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Comparison of Brown Midrib-6 and -18 Forage Sorghum with Conventional Sorghum and Corn Silage in Diets of Lactating Dairy Cows*

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ABSTRACT

Total mixed rations containing conventional forage sorghum, brown midrib (bmr)-6 forage sorghum, bmr-18 forage sorghum, or corn silage were fed to Holstein dairy cows to determine the effect on lactation, ruminal fermentation, and total tract nutrient digestion. Sixteen multiparous cows (4 ruminally fistulated; 124 d in milk) were assigned to 1 of 4 diets in a replicated Latin square design with 4-wk periods (21-d adaptation and 7 d of collection). Diets consisted of 40% test silage, 10% alfalfa silage, and 50% concentrate mix (dry basis). Acid detergent lignin concentration was reduced by 21 and 13%, respectively, for the bmr-6 and bmr-18 sorghum silages when compared with the conventional sorghum. Dry matter intake was not affected by diet. Production of 4% fat-corrected milk was greatest for cows fed bmr-6 (33.7 kg/d) and corn silage (33.3 kg/d), was least for cows fed the conventional sorghum (29.1 kg/d), and was intermediate for cows fed the bmr-18 sorghum (31.2 kg/d), which did not differ from any other diet. Total tract neutral detergent fiber (NDF) digestibility was greatest for the bmr-6 sorghum (54.4%) and corn silage (54.1%) diets and was lower for the conventional (40.8%) and bmr-18 sorghum (47.9%) diets. In situ extent of NDF digestion was greatest for the bmr-6 sorghum (76.4%) and corn silage (79.0%) diets, least for the conventional sorghum diet (70.4%), and intermediate for the bmr-18 sorghum silage diet (73.1%), which was not different from the other diets. Results of this study indicate that the bmr-6 sorghum hybrid outperformed the conventional sorghum hybrid; the bmr-18 sorghum was intermediate between conventional and bmr-6 in most cases. Additionally, the bmr-6 hybrid resulted in lactational performance equivalent to the corn hybrid used in this study. There are important compositional differences among bmr forage sorghum hybrids that need to be characterized to predict animal response accurately.
(**Key words:** brown midrib, forage sorghum, milk production, digestibility)

Abbreviation key: bmr = brown midrib.

INTRODUCTION

Sorghum [*Sorghum bicolor* (L.) Moench.] has become an increasingly important forage crop for dairy producers in the midwestern and plains region of the US. In addition to the drier plains states, recurring climatic conditions in other regions of the US, such as drought, high summer temperatures, or delayed planting, introduce considerable risk into corn (*Zea mays* L.) production for silage. Thus, many dairy producers consider silage-type sorghums as a viable alternative crop. Forage sorghums can be planted later than corn; use water much more efficiently; have high biomass yields; and, when exposed to drought, still produce acceptable silage yields (Sanderson et al., 1992).

However, the DM digestibility of many corn hybrids is typically greater than that for conventional forage sorghum hybrids. Lignin, the primary indigestible component of plant cell walls, limits digestion of cell wall carbohydrates in the rumen. Ordinarily, the whole corn plant contains less lignin than commonly fed sorghum hybrids, as well as a greater content of grain. Because higher lignin concentration reduces the potential extent of ruminal fiber digestion, it often results in increased ruminoreticular fill, reduced DMI, and less milk production for cows fed conventional forage sorghum hybrids (Aydin et al., 1999).

Chemical and genetic approaches have been employed to improve forage fiber digestibility by reducing the amount of lignin or the extent of lignin cross linking with cell wall carbohydrates. Brown midrib (**bmr**) forage genotypes usually contain less lignin and may have altered lignin chemical composition (Bucholtz et al., 1980; Cherney et al., 1991; Vogel and Jung, 2001). To-

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Table 1. Chemical composition of the experimental silages.

