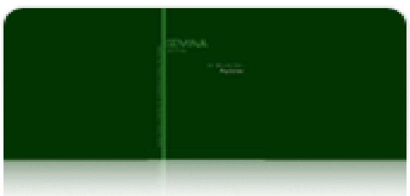

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Analysis of the potentiality haying of native forage species in semiarid region

Análise da potencialidade de fenação de espécies forrageiras nativas do semiárido

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Abstract

The objective of this study was to evaluate the potential hay production from Spiny Amaranth (*Amaranthus spinosus*), Hairy Woodrose (*Merremia aegyptia*), Malva (*Sida galheirensis*), Mucuna (*Mucuna pruriens*) and Ervanço (*Froelichia humboldtiana*), native forage species of the semiarid region of Brazil by observing morphological components of the plant, such as the dehydration curve, crude protein loss (CPL) curve, chemical composition of plant and hay and hay degradability *in situ.* There were differences ($P < 0.05$) among species on leaf, stem and inflorescence quantification with Ervanço, Hairy Woodrose, and Mucuna having a greater number of leaves. There was a linearly increasing response for the dehydration curve of the five forage plants species. Mucuna forage had the greatest hay point at 800 g kg^{-1} dried matter (DM) after 11.8 hours and Woodrose had a lower dehydration efficiency, which required 25 hours of sun exposure. There was no difference in CPL. Mucuna had the lowest crude protein (CP), neutral detergent fiber (NDF) and acid detergent fiber (ADF) content, 8.4, 67.7 and 73.8 g kg DM^{-1} in hay in relation to the plant, respectively. Ervanço, Spiny Amaranth, Hairy Woodrose and Malva hay had more of soluble fraction "a" of DM of 31.0, 26.2, 22.1 and 9.7 g kg^{-1} DM than Mucuna, respectively. Spiny Amaranth and Malva hay had values of 335.4 and 193.2 g kg^{-1} DM of fraction "b" more than Ervanço hay, respectively. For fraction "a" of CP, Spiny Amaranth and Hairy Woodrose hay obtained 312.6 and 227.4 g kg^{-1} CP more than that observed for Malva, respectively. Mucuna had better hay potential among the forage studied in the semiarid region of Brazil.
Key words: Bromatology. Degradability *in situ.* Hay quality. Native species.

Resumo

O objetivo foi avaliar a potencial produção de feno das espécies forrageiras nativas da região semiárida do Brasil, Bredo (*Amaranthus spinosus*), Jititana (*Merremia aegyptia*), Malva (*Sida galheirensis*), Mucuna

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(*Mucuna pruriens*) e Ervanço (*Froelichia humboldtiana*) a partir dos componentes morfológicos da planta como a curva de desidratação, perda de proteína bruta (PPB), composição química da planta, feno e degradabilidade *in situ* do feno. Houve diferenças (P < 0,05) entre as espécies para produção de folha, caule e quantificação da inflorescência com Ervanço, Jitirana e Mucuna apresentando um maior número de folhas. Houve aumento linear para a curva de desidratação das cinco espécies de plantas forrageiras. Mucuna apresentou maior ponto de feno de 800 g kg MS^{-1} depois de 11,8 horas e a Jitirana apresentou menor eficiência para desidratar, que foi após 25 horas de exposição ao sol. Não houve diferença para a perda de PB. Mucuna apresentou redução da PB, FDN e FDA apenas 8,4; 67,7 e 73,8 g kg MS^{-1} para o feno em relação à planta comparado com Ervanço, Bredo, Jitirana e Malva e apresentou mais fração solúvel "a" da MS de 31,0; 26,2; 22,1 e 9,7 g kg MS^{-1} que a Mucuna. O Bredo e a Malva apresentaram feno com 335,4 e 193,2 g kg MS^{-1} da fração "b", respectivamente, maior que o feno de Ervanço. Para a fração "a" da PB, feno de Bredo e Jitirana apresentaram 312,6 e 227,4 g kg PB^{-1} mais que o feno de Malva. Mucuna apresentou o melhor potencial forrageiro entre as espécies nativas estudadas da região semiárida do Brasil.
Palavras-chave: Bromatologia. Degradabilidade *in situ*. Qualidade de feno. Espécies nativas.

