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Nutritional value of Xaraes and Piata palisadegrass silages prepared with additives or wilting

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ABSTRACT. The nutritional value of Xaraes and Piata palisadegrass silages wilted or with additives was evaluated in a completely randomized design (2x4 factorial arrangement), being two cultivars of *Brachiaria brizantha* (Xaraes and Piata palisadegrass) and four ensiling methods as treatments: T_1- control, *in natura* forage (INF); T_2 – INF wilted for 4 hours under the sun; T_3- INF + bacterial additive (BactoSilo® Lallemand) 2 g ton^{-1} of *in natura* forage; T_4 – INF + 15% of pearl millet meal. For ensiling, the grasses were harvested in the growth stage of 40 days, at 20 cm from the ground level. The addition of the inoculant and millet meal improved the fermentative and chemical parameters of both cultivars silages, by increasing soluble carbohydrates (SC), CP and TDN contents and reducing ammonia-nitrogen and pH. Because of its composition, 15% of millet meal inclusion affected SC, NDF, ADF and increased the IVDDM of silages. Bacterial inoculant or millet meal inclusion enhanced the nutritional value of *Brachiaria brizantha* silages and, could have a positive performance response on ruminants fed with these silages. Wilting was also effective in improving the fermentative stability of grass silages and may be a cheaper alternative to additives.

Keywords: *Brachiaria brizantha*, millet meal, bacterial inoculant.

Valor nutricional das silagens de capins Xaraes e Piatã emurchecidas ou acrescidas de aditivos

RESUMO. O valor nutricional de silagens pré-secadas ou aditivadas dos capins Xarães e Piatã foi avaliado em delineamento experimental inteiramente casualizado (esquema fatorial 2x4), sendo duas cultivares de *Brachiaria brizantha* (Xarães e Piatã) e quatro métodos de ensilagem: T_1- controle, forragem *in natura* (FIN); T_2- FIN pré-secada ao sol por 4 horas; T_3- FIN + aditivo bacteriano (BactoSilo® Lallemand) 2 g t^{-1} FIN; T_4- FIN + 15% de farelo de milheto. Para a ensilagem, os capins foram colhidos no estágio de crescimento de 40 dias, a 20 cm do nível do solo. A adição do inoculante e farelo de milheto melhoraram os parâmetros fermentativos e bromatológicos das silagens, elevando os teores de carboidratos solúveis (CHOS), PB, NDT e reduzindo o nitrogênio amoniacal e pH. Devido a sua composição, a adição de 15% de farelo de milheto, afetou os CHOS, FDN, FDA e incrementou a DIVMS nas silagens. A adição de inoculantes bacterianos ou farelo de milheto melhorou o valor nutricional das silagens de *Brachiaria brizantha* e, poderiam ter resposta positiva no desempenho de ruminantes alimentados com estas silagens. O pré-emurchecimento foi efetivo no incremento da estabilidade fermentativa de silagens de capim e, pode ser uma alternativa mais econômica aos aditivos.

Palavras-chave: *Brachiaria brizantha*, farelo de milheto, inoculante bacteriano.

Introduction

Forage production is dependent on seasonal climatic factors such as rainfall, temperature, lighting, and thus varies between high in the rainy season, and low in the dry season under tropical conditions. In livestock production systems with tropical grasses as the staple food, it is important to evaluate the nutritional value of silages prepared with the high forage volumes produced in the summer to meet the animals' requirements during the winter.

In order to diversify forage options, Embrapa developed new cultivars of *Brachiaria brizantha* (cv. Xaraes and cv. Piata), which presented optimal performance on soils of medium to high fertility, with high regrowth rate and good nutritional value (EMBRAPA, 2008). Besides being used for grazing, these forages present nutritional characteristics suitable for ensiling (COSTA et al., 2011).

Nevertheless, forage grasses have characteristics that limit the process of making good silages. The low content of dry matter, soluble carbohydrates and high buffering power can inhibit the rapid decrease in pH, which may lead to secondary fermentations in the silo. Conversely, when ensiled at young stage, they present a greater nutritional value (SILVA et al., 2011).

