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Nutritive value and degradability "in situ" of dry matter elephant grass silages with addition of babassu meal

Ricardo Alves de Araújo[1*], Rosane Cláudia Rodrigues[2], Clésio dos Santos Costa[1], Francisco Naysson Sousa Santos[3], Carlos Magno Lima Galvão[2], Francivaldo Oliveira Costa[2], Ivone Rodrigues da Silva[2] and Sanayra da Silva Mendes[2]

[1]Department of Animal Sciences, Federal University of Paraíba, João Pessoa, Brazil.
[2]Department of Animal Sciences, Federal University of Maranhão, Chapadinha- Maranhão, Brazil.
[3]Fundação de Amparo à Pesquisa e ao Desenvolvimento Científico e Tecnológico do Maranhão – FAPEMA, Brazil.

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The goal of this study was to evaluate the nutritive value and the in situ degradability of elephant grass (*Pennisetum purpureum* Schum) silages with addition of babassu meal (BaM). PVC silos with 0.25 m in diameter and 0.75 m in height were used. It was done by adopting a compression of 550 kg/m^3 in a completely randomized design with five repetitions. It was found that increasing linear effect (P< 0.05) on the average content of silage DM, estimating an increase of 0.74% for each unit added. The crude protein content of the silage without BaM was lower than the fresh grass. There was a linear effect on the levels of neutral detergent fiber, with an estimated reduction of 0.17% per unit added. Acid detergent fiber and lignin showed linear response to increasing levels of BaM. Disappearance of DM was significant to the extent that the material remained in the rumen, the best disappearance values were observed in the time of 72 h for all levels of inclusion and among the levels of inclusion of 20% showed the best values of the disappearance of DM at all incubation times. The bran of babassu oil improves the nutritive value, the degradation parameters and provides better conservation of ensiled mass.

Key words: Additive, conservation, by-product, *Pennisetum purpureum.*

INTRODUCTION

The use of silages of tropical grass has become very common in the production of ruminants, as a way to use the surplus of forage production of rainy period of the year to minimize the problem of food shortage in the dry period. Among the perennial grasses, the elephant grass is one of the most used alternatives. Its use is indicated mainly by reason of their characteristics of production of dry matter and of its nutritional value. Santos et al. (2010) stated that the silage tropical grass is an alternative for silage of traditional cultures and has as advantages the use of perennial crops and the use of the surplus produced in the season of the waters.

The tropical forage grasses not present appropriate levels of dry matter (DM), soluble carbohydrates and

*Corresponding author. E-mail: ricardo_zoo@hotmail.com.

Table 1. Chemical composition of elephant grass and the babassu meal.

Grass	Chemical composition (%Dry matter)					
	DM[1]	CP[2]	NDF[3]	ADF[4]	Lignin	Hemicellulose
Elephant grass	17.9	9.5	72.20	35.02	43.08	31.94
Babassu meal	94.25	16.85	68.98	34.73	31.69	33.04

[1]Dry matter, [2]Crude protein, [3]Neutral detergent fiber, [4]Acid detergent fiber

values of power plug that provide efficient fermentation process. Grass silage with less than 21% of DM, soluble carbohydrates below the 2.2% in green and low soluble carbohydrates and power plug presents a greater possibility of secondary fermentation, which in turn are undesirable.

In this sense, Zopollatto et al. (2009), analyzing various work on silage of tropical forage grasses, cited data that the low levels of DM and soluble carbohydrates in the ideal time of harvest. These situations can be modified by the use of techniques such as mixing of products to earth grass silage (additives) or by partial withdrawal of the water of the plant by wilting.

In this context, the use of vegetables by-products regional become compelling alternatives to reduce the cost in animal feed and reduce the negative impacts of when this material is discarded into the environment. The babassu meal (BaM) is a by-product found in large scale in the state of Maranhão, in view that the same are the biggest areas of babassu palm of Brazil. Its importance increases even more by their exploitation represent a form of income of more than 400 thousand families in Maranhão, Brazil.