Introduction

In semiarid regions, native forage plants are the main food source in the diet of herbivores. The most prominent vegetation in the semiarid region of Brazil is the Caatinga, which covers up about 86.1% of this area, 53% of the area of Northeast Brazil and 9.8% of Brazilian territory (SOUZA et al., 2015). These plants naturally make up native pastures.

Specimens of this vegetation are herbaceous plants such as Spiny Amaranth (*Amaranthus spinosus*), Hairy Woodrose (*aegyptia Merremia*), Malva (*Sida galheirensis*), Mucuna (*Mucuna*) and Ervanço (*humboldtiana Froelichia*), which produce considerable amounts of dry forage mass. However, only part of that biomass is available to animals grazing during the period of food shortage (PEREIRA FILHO et al., 2013) that comprises the dry season without rainfall, which can last up to eight months depending on the region. Such facts have led researchers to look for alternative management strategies for Caatinga, aiming to quantitatively and qualitatively enhance these forage resources for livestock production.

In this context, food strategy planning is essential for the production systems of this region, especially for those that have forage plants as their food basis and whose production fluctuates annually (SILVA et al., 2014a). Because of climate variations, animal production is influenced by the seasonality of forage production (BEZERRA et al., 2015). One of the ways to reduce the negative impacts on livestock production resulting from forage deficit is to preserve these resources when the nutritional value is highest (FERREIRA et al., 2014) in the form of hay or silage.

Among the alternatives for preserving forage mass, the technique of making hay is easy to implement when compared to silage. That is why knowing the forage potential of the plants to be preserved as hay will provide more options for farmers in these regions. This is accomplished by the preserving these native plants because they are alternatives to conventional foraging not currently in common use. Preserving the native plants also supports future agronomic evaluations of the most promising species. Having that in mind, the objective of this work was to evaluate the potential hay production from native forage species of the semiarid region of Brazil and to assess the morphological components, dehydration curve, crude protein loss (CPL) curve, chemical composition of plant and hay, and the hay degradability *in situ* of the native plants.

Material and Methods

This study followed the ethical principles of the Ethics Committee for Animal Experimentation of the Federal University of Piauí under protocol number 016/14.

The research was conducted at the *Campus* Professora (Teacher) Cinobelina Elvas (CPCE) of the Federal University of Piauí (UFPI), in Bom Jesus, Piauí, Brazil (09º04′28″S; 44º21′31″O; 277 m altitude). The climate is characterized as hot and semi-humid with two distinct seasons, one dry and one wet. The data concerning the weather conditions observed during the experiment were collected at the Bom Jesus Automatic Weather Station at CPCE/UFPI, which is part of the National Institute of Meteorology (INMT) (Table 1). The predominant soil is yellow latosol, which is shallow and drained with a high average natural fertility (EMBRAPA, 2006). The Caatinga is the predominant vegetation.

Table 1. Climatic variables recorded in the morning and afternoon period from 26 to 27 May 2014 in Bom Jesus, Piauí, Brazil.

Period	Temperature (ºC)	Relative humidity (%)	Rainfall (mm)	Insolation (sun hours day^{-1})	Cloudiness (tenths 1-10)	Wind speed (m s^{-1})
Morning	25.3	76.5	0.0	6.3	2.6	2.6
Morning	32.2	40.0	0.0			
Afternoon	25.1	62.5	0.0	10.5	5.6	5.2
Afternoon	34.5	28.5	0.0			

Source: Instituto Nacional de Meteorologia - INMT (2014).

Five native herbaceous species from the semi-arid region of Brazilian that had some forage potential were used: Spiny Amaranth (*Amaranthus spinosus*), Hairy Woodrose (*aegyptia Merremia*), Malva (*Sida galheirensis*), Mucuna (*Mucuna*) and Ervanço (*Froelichia humboldtiana*). Morphological component assessments were made (number of leaves, stems, inflorescences, and the leaf:stem ratio), which were obtained by separating of the leaves, stems, and inflorescences. The design was completely randomized with five treatments and three replications.

