J. Dairy Sci. 92:313–323
doi:10.3168/jds.2008-1482

Intake and milk production of cows fed diets that differed in dietary neutral detergent fiber and neutral detergent fiber digestibility[1]

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ABSTRACT

The objectives of this study were to determine how feeding diets that differed in dietary neutral detergent fiber (NDF) concentration and in vitro NDF digestibility affects dry matter (DM) intake, ruminal fermentation, and milk production in early lactation dairy cows. Twelve rumen-cannulated, multiparous Holstein cows averaging 38 ± 15 d (±standard deviation) in milk, and producing 40 ± 9 kg of milk daily, were used in a replicated 4 × 4 Latin square design with 28-d periods. Treatment diets were arranged in a 2 × 2 factorial with 28 or 32% dietary NDF (DM basis) and 2 levels of straw NDF digestibility: 1) LD, untreated wheat straw (77% NDF, 41% NDF digestibility) or 2) HD, anhydrous NH_3-treated wheat straw (76% NDF, 62% NDF digestibility). All 4 diets consisted of wheat straw, alfalfa silage, corn silage, and a concentrate mix of cracked corn grain, corn gluten meal, 48% soybean meal, and vitamins and minerals. Wheat straw comprised 8.5% DM of the 28% NDF diets and 16% DM of the 32% NDF diets. Cows fed 28% NDF and HD diets produced more milk, fat, and protein than those consuming 32% NDF or LD diets. Dry matter intake was greater for cows consuming 28% NDF diets, but intakes of DM and total NDF were not affected by in vitro NDF digestibility. Intake of digestible NDF was greater for cows consuming HD diets. Ruminal fermentation was not affected by feeding diets that differed in NDF digestibility. Ruminal NDF passage rate was slower for cows fed HD than LD. No interactions of dietary NDF concentration and in vitro NDF digestibility were observed for any parameter measured. Regardless of dietary NDF concentration, increased in vitro NDF digestibility improved intake and production in early lactation dairy cows.
Key words: neutral detergent fiber digestibility, neutral detergent fiber, intake, milk production

INTRODUCTION

Forages typically make up half or more of the diet of lactating cattle and profoundly affect energy and carbohydrate intake. Maximizing digestible carbohydrate intake from forage is an important management goal, because energy needed for maintenance and milk production often exceeds the amount of energy high-producing cows can consume.

Forage NDF is a major factor affecting feed intake and rumen fill in high-producing cows. Waldo (1986) suggested that diet NDF content is the best single chemical predictor of DMI in dairy cows. Mertens (1987) proposed that voluntary feed intake of dairy cattle is limited by digestive tract fill when high-NDF diets are fed. Forage NDF, however, is not a homogeneous dietary component. Ruminal digestibility of forage NDF can range from less than 25% to over 75% for different forage types (NRC, 2001). Several studies with brown midrib mutant (***bm3***) corn silage demonstrated that lactating dairy cows will consume more DM and produce more milk when fed corn silages that have greater NDF digestibility (**NDFD**; Dado and Allen, 1996; Oba and Allen, 1999a, 2000a; Tine et al., 2001; Qiu et al., 2003). Oba and Allen (1999b) evaluated the relationship of NDFD and animal performance in published research and estimated that a 1-unit increase in forage NDFD in vitro or in situ was associated with increases of 0.17 kg/d of DMI, 0.23 kg/d of milk yield, and 0.25 kg/d of 4.0% fat-corrected milk.

Direct evaluation of the effect of forage NDFD on animal performance is complex, because it is difficult to obtain forages that differ only in NDF digestibility. Previous experiments that suggested that higher NDFD improved intake and animal performance have had the effect of NDFD confounded by differences in forage NDF concentration or differences in the types and quantities of dietary NDF used to formulate test diets, or both (Grant et al., 1995; Dado and Allen, 1996; Oba and Allen, 1999a, 2000a; Weiss and Wyatt, 2002; Qiu et al., 2003). Treating wheat straw with anhydrous NH_3 has been shown to consistently increase NDFD with little change in the chemical composition of the straw (Sundstøl et al., 1978). Use of untreated

Received June 24, 2008.
Accepted July 24, 2008.
[1]This research was supported by the University of Wisconsin College of Agricultural and Life Sciences, USDA Cooperative State Research, Education, and Extension Service Hatch.
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and ammoniated straw could serve as a good model for altering dietary NDFD with minimal experimental confounding.

