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Protein and carbohydrate fractionation of Piata palisadegrass ensiled with energetic meals

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ABSTRACT. This study determined the fractionation of protein and carbohydrate of Piata palisadegrass ensiled with energetic meals. The experiment was developed at the Federal Institute of Goiás State, Rio Verde Campus, using a completely randomized design with four replications, in a 4 x 5 factorial arrangement, being four energetic meals (millet, corn, sorghum and wheat) and five levels of addition (0, 8, 16, 24 and 32%). The meals were obtained by grinding the grains, where the levels of addition were calculated based on natural material. The results indicated that the energetic meals represented good sources of additives for ensiling Piata palisadegrass, for considerably improving protein and carbohydrate fractions. However, among the meals used, the sorghum was less efficient by presenting a lower protein fraction (A) and higher fraction C, compared with other additives. The meals of wheat and sorghum showed higher contents of carbohydrate fractions (A+B1 and C). It is recommended the level of addition of 24% of meals, for providing better nutritional value to silage.

Keywords: additive, *Brachiaria brizantha,* corn, millet, sorghum, wheat.

Fracionamento de proteínas e carboidrato do capim-piatã ensilado com farelos energéticos

RESUMO. Desenvolveu-se esse estudo com objetivo de determinar o fracionamento de proteínas e carboidratos do capim-piatã ensilado com farelos energéticos. O experimento foi conduzido no Instituto Federal Goiano, Campus Rio Verde. O delineamento experimental utilizado foi inteiramente casualizado, com quatro repetições, em esquema fatorial 4 x 5, sendo quatro farelos energéticos (milheto, milho, sorgo e trigo) e cinco níveis de adição (0, 8, 16, 24 e 32%). Os farelos utilizados foram obtidos através da moagem dos grãos, onde a adição dos níveis foi calculada com base na matéria natural do capim-piatã. Os resultados demonstraram que os farelos energéticos, apresentam boas fontes de aditivos para a ensilagem, por trazer melhorias consideráveis nas frações proteínas e fração carboidratos. No entanto, dentre os farelos utilizados o de sorgo mostrou menos eficiente por apresentar menor fração protéica (A) e maior fração C, quando comparados com os outros aditivos. E os farelos de trigo e sorgo apresentaram maiores frações carboidratos (A+B1 e C). Recomenda-se a adição do nível de 24% dos farelos, por proporcionar melhor valor nutritivo da silagem.

Palavras-chave: aditivo, *Brachiaria brizantha,* milho, milheto, sorgo, trigo.

Introduction

Brazil has emerged as a major producer of meat and milk in the world, with most of these animals raised on pasture with the need for quality food throughout the year, justifying the maintenance of production performance. However, due to food shortage in the dry period, there is need for the use of forage conservation technologies to maintain a higher quality food in times of shortages, due to the seasonality of forage production (BUMBIERIS JUNIOR et al., 2007).

The use of tropical forage grass silage is becoming an increasingly common practice for feeding cattle (PINTO et al., 2012). Among them, *Brachiaria brizantha* cv. Piatã stands out due to high capacity of forage production and high nutritional value, which makes it one of the main options for intensive animal production systems. There are still few researches on the ensiling process of this grass, making necessary additional studies, since the use of this genus as silage has aroused the interest of farmers, by presenting striking features for the quality of silage (COSTA et al., 2011; EPIFANIO et al., 2014).

Nevertheless, when cut for silage, tropical grasses have limiting characteristics, due to high moisture and low concentration of soluble carbohydrate, favoring undesired fermentation, which increases quantitative and qualitative losses and limits the voluntary intake by animals (PAZIANI et al., 2006).

Among the possible techniques, natural additives are being disseminated because they act as absorbents, and assist in suitable fermentation. The additive should be low cost and of easy acquisition and manipulation (OLIVEIRA et al., 2010). Among the various alternatives, there is the energetic meals, such as corn, sorghum, millet and wheat, which are produced in large quantities in the Central West region.

The evaluation of the nutrients in food to meet the nutritional requirements for animal performance is important for the nutrition of ruminants. Therefore, knowledge of fractions of protein and carbohydrate is important in the nutritional aspect, for the formulation of balanced diets and the better synergy between these sources can maximize animal performance (BUMBIERIS JUNIOR et al., 2011).

