Revista Ciência Agronômica, v. 49, n. 1, p. 141-149, jan-mar, 2018
Centro de Ciências Agrárias - Universidade Federal do Ceará, Fortaleza, CE
www.ccarevista.ufc.br

Artigo Científico
ISSN 1806-6690

Ruminal degradability of brown-midrib sorghum-sudangrass hybrids for cutting and grazing[1]

Degradabilidade ruminal de híbridos de sorgo sudão para corte e pastejo portadores de nervura marrom

Deborah Alves Ferreira[2]*, Lúcio Carlos Gonçalves[3] and José Avelino Santos Rodrigues[4]

ABSTRACT - Greater ruminal degradability has been reported in mutant plants with brown midrib (*bmr*). The aim of this study was to evaluate the *in situ* degradability of dry matter (DM), neutral detergent fibre (NDF) and crude protein (CP) in the experimental sorghum-sudangrass *bmr* hybrids BR007 x Tx2784*bmr* and Tx635x Tx2785*bmr*, conventional experimental hybrids CMSxS206 x Tx2784 and Tx636 x Tx2785, and the control hybrid BRS801, harvested 51 days after planting. Three sheep with ruminal cannulae were used. The experimental design was of randomised complete blocks in subdivided lots. The mean values for DM and NDF disappearance were higher in the *bmr* hybrids after 6 h incubation. These plants had a higher rate of degradation (mean value of 6.93%/h) for fraction *b* of the DM compared to conventional plants (mean value of 5.73%/h), and greater effective DM degradability. The mean values for effective NDF degradability at passage rates of 2, 5 and 8%/h were 72.7% and 62.0%, 56.1% and 45.6%, and 47.1% and 37.3% for the *bmr* and conventional hybrids respectively. The experimental mutant hybrids showed higher values for effective CP degradability in relation to the remainder, however, the differences were more subtle in relation to those seen for DM and NDF. The results of the present work show the potential of using sorghum-sudangrass *bmr* hybrids in systems of ruminant production with high nutritional requirements.

Key words: Forage. *In situ*. Ruminants. *Sorghum bicolor*. *Sorghum sudanense*.

RESUMO - Maior degradabilidade ruminal tem sido relatada para plantas mutantes, portadoras de nervura marrom (*bmr*). Objetivou-se avaliar a degradabilidade *in situ* da matéria seca (MS), fibra em detergente neutro (FDN) e proteína bruta (PB) de híbridos de sorgo com capim Sudão experimentais *bmr*, BR007 x Tx2784*bmr* e Tx635x Tx2785*bmr*, experimentais convencionais CMSxS206 x Tx2784 e Tx636 x Tx2785 e o híbrido testemunha BRS801, colhidos 51 dias após o plantio. Utilizou-se três carneiros dotados de cânula ruminal. O delineamento utilizado foi o de blocos ao acaso em parcelas subdivididas. O desaparecimento médio da MS e da FDN foram superiores para os híbridos *bmr* a partir de 6 h de incubação. Estas plantas apresentaram maior taxa de degradação (média de 6,93%/h) da fração b da MS em relação as plantas convencionais (média de 5,73%/h) e maior degradabilidade efetiva da MS. As degradabilidades efetivas médias da FDN nas taxas de passagens de 2; 5 e 8%/h foram de 72,7% e 62,0%; 56,1% e 45,6%; e de 47,1% e 37,3% para os híbridos *bmr* e convencionais, respectivamente. Os híbridos experimentais mutantes apresentaram maiores degradabilidades efetivas da PB em relação aos demais, entretanto, as diferenças foram mais sutis em relação às diferenças observadas para MS e FDN. Os resultados do presente estudo mostram o potencial de utilização dos híbridos de sorgo Sudão *bmr* em sistemas de produção de ruminantes com elevada exigência nutricional.

Palavras-chave: Forrageira. *In situ*. Ruminantes. *Sorghum bicolor*. *Sorghum sudanense*.

