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Productivity of lactating dairy cows fed diets with teff hay as the sole forage

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ABSTRACT

Groundwater depletion is one of the most pressing issues facing the dairy industry in arid regions. One strategy to improve the industry's drought resilience involves feeding drought-tolerant forage crops in place of traditional forage crops such as alfalfa and corn silage. The objective of this study was to assess the productivity of lactating dairy cows fed diets with teff hay (*Eragrostis tef*) as the sole forage. Teff is a warm-season annual grass native to Ethiopia that is well adapted to drought conditions. Nine multiparous Holstein cows (185 ± 31 d in milk; mean ± standard deviation) were randomly assigned to 1 of 3 diets in a 3 × 3 Latin square design with 18-d periods (14 d acclimation and 4 d sampling). Diets were either control, where dietary forage consisted of a combination of corn silage, alfalfa hay, and native grass hay, or 1 of 2 teff diets (teff-A and teff-B), where teff hay [13.97 ± 0.32% crude protein, dry matter (DM) basis] was the sole forage. All 3 diets were formulated for similar DM, crude protein, and nonfiber carbohydrate concentrations. Control and teff-A were matched for concentrations of neutral detergent fiber (NDF) from forage (18.2 ± 0.15% of DM), and teff-B included slightly less, providing 16.6% NDF from forage. Dry matter intake, milk and component production, body weight, body condition score, as well as DM and NDF digestibility were monitored and assessed using mixed model analysis, with significance declared at $P < 0.05$. Treatment had no effect on dry matter intake (28.1 ± 0.75 kg/d). Similarly, treatment had no effect on milk production (40.7 ± 1.8 kg/d). Concentrations of milk fat (3.90 ± 0.16%) and lactose (4.68 ± 0.07%) were also unaffected by treatment. Teff-A and teff-B increased milk protein concentration compared with the control (3.07 vs. 3.16 ± 0.09%). Treatment had no effect on energy-corrected milk yield (43.4 ± 1.3 kg/d), body weight, or body condition score change. Additionally, treatment had no effect on total-tract DM or NDF digestibility. Results from this study indicate that teff hay has potential to replace alfalfa and corn silage in the diets of lactating dairy cattle without loss of productivity.
Key words: drought, forage, lactation, grass

INTRODUCTION

Drought is one of the most significant issues threatening the dairy industry today. For producers located in arid regions of the United States, irrigation for growing feed presents the greatest water-utilization challenge. In fact, water used for growing the crops that feed cattle accounts for more than 90% of the water used to support milk production (Innovation Center for US Dairy, 2013). Declining ground water levels are making it more difficult to produce feed locally in some areas (Cross, 2015), and management strategies intended to maintain surface water levels will only put more stress on groundwater reserves (Famiglietti, 2014). As groundwater levels decrease, some wells are no longer able to support the production of alfalfa and corn silage, forage crops with significant water demands. Without an industry-wide shift toward water conservation, the sustainability of the dairy industry in arid regions is questionable.

Water-efficient forage crops with acceptable nutritional value could prove an attractive alternative to traditional forage crops. Teff (*Eragrostis tef*) is a warm-season annual grass (C4 physiology) native to Ethiopia that is well adapted to arid conditions. Since 4000 B.C., teff has been used as a grain crop for human consumption. Upon its introduction to the United States, researchers evaluated teff as a forage crop (Miller, 2011). Although teff grass has potential to fit the needs for forage production in areas threatened by drought, very little is currently known about how dairy cows might perform when fed a teff-based diet.

