Fermentation losses of cactus silages with elephant grass

Rodrigo da Silva Santos[1], João Virgínio Emerenciano Neto*[1,2], Breno Ramon de Souza Bonfim[1], Uesdra Lucas Fônseca dos Santos[1,2], Arquinor Conceição Rodrigues[1], Fábio Nunes Lista[1], Gelson dos Santos Difante[3], Jéssica Daisy do Vale Bezerra[1,2]

[1] Universidade Federal do Vale do São Francisco-UNIVASF, Petrolina, PE, Brazil.

[2] Programa de Pós-Graduação em Ciência Animal-UNIVASF.

[3] Universidade Federal do Mato Grosso do Sul, Campo Grande, MS, Brazil.

*Corresponding author: joao_neto@zootecnista.com.br

Received: July 20, 2020; Accepted: October 11, 2020.

ABSTRACT

This study proposes to evaluate fermentation losses and dry matter recovery rate in cactus silages with elephant grass. The experiment was laid out in a completely randomized design with eight replicates. Treatments consisted of cactus silages with increasing levels of elephant grass (10, 20, 30 and 40 % on a fresh-weight basis). The material was ensiled in experimental PVC tubes and was evaluated after 200 days of fermentation. The inclusion of elephant grass in the silage did not influence its pH (4.55), effluent losses (77.78 kg/t of fresh matter) or dry matter recovery rate (69.03 %), but induced a linear increase in dry matter content (from 8.33 to 14.80 %) and a decrease in gas losses (from 30.33 to 17.20 %). The addition of up to 40 % elephant grass improves the fermentation profile of cactus silage.

Keywords: Fermentation profile*, Opuntia ficus-indica, Pennisetum purpureum,* pH.

INTRODUCTION

Northeast Brazil is characterized by periodic droughts of greater or lesser intensity. This phenomenon directly affects the potential of livestock activity carried out in that region, since the profitability of herds in the dry season is reduced due to the decline in herbage availability and quality caused by irregular rainfall distribution (Wanderley *et al*., 2012).

For animals to fully express their productive potential, fodder must be available in satisfactory quantity and quality throughout the year (Souza-Sobrinho *et al*., 2011). In this respect, spineless cactus (*Opuntia and Nopalea*) emerges as an alternative for the semi-arid regions of Northeast Brazil due to its efficient water utilization potential, ability to withstand long periods of drought, and for constituting an excellent source of energy with high non-fibrous carbohydrates contents, which make it a great option for use in animal feed (Lopes *et al*., 2012).

Elephant grass (*Pennisetum purpureum* Schum.) is one of the most widely used forages in fodder crops. As such, it is commonly employed in many production systems (Emerenciano-Neto *et al*., 2019), mainly dairy farms. However, during the rainy season, producers generally cease using those crops, since there is an abundance of feed in pasture areas. Thus, a possible strategy to take advantage of the surplus fodder crop production during the favorable season is preserving the forage in the form of silage with the cactus, thereby ensuring the availability of animal feed in the dry season.

In addition to being nutritious, another reason that justifies ensiling the cactus is its potential as a source of water, since the water stored by the cladodes in the rainy season can be offered to the animals during periods of scarcity. However, the cactus pear must be offered with a fiber source in order to balance the DM content, thus reducing the risks of nutritional disorders in ruminants (Macêdo *et al*., 2017).

Quantifying losses is a measure of great importance to determine the fermentation quality of the ensiled material, since the preserved forage has its nutritional value significantly altered depending on the procedures adopted in its preparation and biochemical and microbiological phenomena that take place in the preservation process (Jobim *et al*., 2007). Silages with low buffering power or exposed to oxygen, favor the growth of yeasts, molds and acetic acid's bacteria. Many of these microorganisms grow at pH 3.5 and use fermentation products for their development, causing deterioration and loss of the most digestible parts of the silage (Muck *et al*., 2010). On this basis, the present study proposes to evaluate the fermentation losses occurring in cactus silages with increasing levels of elephant grass.

MATERIAL AND METHODS

The experiment was conducted at the Agricultural Sciences Campus of the Federal University of Vale do São Francisco - UNIVASF, located in the municipality of Petrolina - PE, Brazil (9 ° 11 S and 41 ° 01’ W). According to the Köppen classification, the climate of the region is a BSh type, which characterizes a hot and dry region.