DOI: 10.5935/1806-6690.20180016
* Autor para correspondência
Recebido para publicação em 01/02/2016; aprovado em 20/03/2017
[1]Parte da Tese de Doutorado em Zootecnia da primeira autora, apresentada na Universidade Federal de Minas Gerais/UFMG
[2]Escola de Medicina Veterinária e Zootecnia, Universidade Federal do Tocantins, Araguaína-TO, Brasil, deborah.alvesferreira@gmail.com
[3]Departamento de Zootecnia, Escola de Veterinária, Universidade Federal de Minas Gerais, Belo Horizonte-MG, Brasil, luciocg@vet.ufmg.br
[4]Pesquisador da Embrapa Milho e Sorgo, Sete Lagoas-MG, Brasil, avelino.rodrigues@embrapa.br

INTRODUCTION

The production of meat and milk from animals kept in tropical pastures is directly related to the quality of the available forage. Digestible energy intake and animal performance are determined by the interactions between the chemical and physical characteristics of the forage and the mechanisms of digestion, metabolism and voluntary intake (REIS *et al*., 2012). For nutritionists, information about the ruminal digestion of forages is of fundamental importance, as this is the principle site for the digestion of fibrous feed, and according to Nocek (1988), knowledge of nutrient availability in this compartment makes it possible to establish the quantity and proportion of nutrients required for maximum microbial and animal response.

The first limitation on the rapid degradation of cell wall polysaccharides (cellulose and hemicelluloses) is the presence of lignin (VAN SOEST, 1994). This limitation is associated with the physical presence of the lignin, its chemical nature, and its phenolic bonds to polysaccharides (CASLER; JUNG, 2006). Mutant *bmr* (brown midrib) plants (FERREIRA *et al*., 2015) have attracted the attention of researchers as they display greater ruminal digestibility in comparison to conventional isogenic plants. Phenotypically, there is brownish pigmentation of the midrib in the leaf and of the medulla in the stem associated with lignified tissue (SATTLER *et al*., 2014; VERMERRIS; SHERMAN; McINTYRE, 2010).

Bmr plants generally have a lower lignin content (AGUILAR *et al*., 2014; BARRIÈRE *et al*., 2007; VERMERRIS; SHERMAN; McINTYRE, 2010) and present changes in the composition and/or type of linkage between carbohydrates in the cell wall, resulting in increased digestibility of the neutral detergent-soluble fibre (NDF) (BARRIÈRE *et al*., 2007). *In vitro*, *in situ* and *in vivo* studies of digestibility have shown that forage sorghum, and Sudan grass and its *bmr* hybrids have a greater extent for NDF digestion compared to conventional genotypes (BECK *et al*., 2007; FERREIRA *et al*., 2015; LEDGERWOOD *et al*., 2009).

The sorghum-sudangrass hybrids obtained when crossing *Sorghum bicolor* (L.) Moench and *Sorghum sudanense* (Piper) Stapf, have been well accepted by cattle farmers (FERREIRA *et al*., 2015), because they have flexible planting times and high production potential, and are an option for intensifying animal production, especially at times of feed shortage (SIMILI *et al*., 2008).

Combining the importance of sorghum-sudangrass hybrids as an annual forage in the composition of diversified feeding systems, with the increasing demand for forages of greater nutritional value, the aim of this study was to evaluate the ruminal degradability of dry matter (DM), NDF and crude protein (CP) in conventional experimental sorghum-sudangrass hybrids and *bmr* hybrids, carriers of brown midrib.

MATERIAL AND METHODS

Five sorghum-sudangrass hybrids (*Sorghum bicolor* x *Sorghum sudanense*), of which two were experimental *bmr* hybrids (BR007 x Tx2784*bmr* and Tx635 x Tx2785*bmr*, containing the *bmr*-6 gene for the brown-rib phenotype), two conventional experimental hybrids (CMSxS206 x Tx2784 and Tx636 x Tx2785) from the breeding program of the Embrapa National Research Centre for Maize and Sorghum, and one commercial hybrid (BRS801) from the same institution, were developed, planted and harvested at Embrapa Milho e Sorgo. This company is located in Sete Lagoas in the State of Minas Gerais, at 19º28’ S and 44º15’ W, in a region with an average altitude of 732 m and a climate of type AW according to the Köppen classification (savannah climate, with dry winters and an average temperature over 18 °C in the coldest month).