Even with great emphasis on the economy of the states of the Union, is a by-product that needs more studies on the exploitation of its potential, since its economic utilization is connected to the extraction and exploitation of oil of coconut of babassu rejecting 90% of the fruit, that can be leveraged with the technologies available, either as an energy source, as raw material for the steel industry, of food, animal nutrition, among others.

Of meals produced in Brazil the babassu meal is little used in animal feed, due to its very varied, bromatologic composition and to be produced on a small scale, its greater use is in the north and northeast regions that are the largest producers of fruit.

Given the importance of the use of the silages in ruminant feed this work aimed to evaluate the nutritive value and the in situ degradability of dry matter of elephant grass silages with different proportions of babassu meal.

MATERIALS AND METHODS

The experiment was conducted in the sector of foraging located in the Center of Agrarian Sciences and Environmental Federal University of Maranhão, in Chapadinha. The grass was cut manually, close to the ground, when it reached an average height of 1.6 m and 45 days of age of regrowth. It was placed in a shed covered for the withering, for a period of six hours, and later was chopped into particles of approximately 2 cm, in forage machine attached to the tractor. The babassu meal was acquired in an industry oil industry located in the city of Itapecuru-Mirim, East Maranhão, Brazil.

Experimental design and treatments

The meal of babassu was added to grass newly harvested minced in five levels (0, 5, 10, 15 and 20%) of natural material of grass, with five repetitions in a completely randomized design. For fabrication of the silages were used PVC silos with 0.25 m diameter and 0.50 m in height, endowed with drains for the collection of the effluent. In each silo was placed on average 2 kg of fresh mixture, adopting a compression of 550 kg/m^3. After filling, the silos were sealed with PVC caps and coated with adhesive plastic tape. On the seventh day, after filling held that seal of existing drains at the top of each silo. The chemical composition analyzes of elephant grass and the babassu bran is presented in Table 1.

After 125 days of silage, has opened the silos, collecting then samples for each experimental unit. For evaluation of the silages bromatologic composition, samples were collected from fresh material of silos, who were submitted to pre-drying in an oven of forced ventilation at 65°C until constant weight, then were crushed in mill Willey type with 5 mm sieve.

Measurements

The dry matter content (DM), crude protein (CP) and pH were calculated according to the recommendations of the AOAC (1990), the neutral detergent fiber (NDF) and acid (ADF) following the procedures of van Soest et al. (1991). The hemicellulose was calculated by the difference between the NDF and ADF and the cellulose content by the difference between the ADF and the lignin.

For assessment of in situ degradability of DM were used nylon bags with dimensions 12 x 8 cm and porosity 50 µm (Ørskov and McDonald, 1979), containing 4 g of the sample in agreement with relation of 42 mg/cm^2 adopted by Campos et al. (2011) and incubated in the beef rumen fistulated in times 6, 24 and 72 h (NRC, 2001) in descending order of time, thereby providing withdrawal of all bags simultaneously of ruminal environment. During the experimental period, including the adjustment period of seven days, total diet was provided for maintenance, according the NRC (2001). The diet was composed of 80% roughage and 20% concentrate and supplied in two meals (at 8 and 16 h), plus mineral mixture and the water at will.

To evaluate the parameters of dry matter degradation (DDM), we used the Brody model according to the equation of Orskov and McDonald (1979) modified by Sampaio (1995): %DegMS=A-Bexp(-C*Time), in which: A = potential degradation of the forage, without time for colonization, that is, if the Deg% at time zero was 0%; B = percentage of degraded material deposited in the rumen without time for colonization; C = degradation rate constant of the material

Table 2. Chemical composition of elephant grass silages with the addition of different levels babassu meal.