The treatments corresponded to the forage species, and each repetition consisted of samples of forage mass of ten plants randomly collected at the site 5 cm above the soil. All collected plants were in the flowering stage. The plants were harvested in the early hours of May 26, 2014 in order to take advantage of the long sun light hours. We used hand pruners, pruning knives, and plastic bags to store the material. Samples were manually separated into leaf, stem and inflorescence fractions. Samples were then weighed and pre-dried in a forced ventilation oven at temperatures between 55 and 65°C until a constant weight was obtained, so that it is possible to establish a proportion of weight based on the dry matter (DM).

To determine the DM dehydration curve and loss of crude protein (CP) of forage species, we used a completely randomized design in a factorial scheme (5 × 7) with three replications. The factors consisted of five forage species and seven forage dehydration times: 0, 2, 4, 6, 8, 10 and 12 hours under the sun. Each repetition consisted of forage mass samples of ten plants randomly collected from 5 cm above the soil. The forage mass collected for each species and the repetitions were taken to a stationary grinder (DPM-2) and were then quickly exposed to the sun from the 26th to 27th of May 2014 for dehydration on a black canvas, which heats up more quickly than the ground and hastens the dehydration process.

During dehydration, the material was turned every 2 hours to standardize and accelerate the dehydration process. In order to evaluate the dehydration curve of the forage species, the moment of harvest of the material was considered time zero.

Thus, forage samples were collected every 2 hours at 0, 2, 4, 6, 8, 10 and 12 hours for further analysis of DM and CP.

In the analysis of the chemical composition of forage species and hay, we used a completely randomized design with five treatments that matched the forage species with three replications. The samples of forage species and hay (samples collected after 12 hours of sun exposure) were analyzed for the dry matter (DM) content (Method 967.03 - AOAC 1990), mineral matter (MM - Method 942.05 - AOAC 1990), ether extract (EE - Method 920.29 -AOAC 1990) and crude protein (CP - Method 981.10 - AOAC, 1990). To determine the fiber content in neutral detergent fiber (NDF) and acid detergent fiber (ADF), we used the methods of Van Soest et al. (1991).

In the evaluation of degradability *in situ*, three sheep about 12 months old and with average weight of 40 kg of the race Santa Inês that had permanent rumen cannulas were used. The animals used in the experiment, belong to the Small Ruminants Research Unit of the Bom Jesus Technical School, located at the CPCE/UFPI. The animals were housed in individual 1.10 m wide × 2.10 m long stalls, with a concrete floor and provided with a drinking and feed trough. All animals had unrestricted access to water.

The experimental isoproteic feeds were formulated according to NRC (2001). During the experiment, the animals were subjected to an adaptation period of 15 days. During this period, the animals were fed with a diet consisting of the forage plants to be evaluated and concentrated feed with corn meal, soybean and a mineral supplement, in the proportion of 60:40, twice a day, at 08h00 am and 06h00 pm, a sufficient amount to allow about 10% of leftovers.

After pre-drying by forced ventilation (60°C), the samples of the different forages were processed in a 2 mm knife mill and packed in 5 × 5 cm nonwoven fabric bags (TNT, 100 g m^{-2}) by the proportion of 20 mg of DM per square centimeter (NOCEK, 1988). The bags with the samples were incubated in duplicate for each incubation time in the rumen of animals. After weighing, the bags were placed in a tulle bag attached to a nylon thread and then deposited in the ventral portion of the rumen, where they remained for the following incubation times: 0, 2, 4, 6, 12, 24, 48, 72, 96 and 120 hours. The bags were placed in reverse order regarding the incubation time in order to be removed simultaneously. The bags were then washed in running water to prevent the rumen microorganisms degradation activity from continuing. Then the bags were placed in a forced ventilation oven at temperatures ranging from 55 to 60°C for 72 hours and they were then cooled in a desiccator and weighed.