Planting took place on 19 November 2005, using three beds (replications), each with four rows of five meters at a spacing between rows of 35 cm, giving a total of 15 beds. Fertiliser was applied when planting, using 400 kg/ha NPK + Zinc (8-28-16). The material was cut 51 days after planting, sampled and dried in a forced ventilation oven at 55 ºC for 48h to determine the pre-dried matter (AOAC, 1995). After pre-drying, the material was taken to the Animal Nutrition Laboratory at the Veterinary School of the Federal University of Minas Gerais, where it was ground into five-millimetre particles using a Wiley mill.

Three rumen-cannulated sheep with a live weight of between 52 and 56 kg were housed in metabolism cages, receiving water and mineral salt at will. The diet consisted of 80% hay from grass of the genus *Cynodon* and 20% commercial concentrate containing 18% CP in the DM. After 14 days for the three animals to adapt to the diet, and before the samples were incubated, the rumen environment was evaluated. Ruminal fluid was withdrawn via cannula 30 min before, and 1, 2, 3, 5, 7 and 9h after feeding. The pH of the ruminal fluid was determined with a potentiometer, and the ammonia nitrogen (mg/100 mL) by distillation with calcium chloride and magnesium oxide (Table 1).

The samples were incubated in the rumen for 0, 6, 12, 24, 48 and 96 h. For incubation, nylon bags with a mesh opening of 50 µm were used, with the amount of sample in each bag giving a mean ratio of 20 mg of sample

Table 1 - Ammonia nitrogen and pH of the ruminal fluid of the experimental animals, collected before (-30 min) and after (1, 2, 3, 5, 7 and 9 h) feeding

Period (h)	pH	$N\text{-}NH_3$ (mg/100mL)
- 30 min	6.76 ± 0.22	11.89 ± 1.91
1	6.50 ± 0.07	37.35 ± 1.53
2	6.38 ± 0.11	25.16 ± 3.89
3	6.68 ± 0.12	20.84 ± 5.27
5	6.49 ± 0.20	10.18 ± 4.64
7	6.59 ± 0.39	7.94 ± 4.73
9	6.52 ± 0.33	6.63 ± 3.68

per cm^2 of bag surface area, as recommended by Nocek (1988). To determine the soluble fractions (time zero), the bags containing the samples were immersed in water, dried in a forced ventilation oven at 55 ºC for 48h, and weighed. To determine the ruminal degradability of the fractions at 6, 12, 24, 48 and 96 h, the bags containing the samples were attached to a nylon rope, 35 cm in length, connected to a 100 g weight, immersed in water, and then inserted into the rumen of the experimental animals via the cannula. For each animal, all treatments from any one incubation period were inserted simultaneously; after 10 days, all the treatments from each incubation period were evaluated in each of the animals. After removal, the bags were immediately immersed in cold water and frozen. After all the treatments for each of the five incubation periods were removed, the bags containing the residues were unfrozen and washed in an automatic washer in three cycles of 5 min each, placed in a forced ventilation oven at 55 ºC for 48 h, and weighed. The incubation residue and the original forage samples were ground in a Wiley mill into one-millimetre particles and used to determine the DM at 105 °C (AOAC, 1995), the NDF (VAN SOEST; ROBERTSON; LEWIS, 1991) with no sodium sulphite or α-amylase, using the ANKOM200® analyser, and the CP by the Kjeldhal method (AOAC, 1995); the CP was only determined in incubation residues of up to 48 h. The acid detergent fibre content (ADF) and acid detergent lignin content (AOAC, 1995) were determined in the original material using an ANKON200® analyser, and the total digestible nutrient content (TDN) was estimated from the TDN equation (%) = 83.79-0.4171*NDF(%) (CAPPELLE *et al*., 2001). The chemical composition of the forages evaluated in this study is shown in Table 2.

