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Pearl millet grain for beef cattle in crop-livestock integration system: intake and digestibility

Grão de milheto para bovinos de corte em sistema de integração lavoura e pecuária: consumo e digestibilidade

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Abstract

The present study aimed to evaluate the nutritional parameters (intake and digestibility) of beef cattle in two genetic groups fed protein-energy supplements formulated by different levels of replacement of maize with pearl millet grain during the dry season. Sixty-four uncastrated young bulls, with an average age of 20 months and an initial body weight of 388 ± 26 kg, were included in the study. The experimental area consisted of four paddocks approximately 4.7 ha in size, composed of *Brachiaria brizantha* 'Marandu' within a crop-livestock integration system. The study was based on a completely randomized factorial design (2×4). Two genetic groups (Crossbred and Nellore) and the effects of replacement of maize with pearl millet grain at 0%, 33%, 66%, and 100% in the supplement formulations were assessed. No significant effects were observed in the genetic groups and with the replacement of maize with pearl millet grain, as well as in the pasture total dry matter (DM) and nutrients intake, or the coefficients of total digestibility of nutrients. The dietary concentration of digested organic matter was not influenced by the replacement levels of pearl millet grain, with values of 514.88, 515.76, 516.01, and 515.98 g kg^{-1} of DM recorded for the 0%, 33%, 66%, and 100% replacement levels, respectively. Therefore, pearl millet grain can be utilized as a partial or total substitute for maize grain as the energetic ingredient in concentrated supplements for Nellore and crossbred beef cattle in pastures managed in crop-livestock integration systems.
Key words: Replacement levels. Pasture. Drought. Supplementation.

Resumo

Objetivou-se avaliar os parâmetros nutricionais (consumo e digestibilidade) de bovinos de corte de dois grupos genéticos, alimentados com suplementos proteico-energéticos formulados a partir de diferentes

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níveis de substituição do milho pelo grão de milheto no período da seca. Foram utilizados 64 novilhos, não castrados, com média de idade de 20 meses e o peso corporal médio inicial de 388 ± 26 kg. A área experimental constituiu-se de quatro piquetes de aproximadamente 4,7 ha, formados com *Brachiaria brizantha* cv. Marandu em sistema de integração lavoura e pecuária. O experimento foi estruturado em esquema fatorial (2x4) distribuído em um delineamento experimental inteiramente casualizado, onde foram avaliados dois grupos genéticos (Mestiços e Nelore) e quatro diferentes níveis de grão de milheto (0%, 33%, 66% e 100%) em substituição ao grão de milho na formulação dos suplementos. Não houve efeito tanto para o fator grupo genético, quanto para os níveis de substituição do milho pelo grão de milheto e ao consumo de matéria seca (MS) total de pasto e dos nutrientes da dieta e para os coeficientes de digestibilidade total dos nutrientes. A concentração dietética de matéria orgânica digerida não foi influenciada pelos níveis de grão de milheto com valores de 514,88; 515,76; 516,01 e 515,98 g kg^{-1} de MS, respectivamente para os níveis 0%, 335, 66% e 100%. O grão de milheto como ingrediente energético de suplementos concentrados pode ser utilizado como substituto ao grão de milho de forma parcial ou total na dieta de bovinos de corte Nelores ou Mestiços em pastos formados no sistema de integração lavoura e pecuária.

Palavras-chave: Níveis de substituição. Pastagem. Seca. Suplementação.

Introduction

Techniques such as crop-livestock integration (CLI) and supplementation of grazing animals are particularly suited to the expansion in the production capacity of beef cattle in presently exploited regions, and these represent a promising alternative for the development of more efficient production systems (ALONSO et al., 2014; OLMEDO et al., 2010).

Batista (2014) observed that offering distinct supplements to finished bovines in CLI systems improved pasture utilization and increased animal performance. Nevertheless, further study on the effects of supplementation in grazing bovines on the CLI system is required, as was suggested by Alonso et al. (2013, 2014) and Batista (2014).

