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Nutritional Value of BRS Capiaçu Grass (*Pennisetum purpureum*) Silage Associated with Cactus Pear

Research Article

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ABSTRACT

The objective of this study was to evaluate the best level of inclusion of cactus pear in the ensiling of elephant grass Brazil seeds (BRS) capiaçu (*Pennisetum purpureum*), its effects on fermentative characteristics; and nutritional value. Experimental treatments consisted of BRS capiaçu grass silage with five levels of inclusion of cactus pear (0, 5, 10, 15 and 20% inclusion as fresh basis) during ensiling. A completely randomized design with five treatments and six replicates was used. The inclusion of cactus pear in BRS capiaçu grass silage did not alter the pH of the ensiled mass (P=0.18), mean of 3.8. The marginal variation between the highest cactus pear inclusion dose and the control group (without cactus pear) for effluent was 50.33%, mean of 1.06% for each percentage unit of cactus pear inclusion. The ash content (P=0.79), total carbohydrates (P=0.30), total digestible nutrients (P=0.79), neutral detergent insoluble protein (P=0.66) and ether extract (P=0.42) did not change with the inclusion of cactus pear, being the averages of 8.01, 2.53, 3.14, 11.74, 80.88 and 44.69%, respectively. *In vitro* digestibility of dry matter (P<0.01) and neutral detergent fiber (P<0.01) increased linearly with the inclusion of cactus pear. The inclusion of up to 5% of cactus pear in silage BRS capiaçu grass improves the fermentation characteristics and the nutritional value of silage.

KEY WORDS digestibility, dry matter, dry matter losses, *Nopalea cochenillifera*, pH.

INTRODUCTION

Because of the higher cost production of grain cereals, forage crops have been widely cultivated to feed for ruminants (Sampaio *et al.* 2017; Mapato and Wanapat, 2018). The grasses of the species *Pennisetum purpureum* Schum. (elephant grass), for example, are widely studied worldwide because of the high mass production per unit area. Mainly small dairy cattle producers and some beef cattle, grow elephant grass for silage or cut daily on the properties (fresh cultivation), especially for use in times of shortage forage (dry season). However, in the rainy season, elephant grass like BRS capiaçu grows very fast (up to 5 meters in height, Pereira *et al.* 2017) and cut management is not carried out at the correct time, which reduces the nutritional value of forage.

With time of the rainy season for up to six months in Central Brazil, elephant grass is operated for cutting after 150 days of age with a high DM content (above 30%), fiber, and the low content of Non-fiber carbohydrates (NFC) (<10% of dry matter (DM)) and crude protein (CP). Thus, some producers burn this forage mass as a management strategy to raise new tillers and others to burn accidentally (Roth *et al.* 2018). Especially in semiarid climates region, the burning of forage mass is a big waste due to the seasonality of forage production.

One strategy for not burning or discarding this low-grade forage is silage. However, for adequate fermentation of the mass, some factors such as DM content, low buffer capacity and high soluble carbohydrate content are fundamental to obtain adequate mass fermentation capacity (Rigueira *et al.* 2018; Borreani *et al.* 2018; Kung *et al.* 2018). A low-cost alternative to correct the nutrients of elephant grass managed after 150 days of silage regrowth is the inclusion of forage palm (*Opuntia* or *Nopalea*). The cactus pear presents low content of DM (10%), CP (5% of DM) and fibrous fraction (up to 30% of DM) and high NFC content (65% of DM) (Leite *et al.* 2018).

Therefore, it is necessary to study, to know the best level of inclusion. Also, to know what impacts on the fermentative characteristics and nutritional value of the silage produced. Kung *et al.* (2018) emphasized that pH assessments and DM losses are fundamental to characterize the fermentation capacity of the ensiled mass. Rigueira *et al.* (2018) and Mapato and Wanapat, (2018) verified that analyzes of the chemical-bromatological composition and digestibility are important for the correct formulation of diets for ruminants, besides contributing in the preparation of a food analysis table.

Thus, the objective of this study was to evaluate the best level of inclusion of cactus pear in the ensiling of elephant grass BRS capiaçu (*Pennisetum purpureum*), its effects on fermentative characteristics; and nutritional value.

MATERIALS AND METHODS

The experiment was carried out in accordance with the Brazilian laws of ethics in animal experimentation, and it was approved by the Ethics Committee on Use of Animals of the State University of Montes Claros (CEBEA-UNIMONTES) (protocol number 175/2018).