To estimate the disappearance of nutritional components, the following model proposed by Ørskov and McDonald (1979) was used: $p = a+b\,(1- e^{-ct})$, where p is the potential degradability, *a* is the water-soluble fraction, *b* is the insoluble but potentially degradable fraction, *c* is the rate of degradation of fraction *b*, and t is the period of incubation in the rumen. Values for effective degradability were calculated using the passage rate values suggested by the Agricultural Research Council (1984), of 2%/h, 5%/h, and 8%/h, corresponding to low, medium and high intake respectively, as per the model proposed by Ørskov and McDonald (1979): $ED = a + [(b*c) / (c+k)]$, where ED is the effective degradability, and k is the ruminal passage rate for particles.

In order to evaluate the disappearance data for DM, NDF and CP in the forages, a randomised block design in split plots was used, considering the animals as blocks, the hybrids as plots, and the incubation periods as split plots,

Table 2 - Chemical composition and TDN values in conventional and *bmr* sorghum-sudangrass hybrids

Hybrid	DM (%)	% DM				
		CP	NDF	ADF	Lignin	TDN
BR007 x Tx2784*bmr*	7.69	18.2	54.0	33.3	3.39	61.28
Tx635 x Tx2785*bmr*	7.10	15.2	59.6	38.1	3.61	58.94
CMSxS206 x Tx2784	8.27	14.0	62.4	39.1	3.76	57.75
Tx636 x Tx2785	7.97	13.4	64.8	41.9	3.52	56.74
BRS 801	8.25	13.6	61.6	38.8	4.12	58.10

as per the model: $Y_{ijk} = \mu + A_i + F_j + e_{ij} + T_k + FT_{jk} + e_{ijk}$, where Yijk = value referring to the observation of hybrid j, in animal i, for incubation period k; μ = mean average; Ai = effect of animal i (i = 1, 2, 3); Fj = effect of hybrid j (j = 1, 2, 3, 4, 5); e_{ij} = error of the i-th block in observation Y_{ijk}; Tk = effect of incubation period k (k = 6, 12, 24, 48 and 96); FTjk = interaction of the effects of hybrid j for incubation period k; e_{ijk} = random error associated with the observation. The mean values were compared by SNK test at 5% probability, using the SAEG 7.0 software.

RESULTS AND DISCUSSION

Data for DM disappearance in the hybrids under evaluation can be seen in Table 3. The experimental hybrid BR007 x Tx2784*bmr* was superior to the conventional experimental hybrids for all incubation periods.

The hybrid Tx635 x Tx2785*bmr* showed a DM disappearance similar to the conventional experimental hybrids at time zero, but was superior to these and the control hybrid after 6 h incubation. From 48 h incubation, the experimental *bmr* hybrids each had a similar value for DM disappearance, higher than in the other hybrids.

After 6 h of ruminal degradation, the mutant hybrids provided a larger amount of nutrients for microbial fermentation. Accordingly, it can be inferred that these hybrids have the potential for use in animals with high nutritional requirements and high intake, as they have a greater ruminal passage rate. In these animals, digesta remaining for a shorter period in the rumen suggests the need for using forages that show more rapid availability of nutrients and energy. The use of forages with a greater potential for DM degradation can result in better use of their nutritional constituents, and reduce the use of more expensive concentrated feed in balancing the diet.

The soluble fractions (a), potentially degradable insoluble fractions (b), rates of degradation (c), and effective degradability (ED), at passage rates of 2%/h, 5%/h, and 8%/h, in the hybrids under study, are described in Table 4.