To estimate the kinetic parameters of the *in situ* degradability of DM and CP, we used the model proposed by Sampaio (1995) from the simplification of the exponential model proposed by McDonald (1981): $PD = a + b (1-e^{-ct})$; where PD is the potential ruminal degradability of food; “a” is the soluble fraction; “b” is the potentially degradable fraction of the insoluble fraction that would be degraded at a rate, “c”; “c” is the “b” fraction degradation rate; and “t” is the incubation time in hours. To estimate the effective degradability (ED), we used the mathematical model: $ED = a + [(b * c)/(c + K)]$; where K is the rate of solids passing through the rumen, defined here as 2, 5 and 8% h^{-1}, which were attributed to low, medium and high food intake, respectively.

The data on the morphological characteristics (leaves, stems, inflorescences and leaf: stem ratio) and chemical composition of the forage species and obtained hay were submitted to analysis of variance and the averages were compared by a Tukey test with a 5% probability. For the DM dehydration curve and CPL in relation to time, the data were subjected to regression analysis at 5% probability. The data was assessed using SISVAR software version 5.3 developed by the Federal University of Lavras according to the methodology proposed by Ferreira (2011).

Results and Discussion

For quantification of leaf, stem and inflorescence per plant there was a difference ($P < 0.05$) between species. Standing out was the Spiny Amaranth (*Amaranthus spinosus*) with less leaves (Table 2), indicating that this species may have experienced prolonged dehydration, since the leaf loses water faster than other plant parts, and they are dropped to conserve water. The Ervanço (*Froelichia humboldtiana*), the Hairy Woodrose (*aegyptia Merremia*) and the Mucuna (*Mucuna*) have a greater number of leaves (247.9, 246 and 235.2 g kg^{-1} of DM) per plant, respectively.

Table 2. Amount of leaf, stem and inflorescence per plant and leaf/stem ratio of five native forage species of the semiarid region of Bom Jesus, Piauí, Brazil.

Variables	Native species					
	Spiny Amaranth	Malva	Mucuna	Hairy Woodrose	Ervanço	CV[1] (%)
Leaf (g kg^{-1} of plant DM)	81.3^{b}	193.7^{ab}	235.2^{a}	246.0^{a}	247.9^{a}	23.67
Stem (g kg^{-1} of plant DM)	434.4^{b}	636.3^{ab}	764.7^{a}	597.2^{ab}	446.8^{b}	17.67
Influorescence (g kg^{-1} of plant DM)	484.2^{a}	169.9^{bc}	0.00^{c}	156.8^{bc}	305.2^{b}	36.23
Leaf / stem	0.18^{a}	0.30^{a}	0.30^{a}	0.41^{a}	0.55^{a}	37.20

Means followed by different letters in the lines, differ significantly ($P < 0.05$) by Tukey test, [1]CV: coefficient of variation.