CLI allows for different production systems, where years or periods of livestock alternate with production of grains, fibers, and use of products and by-products in animal diets, which aim for the recovery of degraded pastures and food production during the off-season (MACEDO, 2009).

In this context, finishing of grazing animals in CLI systems is a good option for the sustainable development of livestock, the provision of grazing during the dry season, and valuable ground cover for the following crops (ALONSO et al., 2013). In CLI, grain production allows the use of products and residues in the animal diet in the form of protein-energy supplements in periods of low nutritional pasture, thereby improving resource utilization efficiency (ALONSO et al., 2014).

Pearl millet is one of the crops that is planted in succession with annual crops and has been of great importance in the Midwest region of Brazil, demonstrating the potential of grain production. Furthermore, it is an energetic ingredient of considerable interest in ruminant diets because of its low cost, especially when compared to maize production. However, despite showing great potential for ruminant feeding, there is limited information available in the literature on its optimal level for use as a maize substitute in supplements. Therefore, the aim of the present study was to determine the effect of increasing replacement levels of maize with pearl millet grain in protein-energy supplements on the intake and apparent digestibility of the diet components in two beef cattle genetic groups finished on pasture in CLI production systems.

Materials and Methods

The present study was conducted at the Farm Dona Isabina, located in the municipality of Santa Carmem-MT with geographical coordinates

12°03′52.07″ S and 55°21′16.92″ W. The study was performed during the dry season, between the months of June and September 2010.

Based on the Köppen-Geiger classification system, the climate in this region is Am type (monsoon climate) and is characterized as tropical rainy with a short rainy season during the driest month. The CLI system module included in the present study had distinct crops for five harvest years. The study started in the fifth crop year (Table 1) during the dry season. No precipitation data was recorded during the study period.

Table 1. Crop distribution as a function of agricultural year.

Agricultural year	Seasons	
	Wet	Dry
01	Soy[(1)]	Sorghum [(3)] + *B. ruziziensis*
02	Soy [(1)]	Maize[(4)] + *B. ruziziensis*
03	Rice[(2)]	Millet[(5)] + Sorghum[(3)] + *B. ruziziensis*
04	Soy [(1)]	Maize [(4)] + *B. brizantha* 'Marandu'
05	*B. brizantha* 'Marandu'	*B. brizantha* 'Marandu'

[(1)]Premature. [(2)]Direct seeding. [(3)]Pasture. [(4)]Second crop. [(5)]Sown over Sorghum + *B. ruziziensis* that had germinated inadequately.
Source: Alonso et al. (2013, 2014).

A total of 64 uncastrated young bulls were selected for the study, comprising 32 animals from Nellore breed and 32 Holstein × Nellore crossbred animals. The average age of all animals was 20 months and the average initial body weight (BW) was 388 ± 26 kg. The animals were randomly divided into four groups, each containing eight animals from both genetic groups. The experimental area entailed four paddocks of approximately 4.7 ha composed of *Brachiaria brizantha* 'Marandu'.

Protein supplements (25% crude protein [CP]) formulated from four different replacement levels of maize with pearl millet grain (0%, 33%, 66%, and 100%) were evaluated (Table 2). Thus, eight treatments involving the interaction between two genetic groups and four levels of replacement were assessed. The feeding supplement, 4.0 kg of natural matter animal^{-1} day^{-1}, was offered at 10 a.m. To minimize any beneficial effect inherent to the pasture, such as possible variations in forage dry matter (DM), the animal groups were rotated between the paddocks every 14 days, while ensuring their respective supplements were preserved.

Table 2. Percentage composition of supplements based on natural matter.