The Cornell Net Carbohydrate and Protein System (CNCPS) considers the dynamics of rumen fermentation and the potential loss of nitrogen as ammonia, in the evaluation of food (SNIFFEN et al., 1992) and aims at adjusting the ruminal digestion of carbohydrates and proteins, to maximize microbial production, reduce losses of nitrogen by the animal and estimate the rumen escape of nutrients (BALSALOBRE et al., 2003).

Thus, Gesualdi Junior et al. (2005) reported that a deeper knowledge of food fractions allows proposing alternatives that reflect directly on improving production systems and promote a fine adjustment in animal nutrition, given the ability to predict the performance of the animals. Accordingly, this study aimed to determine the fractionation of proteins and carbohydrates of Piata palisadegrass ensiled with energetic meals.

Material and methods

The experiment was conducted at the Federal Institute of Goiás State, Rio Verde Campus. The Piata palisadegrass was grown in January 2012, an area of approximately 180 m^2 for the production of silage. The area was prepared with a standardization cut in November 2012, maintenance fertilization with 120 kg nitrogen and 60 kg K_2O at top dressing, using ammonium sulfate and potassium chloride as nutrient sources.

The experiment consisted of a completely randomized design with four replications in a 4 x 5 factorial arrangement, using four energetic meals (millet, corn, sorghum and wheat) and five levels (0, 8, 16, 24 and 32%). The meals used were obtained by grinding the grains in 2 mm-sieve, where the levels of addition were calculated based on natural material of Piata palisadegrass.

For ensiling Piata palisadegrass was harvested at 45 days of regrowth after maintenance fertilization, 20 cm above the ground, using backpack mower. Subsequently, the forage was shredded in stationary shredder into particles of 10 - 30 mm. The material was then homogenized with the meals according to inclusion levels determined and stored in PVC experimental silos measuring 10 cm diameter and 40 cm length. Silos were sealed with PVC lids and adhesive tape so as to prevent the entrance of air. Supplied with Bunsen valves and sealed with adhesive tape. Soon after, they were stored at room temperature and protected from rain and sunlight.

After 60 days of fermentation, silos were opened, and the silage of the top and bottom of each were discarded. The central portion of the silo was homogenized and placed in plastic trays. It was taken about 1 kg of material, which was weighed and taken to a forced ventilation oven at 55°C for 72 hours, to determine the pre-dried material. Then, samples were ground in a Willey mill with a 1 mm mesh sieve, to be analyzed.

Before ensiling, meals and Piata palisadegrass was subjected to Chemical composition (Table 1), according to the methodology of Silva and Queiroz (2002) for dry matter (DM), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), lignin, ether extract (EE), mineral matter (MM) and soluble carbohydrate (CHOsol). The total digestible nutrients (TDN) was obtained using the equation [%TDN = 105.2 – 0.68 (%NDF)], proposed by Chandler (1990). And for *in vitro* dry matter digestibility (IVDMD), we adopted the technique described by Tilley and Terry (1963), adapted to the artificial rumen, developed by ANKON®, using the "Daisy incubator" of Ankom Technology.

Determinations of non-protein nitrogen (NPN), neutral detergent (NDIN) and acid detergent (NIDA) insoluble nitrogen were performed according to the methodology described by Licitra et al. (1996), and the soluble nitrogen (SN) according to Krishnamoorthy et al. (1983). Subsequently, the protein fractionation was calculated for the five fractions (A, B1, B2, B3, and C) by the CNCPS system (SNIFFEN et al. 1992).

The percentage of total carbohydrates (TC) was obtained from equation (SNIFFEN et al., 1992): TC = 100 - (%CP+%EE+%MM).

Table 1. Chemical composition of the Piata palisadegrass, brans and millet, maize, sorghum and wheat, used to produce the silage.