The hybrid BR007 x Tx2784*bmr* had a higher value for the soluble fraction (37.31%) together with an insoluble fraction of reduced value (57.69%) and a high rate of degradation (6.61% / h). The results seen for fractions *a* and *b* are probably due to the greater values for CP and lower values for NDF found with this hybrid respectively (Table 2), contributing to the higher mean value for MS disappearance at zero incubation time (Table 3). This combination of results, coupled with an intermediate rate of degradation for fraction *b* (c), gave the hybrid BR007 x Tx2784*bmr* a greater value for ruminal degradability at the three passage rates under evaluation, demonstrating its superiority at any intake level.

The hybrid Tx635 x Tx2785*bmr* presented an intermediate value for fraction *a* (25.14%) and a high value for fraction *b* (68.15%). However, the rate of degradation of fraction *b* was the highest among the hybrids. Thus, the values for effective degradability for the different passage rates were also higher than those displayed by the conventional experimental hybrids and BRS 801. This suggests that the fibrous fraction of hybrid Tx635 x Tx2785*bmr* is of high ruminal degradability.

Beck *et al*. (2007) found higher values for fraction *a* and for the rate of DM degradation in sorghum-sudangrass *bmr* hybrids (NutriPlus and Dry Stalk) (29% and 4.04%/h respectively) compared to the conventional hybrid (Sweet Sanny Sue) (25.6% and 3.57%/h respectively), at three harvest times. Forages showing greater values for degradation are also more digestible, however they should present high values for the rate of degradation to express the maximum degradation potential in a shorter time, especially when provided to animals that present high intake and consequently greater ruminal passage rates for the digesta. According to Sampaio (1988), rates of

Table 3 - Mean value for dry matter disappearance (%) in conventional and *bmr* sorghum-sudangrass hybrids

Hybrid[a]	Period (h)					
	0	6	12	24	48	96
BR007 x Tx2784*bmr*	36.44 [a]	56.21 [a]	68.84 [a]	83.44 [a]	92.18 [a]	95.14 [a]
Tx635 x Tx2785*bmr*	27.93 [bc]	48.43 [b]	66.38 [a]	80.05 [b]	90.97 [a]	93.75 [a]
CMSxS206 x Tx2784	28.67 [b]	44.16 [c]	57.00 [b]	69.25 [c]	81.17 [b]	86.76 [b]
Tx636 x Tx2785	26.50 [bc]	41.23 [c]	55.35 [b]	71.60 [c]	81.35 [b]	85.63 [b]
BRS 801	24.60 [c]	40.80 [c]	56.66 [b]	71.63 [c]	83.13 [b]	88.82 [b]

[a]Mean values followed by the same letter in a column do not differ by SNK test (p>0.05); CV=3.0%

Table 4 - Soluble fractions (a), potentially degradable insoluble fractions (b), rates of degradation (c), and effective degradability (ED) of dry matter at a passage rate of 2% / h, 5% / h, and 8% / h, in conventional and *bmr* sorghum-sudangrass hybrids

	a (%)	b (%)	c (% / h)	ED 2% / h	ED 5% / h	ED 8% / h	R^2
BR007 x Tx2784*bmr*	37.31	57.69	6.61	81.6	70.2	63.4	0.99
Tx635 x Tx2785*bmr*	25.14	68.15	7.24	78.4	65.4	57.5	0.99
CMSxS206 x Tx2784	30.21	56.63	4.99	70.6	58.5	52.0	0.99
Tx636 x Tx2785	20.96	64.28	6.36	70.0	57.2	49.8	0.99
BRS 801	21.88	66.36	5.85	71.4	57.8	50.0	0.99

degradation lower than 2.0%/h indicate that the feed is of low quality and requires a long residence time in the rumen to be degraded. In this study, all sorghum-sudangrass hybrids presented values greater than 2%h, and can be considered to have good rumen DM degradability, with the experimental *bmr* hybrids being superior. The coefficient of determination (R^2) of 0.990 for all the hybrids indicates a good fit of the results for DM disappearance to the model proposed by Ørskov and McDonald (1979) used in this study.