Ingredients	Levels of replacement (%)			
	0	33	66	100
Mineral mixture[(1)]	2.00	2.00	2.00	2.00
Ground soybean residue	55.27	52.68	50.09	45.78
Ground maize grain	42.73	31.08	19.43	-
Ground millet grain	-	14.24	28.48	52.22

[(1)]Guaranteed levels: Calcium 180.0 g; Sodium 120.0 g; Phosphorous 85.0 g; Sulfur 15.0 g; Magnesium 2.0 g; Zinc 4500.0 mg; Copper 1300.0 mg; Manganese 1150.0 mg; Fluor 830.0 mg; Cobalt 85.0 mg; Iodine 85.0 mg; Selenium 24.5 mg.

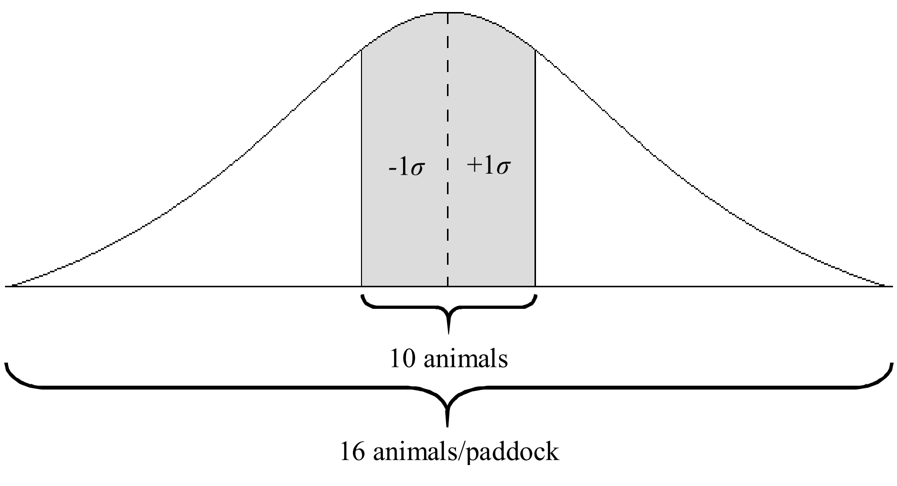
At the beginning of the study, and every 14 days thereafter, pasture samples were collected using two methods. The first method was utilized to evaluate the amount of forage intake by the animals via grazing simulation. In the second method, bulk samples were collected from the pasture (t DM ha^{-1}) by cutting five internal random areas from each paddock. The cuts were made at a height of 0.10 m above the ground, delimited by a metal frame with dimensions 0.50 × 0.50 m. Next, the material of each paddock was homogenized, and two subsamples per paddock were analyzed to determine the *bromatological composition,* the total mass of forage, and the mass of potentially digestible forage.

The total DM and pasture DM (PDM) intake were estimated via an external indicator, titanium dioxide (TiO_2), and an internal indicator – indigestible neutral detergent fiber (iNDF) – from 10 animals per group. Fecal excretion was estimated with TiO_2 mixed with the supplements (20 g $animal^{-1}$ day^{-1}). The internal indicator was ingested for 10 days (7 days for adaptation and 3 days for collection purposes). Fecal samples were collected three times over three consecutive days.

The TiO_2 concentration in the feces was determined following the method described by Myers et al. (2004). The fecal excretion estimate was obtained by the ratio: FE = Dose/FC, where, FE = fecal excretion (g day^{-1}); Dose = TiO_2 daily dose (g day^{-1}); and FC = TiO_2 fecal concentration (g g^{-1}).

The PDM ingestion rate was determined from the iNDF obtained via the *in situ* incubation method, for 240 h (CASALI et al., 2008). The average supplement DM intake was 3.6 kg of DM $animal^{-1}$ day^{-1}, determined from 16 animals submitted to each of the treatments and assessed for pasture intake. This procedure was performed by obtaining the logarithm of fecal DM excretion per kilogram of metabolic body weight (g kg^{-1} $BW^{0.75}$) based on a symmetrical probability distribution. A confidence interval of one standard deviation ($\mu \pm 1\sigma$) was adopted for the average of all observations, corresponding to 68% of the animals contained in this interval (16 animals × 0.68 ≅ 10 animals). This corresponds, therefore, to 10 animals per treatment with an approximate intake of 3.6 kg of DM $animal^{-1}$ day^{-1} (Figure 1).