Chemical composition	Piata palisadegrass	Bran millet	Bran maize	Bran sorghum	Bran wheat
DM (%)	19.20	89.50	88.90	88.80	88.00
CP (%)	13.70	16.18	9.70	10.50	17.12
NDF (%)	66.50	19.03	11.59	14.15	38.81
ADF (%)	38.90	9.53	7.80	8.56	13.50
Lignin	4.35	2.80	1.85	2.30	3.80
EE (%)	2.50	4.39	4.81	4.43	3.95
MM (%)	6.30	3.49	3.45	3.23	4.26
TDN (%)	59.40	81.03	81.67	80.52	74.53
IVDMD (%)	68.30	86.50	87.50	82.40	80.65
CHOsol (%)	2.43	9.75	11.50	10.30	7.30

The fiber carbohydrates (FC) was obtained from the NDF corrected for its content of ash and protein (NDF_{AP}), the non-fiber carbohydrates (NFC), which correspond to fractions A + B1, the difference between total carbohydrate and NDF_{AP} (HALL, 2003), and fraction C, by the indigestible NDF after 144 hours of *in situ* incubation (CABRAL et al., 2004). The fraction B2 corresponds to the available fraction of the fiber and was obtained by the difference between the NDF_{AP} and the fraction C.

Data were subjected to analysis of variance, considering sources of variation the additives and levels of inclusion and interaction between each other. Means were compared by Tukey's test at 5% probability, using the software SISVAR® (FERREIRA, 2011). The levels of additives were evaluated by regression analysis, based on the value of the coefficient of determination; equations were generated from graphs constructed in SigmaPlot.

Results and discussion

Protein fractions (A, B1, B2, B3, and C) total carbohydrate and carbohydrate fractions (A + B1, B2 and C) were affected ($p < 0.05$) by additives, addition levels and interaction between these factors (Tables 2 and 3).

A linear increase was detected for the fraction A, composed of non-protein nitrogen (NPN), with increasing levels of additive in silage (Table 2). For all meals, the level of 32% was the most effective in increasing the fraction A, due to higher crude protein in the meal (Table 1), mainly in millet and wheat meals, thus improving the degradation rate. This result is important because the fraction A is the soluble fraction with rapid ruminal degradation. However, the higher the increase in the fraction A, the greater the need to supply rapidly degradable carbohydrates for proper timing of fermentation of carbohydrates and protein in the rumen (RUSSELL et al., 1992).

Table 2. Protein fractionation of the silage of Piata palisadegrass ensiled with energetic meals.

Additives	Levels of additives (%)					Equation	r^2
	0	8	16	24	32		
	Fraction A (%)						
Millet	30.02a	31.89b	40.08ab	44.22b	53.20a	$Y = 28.1440 + 0.7336x^*$	0.96
Corn	29.93a	33.86a	43.91a	46.60a	52.79a	$Y = 29.7260 + 0.7308x^*$	0.97
Sorghum	29.77a	31.66b	38.91b	44.49b	49.93b	$Y = 28.3220 + 0.6644x^*$	0.97
Wheat	30.15a	34.50a	43.21a	47.19a	53.60a	$Y = 29.8120 + 0.7449x^*$	0.98
CV (%)			5.36				
	Fraction B1 (%)						
Millet	12.12a	12.63b	15.14a	15.33a	15.85a	$Y = 12.1820 + 0.1270x^*$	0.90
Corn	11.63a	12.47b	14.63a	14.74a	14.97a	$Y = 11.4309 + 0.2287x - 0.0036x^{2*}$	0.93
Sorghum	12.07a	12.54b	14.35a	14.42a	14.78a	$Y = 12.1720 + 0.0913x^*$	0.89
Wheat	12.85a	15.17a	16.10a	16.85a	13.04b	$Y = 12.6129 + 0.4700x - 0.0139x^{2*}$	0.88
CV (%)			15.36				
	Fraction B2 (%)						
Millet	12.07a	12.25a	13.65a	14.01a	12.37b	ns	
Corn	12.17a	11.63a	13.70a	13.91a	12.60b	ns	
Sorghum	11.42a	12.37a	13.72a	14.45a	14.73a	$Y = 11.5980 + 0.1087x^*$	0.95
Wheat	11.85a	12.55a	13.70a	12.73a	13.38ab	ns	
CV (%)			11.41				
	Fraction B3 (%)						
Millet	17.93a	16.05a	12.67a	8.43a	7.82a	$Y = 18.1480 - 0.3480x^*$	0.96
Corn	17.66a	15.29a	10.58ab	7.51a	8.11a	$Y = 17.2060 – 0.3360x^*$	0.90
Sorghum	17.09a	15.12a	10.14ab	9.41a	7.24a	$Y = 16.8820 – 0.3176x^*$	0.94
Wheat	17.25a	10.76b	9.96b	8.72a	7.48a	$Y = 16.5871 - 0.6290x + 0.0112x^{2*}$	0.93
CV (%)			10.45				
	Fraction C (%)						
Millet	27.85a	27.17a	18.96b	18.00ab	10.75b	$Y = 29.2200 - 0.5421x^*$	0.93
Corn	28.60a	26.74a	17.76b	17.23b	12.52b	$Y = 28.9040 - 0.5209x^*$	0.93
Sorghum	29.36a	28.30a	22.86a	20.81a	14.21a	$Y = 31.6680 - 0.5141x^*$	0.97
Wheat	27.88a	27.02a	17.02b	14.50b	12.49b	$Y = 28.4420 - 0.5413x^*$	0.90
CV (%)			10.88				

