Agronomy Science and Biotechnology

Research Article

Quality of BRS kurumi ensilage associated with different additives

Igor Ramon Carvalho[1], Ivan Ricardo Carvalho[2,*], Jorge Nunes Portela[1], Graziele Lais Garmatz[1], Murilo Vieira Loro[3], Eduardo Ely Foleto[2], Guilherme Hickembick Zuse[2], João Daniel Broch[1], Fabrício Broch[1] and Luis Eduardo Severo[1]

[1]Instituto Federal de Educação, Ciência e Tecnologia do Rio Grande do Sul, Campus Sertão, Rodovia RS 135, Km 32.5, Distrito Eng. Luiz Englert , Sertão, RS, Brazil, CEP99170-000.
[2]Universidade Regional do Noroeste do Rio Grande do Sul, Núcleo de Ciências Agrários, Avenida do Comércio, nº 3.000, Bairro Universitário, Ijuí, RS, Brazil, CEP 98700-000.
[3]Universidade Federal de Santa Maria, Av. Roraima, nº 1000, Cidade Universitária, Bairro Camobi, Santa Maria, RS, Brazil, CEP97105900.
*Corresponding author, E-mail: carvalhoirc@gmail.com

Citation: Cravalho, I. R., Carvalho, I. R., Portela, J. N., Garmatz, G. L., Loro, M. V., Foleto, E. E., Zuse, G. H., Broch, J. D., Broch, F., & Severo, L. E. (2024). Quality of BRS kurumi ensilage associated with different additives. *Agronomy Science and Biotechnology*, 10, 1-8 https://doi.org/10.33158/ASB.r220.v10.2024

Received: November 23, 2024.
Accepted: December 8, 2024.
Published: February 25, 2025.

English by: Ivan Ricardo Carvalho

Abstract

The objective of this study was to evaluate the impact of different additives in elephant grass silage, cultivar BRS Kurumi, on the nutritional quality of forage in the municipality of Campos Borges, RS. The forage was harvested when the canopy reached 72 cm, cut 10 cm from the ground and exposed for 24 hours to wither. It was then crushed and divided into treatments with and without additives: pure silage; addition of corn bran; addition of wheat bran; addition of rice bran; addition of cassava root; addition of orange pomace. After 66 days, the samples were analyzed for the nutritional characteristics of the silage. The results showed dry matter variation of 17.1% to 20.7% between treatments. The treatments with corn bran, rice bran and orange pomace showed higher levels of crude protein than the other treatments. The lack of rain during the production cycle favored the accumulation of stalks, making dehydration and the increase in dry matter difficult, compromising lactic fermentation and reducing pH. The addition of additives has proven to be an effective strategy to improve the quality of ensiled forage, incorporating soluble carbohydrates, precursors of VFAs.

Keywords: Pasture; natural fields; forage species; sustainability; producing forage; rotated paddocks, continuous grazing.

Introduction

The pasture area in Brazil is estimated at 154 million hectares, distributed across all six biomes. When considering the inclusion of natural fields, especially in Gaucho Pampas (grasslands) and Pantanal, this area reaches 200.6 million hectares. Of this total, around 45 million hectares are used in intercropped systems with annual crops or agroforestry. However, it is estimated that between 50 and 70% of these pasture areas present some degree of degradation, requiring interventions for their recovery.

Well-managed pastures offer an excellent opportunity to increase the efficiency of animal production. In Brazil, most livestock production systems are made up of extensive and semi-intensive models, which use vast areas of natural and cultivated pastures. Given this, the development of knowledge about forage species adaptable to different biomes and the search for new cultivars are essential to increase food production, always in line with the principles of sustainability.

Producing forage in climate transition months of the year is a challenge for many dairy producers, due to the temperature effect that affects the plant's normal cycle. This occurs mainly between the months of March and May and, from October to December, and requires producers to plan forage with forages more adapted to each time of the year, otherwise, there will be a drop in milk production in the periods mentioned. BRS Kurumi is a great option for small and large producers, as in addition to being used for pasture in both rotated paddocks and continuous grazing, there is a new opportunity to use Kurumi for silage.