Composition	Levels of addition of babassu meal (%)					Regression equation	
	0	5	10	15	20		
CP	6.56^{b}	10.33^{ab}	11.73^{a}	13.13^{a}	9.45^{ab}	$\hat{Y}$=-0.04X²+1.03X + 6.36	R²=0.75
pH	3.58^{ab}	3.58^{ab}	3.51^{b}	3.46 ^{a}	3.66^{b}	$\hat{Y}$ = -0.00098X²+ 0.02x + 3.59	R²=0.79
DM	17.38e	23.84^{d}	28.19^{c}	38.65^{b}	42.52^{a}	$\hat{Y}$= 0.002X + 24.81	R²=0.76
NFD	75.23^{b}	73.08^{b}	72.34^{ab}	71.75^{ab}	69.84^{a}	$\hat{Y}$ =0.30X + 74.57	R²=0.73
AFD	46.54^{a}	46.81^{a}	48.70^{b}	49.50^{b}	50.90^{c}	$\hat{Y}$ =0.23X + 46.16	R²=0.89
Lig	5.73^{a}	6.25^{b}	6.43^{b}	6.86^{c}	7.10^{c}	$\hat{Y}$= 0.07X + 5.82	R²=0.92
Hem	28.69^{d}	25.53^{dc}	23.05^{bc}	20.34^{c}	17.95^{a}	$\hat{Y}$=0.53X + 28.5	R²=0.72

Means in the lines followed by the same letter do not differ by Tukey's test (P<0.05).

remaining in the rumen at any incubation time.

Effective dry matter degradability (DEMS) was calculated assuming three ruminal passage rates (2, 5 to 8%/h) through the equation described by Ørskov and McDonald (1979): DE= α+(β'*C/C+k), where: a' = % disappearance at time zero (mean); β'= A-α; C = degradation rat constant rate; k = passage rate.

Statistical analysis

Initially the data were submitted to normality test (Crame-Von Misses) and scapular (Levene) and attended the assumptions, they were submitted to variance analysis by F-test. In the case of significant difference, comparison of averages was by Tukey at 5% probability. The statistical analyzes were performed by the PROC GLM/SAS 9.0 (2002).

For evaluation of degradation, descriptive statistics was performed for the average according the PROC MEANS of SAS (2002). The parameters α, β and c and the in situ degradation curves were obtained according to the equation proposed by Ørskov exponential and McDonald (1979) and determined according to the method of Gauss-Newton through the PROC NLIN of SAS (2002).

RESULTS AND DISCUSSION

The data relating to the chemical composition and regression equations in function of increasing levels of babassu meal (BaM) in silage of elephant grass are presented in Table 2.

It was observed that the silages with the inclusion of babassu meal showed higher levels of CP when compared to silage without BaM, which had its average content of CP reduced from 9.5 to 6.5% in relation to the grass at the natural grass; however there was no influence of inclusion of BaM in additions of 5 and 20%.

For the crude protein content, quadratic effect was observed with the addition of levels of BaM, estimating maximum value of 13.5% CP for the level of 12.87% from the meal. According to Sampaio et al. (2010), the silages without the babassu meal showed levels of CP, inferior to 7%, value considered as minimum level for that where there is proper functioning ruminal. Therefore, the silage without inclusion proved to be an inefficient amount of protein to animals. The low content of CP observed in silage without meal may be attributed to the loss of soluble nitrogen compounds during the withering.

It was verified to have a quadratic effect (P<0.05) levels of meal on pH, estimating minimum value of 3.46 for the level of 15% of babassu meal. It can be observed that this characteristic remained within the optimal range (3.4 to 4.2) for silages well preserved.

Also, an increase in the content of MS with the incorporation of BaM was also notably observed. To carry out the study of the regression equation, linear effect was verified (P<0.05), with an estimated increase of 0.74% in the content of DM per unit of meal added. These increases were also observed by Ferrari et al. (2009) who observed an increase in the content of dry matter of elephant grass silage with the addition of citrus pulp, plus 10% of by-product with an increase of 7.71% in DM content in the silage.

The silages with levels of 0 and 5% meal showed lower levels of DM, which associated with higher pH values recorded, could have contributed to the occurrence of a fermentation inadequate; however, this fact was not observed, since the smell of silages well fermented and firm physical appearance, because during the opening there was a test of observation by the researchers.