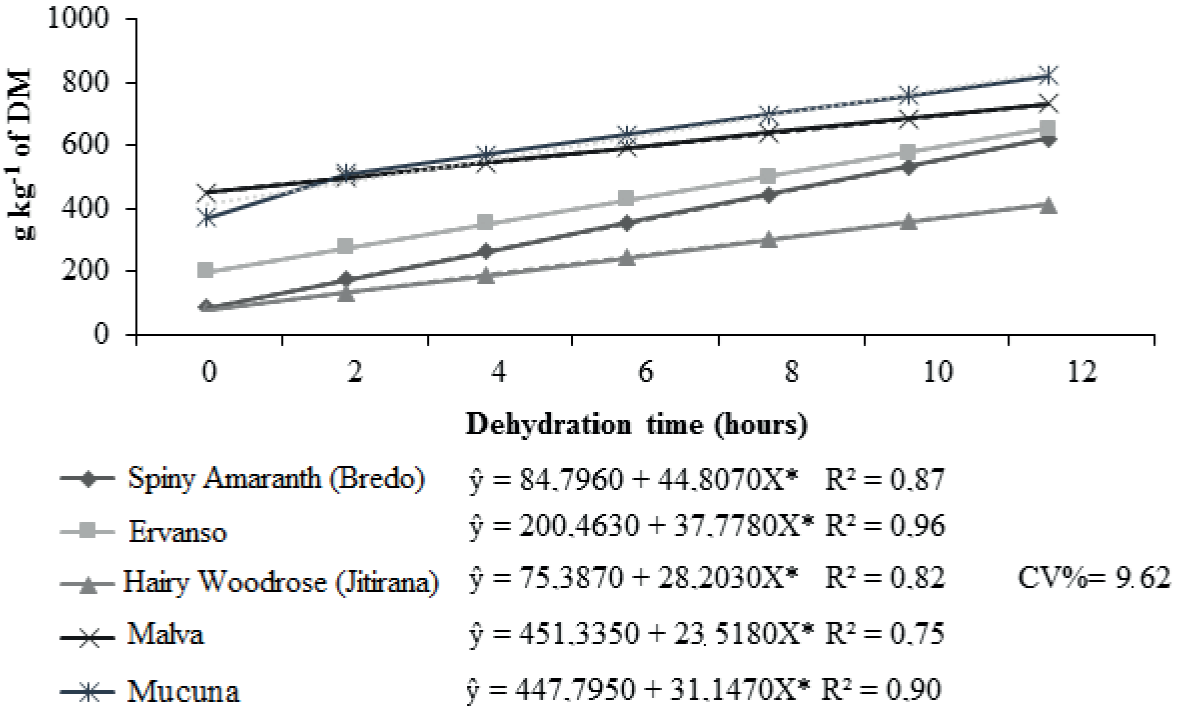
According to Silva (2011), greater leaf production theoretically facilitates the haying process, because more leaves can dehydrate the plant more quickly. It is important to highlight that it will also depend on the plant leaf, since the dehydration in leaves with a high amount of water is slower.

Regarding the amount of stem, there were differences among the studied species, standing out were the Mucuna with a larger amount, 764.7 g kg^{-1} DM per plant (Table 2). The greater the amount of this morphological component hinders the drying of the plant for obtaining quality hay, since the stem has thicker cell walls than the leaves and has no stomata, which hampers dehydration. Spiny Amaranth and Ervanço had less stem. The small stems can be an advantage when using forage plants for haymaking, especially from herbaceous plants. Neres et al. (2011) showed that a larger thickness of the stem can negatively influence the dehydration rate of grasses, given that this fraction has a greater amount of water and reduced water loss when compared with the leaf fraction and whole plant, which is also observed in other species.

The number of inflorescences differed among the forage species studied with greater values for Spiny Amaranth and Ervanço with 484.2 and 305.2 g kg^{-1} DM per plant, respectively. The high numbers of inflorescences can compromise the dehydration process. The inflorescences extend the haymaking process and decrease the amount of nutrients in these forage plants, because of the losses caused by the persistence of moisture in this plant tissue. The leaf: stem ratio of the species did not differ, and among the analyzed forage species the Ervanço showed a ratio of 0.55 (Table 2).

We verified a positive linear response for the dehydration curve of the five forage plant species over a sun exposure period of 12 hours. At night, there was no moisture absorption due to the high temperature and low relative humidity (Figure 1). The results were similar for all of the species studied.

Figure 1. Dehydration curve of native forage species of the semiarid region of Bom Jesus, Piauí, Brazil concerning the periods of sun exposure, in (g kg^{-1} of DM). *Significant at 5%.



Regarding the loss of water, Malva, Mucuna, Ervanço, Spiny Amaranth and Hairy Woodrose at the time of cutting (0 hour) had 451.33, 447.79, 200.46, 84.79 and 75.38 g kg^{-1} DM, respectively (Figure 1). The amount of water in the plant tissue at the time of cutting influences the dehydration time of the forage species; species with a high amount of water take longer to reach the hay point, being of approximately 80% to 85% of DM according to Silva (2011). In addition, according to Silva et al. (2014b), the faster the loss of water from the plant at the time of haymaking, the lower the growth rate of microorganisms that change the chemical composition of hay and the smaller the losses by the plants enzymatic processes. The time the plant takes to dehydrate in the field to achieve the hay point is of great importance and may influence the losses and consequently the quality of the produced hay.