Thus, the use of forage preserved through the silage pre-drying technique aims to guarantee food availability during periods in which production factors, such as temperature, daily light hours and precipitation, are unfavorable and compromise forage production. BRS Kurumi is characterized by its low size, semi-open clumps, green leaves and stems and a short internode. It presents vigorous vegetative growth with rapid leaf expansion and intense tillering. Planting is carried out through vegetative propagation (cuttings). Studies conducted at Embrapa Dairy Cattle show that the rate of forage accumulation during the rainy season varies between 120 and 170 kg DM ha^{-1} day^{-1} (Gomide et al., 2015).

The nutritional value of the BRS Kurumi cultivar is one of its main highlights. Crude protein levels vary between 18% and 20%, while digestibility coefficients range between 68% and 70%, considering forage above the residual cutting height. Due to the high protein content, only energy supplementation is recommended during the rainy season, which can enhance weight gain or milk production in animals (Gomide et al., 2015). Although BRS Kurumi is widely used for grazing, it can also be used as chopped forage in the trough and for silage production. Furthermore, the use of additives in silage can maximize nutritional quality and promote greater gains in animal production. Based on these characteristics, the objective of this study was to evaluate the impact of different additives in elephant grass silage, cultivar BRS Kurumi, on the nutritional quality of forage in the municipality of Campos Borges, RS.

Materials and Methods

The area in which the cultivation of *Pennisetum purpureum* Schum cultivar BRS Kurumi and the cutting of forage occurred was 120 m², located in an agricultural production unit (APU) in the district of Rincão dos Toledos, municipality of Campos Borges, State of Rio Grande do Sul. The implementation of the area began with cultivation, using subsoiling equipment, a leveling harrow and a three-bladed plow to open furrows, 50 cm apart between rows. Planting was carried out on 12/23/2021 with 15 cm long cuttings, which were positioned lying inside the furrows and manually covered with 10 cm of soil. Due to water limitations in the post-planting period, the area was irrigated to form the forage canopy and replanting took place on 02/21/2022 using seedlings, with 23 days of rooting in plastic cups (Figure 1).