In this context, several techniques have been examined to improve the fermentation of silages of these forages. Among them: the wilting allows a dry matter content increase of grasses before ensiling; addition of enzyme-bacterial inoculants at the time of ensiling promotes a sharpest drop in pH and allow controlling losses in the process and increase the availability of soluble carbohydrates (COAN et al., 2005) and, addition of meals or absorbing ingredients provides reduction in the moisture content, incorporation of soluble carbohydrates and increase in nutritional value (COSTA et al., 2011; FERRARI JR. et al., 2009). Thus, the nutritional value of Xaraes and Piata palisadegrass silages produced by different ensiling process was evaluated.

Material and methods

The experiment was conducted at the Universidade de Rio Verde, in Fazenda Fontes do Saber, municipality of Rio Verde, Goiás State. Cultivars of *Brachiaria brizantha* (Xaraes and Piata) came from an area established a year ago. Before harvesting for the ensiling process, 100 kg ha^{-1} nitrogen and 80 kg ha^{-1} K_2O were applied as topdressing, using ammonium sulfate and potassium chloride as sources, respectively.

The experimental design was completely randomized with four replications in a 2 x 4 factorial arrangement, with two cultivars of *Brachiaria brizantha* (Xaraes and Piata palisadegrass) and four silage techniques as treatments: T_1- forage without treatment (control); T_2- *in natura* forage wilted for 4 hours under the sun; T_3- forage with bacterial additive (BactoSilo® of Lallemand) 2 g ton^{-1} of *in natura* forage; T_4 - 15% of pearl millet meal of *in natura* forage, totaling 32 experimental silos.

For T_2, forages were harvested by the morning and remained spread on the field during 4 hours for dehydration (wilting). Meteorological data during the harvest were: rainfall: 0 mm, relative humidity: 75%, maximum temperature: 30.5°C, minimum temperature: 22.3°C, mean temperature: 26.4°C, mean wind speed: 3.5 km h^{-1}.

An enzyme-bacterial inoculant was added in T_2, were used 6 mg (corresponding to 2 g for 1 ton forage) of BACTO SILO® (*Lactobacillus plantarum* MA18/5U and *Pediococcus acidilactici* MA18/5M) diluted in 80 mL distilled water and homogeneously sprayed on 3 kg forage to be ensiled. The millet grains were grinded and the amount applied (15%) was based on the natural matter of forages and homogeneously mixed with the forages.

For all treatments, the grasses were harvested at 40 days after the standardization cut and maintenance fertilization, 20 cm from the ground level using a backpack brush cutter. Then forages were chopped with a stationary shredder into 10-30 mm particles.

Afterwards, materials were stored in PVC experimental silos, with 10 cm diameter and 40 cm length. The ensiled material was compacted with iron pendulum and silos were closed with PVC caps and sealed with adhesive tape to prevent the entrance of air. Soon after were stored at room temperature and protected from rain and sunlight.

After 60 days to ensure full fermentation, silos were opened, discarding the top and bottom portion of each. A period of 3 to 4 weeks has generally been recommended for active silage fermentations to cease and reach a stable phase but Der Bedrosian et al. (2012) suggested that concentrations of soluble N and ammonia-N increased with length of storage, indicating that proteolytic mechanisms were active beyond 2 to 3 mo of storage.

The central portion of the silo was homogenized and placed on plastic trays. Part of fresh silage after opening the silos was separated to analyze fermentation parameters such as pH, soluble carbohydrates (CHOS) and ammonia nitrogen as percentage of total nitrogen ($N\text{-}NH_3$). The pH was determined using a Beckman Expandomatic SS-2 potentiometer after opening the silos, and the CHOS was measured by the colorimetric method (JOHNSON et al., 1966).

Subsequently, the silage was divided into two portions. The first was wrapped in plastic bags and frozen to determine ammonia nitrogen ($N\text{-}NH_3$) as percentage of the total nitrogen, according to AOAC (1980). For the determination of the pre-dried matter, the second portion, of approximately 1 kg, was weighed and taken to a forced air oven at 55ºC for 96 hours until a constant mass was obtained. The samples were ground in a Willey type mill with 1 mm sieve.