Mean values followed by different letters, lowercase in the column (additives) are significantly different by Tukey's test ($p < 0.05$). *5% probability, ns = non-significant at 5% probability.

Table 3. Carbohydrate fractionation of the silage of Piata palisadegrass ensiled with energetic meals.

Additives	Levels of additives (%)					Equation	r^2
	0	8	16	24	32		
			Total carbohydrate (%)				
Millet	87.95a	84.76a	81.75b	81.15ab	78.97b	$Y = 87.2300 - 0.2696x^*$	0.95
Corn	88.16a	86.85a	84.41a	83.35a	81.93a	$Y = 88.1320 - 0.1995x^*$	0.98
Sorghum	87.78a	86.54a	84.01a	82.66a	81.52a	$Y = 87.7820 - 0.2050x^*$	0.98
Wheat	89.32a	82.56b	80.70b	79.83b	77.58b	$Y = 88.6700 - 0.6851x + 0.0112x^{2*}$	0.95
CV (%)			1.58				
			Fraction A+B1 (%)				
Millet	23.80a	29.84a	34.34a	43.98ab	52.58ab	$Y = 22.5680 + 0.8962x^*$	0.98
Corn	23.15a	29.18a	36.32a	45.72a	54.10a	$Y = 22.0060 + 0.9805x^*$	0.99
Sorghum	24.29a	31.86a	36.52a	43.87ab	51.37ab	$Y = 24.3480 + 0.8271x^*$	0.99
Wheat	24.44a	27.48a	32.31a	39.87b	48.38b	$Y = 22.4420 + 0.7534x^*$	0.96
CV (%)			6.98				
			Fraction B2 (%)				
Millet	51.37a	49.53a	48.53a	43.02a	36.48b	$Y = 53.0440 - 0.4536x^*$	0.89
Corn	52.99a	49.73a	48.37a	42.46a	36.97b	$Y = 53.9660 - 0.4914x^*$	0.95
Sorghum	51.37a	47.36a	46.92a	41.80a	36.36b	$Y = 53.4980 - 0.4872x^*$	0.87
Wheat	53.07a	50.69a	48.92a	43.72a	39.36a	$Y = 54.0300 - 0.4299x^*$	0.96
CV (%)			5.35				
			Fraction C (%)				
Millet	23.69a	20.62a	17.12ab	12.99b	10.93ab	$Y = 23.7000 - 0.4144x^*$	0.99
Corn	23.86a	21.08a	15.30b	11.81b	8.92b	$Y = 24.0240 - 0.4894x^*$	0.98
Sorghum	24.33a	20.77a	16.54ab	14.32b	12.26a	$Y = 23.7620 - 0.3824x^*$	0.97
Wheat	22.47a	21.82a	18.77a	16.41a	12.25a	$Y = 23.5140 - 0.3231x^*$	0.95
CV (%)			9.29				

Mean values followed by different letters, lowercase in the column (additives) are significantly different by Tukey's test ($p < 0.05$). *significant at 5% probability.