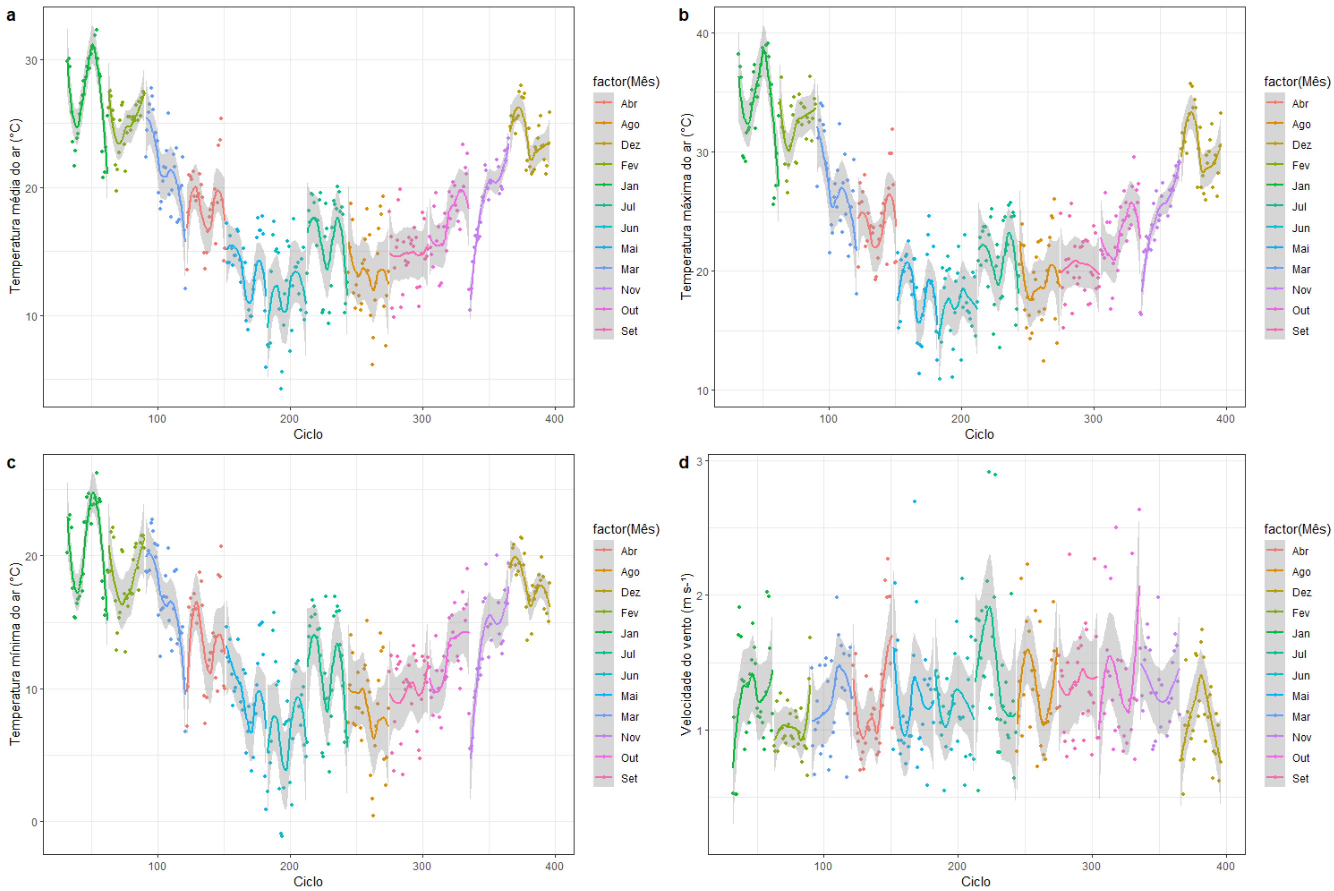

Figure 1. Precipitation conditions and global solar radiation on the surface during the growing cycle of elephant grass cultivar Kurumi. Campos Borges, RS.

Soil sampling and analysis were carried out in March 2022 by the Genetic Improvement Laboratory Grains and Coverage Line of the Northwestern Regional University of the State of Rio Grande do Sul (UNIJUI). The first establishment fertilization occurred on 02/23/2022, broadcast, at a dosage of 300 kg ha^{-1}, formula 05-20-20 (NPK). The cutting to standardize the canopy and encourage tillering occurred on 03/16/2022, 83 days after the first planting and a drum mower was used. The canopy did not meet the fall and winter 2022 cutting height target for forage to be ensiled. On 08/20/2022, the second standardization mowing was carried out, using a backpack mowing machine and leaving a 10 cm high residue. Top dressing was applied seven days after cutting at a dosage of 400 kg ha^{-1}. In September 2022, frost occurred which slowed down the growth of the canopy. Nitrogen fertilizations were carried out: the first on 09/03/2022 (before a rain), the second 15 days later and the third on 10/11/2022 using a dosage of 112.5 kg of N ha^{-1}.

Meteorological data from the canopy growth period were obtained from the NASA Power platform (Nasa Power, 2022). The canopy height was monitored using a graduated ruler (stick) and an acetate sheet (20 x 40 cm) perforated in the center. The blade was moved on the stick until it reached the top of the canopy without compressing leaves. At this point, a reading of the height between the ground and the top of the canopy was obtained. On 10/23/2022 the canopy was 60 cm and on 11/02/2022 it reached 72 cm, where the forage was harvested at 10 cm from the ground level (residue), i.e., defoliation intensity of 86%. The forage was exposed to field conditions for 24 hours to wither, being turned once and collected in bags (Big Bags) to be disintegrated in a crusher without a sieve. A sample was taken from the crushed forage to determine dry matter (DM) using the microwave oven technique, proposed by Oliveira et al. (2015).

The crushed and pre-wilted forage weight from BRS Kurumi was distributed into treatments, with and without the inclusion of additives: T_1: Pure silage; T_2: Silage with added corn bran; T_3: Silage with added wheat bran; T_4: Silage with added rice bran; T_5: Silage with the addition of chopped cassava root; and T_6: Silage with the addition of orange pomace.