Chemical analyses were undertaken to determine the content of dry matter (DM), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), lignin, cellulose and hemicellulose, by the method of Silva and Queiroz (2002). Total digestible nutrients (TDN) were obtained by the equation proposed by Chandler (1990). The in vitro digestibility of dry matter (IVDDM) was determined according to Tilley and Terry (1963), with two-stage incubation of 48 hours.

Before the ensiling process it was carried out the chemical analysis of Xaraes, Piata palisadegrass and millet meal (Table 1).

Table 1. Chemical composition of Xaraes and Piata palisadegrass and of millet meal, used for silage production.

Composition*	Xaraes palisadegrass	Piata palisadegrass	Millet meal
DM (% NM)	19.10	18.80	92.40
CP (% DM)	12.80	13.20	16.50
NDF (% DM)	69.50	67.60	21.60
ADF (% DM)	39.70	37.50	9.40
Lignin (% DM)	4.30	4.25	2.70
Cellulose (% DM)	35.40	33.55	6.70
Hemicellulose (% DM)	29.80	30.10	12.20
TDN (% DM)	57.50	59.40	68.80
IVDDM (%)	63.5	65.4	69.7

*Dry matter (DM), natural matter (NM), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (NDF), total digestible nutrients (TDN) and *in vitro* digestibility of dry matter (IVDDM).

Data were subjected to analysis of variance, considering the silage techniques, the two *Brachiaria brizantha* cultivars and the interaction between these factors as variation sources. The means were compared by Tukey test at 5% level, using the statistical program SISVAR 4.6 (FERREIRA, 2000).

Results and discussion

There were no differences between cultivars of *Brachiaria brizantha* silages for ($p > 0.05$) for CP, N-NH_3, CHOS, NDF, ADF, lignin, cellulose, hemicellulose content and pH and IVDDM. However, treatments had significant effect ($p < 0.05$) within cultivars for all variables studied specially for inoculant or additive inclusion. Only DM and TDN had a significant interaction ($p < 0.05$) between cultivars and treatments.

For the Xaraes palisadegrass silage, the highest content of DM was observed in treatments with addition of inoculant and of millet meal (Table 2). For the Piata palisadegrass silage, the content of DM was similar among treatments of wilting, addition of inoculant and millet meal, differing only from the control. When compared the content of DM of silages of both cultivars, the Piata palisadegrass silage presented a higher content of DM when added of inoculant. For the other treatments, the DM content of Xaraes and Piata palisadegrass silages was similar.

Similar results were found by Bergamaschine et al. (2006) who verified that additives and 4 hours sun exposure increased the Marandu palisadegrass silages DM content. In an experiment using different levels of millet meal, Costa et al. (2011) also verified that millet meal is an effective additive to absorb water in the silo. The addition of 15% millet meal was sufficient to increase the DM content from 20.5 to 28.4%, from 21.9 to 31.5%, and from 19.7 to 31.0% DM for Marandu, Piata and Xaraes palisadegrass cultivars of *Brachiaria brizantha* silages, respectively.

The N-NH_3 is an index of silage quality and assists in characterizing the fermentation profile occurred in the process and according to McDonald et al. (1991), lower ratios indicate lower proteolysis of the ensiled material and better silage quality. In the present experiment, the N-NH_3 was similar between treatments with bacterial inoculant and with millet meal inclusion and different from wilted and control treatments, which presented higher values. Wilted silages had lower N-NH_3 when compared with control treatment. This result can be related to the lower values of pH for T_2, T_3 and T_4, which could reduce *Clostridium* bacteria. Bacteria of the genus *Clostridium* promote proteolysis and release of ammonia nitrogen during the ensilage process (VIANA et al., 2013).

Table 2. Content of dry matter (DM), ammonia-nitrogen as percentage of total nitrogen (N-NH_3), soluble carbohydrates (CHOS) and pH of Xaraes and Piata palisadegrass silages in different treatments.