Silages with 20% of BaM, despite having presented a high value of DM, had a high pH which occurred due to the high content of CP that influenced buffering of the middle and prevented the pH reduction. These data indicate that the BaM appeared to be an additive efficient in raising the content of DM of silage of elephant grass, produced with high moisture content, because with only 10% of byproduct came 28.19% of DM. Such fact can be attributed, among others, to the high content of dry matter of meal (94.25%), as well as to its high hygroscopic capacity.

Pompeu et al. (2006) worked out the addition of increasing levels of pineapple by-product of the observed linear increase in the levels of dry matter of the silages. For each 1% addition of the by-product of pineapple, there were increases of 0.71% points in DM levels.

Although the moisture content has been above 70% on silage witness and inclusions of 5, 10 and 15% of BaM,

Table 3. Average values of disappearance of dry matter (%) according to the level of addition of babassu meal in elephant grass silage and the incubation time.

Level of addition of babassu meal (%)	Incubation time (hours)			CV (%)
	6:00	24:00	72:00	
0	39.0^{Cc}	46.3^{Bc}	53.0^{Ab}	4.56
5	42.4^{Cbc}	47.6^{Bbc}	54.6^{Ab}	4.21
10	47.2^{Bb}	49.8^{Bbc}	56.6^{Aab}	4.65
15	47.2^{Bb}	51.4^{ABab}	54.8^{Ab}	4.61
20	52.0^{Ba}	55.6^{ABa}	60.2^{Aa}	4.67

Means followed by letters equal uppercase (row) sensitive (columns) do not differ by the Tukey's test (P<0.05).

there were apparently unobserved losses arising from possible undesirable fermentations by bacteria heterolactic or even by rot common in wet silages. The silages showed pleasant aroma and in all of them was observed the characteristic smell of homolactic silages.

A decreasing linear effect (P<0.05) levels of babassu meal was observed on the levels of NDF silages. This reduction in the levels of NDF silages may be related to the use of part of hemicellulose as substrate for the fermentation; moreover, these declining trends are assigned to lower content of NDF from the meal (64.73%) in relation to the elephant grass (75.02%).

To compare the contents of NDF of grass at the moment of the silage with the silage without meal, there are values of 75.02 and 75.23%, respectively. This difference was caused by losses of soluble components of dry matter, MCdonald (1991), increasing the concentration of components of the fibrous fraction.

There was also an increase in ADF as the meal was included, being that for contents of ADF, no difference was observed between the silages without inclusion and 5%. Also, we observed increases in order of 0.21% units to each addition of 1% of BaM. These data are reports of Vieira et al. (2007), who observed a linear reduction in the levels of ADF with the addition of BaM to silages.

Elevations of ADF observed may compromise the nutritional value of the silages already mentioned by second Van Soest (1994) as there is a negative correlation between high ADF producers with the digestibility of dry matter, since an increase in the cell wall components less digestible (cellulose and lignin) by ruminal bacteria was observed. This reduction was due basically to the decrease in the NDF content of the silages, since there was no effect only at level 20% of BaM about the content of ADF silages. As the reduction in the fat content of hemicellulose was proportional to the reduction in the content of NDF, there was no loss of hemicellulose by fermentation.

The lignin content of the silages showed linear response ascending (P<0.05) levels of babassu meal, which varied from 5.73 to 7.10% in the levels of 0 and 20% of BaM, respectively. The content of hemicellulose silages showed a decreasing linear response (P<0.05) levels of babassu meal. The results obtained for the disappearance of dry matter are presented in Table 3. The disappearance of DM was significant to the proportion with which the material remained in the rumen, and the best values were observed at 72 h for all levels of inclusion.

Among the inclusion levels, 20% showed the best values of disappearance in all incubation times (6, 24 and 72 h), followed by the inclusion of 15% of babassu meal, this being less than 9.61% (6 h), 7.55% (24 h), 8.99% (72 h), however at the time of 72 h 15% of inclusion was only 5.98% less as compared to 20% of inclusion.