The experiment was conducted at the State University of Montes Claros - UNIMONTES, Campus Janaúba-MG, in the North of Minas Gerais state. The geographical coordinates are Latitude: 15˚ 48 '09 "S, Longitude: 43˚ 18' 32" W and Altitude: 533 m 15˚ 47` 50``. The mean annual precipitation of the region is 700 mm with an average annual temperature of 28 ˚C, relative humidity of about 65%, with the predominant climate type Aw (Antunes, 1994).

Experimental treatments consisted of BRS Capiaçu grass silage with five levels of inclusion of cactus pear (0, 5, 10, 15 and 20% inclusion as fresh basis) during ensiling. A completely randomized design with five treatments and six replicates was used. The composition of the cactus pear and BRS capiaçu grass, as fresh basis, at 150 days of age, used in the experiment can be observed in the Table 1.

The forage was collected in a pre-installed area at the UNIMONTES experimental Farm. The cutting of BRS capiaçu grass was performed manually and crushed in a chopper crushing machine coupled to an electric motor. The cactus pear (*Nopalea cochenillifera* Salm-Dyck cv. Ipa Sertânia) was harvested after two years of planting, fertilized with cattle manure (60 t/ha, 1.1% nitrogen). The machine knives were set to grind/cut the forage to a particle size of 1.5 cm. After grinding/cutting and homogenization of all the material, five mounds were formed and the additive added in the respective proportions. For silage, experimental silos of polyvinyl chloride (PVC) were used, with 50 cm of length and 10 cm of diameter. In the bottom of the silos they contained 10 cm of dry sand, separated from the forage by a foam to quantify the produced effluent. After complete homogenization of the forage with the additive, the material was deposited in the silos and compacted with the aid of a wooden plunger. After filling, the silos were closed with PVC caps containing "*bunsen*" valve. After the process of ensilage, the silos were sealed with tape properly, weighed and stored at room temperature.

The silos were opened at 60 days after silage. Samples were collected in the middle of the silo after discarding the top of the silages. In duplicate, the samples were pre-dried in a forced ventilation oven with a temperature of 55 ˚C for 72 hours. After this period, the pre-dried silage was milled in a Willey-type mill in 1 mm diameter sieves for the chemical-bromatological analysis.

The DM losses, in the silages in the form of effluents, gases and the DM recovery were quantified by weight difference, according to Schmidt *et al.* (2011).

After drying, the silage corresponding to each treatment was analyzed for DM, ash, ether extract (EE), CP, lignin (LIG), neutral detergent fiber (NDF) corrected for ash and protein (NDFap), hemicellulose (HEM), cellulose (CEL), and neutral detergent insoluble crude protein and acid detergent insoluble crude protein were prepared according to procedures described by Detmann *et al.* (2012). The total carbohydrate content (TC) was estimated by the equation: TC (%)= 100 - [CP (%) + EE (%) + ashes (%)] and those of NFC according to Sniffen *et al.* (1992). Total digestible nutrients (TDN) were estimated using the formula: TDN= 40.2625 + 0.1969 CP + 0.4028 NFC + 1.903 EE - 0.1377 ADF (Weiss, 1998).

The *in vitro* digestibility of dry matter and *in vitro* digestibility NDF was determined according to the methodology described by Tilley and Terry (1963), using the *in vitro* incubator of the Tecnal® (TE-150), with modification of the bag material used (7.0×7.0 cm), made with TNT (100 g/m^2; Detmann *et al.* (2012).

Table 1 Chemical composition of cactus pear and BRS capiaçu grass as fresh basis

Item (g/kg of DM)	Cactus pear[1]	BRS capiaçu grass[2]
Dry matter	100	270
Ash	157	87.1
Crude protein	130	78
Ether extract	15	14
Neutral detergent fiber	320	730
Acid detergent fiber	220	490
Lignin	-	78
Non fibrous carbohydrates	650	80
Total digestible nutrients	600	400

DM: dry matter.
[1] *Nopalea cochenillifera* Salm-Dyck cv. Ipa Sertânia.
[2] 150 days of regrowth (Monção *et al*. 2019a; Monção *et al*. 2019b).