Treatments	Cultivars	
	Xaraes	Piata
	DM (% NM)	
Control	20.05 Ca	20.47 Ba
Wilted (4 hs)	22.85 Ba	24.44 Aa
Bacterial inoculant	24.07 Ab	26.05 Aa
Millet meal (15% MN)	24.84 Aa	26.52 Aa
CV (%)	5.12	
	N-NH_3 (% of total N)	
Control	10.8 Aa	10.3 Aa
Wilted (4 hs)	8.6 Ba	7.9 Ba
Bacterial inoculant	4.4 Ca	4.8 Ca
Millet meal (15% MN)	3.7 Ca	4.0 Ca
CV (%)	10.4	
	CHOS (% DM)	
Control	2.53 Ca	2.75 Ca
Wilted (4 hs)	3.75 Ca	3.15 Ca
Bacterial inoculant	5.12 Ba	5.08 Ba
Millet meal (15% MN)	9.25 Aa	10.20 Aa
CV (%)	9.76	
	pH	
Control	5.00 Aa	4.95 Aa
Wilted (4 hs)	4.00 Ba	4.00 Ba
Bacterial inoculant	4.25 Ba	4.00 Ba
Millet meal (15% MN)	4.00 Ba	4.00 Ba
CV (%)	5.74	

Coefficient of variation (CV). Mean values followed by different letters, upper case in the column (treatments) and lower case in the row (cultivars) are significantly different by Tukey's test ($p < 0.05$).

The highest N-NH_3 in the control can be due to the lower content of readily fermentable carbohydrate, lower content of DM and increased buffering capacity, typical of perennial grasses (LEONEL et al., 2009).

Except for the control, all treatments presented $N-NH_3$ values consistent with those recommended for a high quality silage. These contents remained below 10% indicating that the silage had a good quality for this parameter according to Tomich et al. (2004). Therefore, the fermentation did not result in an excessive breakdown of protein into ammonia, and amino acids comprised the majority of non-protein nitrogen (VAN SOEST, 1994).

Regarding the content of CHOS (Table 2), the control and wilted treatments presented similar values, being different from other treatments. The addition of millet meal provided the highest content of CHOS, for both Xaraes and Piata palisadegrass silages, with increases of 80.6 and 100.7%, respectively in relation to silages that received the bacterial inoculant. The CHOS content in treatments T_1, T_2, and T_3 was lower than the minimum level of 8-10% DM recommended by McDonald et al. (1991) for a suitable fermentation.

Evaluating the quality and nutritional value of Marandu palisadegrass silage produced with additives and wilted forage; Bergamaschine et al. (2006) registered content of CHOS of 2.23 and 2.50% for treatments with enzyme-bacterial additive and wilted forage, respectively. These values were lower than found in our study.

Considering the pH (Table 2), in the silage of both grasses, the treatments with wilting, inoculant and millet meal were efficient to lower the silage pH. This is important to maintain the acidification of silage by means of lactic acid that inhibits the action of undesirable bacteria on the ensiled mass (McDONALD et al., 1991).

Higher pH values in control silages are due to the lower content of soluble carbohydrates (Table 2) in *Brachiaria* cultivars and low DM content at the cutting time (Table 1). McDonald et al. (1991) reported that the high moisture and low soluble carbohydrates content at the time of cutting of tropical grasses are factors that inhibit the suitable fermentation, hindering the production of good quality silages. These factors negatively affect the fermentation, preventing the rapid pH decrease to proper levels (3.8 to 4.2) and allowing undesirable secondary fermentations (JAYME et al., 2009). Thus, the final pH of the silage indicates the quality of the fermentation process, and its value inside the silo should become as fast as possible low enough to inhibit the development of undesirable bacteria like *Clostridium* (McDONALD et al., 1991).

Reduction in pH values were also registered by Ferrari Jr. et al. (2009), which investigated additives (*Lactobacillus plantarum* and *Pediococcus pentosaceus*) in elephant-grass silage, and observed changes in the fermentation profile in the silo, providing silages with pH lower than the control silage, from 3.36 to 3.15.

Both silages had the highest CP values in treatments with inoculant or millet meal addition, with an increase of 37.6 and 42.8%, respectively, in relation to the control (Table 3). The millet meal is considered a good additive for the ensiling, given its quality characteristics (GUIMARÃES JR. et al., 2008). The higher CP content (16.5%) in millet grains increased total protein of the silages. An increase of CP content in Tanzânia guineagrass silages after millet meal inclusion was also observed by Paziani et al. (2006).