The design was completely randomized, with four replications composed of Micro silos, built in polyvinyl chloride (PVC) pipes with 10 cm in diameter (78.5 cm²), 50 cm in height and with mobile plugs at both ends. The volume per Micro silo was 3,925.00 cm³ and density of 565 kg m-3, totaling 2,220 kg of pre-wilted forage. The micro silos were prepared with a base of 400 grams of sand, dried in an electric oven at 300 °C for 15 minutes, to absorb excess effluents. The sand layer was overlaid with 10 micron polyamide mesh to isolate the ensiled forage.

With the dry matter content of the pre-wilted silage calculated, resulting in 25% DM, the food additives were added, corresponding to 10% of the ensiled DM. For orange and cassava pomace, the DM was determined, according to Oliveira et al. (2015). The additives were incorporated into the crushed forage in a bucket and then taken to the micro silos and compacted manually using a wooden handle with a diameter of 8.0 cm and one meter in length. As the forage was compacted, the micro silos were closed with the lid, sealed with the aid of transparent adhesive tape and stored in a protected environment for 66 days until opening on 01/09/2023.

The opening occurred with the removal, first of the lower lid, where the sand was located, then the upper lid. By releasing both ends, it was possible to remove the silage that was compacted and weigh it. The silage sampling for bromatological analysis was 1.0 kg, packed in plastic bags with identification of the treatment and repetition and sent to the Genetic Improvement Laboratory of the UNIJUI Grains and Coverage Line, which took place on 01/17/2023. The samples were stored in a refrigerated environment until 01/23/2023, when they entered the analysis routine with the determination of partially dry matter (PDM), ground and subjected to analysis of: dry matter (DM, %), crude protein (CP , %), neutral detergent fiber (NDF), acid detergent fiber (ADF), non-fibrous carbohydrates (NFC), total carbohydrates (TC), lignin, lipids, mineral material, calcium, phosphorus, potassium, magnesium, sulfur and pH and soluble solids (SS). The equipment used was a food analyzer using Near Infrared Spectroscopy (NIRS) technology, Model DA 7200.

The meteorological components were stratified by months and plotted on graphs to highlight their trends in relation to the cycle days. Subsequently, the assumptions of normality and homogeneity of residual variances were made. Afterwards, analysis of variance was carried out at 5% probability using the F test. The variables that showed significance were broken down using Tukey analysis at 5% probability. All analyzes were performed using the R software (R Core Team, 2024).

Results and Discussion

According to Bach & Schmidt (2014), to determine the point at which to harvest forage for ensiling, it is essential to evaluate its dry matter content, as when determining the appropriate time to ensile the forage, through dry matter, if obtain a more satisfactory result. The DM content of pre-wilted forage was calculated at 25% DM, according to the methodology described by Oliveira et al. (2015) and in silage the values found were 17.1 to 20.7% (Table 1), therefore much lower than that recommended by McDonald (1981). Where the dry matter levels of the ensiled forage must be greater than 30% to obtain satisfactory fermentation.

Lower DM levels allow the proliferation of bacteria responsible for undesirable fermentation and consequently for losses observed in silages. The expectation was to obtain around 30% DM of post-ensiled forage, a condition that did not occur, but possibly because the forage was cut at 10 cm above ground level, a canopy stratum characterized by a large presence of stems. In the process, the forage was disintegrated and crushed 24 hours after cutting, when the micro silos were made. This factor may have retained a greater concentration of water in the culm morphological component.

The pH ranged from 5.28 to 5.61, higher than that described in the literature as an indicator of anaerobic fermentation and with a strong presence of lactic acid bacteria. According to Carvalho et al. (2008) in good quality silage, its pH varies from around 3.8 to 4.2, thus justifying that the pH values have exceeded desirable values. The pH parameter is strictly associated with the concentration of DM and soluble carbohydrates, precursors for efficient anaerobic fermentation.

The NDF of pure silage was 48.56%, higher than that of silage with the addition of rice bran (T_4), which presented a concentration of 41.61 (Table 1 and Figure 2).