We observed a dehydration peak in the first 2 hours for all species, as a result the dehydration rate was 141.54, 89.61, 75.55, 56.40 and 47.03 g kg^{-1} DM for Mucuna, Spiny Amaranth, Ervanço, Hairy Woodrose and Malva, respectively (Figure 1). Calixto Jr. et al. (2012) evaluated the stargrass (*Cynodon nlemfuensis*) dehydration rate, which had a greater dehydration rate in the first hours after cutting. It is worth emphasizing that the greater the dehydration rate, the greater the increase in DM and the faster the plant reaches the hay point. Open stomata may have sped the dehydration process. Stomata close in the first hours after cutting or when the water loss reaches 20–30% of total water content (McDONALD; CLARK, 1987). After the closure of stomata, the dehydration may occur through cuticular evaporation, which reduces water loss (REES, 1982).

The forage plants Mucuna, was the one who reached the hay point (821.55 g kg^{-1} of DM) after 12 hours of exposure to the sun, while forage species Malva, Ervanço and Spiny Amaranth reached the hay points 733.55, 653.79 and 622.39 g kg^{-1} of DM, respectively, after 12 hours of sun exposure (Figure 1). Malva would need 14.8 hours of sun exposure to reach the hay point (800 g kg^{-1} DM). The species Spiny Amaranth and Ervanço required 15.9 hours of sun exposure, which is the time required for the species to reach the ideal dehydration point for forage preservation with 800 g kg^{-1} DM.

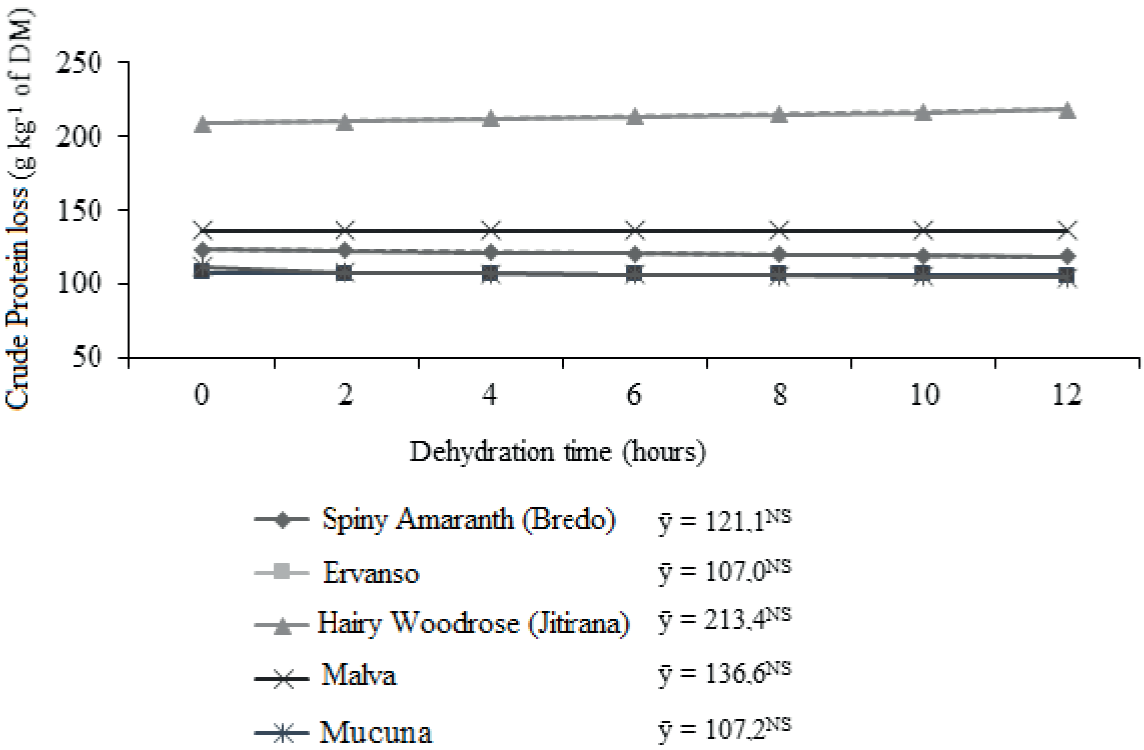
Hairy Woodrose was the only species that had lower efficiency to dehydrate and get to the hay point with greater moisture content in the early dehydration period. That is at 0 hour having 75.38 g kg^{-1} DM and reaching 413.82 g kg^{-1} DM after a period of 12 hours of dehydration (Figure 1). Among the species studied, Hairy Woodrose would need 25 hours of sun exposure to reach the hay point (Figure 1). According to Martins et al. (2008), plants from dry climates and saline environments may have stomata with ostioles blocked by wax deposits, which can be an adaptation to reduce water loss. However these are also harmful to the haymaking process. Therefore, it is not recommended to produce hay with Hairy Woodrose because it takes too much time to dehydrate. According to Collins and Coblentz (2007), moisture contents above 150–200 g kg^{-1} of hay DM lead to an increase in microbial activity. Heating temperatures that can exceed 50°C can cause a loss of nonstructural carbohydrates by the sugars oxidation, which reduces the total digestible nutrients and hay quality.