These results differ from Andrade et al. (2010) who evaluated the elephant grass silage containing cassava meal, coffee husk and cocoa meal, and found a linear decrease of the fraction A with added levels of additives. According to the authors, this was due to low dry matter content (18.7%) that interfered with the availability of degradable protein.

In the silage without additives, the fraction A was similar ($p > 0.05$). However, with the addition of 8, 16 and 24%, the highest fractions were obtained with corn and wheat meals. At the level of 32%, only sorghum meals was different ($p < 0.05$) from other additives with lower fraction A. Similar results were obtained by Viana et al. (2012), which evaluated the fractionation of carbohydrate and protein of silages of different forages, and verified that the silage of sorghum-sudan and forage sorghum had lower fractions A, compared with corn and sunflower silage.

The increasing addition of additives promoted a linear increase of fraction B1 for millet and sorghum meals, and quadratic increase (Table 2), for corn and wheat meals, where the maximum point was estimated at the level of 31.76 and 16.91%, respectively. These results show that the addition of meals in the Piata palisadegrass silage contributed to increase the fraction B1, which is also the soluble fraction of rapid degradation in the rumen (SNIFFEN et al., 1992), favoring ruminal degradation. According to Pereira et al. (2010), energetic additives can ensure better synchronization of fermentation between carbohydrate and protein in the rumen and thus promote a greater microbial growth, resulting in better nutrient utilization and animal performance.

As for the additives within each level (Table 2), in the silage without additives and at levels of 16 and 24%, fractions B1 were similar ($p > 0.05$) among the meals. At the level of 8% the wheat meal showed the highest fraction. At level 32%, millet, corn and sorghum meals showed similar fractions, differing ($p < 0.05$) from the wheat meal with lower fraction B1 (13.04%). Lower results were reported by Pereira et al. (2007) evaluating Tifton-85 silage, which verified values of 2.97% for the control silage, while by adding residue from the processing of corn and corn meal, the fractions were 2.11 and 1.91% respectively.

Some authors have observed deficiency in the fraction B1 in protein of tropical grasses (RUSSELL et al., 1992; SNIFFEN et al., 1992) with less than 10% of total crude protein (BALSALOBRE et al., 2003). However, for all additives and levels, the values of fraction B1 were higher than 10.67%, showing improvement in the fraction B1.

The fraction B2 is the fraction with an intermediate degradation rate (BRENNECKE et al., 2011). In the present study, when assessed the levels of the additives in silage, only the sorghum meal was affected ($p < 0.05$), showing a linear increase with increased levels in silage (Table 2). Comparing the additives within each level, the silage without additives and at 8, 16 and 24%, the fraction B2 values were similar ($p > 0.05$) among the meals. Nevertheless, at 32%, only the sorghum meal was different ($p < 0.05$) from millet and corn meals, with higher fraction B2. This result may be related to the lower fraction A obtained in the sorghum meal.

The addition of the levels of meals linearly reduced fraction B3 for millet, corn and sorghum meals with increased levels in the silage. However, for the wheat meal there was a quadratic reduction, and the minimum point was estimated at 28.08%. Although digestible the protein fraction (B3) has ruminal degradation rate of 0.02-1.0% h^{-1} (PIRES et al. 2009; SNIFFEN et al. 1992). As the B3 fraction is represented by the cell wall binding proteins that present slow degradation rate, primarily being digested in the intestine (CABRAL et al., 2004), it is suggested that without adding meals at ensiling Piata palisadegrass increases non-degraded protein in the rumen, since larger fractions B3 and marked reduction in fraction A was observed in the silage without the addition of additives for all the meals, showing a lower contribution to digestion of silage.

Regarding the meals within each level, Table 2 shows that without additives and at 24 and 32%, fractions B3 were similar ($p > 0.05$) between the meals. At the level of 8% the wheat meal had lower fraction B3, differing ($p < 0.05$) from other meals. And at 16%, a significant effect ($p < 0.05$) was detected between millet and wheat meals. Superior results were observed by Pires et al. (2009) that evaluated the elephant grass silage with 15% cassava meal and cocoa meal and observed levels of fraction B3 of 19.5 and 21.5% respectively.