Table 1. Indicators of pH and concentration of dry matter (DM), neutral detergent fiber (NDF), acid detergent fiber (ADF), non-fibrous carbohydrates (NFC), total carbohydrates (TC) and lignin in forage silages from BRS Kurumi with and without additives. Campos Borges, RS.

Treatments	pH	DM	NDF	ADF	NFC	TC	Lignin
		(%)					
T1[1]	5.48	17.1	48.56 a[2]	26.52 ab	30.63	79.19 a	3.62 b
T2	5.44	18.1	44.48 ab	28.16 ab	28.27	72.75 b	6.06 a
T3	5.36	20.7	43.65 ab	26.54 ab	29.25	72.90 b	5.08 ab
T4	5.61	18.7	41.61 b	24.95 b	29.84	71.45 b	5.46 ab
T5	5.48	18.7	44.36 ab	28.56 ab	29.82	74.18 ab	5.69 ab
T6	5.28	17.9	47.76 ab	30.60 a	23.34	71.10 b	6.30 a

[1]T1: Pure silage; T2: Silage with added corn bran; T3: Silage with added wheat bran; T4: Silage with added rice bran; T5: Silage with the addition of chopped cassava root; and T6: Silage with the addition of orange pomace. [2]Lowercase letters compare means in the column with Tukey at 5%.

Valadares-Filho, Machado, Furtado, Chizzotti and Amaral (2018) obtained NDF results of 61.47% in silage. Monteiro, Abreu, Cabral, Ribeiro and Reis (2011), in a study that used rice bran as an additive in silage, obtained a NDF result of 60.89%. As for ADF, the silage with the addition of orange pomace presented a concentration of 30.60% and was higher than the silage with the addition of rice bran, which presented 24.95% of ADF. Studies carried out by Valadares-Filho et al. (2018) resulted in the amount of 37.70% of ADF. However, Monteiro et al. (2011) obtained a result of adding 38.08% ADF when adding rice bran. Pereira, Banys, Silva, Gonçalves and Pereira (1999) in work carried out with the addition of citrus pulp obtained the result, when adding 10% as an additive, 43.59% of ADF.

The bromatological expectation was that the lower concentration of NDF and ADF in silage with the addition of rice bran, compared to pure silage, would result in a higher concentration of non-fibrous carbohydrates. However, this response was not observed, even without statistical significance. According to Ferrari et al. (2001), the NFC content necessary to obtain positive results in the fermentation of ensiled dough is approximately 15%. The concentration of total carbohydrates was higher in pure silage compared to silages that received the addition of corn bran, wheat bran, rice bran and orange pomace.

In this study, the values of non-fibrous carbohydrates varied between 23.34% and 30.63%, with the treatment with the addition of orange pomace showing the lowest result, while pure silage without additives obtained the highest value. Monteiro et al. (2011), in a study with elephant grass silage, found NFC values of 14.03% in pure silage. As for lignin, pure silage presented the lowest concentration (3.62%) compared to silages with the addition of corn bran and orange pomace. In the study by Monteiro et al. (2011), pure elephant grass silage presented 6.74% lignin. Ferrari et al. (2001), when using cassava bran as an additive, observed that lignin values decreased in relation to pure silage, although without a statistically significant difference. In relation to crude protein (CP), the lowest values were recorded in pure silage, compared to silages that received the addition of corn bran, wheat bran, rice bran and orange pomace (Table 2 and Figure 2).

Table 2. Concentration of crude protein (CP), ether extract (EE), mineral matter (MM), calcium (Ca), phosphorus (P), potassium (K), magnesium (Mg), sulfur (S) and SS in forage silages BRS Kurumi with and without additive. Campos Borges, RS.