The method used for *in vitro* digestibility simulates a ruminal digestion for 48 hours, followed by a digestion with pepsin and weak acid (pH) for another 48 hours. Two crossbred cattle were used as inoculum donors. The animals were adapted to the diet with sorghum silage (*Sorghum bicolor* (L.) Moench) and cactus pear for 14 days.

The data were submitted to statistical analysis using PROC GLM and PROC REG (SAS, 2008), and when the variables were significant by the F-test, the inclusion rates of cactus pear were submitted to analysis regression analysis. The regression equations were selected based on the trend of the data and higher coefficient of determination (R^2). The probability was 5%.

RESULTS AND DISCUSSION

The inclusion of cactus pear in BRS capiaçu grass silage did not alter the pH of the ensiled mass (P=0.18). Effluent (P<0.01) and gases (P=0.01) increased linearly with the inclusion of cactus pear (Table 2).

The marginal variation between the highest cactus pear inclusion dose and the control treatment (without cactus pear) for effluent losses was 50.33%, mean of 1.06% for each percentage unit of cactus pear inclusion. For each 1% of cactus pear inclusion, there was a 1.06% increase in gas losses and a 1.05% reduction in DM recovery (P=0.01; Table 3). There was a reduction of 11.37% in the DM content (P=0.02) with the inclusion of the cactus pear. The CP content showed a quadratic behavior of regression with maximum point in the dose of 5.75% of cactus pear. The ash (P=0.79), TC (P=0.30), TDN (P=0.79), neutral detergent insoluble crude protein (NDICP, P=0.66) and EE (P=0.42) did not change with the inclusion of cactus pear, being the averages of 8.01, 2.53, 3.14, 11.74, 80.88 and 44.69%, respectively. The content of acid detergent insoluble crude protein (ADICP; P=0.01) increased linearly with the inclusion of cactus pear. The mean values for NDF (P=0.01), acid detergent fiber (ADF, P=0.02) and NFC (P=0.04) were adjusted to the quadratic regression model.

The maximum points of 13.75%, 7.25% and 7%, respectively. *In vitro* digestibility of DM (P<0.01) and NDF (P<0.01) increased linearly with the inclusion of cactus pear.

Due to the low DM content, the use of cactus pear in the silage of tropical grasses is not common, even because grasses also present low DM content when handled at the correct cutting height. In this research, it was verified that the pH was not altered with the inclusion of the forage palm, the average being verified (3.8) below that recommended (4.3-4.7) by Kung *et al.* (2018) for grass silage and in the range ideal for corn silage (3.7-4.2).

These characteristics indicate that forage palm, due to the high NFC content, 65% of DM, provided energy for lactic acid bacteria (LAB) to produce lactic acid whose pKa value of 3.86 favoring the rapid reduction of pH, which is important for the conservation of the nutrients of the ensiled mass.

However, high cactus pear moisture content (90% as fresh basis) increased silage effluent and gas losses. Cactus pear increased gas losses, probably due to the increase of gas-producing microorganisms, such as *Enterobacteria* and *Clostridial* bacteria that develop in poorly fermented silages (Kung *et al*. 2018).

It should be emphasized that the increase in effluent losses with the inclusion of cactus pear favors higher losses of nutrients by percolation with the effluent produced during silage. According to Bolsen (2018), after 15-20 days of ensiled mass, numerous gases are produced inside the silo during fermentation as carbon dioxide and nitric oxide that can cause intoxication in humans and animals housed near the silos.

The inclusion of cactus pear in BRS capiaçu grass silage reduced DM content, which is why there was an increase in losses due to gases and effluents. Kung *et al.* (2018) noted that DM content of grass silage should range from 25% - 35% for adequate fermentation. The inclusion of 5% of cactus pear allows DM content of 26.24%, being in the ideal recommended range.

Table 2 Fermentative characteristics and nutritional value of the silage BRS capiaçu with inclusion of cactus pear