Figure 1. Symmetric distribution of supplement DM intake and DM fecal excretion (g kg^{-1} $BW^{0.75}$) with confidence interval, $\mu \pm 1\sigma$.



Total DM intake (TDMI) was calculated from the FE and iNDF data based on the equations: $TDMI = TI_{iNDF}$; $TI_{iNDF} = TFE_{iNDF}$; and $S_{DMI} \times S_{iNDF} + F_{DMI} \times F_{iNDF} = DM_{fecal} \times iNDF_{fecal}$, where, TDMI = total dry matter intake (kg day^{-1}); TI_{iNDF} = total intake of indigestible neutral detergent fiber (kg day^{-1}); TFE_{iNDF} = total fecal excretion of indigestible neutral detergent fiber (kg day^{-1}); S_{DMI} = supplement dry matter intake (kg day^{-1}); S_{iNDF} = supplement indigestible neutral detergent fiber (g 100^{-1} g); F_{DMI} = forage dry matter intake (kg day^{-1}); F_{iNDF} = forage indigestible neutral detergent fiber (g 100^{-1} g); DM_{fecal} = fecal dry matter (kg day^{-1}); and $iNDF_{fecal}$ = fecal indigestible neutral detergent fiber (g 100^{-1} g).

The supplements and pasture laboratory tests (Table 3) were performed based on methods described in Silva and Queiroz (2002) with the exception of the neutral detergent fiber (NDF) assessment, which was performed using the methods described by Mertens (2002). The contents of neutral detergent insoluble nitrogen (NDIN) and in acid detergent (ADIN) were obtained based on procedures described by Licitra et al. (1996).

Table 3. Supplements, pasture chemicals, and bromatological composition.

Item	Levels of replacement (%)				Pasture
	0	33	66	100	
Dry matter (%)	89.63	89.76	89.89	90.12	52.49
Organic matter	95.36	95.54	95.71	96.00	92.57
Crude Protein	25.03	25.28	25.53	25.95	5.74
NDIN[1,3]	16.53	18.55	20.57	23.94	42.56
ADIN[2,3]	6.27	6.61	6.96	7.53	11.83
Neutral detergent fiber (NDF)	18.40	18.54	18.69	18.93	68.41
NDF corrected for ash and protein (NDFap)	13.93	14.23	14.53	15.03	63.71
Indigestible NDF (iNDF)	11.42	11.70	11.98	12.44	38.27

(1) Neutral detergent insoluble nitrogen. (2) Acid detergent insoluble nitrogen. (3)% of total N.

The study was designed under a factorial arrangement (2×4), with two genetic groups and four levels of maize replacement with pearl millet grain, distributed in a completely randomized design with an 84-day experimental period. The initial BW of the animals was used as the covariate. The measured parameters were submitted to the Kolmogorov-Smirnov normality test (PROC UNIVARIATE) and assessed with the variance analysis process (PROC GLM). Furthermore, the parameters were analyzed by orthogonal contrasts. The best model was the largest polynomial degree with $P<0.05$ (PROC GLM) and its parameters were estimated by PROC REG. The program Statistical Analysis System (SAS, 2002) was utilized for all the statistical analyzes with a 0.05 significance level.

Results and Discussion

No significant effects ($P>0.05$) were observed in the genetic group or in the different replacement levels of maize with pearl millet grain, as well as in the pasture total DM and nutrients intake (Table 4), or the coefficients of total tract digestibility of nutrients (Table 5).