Item	Forage sorghum			Corn silage
	Normal	bmr-6[1]	bmr-18	
DM, %	30.6	32.9	34.1	34.4
	(% of DM)			
CP	7.3	7.5	7.8	8.4
ADF	37.7	33.6	28.5	28.5
NDF	58.1	50.2	48.2	46.1
Starch	10.9	16.8	14.5	19.9
ADL[2]	2.89	2.30	2.52	2.64
$KMnO_4$ lignin[3]	8.8	6.90	6.22	5.53
Ash	4.1	4.5	3.3	2.7
pH	4.00	4.08	4.03	3.90
Particle distribution	(% as-fed)			
>19 mm	8.6	6.5	9.8	19.7
19 to 8 mm	49.9	50.4	60.5	63.5
<8 mm	41.4	43.0	29.7	16.8

[1]bmr = Brown midrib.

[2]ADL = Acid detergent lignin.

[3]Lignin measured by permanganate procedure.

date, genetic control of the lignification process through manipulation of the bmr trait has offered the most direct and productive approach to reducing lignin content and increasing digestibility of forage sorghums (Gerhardt et al., 1994). In situ and in vitro digestion studies have shown that bmr forages have greater extent of NDF digestion than their conventional counterparts (Grant et al., 1995). Previous research (Aydin et al., 1999) observed greater milk production for Holstein dairy cows fed bmr forage sorghum vs. conventional forage sorghum, with milk production similar to cows fed corn silage.

Even though it is often not specified in research reports, there are three bmr loci (bmr-6, bmr-12, and bmr-18; bmr-12 and bmr-18 may be allelic) that have been identified in sorghum (Porter et al., 1978). Previous research reported by Aydin et al. (1999) used a bmr-6 forage sorghum hybrid. However, chemical differences resulting from different mutations in the lignin biosynthesis pathway may exist among bmr-6, bmr-12, or bmr-18 hybrids. To date, no research has compared different bmr hybrids for their effect on dairy performance relative to conventional sorghum or corn silage.

Therefore, the objective of this experiment was to determine the effect of a conventional forage sorghum, bmr-6 forage sorghum, bmr-18 forage sorghum, or a dual-purpose corn hybrid on lactational performance, ruminal fermentation, and total tract nutrient digestibility in Holstein dairy cows.

MATERIALS AND METHODS

Forage Harvesting

All forages used in this experiment were harvested in the fall of 2001 at the University of Nebraska Agricultural Research and Development Center located near Mead, NE. Conventional, bmr-6, and bmr-18 (SG-SileAll, SG-BMR100, SG-XP-18; Garrison and Townsend, Inc., Hereford, TX) forage sorghums were grown in adjacent fields without irrigation and harvested at the late-dough stage of maturity. The sorghum hybrids were harvested using a field chopper with knives adjusted to a 1-cm theoretical length of cut. The yield of the conventional forage sorghum was 14,600 kg/ha (DM basis), bmr-6 yielded 9700 kg/ha (DM basis), and bmr-18 yielded 13,500 kg/ha (DM basis). Non-irrigated corn silage (Pioneer 34R07; Pioneer Hi-Bred Int., Des Moines, IA) was harvested at two-thirds milk line stage of maturity with a field chopper with knives adjusted to a 1-cm theoretical length of cut. The yield of the corn silage was 12,800 kg/ha (DM basis). All 4 forages were ensiled without use of inoculants in separate plastic silage bags prior to the start of the experiment. The chemical composition of the experimental silages is summarized in Table 1.

Cows and Treatments

Sixteen multiparous Holstein cows (4 ruminally fistulated) were used in a replicated Latin square design with 28-d periods; the first 21 d served as an adaptation period, and the last 7 d served as a collection period. Cows averaged 124 ± 28 DIM when assigned to diets. Diets contained approximately 40% test silage, 10% alfalfa silage, 3.7% whole cottonseed, 22.7% wet corn gluten feed, and 23.6% of a concentrate mix consisting of ground corn, soybean meal, blood meal, minerals, and vitamins (Table 2). Diets were formulated to contain similar CP and RUP and to differ in NDF and lignin content because of source of silage. Cows were housed

Table 2. Ingredient and chemical composition of experimental diets.