Item (% DM)	Inclusion of cactus pear (as fresh basis)					SEM	P-value	
	0	5	10	15	20		Linear	Quadratic
pH	3.68	3.82	3.60	3.44	4.65	0.36	0.18	0.11
Effluent	36.27	46.29	32.31	49.61	61.24	5.78	< 0.01	0.12
Gas losses	19.40	22.52	40.32	36.22	39.02	4.3	0.01	0.71
DM recovery	80.60	77.48	59.68	63.77	60.97	4.30	0.01	0.71
DM	26.10	26.24	22.91	23.30	23.13	1.11	0.02	0.46
Ash	8.77	7.19	8.11	7.66	8.32	0.51	0.79	0.11
Crude protein	8.03	8.84	9.15	7.37	6.42	0.65	0.03	0.03
NDICP	1.99	2.62	2.78	2.36	2.93	0.43	0.24	0.66
ADICP	1.28	1.54	2.05	1.98	1.92	0.16	0.01	0.06
Ether extract	3.16	3.05	3.30	3.33	2.88	0.25	0.74	0.34
Neutral detergent fiber	71.11	70.60	71.61	73.21	69.36	0.58	0.63	0.01
Acid detergent fiber	51.69	50.26	51.49	53.23	48.36	0.67	0.10	0.02
Lignin	12.66	11.17	11.69	12.51	10.71	0.56	0.16	0.88
Total carbohydrate	80.05	80.93	79.44	81.64	82.38	0.86	0.06	0.30
Non-fiber carbohydrates	8.94	10.33	7.83	8.43	13.02	1.20	0.11	0.04
Total digestible nutrients	44.32	45.04	44.40	44.11	45.58	0.60	0.41	0.42
In vitro digestibility of dry matter	44.17	42.37	45.86	53.29	50.71	1.83	< 0.01	0.73
In vitro digestibility of neutral detergent fiber	26.96	24.68	30.90	42.81	36.08	2.88	< 0.01	0.77

DM: dry matter; NDICP: neutral detergent insoluble crude protein; ADICP: acid detergent insoluble crude protein.
SEM: standard error of the means.

Table 3 Regression equations for variables on BRS capiaçu grass silages with increasing levels of cactus pear

Item (% DM)[1]	Regression equation	R^2
Effluent	$\hat{Y}= 34.49 + 1.06*X$	0.56
Gas losses	$\hat{Y}= 20.90 + 1.06*X$	0.73
DM recovery	$\hat{Y}= 79.09 - 1.05*X$	0.73
DM	$\hat{Y}= 26.11 - 0.18*X$	0.70
Crude protein	$\hat{Y}= 8.10 + 0.23*X - 0.02*X^2$	0.90
ADICP	$\hat{Y}= 1.41 + 0.03*X$	0.70
Neutral detergent fiber	$\hat{Y}= 70.48 + 0.33*X - 0.012*X^2$	0.34
Acid detergent fiber	$\hat{Y}= 50.83 + 0.29*X - 0.02*X^2$	0.32
Non-fiber carbohydrates	$\hat{Y}= 9.81 - 0.42*X + 0.03*X^2$	0.70
In vitro digestibility of DM	$\hat{Y}= 42.48 + 0.48*X$	0.70
In vitro digestibility of neutral detergent fiber	$\hat{Y}= 25.01 + 0.72*X$	0.62

DM: dry matter and ADICP: acid detergent insoluble crude protein.
R^2: coefficient of determination.
* (P<0.01).

The inclusion of fresh cactus pear in the silage of low quality grasses is only important for cost reduction or in properties whose availability of moisture scavenging additives is difficult to access. The pre-dried cactus pear it would be an alternative, but the high cost for drying makes it unfeasible. But there are no studies with pre-dried cactus pear meal in grass silage.

The inclusion of fresh cactus pear in grass silage reduced the crude protein content of silage by 20.04%. This was because there was a dilution effect, besides, losses in the form of ammoniacal in the effluents (Kung *et al.* 2018; Bolsen, 2018).

For NDF and ADF levels of BRS capiaçu grass silage, the inclusion of cactus pear in the silage increased the NFC content of the silage up to the 5% inclusion level. Effluent was probably the factor responsible for reducing NFC at levels above 5% inclusion.

The increments are justified by the high NFC content of cactus pear (650 g/kg of DM). The availability of non-fibrous carbohydrates, especially soluble carbohydrates, is important for LAB to produce lactic acid, responsible for the reduction of the pH of the ensiled mass. In addition, NFCs of cactus pear contributed to the improvement of DM and fibrous fraction digestibility. In this study, the inclusion of cactus pear increased DM digestibility by 12.89% and NDF digestibility by 25.27%. This was due to the availability of energy for ruminal bacteria to degrade the silage cell wall components (Van Soest, 1994).

CONCLUSION

The inclusion of up to 5% of cactus pear in silage BRS capiaçu grass improves the fermentation characteristics and the nutritional value of silage.

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