The first edition of Br-Corte (VALADARES FILHO et al., 2006) demonstrates no genetic group differences regarding DM intake. However, Azevêdo et al. (2010) concluded that a single equation cannot be used to predict the DM intake for beef cattle in tropical conditions owing to differences between Zebu and crossbred animals. It has been suggested that DM intake varies between bovines of different genetic groups. According to the Nutrient Requirement Council – NRC (2000), DM intake of Holstein young bulls is larger than that of beef cattle steers having the same BW. Thus, it is recommended that DM intake be increased by 4% in crossbred Holstein and beef "type" bovines. In addition, high-performance bovines obtained from *Bos taurus taurus* and *Bos taurus indicus* crossbreeding demonstrate a higher voluntary intake in feedlots than do Nellore bovines (VALADARES FILHO et al., 2010).

It is acknowledged that the ratio between CP and digested organic matter (CP:DOM) is indicative of the dietary protein:energy ratio, which helps understand the metabolic effects of protein on intake, since this ratio is a regulation parameter of the voluntary intake of ruminants. The PDM intake of animals raised in the tropics is maximized when the CP:DOM ratio is approximately 288 g CP kg^{-1} of DOM (DETMANN et al., 2014). This value is similar to that found in the present study (Table 4), which might explain the similar intake (P>0.05) observed in crossbred and Nellore cattle.

Table 4. Voluntary intake average values of total dry matter (DM), pasture dry matter (PDM), organic matter (OM), crude protein (CP), neutral detergent fiber (NDF), digested organic matter (DOM), and CP:DOM as a function of the genetic group (GG) and replacement levels (RL).

Item	Genetic group		P-value	Replacement levels (%)				CV (%)	GG × RL[1]	Contrasts[2]	
	Nellore	Cross-breed		0	33	66	100			L	Q
				kg day^{-1}							
DM	8.35	8.28	0.9242	9.01	7.90	8.20	8.16	14.35	0.1951	0.5096	0.5270
PDM	4.76	4.69	0.9239	5.44	4.32	4.63	4.53	25.80	0.1951	0.4794	0.5557
OM	7.76	7.69	0.9243	8.34	7.34	7.62	7.59	14.02	0.1953	0.5273	0.5237
CP	1.11	1.11	0.9246	1.12	1.08	1.11	1.13	9.19	0.1948	0.7680	0.3876
NDF	3.93	3.88	0.9242	4.38	3.62	3.83	3.79	21.09	0.1951	0.5050	0.5432
DOM	3.98	3.95	0.9015	3.94	3.89	3.87	3.97	10.15	0.1893	0.5789	0.5895
CP:DOM	279.15	280.15	0.9472	284.6	280.36	277.89	284.13	12.03	0.1975	0.5862	0.5584
				g kg^{-1} of BW							
DM	19.15	17.86	0.4768	19.51	17.48	18.55	18.39	14.36	0.2876	0.7160	0.6022
PDM	10.92	10.10	0.6399	11.84	9.59	10.49	10.28	25.60	0.2548	0.5910	0.6028
NDF	0.87	0.89	0.5896	0.96	0.80	0.86	0.85	16.13	0.2865	0.5998	0.6175

(1) Interaction between genetic group (GG) and replacement levels (RL) of maize with pearl millet grain. (2) Linear and quadratic order effects of the replacement levels of maize with pearl millet grain.

Several studies in the Brazilian literature have inferred that the inclusion of nitrogenous compounds in the dietary supplement of cattle fed with tropical grasses could promote an increase in forage intake until an approximate concentration of 90 g CP kg^{-1} of DM (FIGUEIRAS et al., 2010) or 102.4 g CP kg^{-1} of DM (SAMPAIO et al., 2010) is obtained. CP concentrations above these values would not promote any intake stimulus, as the microbial requirements regarding nitrogen compounds would have been met (DETMANN et al., 2010). This effect would explain the results observed in the present study for the non-significance (P>0.05) of the voluntary DM intake (Table 4), since the average CP concentration in the different supplements was 916 g CP kg^{-1} of DM.