	Forage sorghum			
Item	Normal	bmr-6[1]	bmr-18	Corn silage
Ingredients, % of DM				
Alfalfa hay[2]	10.0	10.0	10.0	10.0
Normal sorghum silage	40.0	—	—	—
bmr-6 sorghum silage	—	40.0	—	—
bmr-18 sorghum silage	—	—	40.0	—
Corn silage	—	—	—	40.0
Wet corn gluten feed[3]	22.7	22.7	22.7	22.7
Whole linted cottonseed[4]	3.7	3.7	3.7	3.7
Grain mixture[5]	23.6	23.6	23.6	23.6
Composition, % of DM				
DM, %	59.3	60.2	60.7	60.8
CP	17.6	17.7	17.8	18.0
RUP[6]	6.8	6.8	6.8	6.7
ADF	24.4	22.8	20.8	20.7
NDF	43.2	40.1	39.3	38.3
Starch	17.4	19.7	18.8	21.0
ADL[7]	2.78	2.54	2.63	2.62
$KMnO_4$ lignin[8]	6.14	5.38	5.11	5.12
Ash	4.5	4.6	4.2	3.9
Particle distribution				
>19 mm	35.2	14.7	33.6	23.1
19 mm to 8 mm	13.1	13.9	7.7	22.6
<8 mm	51.7	71.4	58.7	54.3

[1]bmr = Brown midrib.

[2]Alfalfa hay contained (DM basis) 21.6% CP, 35.2% ADF, 29.6% NDF, 2.23% ADL (acid detergent lignin), 11.0% permanganate lignin, and 5.9% ash.

[3]Wet corn gluten feed contained (DM basis) 23.6% CP, 12.1% ADF, 43.0% NDF, 2.0% ADL, 2.5% permanganate lignin, and 2.5% ash.

[4]Whole linted cottonseed contained (DM basis) 23.9% CP, 45.8% ADF, 50.1% NDF, 12.9% ADL, and 3.4% ash.

[5]Grain mixture consisted of 52.1% ground dry corn, 34.7% soybean meal (46.5% CP), 3.3% blood meal, 3.3% limestone, 2.2% tallow, 1.6% sodium bicarbonate, 1.5% dicalcium phosphate, 0.5% salt, 0.35% magnesium oxide, and 0.6% of a micromineral and vitamin premix.

[6]Ruminally undegraded protein was calculated using values reported by NRC (2001).

[7]ADL = Acid detergent lignin.

[8]Lignin measured using the permanganate procedure.

in a tie-stall barn and were fed using individual feed boxes. Diets were fed as TMR and offered once daily in amounts to ensure 10%orts; offered feed and orts were recorded daily. Cows were removed from the barn twice daily for milking, exercise, and detection of estrus for a total of approximately 4 h. Surgery of the 4 fistulated cows were performed under conditions described in animal use protocols approved by the Institutional Animal Care and Use Committee at the University of Nebraska, as was the housing of all cows in this experiment.

Sample Collection and Analysis

Samples of each silage, TMR, and individual dietary ingredients were collected weekly, composited by period, and analyzed for chemical composition. Silage pH was measured on fresh silage samples. Composite samples were oven-dried (60°C), ground through a Wiley mill (1-mm screen; Arthur H. Thomas Co., Philadelphia, PA), and analyzed for CP (AOAC, 1996), NDF (with heat stable α-amylase; ANKOM Tech. Corp., Fairport, NY), ADF (Van Soest et al., 1991), ADL (Van Soest, 1963), permanganate lignin (Goering and Van Soest, 1970), and starch (Fleming and Reichart, 1980). Phosphorus was determined using an alkalimetric ammonium molybdophosphate method with spectrophotometer (AOAC, 1996). Particle size distribution (as-fed basis) was determined using the Penn State particle separator (Lammers et al., 1996).

Daily milk production was recorded electronically for all cows. Composite a.m. and p.m. milk samples were collected over 4 consecutive milkings during the last 7 d of each period and analyzed for fat, protein, and lactose (B-2000; Bentley Instruments, Chaska, MN). Calculation of milk composition was weighted according to the a.m. and p.m. milk production. Body weight was recorded for 2 d immediately after the a.m. milking for

1 wk prior to initiation of the trial and the last 2 d of each period.