The species used to make the silages [spineless cactus (*Opuntia ficus-indica* cv. Gigante, Fig. 1A), at six months of age; and elephant grass (*Pennisetum purpureum* cv. Napier, Fig. 1B), at 120 days of age (old grass; low nutritional value) were harvested at the agrostology field.

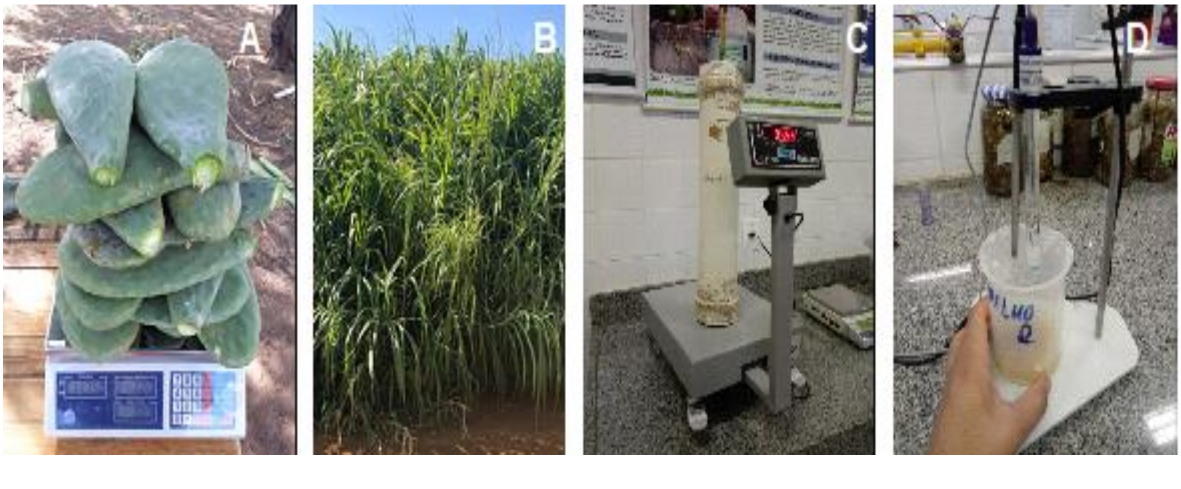

Figure 1. *Opuntia ficus-indica* cv. Gigante (A), *Pennisetum purpureum* cv. Napier (B), experimental silo (C) and pH measurement (D).

A completely randomized design was adopted with four treatments and eight replicates. The treatments consisted of four cactus silages with the inclusion of increasing levels of elephant grass (10, 20, 30 and 40 %). The species were minced separately through a stationary forage chopper and subsequently mixed manually, according to the proportions of the respective treatment, on a fresh-weight basis.

The material was ensiled in experimental PVC tubes (50 cm long × 10 cm wide, Fig. 1C) equipped with a rubber valve on the lid that allowed the escape of gases and a set of nylon fabric plus sand at the bottom to recover the effluent. Compaction was done manually, using a wooden stick. Subsequently, the silos were sealed with adhesive tape, weighed and stored in the laboratory until opening.

The silos were weighed again and opened after 200 days of fermentation to evaluate the fermentation profile. The pH was measured with a digital potentiometer (Fig. 1D), using 9 g of fresh silage in 60 mL distilled water for 30 min (Silva and Queiroz, 2002). Samples (200 g) of the material were collected and dried in a forced-air oven at 55 ºC for 72 h to determine the dry matter content before and after opening the silos.

Gas losses were calculated as the difference between the silo weights on closing and opening. Effluent production was determined as the weight difference of the nylon fabric plus sand set on opening and before ensiling. Finally, dry matter recovery was calculated based on the weight and dry matter content of the forage before ensiling and after the silos were opened, following the methods described by Jobim *et al*. (2007).

The data were subjected to analysis of variance and regression ($P<0.05$), using SISVAR software (Ferreira, 2011). The models that would best explain the results were chosen based on the coefficient of determination (R^2).