Table 5. Average values of the digestibility coefficients (g 100^{-1} g) of dry matter (DM), organic matter (OM), crude protein (CP), neutral detergent fiber (NDF), and digested organic matter (DOM) dietary concentration (g kg^{-1} DM) based on the genetic group (GG) and replacement levels (RL).

Item	Genetic group		P-value	Levels of replacement (%)				CV (%)	GG × RL[1]	Contrasts[2]	
	Nellore	Cross-breed		0	33	66	100			L	Q
Digestibility coefficients											
DM	0.436	0.459	0.6746	0.447	0.497	0.399	0.447	19.87	0.6879	0.8288	0.8690
OM	0.480	0.531	0.3398	0.520	0.541	0.466	0.495	17.12	0.3712	0.6786	0.9120
CP	0.551	0.627	0.0637	0.563	0.629	0.583	0.583	20.71	0.3718	0.9396	0.4032
NDF	0.502	0.556	0.3900	57.34	0.609	0.505	0.430	19.54	0.2788	0.0993	0.2397
DOM	515.77	518.09	0.2011	514.88	515.76	516.01	515.98	18.25	0.4035	0.4849	0.4955

(1) Interaction between genetic group (GG) and replacement levels (RL) of maize with pearl millet grain.
(2) Linear and quadratic order effects of the replacement levels of maize with pearl millet grain.

With respect to the digestibility, based on a study by Hunter and Siebert (1985) an increased digestibility tendency was observed in the subspecies *Bos taurus indicus* for diets low in N and S concentrations, which usually occurs during the unfavorable season in the development of forage plants. However, in the present study, the supply of protein-energy supplements increased the energy availability for both genetic groups in a similar way (P>0.05), which can be explained by the DOM intake (Table 4) and the DOM dietary concentration (Table 5).

Thus, when a high-quality diet is offered to the animals, which usually occurs in pasture production systems during the rainy season, in the form of protein-energy supplements, there is little evidence of any differences between genetic groups, since the nutrients supply is adequate for high performance in the animals. This effect demonstrates that, independent of genetic group, the animals express their productive potential in a similar way when nutritional demands are met.

Regarding the increasing inclusion of pearl millet grain in supplements, the results of the present study are consistent with findings by Silva et al. (2009) that, regardless of the energy sources included in the supplements formulation, it is possible that total DM intake of grazing animals is not significantly influenced by these ingredients. In fact, Cardoso et al. (2013) and Nascimento et al. (2009) observed no effects associated with different energy sources in protein-energy supplements on total DM and grazing DM intake in grazing cattle. Similarly, Silva et al. (2014) observed that pearl millet grain could fully replace maize in high supplement diets for confined cattle.

However, Mustafa (2010) inferred that the increase in the replacement of maize by pearl millet grain could promote reductions in total DM intake and/or intake of some components of the ruminants' diet. According to the author, this intake decrease indicates that the replacement levels should only be partial, as the introduction of pearl millet in the dietary supplement would increase the ingestion of NDF due to its higher fiber content. However, despite increased NDF corrected for ash and protein (NDFap) content with the increase of millet grain in the supplements formulation (Table 3), a higher NDF intake (P>0.05) was not observed when 100% of maize was replaced with pearl millet grain in the present study (Table 4).

These results may be attributed to the nutritional composition of the supplements, that is, in both treatments, the dietary components intake was based on the balanced provision of nutrients via supplements. It was observed that in supplements with higher contents of pearl millet grain, the NDF, iNDF, NDFap, and acid detergent fiber (ADF) were higher than in supplements containing higher amounts of maize grain (Table 3).

Although the supplements with higher content of pearl millet grain contained higher concentrations of fibrous constituents, which eventually could depress DM intake, it is assumed that the effect of the CP profiles of the supplements might have contributed to preserve the digestibility and fiber intake via the supplements. Despite similar CP levels in the supplements, an increase of 44.83% in the NDIN content (i.e., slowly available nitrogen) was observed in the diets containing greater inclusion of pearl millet grain. This factor might have contributed to the preservation of the availability of N to the fibrolytic microorganisms, favoring digestibility over time of the dietary nutrients assessed, which explains the similar responses to different levels of replacement.