The lesser disappearance of dry matter (DDM) was noted in the treatment without the inclusion of babassu meal. At 6 and 24 h, already in the time of 72 h there was no significant difference (P>0.05) between treatment 5 and 15%. Despite the DDM is lower in treatment 0%, the curve of degradation was more accentuated because the degradation was slower, that is, for the time 6 to 72 h the disappearance of DM was 26.41%, that is, 48.43% higher than the treatment of 20% of inclusion of babassu, since from the time 6 to 72 h, the disappearance of DM was 13.62%.

Rêgo et al. (2010), working with the inclusion of the penduncle of cashew dehydrated in silage of elephant grass, an ascending linear behavior was observed for the same time of incubation studied in the present work; 0.64% points for each 1% of inclusion of the by-product of the cashew.

For all treatments, it was noted that with the increase in the level of inclusion of BaM in elephant grass silage the disappearance of DM from beginning to end tends to be smaller, since this material becomes much more usable quickly in time to lower incubation in relation to low levels of inclusion, being the main characteristic of the nutritive value of the silage which tends to be influenced by the increase of BaM. In Table 4 are presented the values for the parameters of ruminal degradation.

With the inclusion of 5 and 10% of babassu bran obtained values of potential degradability (A) higher than the other treatments with 69 and 68% respectively, however, presented degradation rates (C) low (< 0.025), what influenced in effective degradability (ED) in three

Table 4. Ruminal degradation parameters *in situ* dry matter of silage of elephant grass with addition of levels babassu meal.

Level of addition of babassu meal (%)	Ruminal degradation parameters						
	α	β	C.10^2	R^2	ED2%	ED5%	ED8%
0	53.0	34	4.0	98.5	47.02	43.04	41.05
5	69.0	39.0	1.0	97.8	49.72	44.90	43.29
10	68.0	33.0	1.0	97.7	52.86	49.08	47.82
15	61.0	25.0	2.0	98.3	53.43	50.19	48.89
20	61.0	20.0	4.0	97.4	57.41	55.02	53.83

α = Soluble fraction or readily degradable (%); β = Insoluble fraction or slowly degradable (%); c = Rate of degradation of β (%h^{-1}); R^2= Coefficient of determination; ED= Effective digestibility for passage rates of 2, 5 and 8%h^{-1}.

rates of passages of the two treatments: 2% (49.72 on 52.86%), 5% (44.90 on 49.08%) and 8% (47.82 on 43.29%), simultaneously. According to Borges (1997), the fodder feature more digestible high values of 'A', but also need the high values of 'c', for which they achieve the maximum potential degradation in less time.

The parameters 'a' and 'c' are the main in the qualification of a forage harvester. A high value 'A' indicates a very degradable material, while greater value of 'c' means less time for the disappearance of potentially degradable fraction, being that fodder of high quality must submit degradation rates higher than 2%h^{-1}.

Among the inclusion levels, 0% presented low degradation parameters in relation to the other, despite presenting a desirable rate of degradation (4.0%) that influenced the effective digestibility values slightly below the level of 5%; in that way, the BaM increment helps in the potential degradability. However, it affects the rate of degradation, thus affecting the digestibility effectively, thereby identifying, explicitly, two of the main elements of qualification of forage harvesters, which are: the rate of degradation (C) and the potential degradability (A) (Sampaio et al., 1995).

With the inclusion of 20% of babassu meal, despite a potential degradability 11.51% less than the inclusion of 10% of babassu meal, this presented values of effective high digestibility in different rates of passages with 2% (57.41%), 5% (55.02%) and 8% (53.83%) in relation to the other, due to the rate of degradation being acceptable (4.0%).

It is observed that for all levels of inclusion of babassu meal, the values of these tend to diminish with increase in the rate of passage, which occurs because the remains of the material aims to be lower, thus complicating the accession of microorganisms to the food. In this way, there exists a lower passage rate of the largest.

Conclusions

The addition of BaM to silage of elephant grass promotes increments on DM and CP, reduces the levels of NDF, hemicellulose and increases ADF and lignin. With the inclusion of up to 20% of babassu meal, values of dry matter degradability and the parameters of acceptable ruminal were obtained. The inclusion of babassu meal did not affect the fermentation, because the silages showed pleasant aroma.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interest.

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