Regarding the loss of the protein value of the forage plants studied, there was no difference ($P > 0.05$) for the period of sun exposure for hay production (Figure 2). This fact shows that during the haying process there is no loss of protein value for the species studied with increased dehydration time. We did not expected this, since it was expected that there was some loss of crude protein in the material for some species. This fact can be attributed mainly to climatic conditions of the region and the material drying period in the field (Table 1). This is because on the days when the material was exposed to dehydrate the weather was dry and hot and the sun exposure time of forage plants was of 12 hours.

The species Hairy Woodrose, Malva, Spiny Amaranth, Ervanço and Mucuna showed average CP contents of 213.4, 136.6, 121.1, 107.0 and 107.2 g kg^{-1} of DM, in relation to the dehydration time (Figure 2), respectively. Although CP may suffer microbiological degradation, it did not show losses by microbial breathing in this study. This can be explained because the hay production conditions during this time were favorable. There was no precipitation or losses as a result of high temperature of the hayed material. In the use of hay in a short period of less than 60 days, CP content tends to be greater due to the oxidation of total soluble carbohydrates. After this period, hay is likely to incur losses of 2.5 g of CP kg^{-1} of DM per month due to the volatilization of the ammonia produced by microbial breathing (COBLENTZ; HOFFMAN, 2009). Silva et al. (2013), who evaluated whole plant hay of Estilosantes cv. Campo Grande, found a CP of 118.84 g kg^{-1} DM, which is lower than the average value observed for Malva, Hairy Woodrose and Spiny Amaranth in this study.

Hairy Woodrose's CP value is greater than that observed by Arruda (2011). After evaluating five legumes of the Brazilian semiarid region, they observed an average value of 193.9 g kg^{-1} of DM for the CP content. The author reported that species with greater contents in the protein fraction may be appropriate for alternative haymaking.

Figure 2. Crude protein loss (CPL) curve of native forage species of the semiarid region of Bom Jesus, Piauí, Brazil in relation to the periods of sun exposure, in (g kg^{-1} of DM). ^{NS} not significant at 5%.



For the chemical composition of the plant and produced hay, there was a difference ($P < 0.05$) in DM, CP, organic matter (OM), mineral matter (MM), ether extract (EE), neutral detergent fiber (NDF) and acid detergent fiber (ADF) contents among the species (Table 3). Malva had a CP, ADF and EE content of 134.8, 439.7 and 29.3 g kg^{-1} DM and hay values of 139.2, 453.8 and 34 g kg^{-1} DM, respectively. Moreira et al. (2006) observed greater values, which were 92.1, 378.1 and 16.2 g kg^{-1} DM for CP, ADF and EE content, respectively. Benício et al. (2011) obtained even lower DM and NDF values both for the plant and for hay, when compared to our study.