Table 3. Content of crude protein (CP), total digestible nutrients (TDN), neutral detergent fiber (NDF) and acid detergent fiber (ADF) of silages of Xaraes and Piata palisadegrass in different treatments.

Treatments	Cultivars	
	Xaraes	Piata
	CP (% DM)	
Control	8.72 Ca	10.07 Ba
Wilted (4 hs)	10.89 Ba	10.23 Ba
Bacterial inoculant	12.00 Aa	12.04 Aa
Millet meal (15% MN)	12.46 Aa	12.95 Aa
CV (%)	9.52	
	TDN (% DM)	
Control	69.12 Ba	68.98 Ba
Wilted (4 hs)	71.60 ABa	68.92 Bb
Bacterial inoculant	72.51 ABa	72.18 Ba
Millet meal (15% MN)	74.08 Aa	75.91 Aa
CV (%)	2.50	
	NDF (% DM)	
Control	71.00 Aa	72.75 Aa
Wilted (4 hs)	68.50 Aa	66.00 Ba
Bacterial inoculant	69.50 Aa	69.17 Ba
Millet meal (15% MN)	66.25 Ba	66.10 Ba
CV (%)	2.51	
	ADF (% DM)	
Control	44.25 Aa	44.75 Aa
Wilted (4 hs)	40.50 Ba	40.50 Ba
Bacterial inoculant	39.00 Ba	39.25 Ba
Millet meal (15% MN)	36.25 Ca	35.50 Ca
CV (%)	4.05	

Dry matter (DM); coefficient of variation (CV). Mean values followed by different letters, upper case in the column (treatments) and lower case in the row (cultivars) are significantly different by Tukey's test ($p < 0.05$).

When analyzed the TDN content (Table 3), for the Xaraes palisadegrass silage, only the millet meal treatment was different from the control. The Piata palisadegrass silage presented TDN content similar between control, wilted and inoculant treatments, being different only from the millet meal. For the silages of both cultivars, the highest content of TDN was achieved in the treatment with millet meal, owing the higher TDN content of this ingredient.

Comparing cultivars within each treatment, only in the wilted treatment there was a significant difference in the content of TDN for the silage of cultivars, with the Xaraes palisadegrass silage presenting higher content of TDN relative to Piata palisadegrass silage. In other treatments, the TDN content was similar.

With regard to NDF content (Table 3), only the treatment with 15% millet meal inclusion was consistent in reducing NDF content. This reduction is due to a dilution effect on the fiber because of the lower NDF values in the millet meal (21.60%). Bacterial inoculant effect was small and inconsistent. Nadeau et al. (2000) and Rodrigues et al. (2003) reported no effect of inoculant on cell-wall concentration.

For both silages, the lowest ADF values were observed in the treatment with 15% millet meal (Table 3). A decrease in ADF content was also observed by Paziani et al. (2006) when millet meal was added in the ensiling process. ADF content was similar in T_2 and T_3 but different from the control, corroborating Bergamaschine et al. (2006) who evaluated the quality and nutritional value of silages of Marandu palisadegrass produced with additives or wilted forage, and observed similar content of ADF of treatments wilted for 4 hours (42.33%) and enzyme-bacterial inoculant (42.58%). Meanwhile, Coan et al. (2005) examined silages of Tanzânia and Mombaça guineagrass with enzyme-bacterial inoculant and found that the inoculant had no effect in reducing the content of ADF of silages. These authors still reported that this result can be explained by the lack of activity of enzymes in the enzyme-bacterial inoculant, which promote the solubilization of cell wall constituents and increase the availability of soluble carbohydrates for fermentation by lactic acid bacteria.

Analyzing the content of lignin (Table 4) it is observed that the addition of inoculant and millet meal reduced the lignin content in the Xaraes palisadegrass silage. Comparing these treatments with the wilted silage, a decrease of 6.49 and 7.65% was registered for lignin content, respectively. Moreover, the control had the highest value of lignin content.

For both silages, a significant difference was detected in the lignin content between control and millet meal. Such result is related to the lowest concentration of lignin in the millet meal (2.7%), which contributed with reduced content of lignin in the silage; due to the dilution effect. The inoculant effects on lignin were a bit in consistent and differed between cultivars, showing effect in Xaraes and no effect in Piata palisadegrass silages when compared with the control treatment. Rodrigues et al. (2003) investigated the addition of microbial inoculants on the chemical composition and fermentation of elephant grass silage but did not find significant effect on the lignin content.