This study was conducted to investigate the effect of feeding diets that differed in dietary NDF concentration and in vitro NDFD on DMI, ruminal fermentation, and milk production in early lactation dairy cows. Wheat straw was incorporated into test diets to provide a concentrated source of NDF. Untreated and ammoniated wheat straw were used to vary the concentration of digestible fiber with minimal effects on the concentrations of other dietary ingredients or dietary nutrients. We hypothesized that feeding early lactation cows diets with higher NDFD would increase energy intake and productivity.

MATERIALS AND METHODS

Preparation of Wheat Straw

Wheat straw (**WS**) ammoniation was accomplished by a stack method similar to that described by Sundstøl et al. (1978). Small square bales of WS that weighed approximately 20 kg each were stacked in a 2.7-m-diameter plastic silage bag (Ag Bag International, Warrenton, OR). A 15 m × 7.5 cm diameter pipe with evenly spaced openings was positioned through the center of the bales within the bag. The pipe protruded from one end of the bag, and the plastic was wrapped around the pipe to seal off the interior of the bag from the outside. The other end of the bag was tightly sealed. Anhydrous NH_3 was then applied at 0.048 g of NH_3/kg of WS DM. The WS remained in the sealed bags for 53 d, with an average recorded daily outside temperature of 13°C. Bales of anhydrous ammoniated WS were then removed from the bag and chopped with a stationary tub grinder (Gehl Implement, West Bend, WI) to a geometric mean particle length of 8.35 mm.

Animals

The Animal Care and Use Committee of the College of Agriculture and Life Sciences of the University of Wisconsin-Madison approved all procedures involving animals. Twelve multiparous lactating Holstein cows from the University of Wisconsin-Madison Dairy Cattle Research Center were used. All cows were fitted with rumen cannulas 3 wk before the experiment. At the beginning of the experiment, cows averaged 38 ± 15 DIM (±SD) and produced 40 ± 9 kg of milk daily. Body weights of the cows averaged 638 ± 54 kg and 658 ± 52 kg at the beginning and end of the study, respectively.

Cows were housed in a stanchion barn and fed individually. Wood shavings were used as bedding. Cows were milked twice daily at 0400 and 1600 h in a milking parlor and were allowed access to an outside concrete area daily for 2 h after each morning milking, except on days when rumen pH, NH_3-N, and VFA were collected. All cows had free access to water.

Experimental Design and Diets

The trial was designed as a replicated 4 × 4 Latin square. Experimental periods were 28 d (21 d of treatment adaptation and 7 d of data collection). Treatments were arranged as a 2 × 2 factorial with 2 levels of dietary NDF concentration: 28 vs. 32% (DM basis) and 2 levels of in vitro NDF digestibility: lower in vitro NDF digestibility, obtained with untreated WS (LD), and higher in vitro NDF digestibility, obtained by treating WS with anhydrous NH_3 (HD). Ingredient compositions of the experimental diets are shown in Table 1. Dietary NDF concentration was adjusted by replacing alfalfa silage and corn silage with wheat straw. Wheat straw comprised 8.5% of the DM for the 28% NDF diets and 16% of the DM for the 32% diets. Alfalfa silage and corn silage NDF content averaged 37 and 35% (DM basis), respectively (Table 2). Urea was added to diets containing untreated WS to assure that all diets contained similar levels of ruminally available CP. All diets were formulated to be isonitrogenous and to meet or exceed the National Research Council (2001) recommendations for CP, Ca, P, NaCl, and vitamins A, D, and E of a 600-kg multiparous cow producing 40 kg of milk/d.

Diets were fed as a TMR, with ratios of forage to concentrate of 58:42 and 62:38 in 28% NDF and 32% NDF diets, respectively. Cows were fed for ad libitum intake twice daily at 1000 and 1500 h in equal portions. The amount of feed offered was adjusted daily to obtain approximately 10% orts (as-fed basis).

Sample Collection and Analysis

Milk production was recorded at each milking during the final 7 d of each period. Milk samples from the a.m. and p.m. milking collected on 4 consecutive days (d 24 to 27 of each period) were analyzed for protein, fat, lactose, and MUN by infrared analysis (Agsource Milk Analysis Laboratory, Menomonie, WI) with a Fossmatic-605 (Foss Electric, Hillerød, Denmark). Body weight was measured at 0900 h, 2 d before the start of the first period and on the last 2 d of each period.

Dry matter contents of the feed components were determined weekly using a 60°C forced-air oven for 48 h; results were used to make weekly adjustments to