Hernandez et al. (2002) studied the degradation rates of several foods. With respect to proteins, these authors classified both maize and millet grain as slowly degradable. They compared the degradation rate (Kd h^{-1}) of fraction B with that of the percentage of rumen undegraded protein (RUP), and they found that millet grain showed a higher degradation rate of fraction B and a higher percentage of rumen degradable protein (RDP).

RDP is considered the most important supplement for cattle fed with low-quality forage (RUFINO et al., 2016). Thus, the inclusion of millet grain would increase the protein "pool" readily available for the growth of fibrolytic bacteria, since under nitrogen availability restrictions this supply significantly increases the activity of this population (RUSSELL et al., 1992).

The similarity observed between the evaluated supplements supports the idea that in diets with protein-energy supplementation involving low nutritional forage there is an increase in the rate of passage of fibrous particles. This effect reduces the rumen fill promoted by dietary fiber, in particular the iNDF, increasing the intake of forage due to improved fiber degradation. Independent of the level of millet grain inclusion, there were no significant differences (P>0.05) in the CP:DOM ratio (Table 4), which indicates that the total replacement of maize with pearl millet grain allowed maximization of the total DM intake.

In addition, the animals showed a good response to the inclusion of pearl millet grain in their diet, suggesting no acceptability differences between the two energy sources or any post-digestive disorder, which might cause intake perturbations, as suggested by Bergamaschine et al. (2011). The existence of synergisms between nutritional variables contained in the diet should also be highlighted. The interaction between CP and carbohydrates can affect the digestibility in different ways and, in some situations, negatively influence production. Furthermore, an increase in the level of non-fibrous carbohydrates in the rumen also increases the need of supplementation with RDP, owing to the requirement of amino acids and peptides for maximum microbial efficiency (RUSSELL et al., 1992). In this regard, the present study sought to meet the assumption of maximum microbial efficiency via the use of non-fibrous carbohydrate-rich energy sources, associated with a RDP source (Table 3).

Our results showed that the replacement of the energetic ingredient allowed maintenance of the digestibility of the fibrous component of the diet because of the existence of a protein profile characteristic of the maize grain. This characteristic of maize grain is a fraction known as α-zein, which has low rumen degradability and might lead to a reduction in ammonia nitrogen concentration causing a decrease in the density of fibrolytic microorganisms, thus affecting the digestibility of vegetable fiber (NASCIMENTO et al., 2009).

It should be noted that the prevention of this reduction effect due to the α-zein fraction of maize in animal production could be carried out not only with the addition and/or replacement with pearl millet grain but also through the careful selection of supplement protein ingredients. Gonçalves et al. (2010) demonstrated that when a high nutritional value protein source is added, such as soybean meal, inclusion of pearl millet grain might lead to a reduction of NH_3 in the rumen. These authors state that this reduction results from the replacement of energetic grains such as maize grain with pearl millet grain, which leads to a decrease of soybean meal in the diets, as the CP content of pearl millet grain is approximately 4% higher than that of maize grain.

In general, with respect to the dietary concentration of DOM (Table 5), concentrated supplementation with any of the energetic ingredients studied led to similar (P>0.05) supplements. This reveals that, under the conditions of the present study, the supply of concentrate supplements with different levels of replacement of the energetic ingredients allowed the maintenance of the digestibility of the total diet of grazing bovines.

Conclusions

The diet of beef cattle in a CLI system involving protein-energy supplements with replacement of maize with pearl millet grain does not alter the dietary concentration of DOM or the PDM and DOM intake.

Regardless of the replacement level of pearl millet grain, Nellore and crossbred beef cattle demonstrated no differences in the intake and digestibility of dietary nutrients.

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