Total chewing, eating, and ruminating times were determined by individual observation of all cows every 5 min for a 24-h period during wk 4 of each period. Samples of ruminal fluid were collected beneath the ruminal digesta mat at 6-h intervals for 24 h during wk 4 of each period from ruminally fistulated cows assigned to each treatment. A portable pH meter was used to determine the pH of ruminal fluid immediately following collection; fluid was then frozen and stored for VFA determination. The VFA concentrations were determined by GLC (Erwin et al., 1961) with a gas chromatograph (model 5890; Hewlett Packard, Wilmington, DE) with a 2-mm i.d. column that was 2.4 m in length and packed with SP1200 (Supelco, Inc., Bellefonte, PA). The rate of N_2 flow was 20 mL/min, injection temperature was 170°C, column temperature was 120°C, and flame ionization detector temperature was 200°C.

Fecal samples were collected daily at the a.m. feeding during the last 6 d of each period using the protocol of Nakamura and Owen (1989) to estimate total tract nutrient digestibility. Fecal samples were frozen and composited by period prior to chemical analyses. Composite samples were dried for 48 h (60°C), ground through a 1-mm Wiley mill screen, and analyzed for DM, CP, NDF, starch, and P. Indigestible NDF (120-h in vitro incubation) was used as the internal marker, and total tract digestibility of DM, CP, NDF, starch, and P were calculated according to Cochran and Galyean (1994): % nutrient digestion = 100 − 100 × ([% marker in feed × % nutrient in feces] ÷ [% marker in feces × % nutrient in feed]).

Ruminal evacuations were performed the last day of each period on the 4 fistulated cows 2 h prior to feeding to determine total ruminal volume and mass of the digesta. A representative sample of ruminal contents was collected at each sampling and stored at −20°C until further analysis. Prior to analysis, ruminal content samples were thawed, dried at 60°C for 72 h, and ground through a 1-mm Wiley mill screen. Samples were analyzed for DM, NDF, starch, and indigestible NDF (at 120 h). Ruminal pool sizes were calculated by multiplying the digesta DM weight by the concentration of each component. Ruminal turnover rate was calculated according to Oba and Allen (2000): turnover rate in the rumen (%/h) = (intake of component/ruminal pool of component)/24 × 100.

Fractional rate of digestion and potential extent of NDF digestion of each silage were measured using the in situ bag technique. Silage samples were oven dried (60°C) and ground though a Wiley mill (2-mm screen). Dacron bags (10 ± 20 cm; ANKOM Tech. Corp.) with a mean pore size of 53 μm were filled with 5 g of substrate and incubated in duplicate in the rumen of each fistulated cow for 0, 6, 12, 18, 24, 48, 72, and 96 h. In situ bags were removed from the rumen, rinsed, dried at 60°C, and weighed. Contents were analyzed for NDF at each time point. Kinetics of NDF digestion and apparent extent of ruminal NDF digestion were calculated as described by Grant (1994).

Statistical Analyses

Data were analyzed as a replicated 4 × 4 Latin square design using the PROC MIXED procedure of SAS (1999). The model contained effects for square, cow within square, period, treatment, square × treatment, and residual error. Differences among treatment means were detected using the Tukey procedure (Neter et al., 1985). Significance was declared at $P < 0.05$ unless otherwise stated.