Treatments	CP	EE	MM	Ca	P	K	Mg	S	SS
	(%)								
T1[1]	4.94 b[2]	4.93	10.94	0.93	0.22	1.06	0.10	0.19 c	13.25
T2	12.08 a	4.30	10.87	1.02	0.27	1.47	0.22	0.20 abc	11.02
T3	11.23 a	4.55	11.31	1.00	0.25	1.42	0.19	0.21 abc	11.51
T4	12.43 a	4.64	11.47	1.04	0.27	1.60	0.25	0.22 a	11.03
T5	9.95 ab	4.44	11.43	0.97	0.24	1.36	0.20	0.19 bc	11.42
T6	12.77 a	4.41	11.71	0.86	0.31	2.10	0.26	0.21 ab	8.63

[1]T1: Pure silage; T2: Silage with added corn bran; T3: Silage with added wheat bran; T4: Silage with added rice bran; T5: Silage with the addition of chopped cassava root; and T6: and Silage with the addition of orange pomace. [2]Lowercase letters compare means in the column with Tukey at 5%.

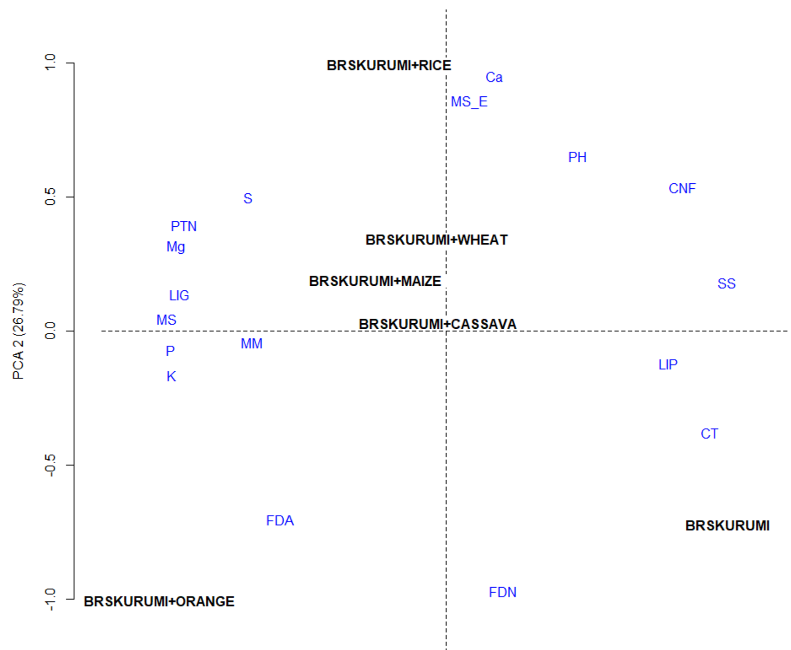

Figure 2. Biplot of the analysis of main components for the characters evaluated in forage silage from BRS Kurumi with and without additive. Campos Borges, RS.

According to Paiva, Lana, Oliveira, Leão and Teixeira (2013), a crude protein (CP) in the range of 12% in forage is sufficient to meet the maintenance requirements of Holstein cows, with the animals' energy needs met, as evidenced by the stabilization of body weight. Therefore, treatments with the addition of corn bran, rice bran and orange pomace would be ideal CP conditions for maintaining these animals.

The concentration of ether extract varied between 4.30% and 4.93%. In contrast, Valadares-Filho et al. (2018) obtained a value of 2.28%, while Monteiro et al. (2011), using silage with cassava bran, reported similar results, with 2.31% ether extract. The mineral matter content varied from 10.87% to 11.71%. Valadares-Filho et al. (2018) found close values, around 9.32%. Calcium concentrations ranged between 0.86% and 1.04%, while phosphorus concentrations ranged from 0.22% to 0.31%. According to Andrade, Wignez, Braun and Possenti (1998), in corn cultivars for silage, calcium values were between 0.20% and 0.32%, indicating that calcium concentrations in elephant grass silage were higher than those in corn. Regarding phosphorus, the values for both species were similar, with corn presenting between 0.23% and 0.28%.

Potassium concentrations ranged from 1.06% to 2.10%, and magnesium concentrations from 0.10% to 0.26%. For sulfur, silages with the addition of rice bran showed higher concentrations compared to pure silage and silage with the addition of chopped cassava root. Andrade et al. (1998) reported that corn cultivars for silage had potassium levels between 1.10% and 1.44% and magnesium between 0.021% and 0.21%, values close to those observed in elephant grass silage. Regarding sulfur, the same authors found values between 0.11% and 0.12%, while in this study the results varied between 0.19% and 0.22%.