For the fraction C there was a linear decrease for all meals with increasing levels of additives at ensiling, with reduction of 17.1, 16.0, 16.8 and 15.3 percentage units, compared the non-addition of additives and the level of 32% to corn, millet, sorghum and wheat meals, respectively. This result is important, because the fraction C corresponds to unavailable nitrogen and consists of protein and nitrogen compounds associated with lignin (SNIFFEN et al., 1992; VAN SOEST, 1994). Krishnamoorthy et al. (1983) reported that this fraction can not be degraded by bacteria in the rumen and does not provide amino acids for post-ruminal digestion. This shows that in the silage without additives and at levels of 8 and 16%, part of the protein of silages is not used for microbial growth or even as a source of true protein in post-ruminal digestive tract.

These results indicate the importance of supplying additives to tropical grasses silages, because according to Sniffen et al. (1992), the increase in the fraction C promotes the formation of Maillard products caused by heating in the silo provoked by undesired fermentation due to the high moisture content of the forage. In this case, the decrease of the fraction C, when added the levels, especially the 32%, can be attributed to the quality of meals, being considered as good additives for the ensiling process, by retaining the moisture of the Piata palisadegrass at cut (19.20%) and adding soluble carbohydrates, resulting in a silage of better quality.

Comparing the meals within each level (Table 2), in the silage without additives and at 8%, fractions C were similar ($p > 0.05$) between the meals. But at levels of 16, 24 and 32% the largest fractions were obtained with sorghum meal, differing ($p < 0.05$) from millet, corn and wheat meals. Higher fractions C were also registered by Viana et al. (2012), which evaluated the fractionation of protein of silages from different forage, and found a higher fraction C for sorghum-sudan silage (20.6%), followed by forage sorghum silage (18.3%) and sunflower (16.6%), and the corn silage had the lowest fraction C (14.1%).

Assessing the carbohydrate fractionation, in Table 3 is observed a linear reduction in total carbohydrates for millet, corn and sorghum meals with the addition of meals, and this reduction was more pronounced at the level of 32%. However, only for the wheat meal the reduction was quadratic, with the minimum point estimated at 30.58%. Note that the reduction of total carbohydrates may be related to higher levels of crude protein (CP) and ether extract (EE) obtained at the level of 32%, particularly for millet and wheat meals. Sniffen et al. (1992) explained that high levels of these fractions (CP and EE) can interfere with the estimation of total carbohydrates, causing its reduction.

Reductions in content of total total carbohydrates were also observed by Carvalho et al. (2008) who examined the elephant grass silage with cocoa meal, and found a linear decrease in total carbohydrates, with a reduction of 0.22 percentage to every unit meal added. The same was observed by Andrade et al. (2010), with the elephant grass silage, found a reduction of 9.21% in the content of carbohydrates of cocoa meal compared to cassava meal and coffee husk.

In the silage without additives, the content of total carbohydrates was similar between the meals. At the level of 8%, only the wheat meal was different ($p < 0.05$) from other meals, with lower total carbohydrates. At 16, 24 and 32%, corn and sorghum meals showed the highest values, differing ($p < 0.05$) from millet and wheat meals (Table 3). The content of total carbohydrates obtained was similar to reported by Pires et al. (2009), evaluating the total carbohydrates of elephant grass silage containing coffee husk, cocoa meal, cassava meal, and found concentrations of 88.6, 81.1, 83.8%, respectively.

For the carbohydrate fraction A+B1 a linear increase was observed with increased additives at ensiling for all meals (Table 3). The addition of 32% led to an increase of 28.78, 30.95, 27.08 and 23.44 percentage units compared to no-additive silage, for millet, corn, sorghum and wheat meals, respectively. These results point out the importance of adding energetic meals at ensiling Piata palisadegrass, favoring ruminal degradation, whereas the fraction A+B1 is the soluble fraction with rapid ruminal degradation (SNIFFEN et al., 1992).