Ferraretto *et al*. (2015) evaluated a supply of *bmr* and conventional maize silage to high-production dairy cows (average of 47.9 kg of milk per day). The researchers found greater DM intake, with consequently higher milk yield, in animals receiving mutant-maize silage; they also found greater yields of milk protein and lactose, associated with a lower value for milk urea nitrogen. According to the authors, this result was due to the greater DM and nutrient intake, and the potentially greater flow of microbial protein to the duodenum.

Holt *et al*. (2013) also evaluated the use of mutant *bmr* maize in the preparation of silage for dairy cows receiving a diet containing 60% of forage. In that study, the researchers found that there was no difference in DM intake, or milk production and composition, during the first 60 days of lactation when silage was prepared with *bmr* maize compared to normal maize, but there was a tendency to reduce the mobilisation of body reserves ($p<0.09$). However, after peak lactation (60 to 180 days lactation), there was an increase of 2.2 kg of milk per day ($p<0.01$), probably due to an increase in intake of 1.1 kg of DM ($p<0.07$). They therefore considered that the use of *bmr* plants could have beneficial effects in reducing body mobilisation in cows that have recently calved, without limiting intake around peak lactation and resulting in extended peak production. These results give a glimpse of the potential of using mutant *bmr* sorghum-sudangrass hybrids in animal production, since the high DM degradation seen in the present study also has a great potential to express higher DM intake and animal performance, as reported by Reis *et al*. (2012).

After 6 h incubation, the experimental *bmr* hybrids showed greater NDF disappearance (Table 5).

It can be seen that the potentially degradable insoluble fraction (b) was greater in hybrid Tx635 x Tx2785*bmr* (80.13%). Hybrid BR007 x Tx2784*bmr* displayed a smaller fraction *b* compared to hybrid Tx635 x Tx2785*bmr*. However, Tx635 x Tx2785*bmr* showed a higher rate for degradation of fraction *b* of the NDF (5.58%/h) (Table 6).

Table 5 - Mean value for neutral detergent fibre disappearance (%) in conventional and *bmr* sorghum-sudangrass hybrids

Hybrid[a]	Period (h)					
	0	6	12	24	48	96
BR007 x Tx2784*bmr*	21.70 [a]	34.46 [a]	53.18 [a]	74.70 [a]	88.71 [a]	93.04 [a]
Tx635 x Tx2785*bmr*	15.00 [b]	30.82 [a]	54.56 [a]	72.82 [a]	88.03 [a]	91.93 [a]
CMSxS206 x Tx2784	16.57 [b]	23.61 [b]	40.45 [b]	58.67 [b]	72.18 [c]	83.93 [b]
Tx636 x Tx2785	14.76 [bc]	24.24 [b]	43.29 [b]	63.42 [b]	77.41 [b]	82.88 [b]
BRS 801	12.65 [c]	20.59 [b]	42.69 [b]	60.45 [b]	78.92 [b]	85.53 [b]

[a]Mean values followed by the same letter in a column do not differ by SNK test ($p>0.05$); CV=5.6%

Table 6 - Soluble fractions (a), potentially degradable insoluble fractions (b), rates of degradation (c) and effective degradability (ED) of neutral detergent fibre, at a passage rate of 2%/h, 5%/h, and 8%/h, in conventional and *bmr* sorghum-sudangrass hybrids

	a (%)	b (%)	c (%/h)	ED 2%/h	ED 5%/h	ED 8%/h	R^2
BR007 x Tx2784*bmr*	19.19	75.69	5.00	73.3	57.0	48.3	0.992
Tx635 x Tx2785*bmr*	12.97	80.13	5.58	72.0	55.2	45.9	0.993
CMSxS206 x Tx2784	14.22	71.73	3.64	60.5	44.4	36.7	0.990
Tx636 x Tx2785	11.82	72.96	4.64	62.8	46.9	38.6	0.989
BRS 801	9.43	78.62	4.21	62.7	45.4	36.5	0.987

The rates of degradation of fraction *b* of the NDF were lower in the conventional hybrids compared to the mutant hybrids, a result also seen by Beck *et al*. (2007) in sorghum-sudangrass, and by Stone *et al.* (2012) in maize silage. The lowest value was seen in the hybrid CMSxS206 x Tx2784 (3.64%/h) (Table 6). This lower rate of degradation probably resulted in the lowest mean value for NDF disappearance seen for this hybrid after 48h incubation (Table 5).