RESULTS AND DISCUSSION

Silage and Dietary Composition

The chemical composition of experimental silages is presented in Table 1. Similar to previous studies (Thorstensson et al., 1992; Grant et al., 1995), the conventional sorghum silage contained more lignin (measured as acid-detergent lignin or permanganate lignin) than the bmr-6 or bmr-18 sorghum hybrids. The ADF and NDF contents of the conventional forage sorghum were greater than those for the bmr-6 or bmr-18 sorghum hybrids. Similarly, Thorstesson et al. (1992) observed a greater concentration of NDF for conventional sorghum when compared with its bmr-6 or bmr-18 counterparts. However, other studies have observed no difference in ADF and NDF concentrations between conventional and bmr-6 sorghum (Ruiz et al., 1995; Aydin et al., 1999). A review of bmr research by Cherney et al. (1991) indicated considerable variation exists in fiber composition among conventional and bmr sorghum hybrids. The corn silage used in this study had lower NDF and permanganate lignin content, but higher CP, than the forage sorghum hybrids evaluated. When relating lignin data to previously published information, it is important to specify whether the value is acid detergent or permanganate lignin. In our study, for instance, the acid detergent lignin ranked the silages as conventional > corn > bmr-18 > bmr-6; however, permanganate lignin ranked the silages as conventional > bmr-6 > bmr-18 > corn. The primary reason for this difference between the two methods reflects the fact that acid detergent lignin measures core lignin, whereas permanganate lignin measures non-core lignin as well (Van Soest, 1963; Van Soest et al., 1991).

Table 3. Lactational performance as influenced by forage source.

Item	Forage sorghum			Corn silage	SE
	Normal	bmr-6[1]	bmr-18		
DMI					
kg/d	23.2	25.2	23.4	24.3	1.1
% of BW	3.67	3.79	3.65	3.81	0.19
NDF Intake					
kg/d	10.4[a]	9.0[b]	9.9[ab]	9.0[b]	0.4
% of BW	1.62[a]	1.43[b]	1.53[ab]	1.42[b]	0.06
Milk, kg/d	31.0[b]	34.1[a]	32.2[ab]	33.8[a]	1.6
Milk fat					
%	3.57[b]	3.89[a]	3.77[ab]	3.88[a]	0.21
kg/d	1.11[b]	1.34[a]	1.22[ab]	1.32[a]	0.11
Milk protein					
%	2.89	2.89	2.98	2.97	0.14
kg/d	0.91	0.99	0.96	1.00	0.08
Lactose					
%	4.84	4.88	4.90	4.78	0.34
kg/d	1.53	1.68	1.58	1.62	0.17
4% FCM, kg/d	29.1[b]	33.7[a]	31.2[ab]	33.3[a]	2.3
FCM/DMI kg/kg	1.25[b]	1.37[a]	1.35[a]	1.38[a]	0.09
BW, kg	636	639	641	640	16
BW Change, kg/28 d	–1.4	1.0	3.8	4.4	5.2

[a,b]Means within a row with different superscripts differ ($P < 0.05$).

[1]bmr = Brown midrib.

All 4 TMR were similar in DM, CP, and calculated RUP content (Table 2; National Research Council, 2001). The diets primarily differed in lignin, ADF, NDF, and starch content, which reflected the treatment silage in each diet.

Lactational Performance and Feed Intake

Daily DMI was unaffected by diet (Table 3). In contrast, Lusk et al. (1984) observed an increase in consumption of corn silage over bmr-12 sorghum in dairy heifers and noted a similar trend in lactating cows. In addition, several studies have shown an increase in consumption of bmr sorghum when compared with conventional forage sorghum (Grant et al., 1995; Aydin et al., 1999).

Consumption of NDF was greater for cows fed the conventional silage compared with corn or bmr-6 sorghum (Table 3), both on a percentage of BW basis and kilograms per day consumed. The NDF intake was not different for cows fed the bmr-18 diet compared with other diets. Given that consumption of NDF was similar, or slightly less for bmr sorghum vs. conventional sorghum, the positive milk production responses observed in the present study are likely due to differences in lignin content and NDF digestibility of the silages.

Milk production and milk fat differed among diets (Table 3). Cows fed the bmr-6 sorghum and corn silage had similar milk production. Cows fed conventional sorghum had the lowest milk production, and cows fed the bmr-18 did not show differences in milk production from cows fed the other diets. This pattern was also observed for milk fat production. In contrast, previous studies have shown milk production to be equivalent between dual-purpose corn hybrids and bmr forage sorghums (Lusk et al., 1984; Grant et al., 1995). There were no effects of diet on milk protein or lactose production, which agrees with the results of Lusk et al. (1984). However, other researchers have shown corn silage to increase milk protein and lactose when compared with

Table 4. Chewing activity as influenced by forage source.