Meanwhile, Carvalho et al. (2008) reported that foods with high fraction A+B1 are considered good sources of energetic to increase rumen microorganisms using non-fiber carbohydrates. Therefore, the higher the elevation of values of the fraction A+B1, the greater the need to supply rapidly degradable carbohydrates for proper timing of fermentation of carbohydrates and protein in the rumen, with the purpose of synchronization between the release of energetic and nitrogen (RUSSELL et al., 1992). Accordingly, among the meals used the millet and wheat meals had higher crude protein, with values of 16.18 and 17.12%, respectively.

In the silages without additive and with levels of 8 and 16%, fractions A+B1 were similar between the meals. At 24 and 32%, only the wheat meal was different ($p < 0.05$) from corn meal, with lower fraction. This is due to the higher content of fiber fractions in the wheat meal compared with other meals (Table 1).

The addition of increasing levels of additives led to a linear reduction in the carbohydrate fraction B2 (Table 3), for all meals studied. This reduction may be correlated with lower NDF in energetic meals relative to Piata palisadegrass (Table 1), which explains the lower content of this fraction when additives were added at ensiling, and according to Carvalho et al. (2007) the NDF influence the results of the fraction B2. According to Oliveira et al. (2012), forage foods usually have higher NDF content and therefore, higher values of the fraction B2. This component provides energetic slowly in the rumen and can affect the efficiency of microbial synthesis and animal performance. In such cases, the material must be supplemented with readily available energetic sources in the rumen, when there are no protein limitations in quantity and quality. In this sense, the energetic meals used in this study proved to be effective in reducing this fraction, being an alternative source of potentially digestible carbohydrates.

Reduction of the fraction B2 with addition of additives were also obtained by Pires et al. (2009) who investigated the carbohydrate fractionation in silages of elephant grass with coproducts, and observed that the control silage had higher value of the fraction B2 (68.9%), followed by silages with coffee husk (58.7%), cassava meal (54.4%) and cocoa meal (50.9%). According to the authors the highest value of hemicellulose in elephant grass before ensiling result in a larger fraction B2 in the control silage. It is noteworthy that the reduction of the fraction B2 coincided with the increase of fractions A+B1, which supports the hypothesis of natural decomposition of the cell wall caused by fermentation in the silo, thus contributing to the increase of fractions of high availability (BARCELOS et al., 2001).

When comparing the meals within each level (Table 3), in silages without additive and at levels of 8, 16 and 24%, fractions B2 were similar between the meals. At the level of 32%, only the wheat meal was different ($p < 0.05$) from other meals, with with higher fraction B2.

For the fraction C there was a linear reduction for all meals, with increasing levels of additives in silage (Table 3), with a reduction of 12.76, 15.04, 12.07 and 10.22 percentage units comparing the level zero with 32% for millet, corn, sorghum and wheat meals, respectively. The reduction of the fraction C with the addition of energetic meals is due to the lower lignin concentration of the additives (Table 1), indicating that the energetic meals were efficient in decreasing the fraction C, which is indigestible in the gastrointestinal tract (SNIFFEN et al., 1992).

In relation to meals within each level (Table 3), silages without additive and at 8%, fractions C were similar. At the level of 16%, only the wheat meal was different from corn meal, with higher value. At 24%, fractions were similar for millet, corn and sorghum meals, differing from the wheat meal. And at the level of 32%, the corn meal presented lower fraction C compared with other additives. The fraction C includes the portion of the plant cell wall undigested along the gastrointestinal tract (SNIFFEN et al., 1992), and it is possible that larger fractions in silages with millet, sorghum and wheat meals have been caused by the higher content of lignin, compared with corn meal. Similar results were achieved by Viana et al. (2012) who analyzed the carbohydrate fractionation of different forages and registered that the corn silage had lower fraction C (25.8%), compared to silages of sorghum-sudan, forage sorghum and sunflower.

Conclusion

The energetic meals represented good sources of additives for ensiling Piata palisadegrass for considerably improving protein and carbohydrate fractions. However, among the meals used, the sorghum was less efficient by presenting a lower protein fraction (A) and higher fraction C, when compared with other additives. The meals of wheat and sorghum showed higher contents of carbohydrate fractions (A+B1 and C).

It is recommended the level of addition of 24% of meals, for providing better nutritional value to silage.

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