For the experimental *bmr* hybrids, the high rate of degradation of fraction *b* contributes significantly to express greater effective NDF degradability, even though it shows high values for b, evaluated at a passage rate of 8%/h (Table 6). According to Castro *et al*. (2010) and other researchers, the increase in DM intake for forages with high NDF digestibility could be a result the higher rates of degradability or passage in the *bmr* hybrids, due to the lower lignin content.

Greater values for *in vitro* NDF digestibility (IVNDFD) after 30 h (HOLT *et al*., 2013; STONE *et al*., 2012) or 24, 48, and 96 h incubation (JUNG; MERTENS; PHILLIPS, 2011), and *in situ* NDF degradability after 48 h incubation (CASTRO *et al*., 2010) were seen in mutant *bmr* maize silages compared to conventional maize silages. Dann *et al*. (2008) found a higher value for IVNDFD 30 h in sorghum-sudangrass silage compared to that of conventional maize. After 48 h incubation, Ferreira *et al*. (2015) and Ledgerwood *et al*. (2009) found a higher value for IVNDFD in *bmr* sorghum-sudangrass compared to conventional hybrids.

Not only the amount, but also the composition of the lignin can affect the digestibility of forage, mainly as this determines different types of links between the monomers that comprise the lignin, among them, the cellulose and hemicelluloses (BARRIÈRE *et al*., 2007; JUNG; PHILLIPS, 2010). The chemical composition of the cell wall of the mutant *bmr*-6 plants may show a reduction in lignin content and/or a smaller molar ratio between units of syringylpropane and guaiacylpropane (S/G) (SATTLER *et al*., 2009). These phenotypic changes result from alterations in the activity of the cinnamoyl alcohol dehydrogenase enzyme (CAD), involved in lignin biosynthesis (PALMER *et al*., 2008; SATTLER *et al*., 2009). Although the sorghum-sudangrass hybrids evaluated in the present study have a similar lignin content (Table 2), it suggests that possible differences in lignin composition (undetermined) in the mutant hybrids may have positively influenced cell wall degradation (Table 6).

Dann *et al*. (2008) found that dairy cows with a mean production of 31 kg of milk per day, receiving 35 or 45% of sorghum-sudangrass *bmr* silage instead of conventional maize silage, presented lower DM intake and similar 3.5% fat corrected milk, resulting in greater feeding efficiency ($p<0.001$). The authors reported that animals receiving sorghum-sudangrass *bmr* silage derive greater energy from NDF digestion compared to those receiving maize silage, that based more on starch digestibility, at least during the period under evaluation (84 days, after 81±31 days of lactation), and that sorghum-sudangrass *bmr* can compete nutritionally with maize silage.

At zero time (disappearance of the soluble fraction), it can be seen that the BRS801 control hybrid had the highest value (39.85%), while the experimental hybrid BR007 x Tx2784*bmr* had the lowest value (27.89%) for mean CP disappearance. After 6 h incubation, the experimental hybrid BR007 x Tx2784*bmr* presented the highest value. After 12 h, the experimental hybrid BR007 x Tx2784*bmr* showed a similar value for CP disappearance to the hybrid Tx635 x Tx2785*bmr*, and greater than the other hybrids (Table 7).

The parameters for CP degradation are described in Table 8. The soluble CP fractions in the hybrids under study varied from 28.47% to 39.65%, with the highest value found in the control hybrid BRS801. No differences were seen in this parameter due to the presence of the *bmr* mutation. According to Van Soest (1994), most of the CP soluble fraction in fresh forages consists of peptides, free amino acids, nitrate and amines, making up 14% to 34% of the total protein fraction. Thus, the soluble fractions found in this study may be considered satisfactory.