Table 4. Content of lignin, cellulose, hemicellulose and in vitro digestibility of dry matter (IVDDM) of silages of Xaraes and Piata palisadegrasses in different treatments.

Treatments	Cultivars	
	Xaraes	Piata
	Lignin (% DM)	
Control	5.22 Aa	4.92 Aa
Wilted (4 hs)	4.92 Ba	4.70 Aba
Bacterial inoculant	4.62 Ca	4.52 Aba
Millet meal (15% MN)	4.57 Ca	4.50 Ba
CV (%)	4.36	
	Cellulose (% DM)	
Control	39.02 Aa	39.82 Aa
Wilted (4 hs)	35.97 ABa	35.80 Ba
Bacterial inoculant	34.37 BCa	34.72 Ba
Millet meal (15% MN)	31.67 Ca	31.00 Ca
CV (%)	4.78	
	Hemicellulose (% DM)	
Control	26.75 Ba	25.55 Ba
Wilted (4 hs)	28.12 Aa	28.00 Aa
Bacterial inoculant	30.50 Aa	29.92 Aa
Millet meal (15% MN)	30.00 Aa	30.60 Aa
CV (%)	7.85	
	IVDDM (% DM)	
Control	52.3 Da	53.8 Ca
Wilted (4 hs)	59.5 Ca	61.3 Ba
Bacterial inoculant	62.7 Ba	63.1 Ba
Millet meal (15% MN)	65.8 Aa	66.5 Aa
CV (%)	6.54	

Coefficient of variation (CV). Mean values followed by different letters, upper case in the column (treatments) and lower case in the row (cultivars) are significantly different by Tukey's test ($p < 0.05$).

Regarding the cellulose content, the bacterial inoculant and the millet meal had lower cellulose values than *in natura* forage. Ferrari Jr. et al. (2009) studying the use of additives in capim-elefante paraíso grass observed reduction effect of enzyme-bacterial inoculant on the cellulose content of silages and cited that in grass silages, an small fraction (less than 5%) of cellulose can be fermented by enzymes. Due the low cellulose content in its own composition, 15% millet meal inclusion diluted total cellulose in silage.

The hemicellulose content was lower in the control treatment compared to the other ones for both cultivars. The hemicellulose is the main additional source of substrate for fermentation, and can be consumed in the range of 40-50% by microorganisms in the ensiling process (HENDERSON, 1993). According to Patrizi et al. (2004), *Bacillus* and *Aspergillus* genus produce cellulases, hemicellulases, amylases, Glico-amylases and proteases which promote structural and non-structural carbohydrates digestion. Van Soest (1994) reported that its breakage during the fermentation provides additional sugars for lactic fermentation. Addition of millet meal reduced the hemicellulose content, because this additive has low content of fiber fractions, which can be diluted in the silage.

By assessing the IVDDM of each cultivar (Table 4), the lowest digestibility for the Xaraes palisadegrass silage was acquired in the control, followed by wilted and inoculant treatments. The silage added with 15% millet meal had the highest values of IVDDM. This observation is probably associated with the chemical composition of the fraction with reduced content of NDF and ADF of the silage, which certainly make available readily digestible carbohydrates to ruminal microorganisms (FERNANDES et al., 2002).

However, for the Piata palisadegrass silage, the IVDDM of wilted and inoculant treatments was similar, being superior to the control and inferior to the millet meal treatment, which also presented a higher digestibility when compared with other treatments.

Conclusion

Inoculant or millet meal addition can enhance the nutritional value of Xaraes and Piata cultivars of *Brachiaria brizantha* silages. Both treatments were effective in improving the fermentation and chemical parameters of both cultivars silages, by elevating the CHOS, CP, TDN contents and reducing the N-NH_3 and pH. Because of their composition, 15% of millet meal inclusion provided the best content of CHOS, NDF, ADF and increased IVDDM of silages. Wilting can also be effective in improving the aerobic stability of grass silages and may be a cheaper alternative to additives.

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