RESULTS AND DISCUSSION

Dry matter content increased linearly ($P<0.05$) in response to the inclusion of elephant grass in the cactus silage. The mixture with 40% elephant grass reduced the moisture content of the silage from 91.2 to 84.5 % (Fig. 2A), indicating that the higher the proportion of elephant grass in the silage, the lower the silage moisture content. Nonetheless, according to McDonald (1981), to achieve a satisfactory fermentation process in the silo and obtain good-quality silage, the silage dry matter content should not be less than 30 %. Thus, the inclusion of higher levels of elephant grass may elevate the dry matter content to values considered adequate.

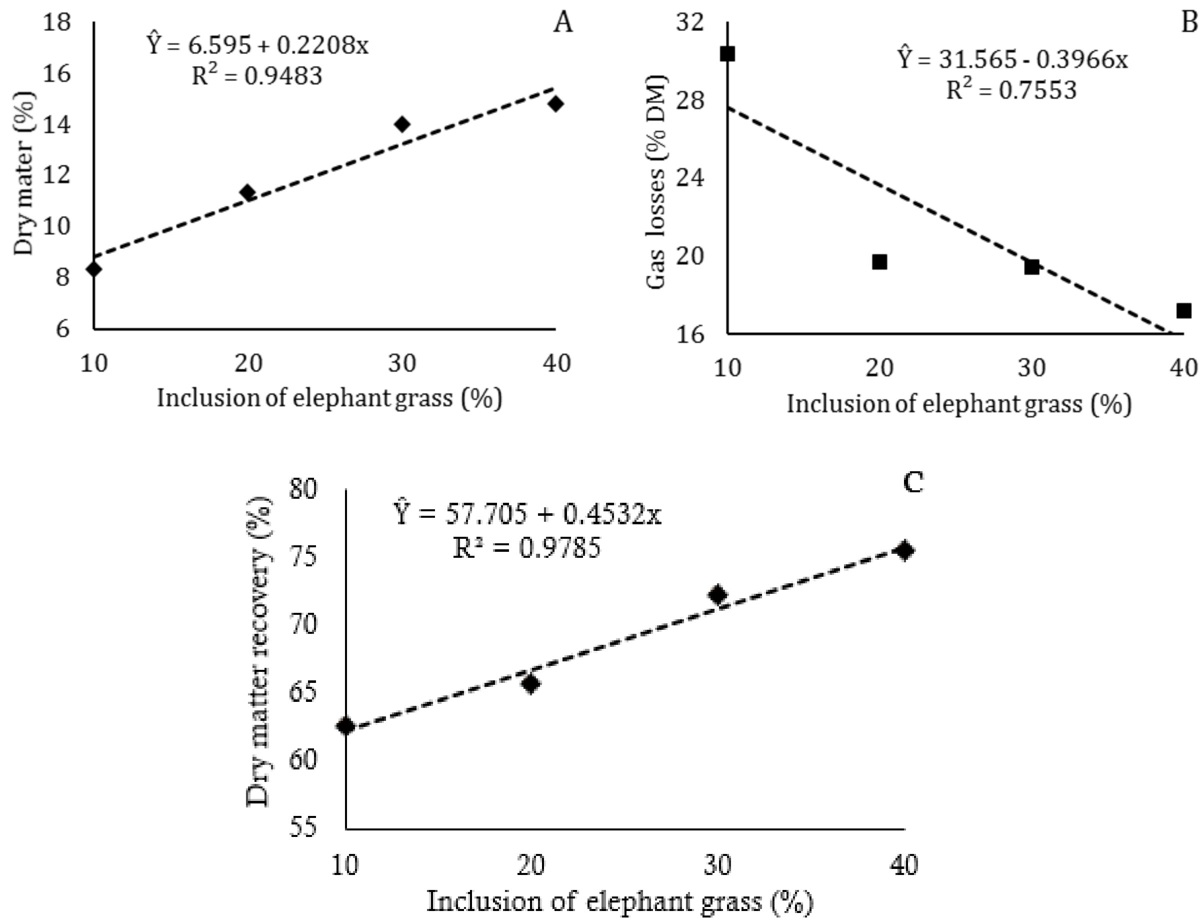

Figure 2. Dry matter content (A), gas losses (B) and dry matter recovery rate (C) in cactus silages with increasing levels of elephant grass. R^2 (determination coefficient).