The potentially degradable insoluble fraction was greatest in the experimental hybrid BR007 x Tx2784*bmr* (63.56%), with the lowest value found in the experimental hybrid CMSxS206 x Tx2784 (50.83%) (Table 8). The experimental mutant hybrids presented greater ED values for CP compared to the other hybrids, however the differences were more subtle in relation to the differences seen in ED for DM and NDF.

Forages display high values for the protein fraction B3, characterised as true protein which is insoluble in neutral detergent, but soluble in acid detergent, and slowly degradable in the rumen as it is bound to the cell wall (VAN SOEST, 1994). In the experimental hybrid BR007 x Tx2784*bmr*, despite having a smaller soluble CP fraction, the greater potentially degradable insoluble fraction with a high rate of degradation resulted in greater values for ED at passage rates of 2% / h 5% / h and 8% / h compared to the other hybrids. This result was probably due to the high rate of degradation of the NDF seen in the hybrid (5.00% / h) (Table 6), which facilitated the access of rumen microorganisms to fraction B3 of the protein. In the hybrid Tx635 x Tx2785*bmr*, the association of a high value for soluble CP (a) and the rate of degradation of the intermediate fraction *b* contributed to the ED values.

Table 7 - Mean value for crude protein disappearance (%) in conventional and *bmr* sorghum-sudangrass hybrids

Hybrid[a]	Period (h)				
	0	6	12	24	48
BR007 x Tx2784*bmr*	27.89 [c]	71.74 [a]	79.70 [a]	89.44 [a]	94.77 [a]
Tx635 x Tx2785*bmr*	36.09 [b]	66.28 [b]	76.67 [ab]	86.45 [ab]	94.07 [a]
CMSxS206 x Tx2784	35.10 [b]	63.87 [b]	74.35 [bc]	81.84 [c]	87.95 [b]
Tx636 x Tx2785	33.60 [b]	63.76 [b]	73.48 [bc]	83.39 [bc]	90.67 [ab]
BRS 801	39.85 [a]	57.31 [c]	70.52 [c]	82.58 [bc]	90.31 [ab]

[a]Mean values followed by the same letter in a column do not differ by SNK test (p>0.05); CV=2.9%

Table 8 - Soluble fractions (a), potentially degradable insoluble fractions (b), rates of degradation (c) and effective degradability (ED) of crude protein, at a passage rate of 2%/h, 5%/h, and 8%/h, in conventional and *bmr* sorghum-sudangrass hybrids

	a (%)	b (%)	c (%/h)	ED (2%/h)	ED (5%/h)	ED (8%/h)	R^2
BR007 x Tx2784*bmr*	28.47	63.56	16.71	85.2	77.4	71.5	0.988
Tx635 x Tx2785*bmr*	36.80	55.68	11.16	84.0	75.3	69.2	0.992
CMSxS206 x Tx2784	35.53	50.83	12.54	79.4	71.9	66.6	0.994
Tx636 x Tx2785	34.34	54.55	11.30	80.7	72.2	66.3	0.992
BRS 801	39.65	52.36	7.20	80.6	70.5	64.4	0.999

CONCLUSIONS

1. The experimental sorghum-sudangrass *bmr* hybrids showed a mean value for disappearance, and kinetic parameters of ruminal degradation of the nutritional constituents, which were similar and superior to the conventional experimental hybrids and BRS 801;
2. The sorghum-sudangrass *bmr* hybrids proved to be promising for the composition of diversified ruminant feeding systems using high-quality fodder;
3. Studies *in vivo* and agronomic evaluations are required for suitable recommendations on the use of sorghum-sudangrass *bmr* hybrids.

ACKNOWLEDGEMENTS

The authors wish to thank the National Council for Scientific and Technological Development - CNPq, Embrapa Milho e Sorgo, and the Department of Animal Science of the Veterinary School of the Federal University of Minas Gerais for their support.

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