Item	Forage sorghum			Corn silage	SE
	Normal	bmr-6	bmr-18		
Eating, min/d	340[a]	287[b]	340[a]	296[b]	17
Ruminating, min/d	420[b]	450[a]	407[b]	433[ab]	15
Total chewing, min/d	760	736	747	728	16

[a,b]Means within a row with different superscripts differ ($P < 0.05$).

[1]bmr = Brown midrib.

Table 5. Ruminal pH and VFA as influenced by forage source.

Item	Forage sorghum			Corn silage	SE
	Normal	bmr-6	bmr-18		
Ruminal pH	5.92	5.96	5.87	5.92	0.05
Total VFA, m*M*	123.0	118.9	124.8	123.7	6.5
VFA, mol/100 mol					
Acetate (A)	75.1	72.1	73.2	73.3	3.9
Propionate (P)	26.8	26.2	30.3	30.2	1.9
n-Butyrate (B)	15.4	14.9	15.5	14.7	0.9
Isobutyrate	1.6	1.5	1.5	1.5	0.1
n-Valerate	2.2	2.1	2.3	2.2	0.2
Isovalerate	1.9	1.9	1.9	1.9	0.1
A:P	2.78[a]	2.77[a]	2.44[b]	2.49[b]	0.11
A + B/P	3.35[a]	3.32[a]	2.96[b]	3.00[a]	0.13

[a,b]Means within a row with different superscripts differ ($P < 0.05$).

normal sorghum and bmr sorghum (Grant et al., 1995; Aydin et al., 1999). Production of 4% FCM followed the same trend as milk production and milk fat concentration. Cows fed bmr-6 sorghum and corn silage had greater FCM production than did cows fed conventional sorghum, with bmr-18 not different from other diets. All bmr sorghum and corn silage diets resulted in greater gross efficiency of FCM production (FCM/DMI) compared with conventional sorghum. Diet had no effect on BW or change in BW during each 28-d period.

Chewing Activity and Ruminal Measurements

Time spent eating was greatest for cows fed the conventional sorghum and bmr-18 sorghum silages (Table 4). Conversely, the bmr-6 sorghum diet elicited greater rumination activity than did the conventional or bmr-18 sorghum diets; corn silage was not different from the other diets. Total chewing activity was unaffected by diet. The observed differences among diets in rumination and total chewing times were small and of doubtful biological significance. As reported by DeBoever et al. (1990), total chewing time has little direct relationship with dietary NDF content for diets containing ≥50% forage.

Total VFA concentration and ruminal pH, averaged over 24 h, did not differ among diets (Table 5). Acetate plus butyrate to propionate ratio was similar for the bmr-6, conventional sorghum, and corn silage diets, but was lower for the bmr-18 diet. Mean ruminal pH was nearly 6.0 for all diets, and all diets had an acetate to propionate ratio >2.0. Similarly, Rook et al. (1977) found no difference in total VFA concentration or ruminal pH for cows fed diets containing 60% bmr or standard corn silage. In a previous study with lactating dairy cows (Grant et al., 1995), ruminal pH and acetate to propionate ratio were not different between conventional and bmr forage sorghum silage diets.

Digestion and Ruminal Turnover of Silages

The fractional rate of NDF digestion measured in situ was greater for the bmr-6 sorghum, bmr-18 sorghum, and corn silage compared with the conventional sorghum (Table 6). A previous study (Aydin et al., 1999) indicated no difference in the rate of NDF digestion among conventional sorghum, bmr sorghum, and corn silages. The potential extent of ruminal NDF digestion was significantly lower for conventional sorghum vs. the bmr-6 or corn silage; bmr-18 silage did not differ

Table 6. In situ NDF digestion kinetics of the experimental silages.