Gas losses responded in a negative and linear fashion (P<0.05), decreasing by 56.88 % as the elephant grass content in the cactus silage was increased from 10 to 40 % (Fig. 2B). This result can be explained by the increasing dry matter content observed as the amount of elephant grass in the silage increased. As stated by Barcelos *et al*. (2018), losses of dry matter in the form of gases are directly linked to the moisture content of the forage ensiled, considering that higher water availability translates into greater losses caused by butyric fermentation, which is normally associated with bacteria of the genus *Clostridium*.

The silage pH was not influenced by the inclusion of elephant grass (Table 1). The average pH measured in this study (4.45) was above the recommended value for high-quality silage, since pH values above 4.2 characterize poor-quality silage (Jobim *et al*., 2007). An important factor for lowering the pH is compaction, since increasing mass density in the silage improves its fermentation profile as a consequence of the pH decline. However, the cactus does not allow for a compaction similar to that achieved with other forage plants due to the risk of greater effluent losses (Silva *et al*., 2019).

Table 1. Potential of hydrogen (pH), effluent losses and dry matter recovery in cactus silages with increasing levels of elephant grass.

Variable	Elephant grass level (% FM)				P-value		SEM
	10	20	30	40	Linear	Quadratic	
pH	4.33	4.67	4.00	4.80	0.4659	0.7216	0.22
Effluent losses (kg/t FM)	88.33	66.0	85.80	71.0	0.0953	0.7967	4.54

FM = fresh matter; SEM = standard error mean.

The inclusion of elephant grass in the silage did not influence (P>0.05) effluent losses, which averaged 77.78 kg/t FM. Effluent production is influenced mainly by the moisture content of the forage; the compaction of the ensiled mass (Pacheco *et al*., 2014); and the particle size of the material after chopping, with greater losses occurring when the particles are too small (Siqueira *et al*., 2007). The low effluent production relative to the high moisture contents observed in the silages can be explained by the presence of mucilage (monosaccharides) in the cactus, which contains hydrophilic molecules that may associate with water, forming viscous solutions or gels (Jani *et al*., 2009).

Dry matter recovery rate increased linearly (P<0.05) as a function of the level of elephant grass in cactus silage. The inclusion of 40 % elephant grass increased the DM recovery rate of the silage from 62.2 to 75.8 % (Fig 2C), being higher than the average value of 71.6 % found by Siqueira *et al*. (2007) in sugarcane silages with and without microbial inoculants. According to Pacheco *et al*. (2014), dry matter recovery is highly correlated with gas and effluent losses since the high DM recovery rate is the result of low production of gases and effluents during the fermentation process of silage.

CONCLUSIONS

The silage based on cactus is a viable alternative to be explored in animal feed, especially in regions with prolonged periods of water shortage. The inclusion of up to 40% elephant grass in cactus silage reduces its moisture content and gas losses, improving its fermentation profile.

ETHICS STATEMENT

“Not applicable”

CONSENT FOR PUBLICATION

“Not applicable”

AVAILABILITY OF SUPPORTING DATA

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

COMPETING INTERESTS

“The authors declare that they have no competing interests”

FUNDING

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) Finance Code 001".

ACKNOWLEDGEMENTS

The authors thank the Science and Technology Support Foundation of Pernambuco State (FACEPE) and the Coordination for the Improvement of Higher Education Personnel (CAPES) for the financial support. To the Group of Studies on Forage Tropical – GEForT/UNIVASF for their assistance in implementing this work.

REFERENCES

Barcelos, A.F.; Carvalho, J.R.R.; Tavares, V.B.; Goncalves, C.C.M. 2018. Valor nutritivo e características fermentativas da silagem de capim-elefante com diferentes proporções de casca de café. *Ciência Animal Brasileira*, Goiânia, 19:1-12. https://doi.org/10.1590/1809-6891v19e-27432.

Emerenciano Neto, J.V.; Bezerra, M.G.S.; França, A.F.; Aguiar, E.M.; Difante, G.S. 2019. Características estruturais e produtivas em híbridos intraespecíficos e interespecíficos de capim-elefante. *Ciência Animal Brasileira*, Goiânia, 20:e-46788. http://dx.doi.org/10.1590/1809-6891v20e-46788.