A notable factor during the forage plant's production cycle was the scarcity of precipitation, which seems to have led the forage canopy to prioritize the accumulation of stalk to the detriment of the leaf blade. This change in the morphological composition of the forage restricted the dehydration process and did not promote the expected increase in dry matter concentration, which would be necessary for efficient lactic acid fermentation and the consequent reduction in pH. Under these conditions, the use of conditioning mowers, which cut and crush the forage, could have facilitated air circulation, increased the exposure surface and reduced drying time in the field. However, the equipment used for cutting was not able to disintegrate the stalks properly. The inclusion of additives proved to be an important strategy for the incorporation of soluble carbohydrates, precursors of volatile fatty acids (VFAs), which are indicative of the quality of ensiled forage.

Conclusion

Water stress limited the cultivar's full productive potential, resulting in a forage canopy with a high volume of stalks and low dry matter, which made the fermentation process difficult. However, the addition of corn bran, rice bran and orange pomace improved the protein levels of the ensiled forage. Future studies could explore ensiling before stem formation, with adequate wilting to achieve ideal levels of dry matter and improve results in the production of this material.

References

Andrade, J. B., Wignez, H., Braun, G., & Possenti, R. A. (1998). Silage production and nutrient recycling in corn. Mineral composition and nutrient recycling. *Animal Industry Bulletin*, *55*(1), 57-61.

Bach, B. C., & Schmidt, P. (2017). *Determination of dry matter in a domestic microwave oven*. Curitiba, PR: Forage Research Center – UFPR.

Carvalho, G. G. P., Garcia, R., Pires, A. J. V., Pereira, O. G., Fernandes, F. E. P., & Carvalho, B. M. A. (2008). Fermentative characteristics of wilted elephant grass silages or with the addition of cocoa bran. *Brazilian Archive of Veterinary Medicine and Zootechnics*, *60*(1), 234-242.

Gomide, C. A. M., Paciullo, D. S. C., Ledo, F. J. S., Pereira, A. V., Morenz, M. J. F., & Santos, A. M. B. (2015). *Informações sobre a cultivar de capim-elefante BRS Kurumi*. Juiz de Fora, MG: Embrapa Gado de Leite.

McDonald, P. (1981). *The biochemistry of silage*. New York: John Willey & Sons.

Monteiro, I. J. G., Abreu, J. G., Cabral, L. S., Ribeiro, M. D., & Reis, R. H. P. (2011). Elephant grass silage added with alternative products. *Acta Scientiarum - Animal Sciences*, *33*(4), 347-352. doi: 10.4025/actascianimsci.v33i4.12629

Oliveira, A., Garcia, R., Pires, A. J. V., Oliveira, H. C., Almeida, V. V. S., Oliveira, U. L. C., & Lima-Júnior, D. M. (2015). Elephant grass silages with or without wilting, with cassava meal in silage production, *Brazilian Journal of Animal Health and Production*, *18*(3), 417-429. https://doi.org/10.1590/S1519-99402017000300002

Paiva, V. A., Lana, R. P., Oliveira, A. S., Leão, M. I., & Teixeira, R. M. A. (2013). Teor de proteína em dietas para vacas holandesas leiteiras em confinamento. *Arquivo Brasileiro de Medicina Veterinária e Zootecnia*, *65*, 1183-1191.

Pereira, R. C., Banys, V., Silva, A. C., Gonçalves, R., & Pereira, A. (1999). Addition of pelletized citrus pulp to elephant grass silage (*Pennisetum purpureum*, Schum) cv. Cameroon. *Alfenas University Journal*, *5*(2), 114-120.

Valadares-Filho, S. C., Machado, P. A. S., Furtado, T., Chizzotti, M. L., & Amaral, H. F. (2018). *Tabelas brasileiras de composição de alimentos para ruminantes*. CQBAL 4.0. BEEFPOINT.