Item	Forage sorghum			Corn silage	SE
	Normal	bmr-6	bmr-18		
Lag, h	0	0	0	0	0
K_d,[1] /h	0.023[b]	0.037[a]	0.034[a]	0.036[a]	0.003
PED,[2] %	70.4[b]	76.4[a]	73.1[ab]	79.0[a]	1.5
48-h NDFD,[3] %	56.4[b]	62.4[a]	61.0[a]	59.1[a]	1.9
r^2	0.95	0.95	0.94	0.92	

[a,b]Means within a row with unlike superscripts differ ($P < 0.05$).

[1]K_d = Fractional rate of NDF digestion.

[2]PED = Potential extent of NDF digestion at 96 h of in situ fermentation.

[3]NDFD = In situ NDF digestion at 48 h of fermentation.

Table 7. Apparent total tract nutrient digestibility and ruminal turnover.

	Forage sorghum				
Item	Normal	bmr-6	bmr-18	Corn silage	SE
Digestibility, %					
DM	52.5[b]	62.9[a]	69.1[a]	60.9[a]	2.5
CP	51.3	59.9	59.2	51.4	4.5
NDF	40.8[c]	54.4[a]	47.9[b]	54.1[a]	1.8
Starch	85.7[b]	82.3[b]	79.7[b]	91.7[a]	1.5
P	49.4[b]	64.6[a]	40.9[b]	33.2[c]	4.4
Turnover, %/h					
DM	3.18	3.90	3.33	2.96	0.90
NDF	2.93	3.21	2.33	2.10	0.75
Starch	49.0[b]	51.6[b]	59.7[b]	83.3[a]	1.5
Indigestible NDF	2.20	1.90	1.80	2.00	1.00

[a,b]Means within a row with unlike superscripts differ ($P < 0.05$).

from the other silages. The NDF digestion at 48 h was significantly less for the conventional sorghum than for the other forages. Previous studies have shown similar results with digestion kinetics of bmr mutants when compared with normal counterparts (Wedig et al., 1987; Fritz et al., 1988; Gerhardt et al., 1994; Aydin et al., 1999). Our study is unique in that we have measured the NDF digestion kinetics of bmr-6 and bmr-18 sorghum and related that to milk and feed intake response. No other study has attempted to measure the difference in animal response (if any) related to bmr allele and hybrid.

Total tract digestibility of NDF for corn and bmr-6 sorghum was greater than that for bmr-18 sorghum, which was greater than that for conventional sorghum (Table 7). Total tract starch digestibility was greater for cows fed corn silage, which presumably reflected greater starch digestibility of the corn vs. sorghum starch (Rooney and Pflugfelder, 1986). Digestibility of DM was least for the conventional sorghum diet. A previous report (Grant et al., 1999) also observed an improvement in NDF and DM digestibility of bmr sorghum compared with conventional sorghum. Interestingly, the bmr-18 sorghum was intermediate between conventional and bmr-6 sorghum for total tract NDF digestibility. Apparent P digestibility was greatest for bmr-6 and least for corn silage. In the present study, urinary and milk P were not accounted for, so P retention could not be measured (Wu et al., 2000). However, the range in P digestibility does indicate a potential to select bmr and conventional sorghum hybrids that have an advantage relative to improved P digestibility.

Turnover of DM, NDF, and indigestible NDF were unaffected by diet (Table 7). However, turnover of starch was greater for the corn silage diet than for any of the sorghum diets. This difference in starch turnover can be attributed to the greater starch content of corn silage compared with the sorghum hybrids.

CONCLUSIONS

Lignin is the primary chemical factor limiting cell wall digestibility. Both bmr forage sorghum hybrids contained less lignin than the conventional sorghum and the corn hybrid. The bmr-6 sorghum outperformed the conventional sorghum hybrid; the bmr-18 sorghum was intermediate in most cases. This study reinforces the potential of some bmr sorghum hybrids to support milk production similar to corn silage when fed to cows averaging approximately 33 kg/d. The bmr hybrids used in this study were not isogenic hybrids. Consequently, the effect of the specific mutation is confounded with hybrid. Nevertheless, this is the first report to indicate that not all bmr hybrids will elicit similar digestibility and performance responses. We are currently developing near isogenic normal and bmr forage and grain sorghum lines for both the bmr-6 and bmr-12/18 mutations.

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