Ferreira, D.F. 2011. Sisvar: a computer statistical analysis system. *Ciência e Agrotecnologia*, Lavras, 35(6):1039-1042. https://doi.org/10.1590/S1413-70542011000600001.

Jani, G.K.; Shahb, D.P.; Prajapatia, V.D.; Jain V.C. 2009. Gums and mucilages: versatile excipients for pharmaceutical formulations. *Asian Journal of Pharmaceutical Sciences*, Nagoya, 4(5):309-323.

Jobim, C.C.; Nussio, L.G.; Reis, R.A.; Schmidt, P. 2007. Avanços metodológicos na avaliação da qualidade da forragem conservada. *Revista Brasileira de Zootecnia*, Viçosa, 36:101-119. https://doi.org/10.1590/S1516-35982007001000013.

Lopes, E.B.; Santos, D.C.; Vasconcelos, M.V. 2012. *Cultivo da palma forrageira.* In: Lopes, EB, Palma forrageira: cultivo, uso atual e perspectivas de utilização no Semiárido nordestino. (1. Ed.), EMEPA-PB, João Pessoa, Brasil, 256 p.

Macêdo, A.J.S.; Santos, E.M.; Oliveira, J.S.; Perazzo, A.F. 2017. Produção de silagem na forma de ração à base de palma: Revisão de Literatura. *REDVET – Revista Electrónica de Veterinaria*, 18(9):1-11.

Mcdonald, P. 1981. *The Biochemistry of Silage*. (Ed) John Wiley & Sons, New York, United States, 226 p.

Muck, R.E. 2010. Silage microbiology and its control through additives. *Revista Brasileira de Zootecnia*, Viçosa, 39: 183-191. https://doi.org/10.1590/S1516-35982010001300021.

Pacheco, W.F.; Carneiro, M.S.S.; Pinto, A.P.; Edvan, R.L.; Arruda, P.C.L.; Carmo, A.B.R. 2014. Perdas fermentativas de silagens de capim-elefante (*Pennisetum purpureum* Schum.) com níveis crescentes de feno de gliricídia (*Gliricidia sepium*). *Acta Veterinaria Brasilica*, Mossoró, 8(3):155-162. https://doi.org/10.21708/avb.2014.8.3.3289.

Silva, D. J.; Queiroz, A.C. 2002. *Análise de Alimentos: Métodos Químicos e Biológicos*. (3. Ed.), UFV, Viçosa, Brazil, 235 p.

Silva, A.L.; Sousa, D. B.; Amorim, D.S.; Santos, M.S.; Silva, K.B.; Nascimento, R.R. 2019. Caracterização morfológica, frequência de colheita e ensilagem de palma forrageira: uma revisão. *Nucleus Animalium*, Ituverava, 11 (1):3-24. http://dx.doi.org/10.3738/21751463.2958.

Siqueira, G.R.; Reis, R.A.; Schocken-Iturrino, R.P.; Pires, A.J.V.; Bernardes, T.F.; Amaral, R.C. 2007. Perdas de silagens de cana-de-açúcar tratadas com aditivos químicos e bacterianos. *Revista Brasileira de Zootecnia*, Viçosa, 36(6):2000-2009. https://doi.org/10.1590/S1516-35982007000900008.

Souza Sobrinho F.; Lédo, F.J.S.; Kopp, M.M. 2011. Estacionalidade e estabilidade de produção de forragem de progênies de *Brachiaria ruziziensis*. *Ciência e Agrotecnologia*, Lavras, 35(4):685-691. https://doi.org/10.1590/S1413-70542011000400006.

Wanderley, W.L.; Ferreira, M.A.; Batista, A.M.V.; Véras, A.S.C.; Santos, D.C.; Urbano, S.A.; Bispo, S.V. 2012. Silagens e fenos em associação à palma forrageira para vacas em lactação: consumo, digestibilidade e desempenho. *Revista Brasileira de Saúde e Produção Animal*, Salvador, 13(3):745-754. https://doi.org/10.1590/S1519-99402012000300014.