing stands, the persistence of the stand over time, and the reduction in yield compared with alfalfa pose challenges to incorporating birdsfoot trefoil as a total alfalfa replacement.

Several studies have shown that birdsfoot trefoil fed to dairy cows as a preserved silage (Hymes-Fecht et al., 2013) or fresh forage (Woodward et al., 2000) increased N utilization, reduced N excretion in urine, and shifted N excretion to feces. However, no studies have been conducted to determine if birdsfoot trefoil preserved as a dry hay have the same effects as fresh or wet-preserved forages. Thus, we sought to determine effects of feeding birdsfoot trefoil hay in high-forage dairy diets on nutrient intake and utilization, ruminal fermentation profiles, and lactational performance of dairy cows. We hypothesized that feeding a birdsfoot trefoil hay-based lactation diet would increase intake of DM and digested NDF by dairy cows compared with alfalfa hay-based diet due to increased NDF digestibility, leading to improved lactational performance and N utilization efficiency.

MATERIALS AND METHODS

The dairy cows used in this study were cared for according to the *Guide for the Care and Use of Agricultural Animals in Research and Teaching* (FASS, 2010) and the Institutional Animal Care and Use Committee at Utah State University. The experiment was conducted at the Caine Dairy Research Center (Wellsville, UT) of Utah State University.

Forage Harvest and Composition

A mature stand of alfalfa hay was the source for the alfalfa hay-containing diets, and it was the second harvest cut the year before the experiment start. Forage was cut at prebloom stage with a conventional mower-conditioner (model 830, John Deere, Moline, IL). The cut forage was allowed to sun-cure for 2 d in the field, turned once with a rake to reduce leaf loss, and then baled later that day with a conventional square baler at between 85 and 87% DM. The hay was stored in metal hay barns until the time of the trial. Hay was bright green, fine stemmed, and mold-free. The birdsfoot trefoil hay used in this experiment was Norcen variety, planted in fall 2009 on a private ranch (Garland, UT), it was also second cutting harvested the year previous to the experiment by mower-conditioner (model 830) and allowed to sun-cure for 5 d before baling. Chemical composition of the hays and corn silage used to construct experimental diets is reported in Table 1.

Cows, Experimental Design, and Diets

Nine multiparous lactating Holstein cows, 3 of which were surgically fitted with rumen cannula (10-cm i.d., Bar Diamond, Parma, ID), were used for this experiment. Cows began the experiment averaging 131 ± 22.6 DIM. Mean BW was 778 ± 73.6 and 787 ± 65.7 kg at the beginning and the end of the experiment, respectively.

The design of the experiment was a triple 3 × 3 Latin square, with cannulated cows comprising one square.

Table 1. Chemical composition (means ± SD) of forages (n = 3)

Item, % of DM (unless otherwise noted)	Forage		
	Corn silage	Alfalfa hay	Birdsfoot trefoil hay
DM, %	30.9 ± 2.26	93.7 ± 0.19	92.7 ± 0.52
OM	94.6 ± 0.21	88.1 ± 0.96	89.5 ± 0.17
CP	5.99 ± 0.003	17.7 ± 0.96	15.8 ± 1.01
NDF	41.7 ± 1.12	34.7 ± 2.28	39.0 ± 3.21
ADF	23.5 ± 0.67	30.0 ± 0.27	33.8 ± 0.63
NFC[1]	47.2 ± 1.45	30.9 ± 1.31	32.8 ± 0.14
IVNDFD,[2] % NDF	41.1 ± 1.75	31.2 ± 2.25	35.8 ± 1.12
Lignin	2.72 ± 0.153	6.59 ± 0.674	7.57 ± 0.556
Condensed tannins	ND[3]	ND	1.05 ± 0.148

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

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

[3]ND = not determined