Because teff is primarily a grain crop in Ethiopia (Mengesha, 1966), several Ethiopian studies have investigated opportunities to improve the feeding value of teff straw (Bonsi et al., 1995, 1996; Mesfin and Ledin, 2004). To optimize the quality of teff grass, harvest

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should occur well before the development of seed heads. As forages mature, quality decreases as photosynthetic products are converted to fibrous, structural components (Van Soest, 1982). In a recent study (Saylor, 2017), greenhouse-grown teff grass harvested well before seed head development (45 d after planting) contained an average of 24.6 ± 0.49% CP. Additionally, the 24-h in vitro NDF digestibility averaged 54.8 ± 0.95%. These results show that, if harvested at an early stage of maturity, teff grass has potential to be a highly nutritious forage. Still, very little work has been done to assess the effects of feeding high-quality teff grass to dairy cattle. Several studies have evaluated responses to teff hay in growing cattle and horses (Staniar et al., 2010; Young et al., 2014). Although studies like these are certainly valuable, maintaining the high DMI and passage rate to support the nutrient requirements of a lactating dairy cow is a more challenging proposition. The objective of this study was to assess the productivity of high-producing dairy cows fed diets with teff hay as the sole forage.

MATERIALS AND METHODS

Experimental procedures were approved by the Institutional Animal Care and Use Committee at Kansas State University.

Design and Treatments

Nine multiparous Holstein cows (185 ± 31 DIM; mean ± SD) from the Kansas State University Dairy Cattle Teaching and Research Unit were randomly assigned to treatment sequence in a replicated 3 × 3 Latin square design. Treatment periods were 18 d, with the final 4 d used for data and sample collection. At the beginning of the experiment, BW of cows were 694 ± 50 kg with a BCS of 3.18 ± 0.24.

Cows were offered 1 of 3 diets, all fed as TMR. Diets were either control (**CON**), where dietary forage consisted of a combination of corn silage, alfalfa hay, and prairie hay, or 1 of 2 teff diets (**teff-A** and **teff-B**), where teff hay was the sole forage. Prairie hay and teff hay were processed with a bale processor to achieve a 3.8 cm theoretical length of cut, and alfalfa hay was processed with a TMR wagon. Chemical composition of the forages used in this study is shown in Table 1. All 3 diets were formulated for similar DM, CP, ether extract, and NFC concentrations (Table 2). The teff-A diet was formulated to provide equivalent NDF from forage (**fNDF**) compared with CON, with the intention of evaluating the effect of teff fiber versus the replaced forage fibers. Because this approach increased dietary NDF, a second experimental diet, teff-B, was formulated to provide equivalent effective fiber as CON, quantified as (fNDF × 2) + NDF (DM basis; Bradford and Mullins, 2012). A portion of the teff was replaced with soybean hulls to accomplish this change while maintaining total NDF at a similar concentration as in the teff-A diet. Although diets were less divergent in effective fiber than the original formulation predicted, this metric for effective fiber equated to 68, 70, and 67 for CON, teff-A, and teff-B, respectively, based on analyzed nutrient concentrations.

Data and Sample Collection

Throughout the experiment, cows were fed twice daily at ≥105% of expected intake. On d 15 to 18 of each treatment period, the amount of feed offered and refused was recorded to determine DMI. Samples of forages and wet corn gluten feed (**WCGF**) were col-

Table 1. Nutrient composition of forages used in the experiment[1]

	Teff hay		Corn silage		Alfalfa hay		Prairie hay	
Nutrient[2]	% of DM	SD	% of DM	SD	% of DM	SD	% of DM	SD
DM, % as fed	92.3	0.3	33.6	2.0	90.4	0.5	93.9	0.6
CP	12.9	0.4	8.4	0.4	19.9	1.0	5.1	0.1
aNDFom[3]	56.1	1.9	40.9	2.5	35.3	2.3	63.4	1.2
ADF	29.8	0.8	24.2	2.3	29.2	1.2	40.3	0.5
NFC	12.2	2.1	40.5	3.2	21.1	0.4	12.8	0.5
Ether extract	1.9	0.1	3.4	0.4	1.8	0.3	2.2	0.1
Ash	8.0	0.3	5.3	0.3	10.1	0.9	8.9	1.2
uNDFom[4]	12.4	5.5	10.9	1.6	20.3	1.5	13.0	4.6

[1]Acquired from samples taken on d 15 to 18 of all 4 periods.

[2]All nutrients, except DM, are reported on a DM basis.

[3]Amylase-treated, ash-free NDF.

[4]Ash-free, undigested NDF remaining after 240 h of in vitro ruminal fermentation.