Regarding Mucuna, we observed a reduction in CP, NDF and ADF in relation to the values observed in plant and hay of 8.4, 67.7 and 73.8 g kg^{-1} DM, respectively (Table 3). Such losses are probably due to the biochemical processes that still occurs in the plant tissues during dehydration, such as metabolic activity at cellular level. Muniz et al. (2011) observed DM, OM, MM, EE, CP, NDF and ADF values similar to those obtained in this study for hay of Chinese Senna (*Senna obtusifolia*), a plant which belongs to the same family of Legumes as Mucuna.

The Hairy Woodrose DM content (Table 3) showed a similar value to that observed by Arruda et al. (2010) which was of 114.3 g kg^{-1} DM and greater values for hay at 903.5 g kg^{-1} DM. We note that according to Silva (2011) hay must have approximately 800–850 g kg^{-1} DM. The DM content recommended above can cause a loss of cellular content because the plasma membrane loses its selective permeability. For Hairy Woodrose CP and NDF, Arruda et al. (2010) observed values of 201.1 and 682.1 g kg^{-1} DM in the plant and 186.0 and 690.55 g kg^{-1} DM in hay, respectively. This shows a difference of -15.1 and 8.45 g kg^{-1} of CP and NDF DM, respectively, in relation to plant and hay. For this study, the differences were 3.4 and 13.2 g kg^{-1} of CP and NDF dry mass, respectively, in relation to the composition of the plant and hay. Negative values indicate material quantity loss probably caused by high plant moisture associated with unfavorable weather conditions during the production of hay.

Table 3. Chemical composition of native forage species plant and hay of semiarid region of Bom Jesus, Piauí, Brazil.

Nutrients	Spiny Amaranth	Malva	Mucuna	Hairy Woodrose	Ervanço	CV%[1]
			Plant (0 h) g kg^{-1} of DM			
DM	140.3^{d}	396.8^{a}	369.5^{b}	123.9^{d}	223.9^{c}	3.70
CP	126.9^{bc}	134.8^{b}	112.7^{bc}	206.1^{a}	109.7^{c}	6.34
OM	824.5^{d}	939.2^{a}	943.3^{a}	869.1^{c}	907.3^{b}	0.52
MM	175.5^{a}	60.8^{d}	56.7^{d}	130.9^{a}	92.7^{c}	4.51
EE	22.5^{a}	29.3^{a}	24.6^{a}	22.1^{a}	28.3^{a}	14.2
NDF	555.2^{c}	578.5^{bc}	677.6^{a}	566.7^{bc}	621.7^{ab}	3.79
ADF	373.1^{c}	439.7^{bc}	534.9^{a}	485.7^{ab}	428.0^{bc}	6.54
			Hay (12 h) g kg^{-1} of DM			
DM	742.7^{a}	735.7^{a}	777.8^{a}	513.0^{b}	709.6^{a}	8.22
CP	122.8^{c}	139.2^{b}	104.3^{d}	209.5^{a}	103.2^{d}	2.53
OM	822.7^{d}	942.5^{a}	946.4^{a}	878.9^{c}	917.2^{b}	0.66
MM	177.2^{a}	57.4^{d}	53.5^{d}	121.0^{b}	82.7^{c}	6.30
EE	11.2^{c}	34.0^{a}	31.6^{a}	13.6^{bc}	25.5^{ab}	18.8
NDF	546.2^{c}	612.2^{ab}	610.2^{ab}	553.5^{bc}	621.0^{a}	3.77
ADF	361.1^{b}	453.8^{a}	461.1^{a}	474.4^{a}	447.2^{a}	4.28

[DM] Dry matter, [CP] Crude protein, [OM] Organic matter, [MM] Mineral matter, [EE] Ether extract, [NDF] Neutral detergent fiber and [ADF]Acid detergent fiber.
Means followed by letters in the line differ statistically at 5% by Tukey test.
[1]CV: coefficient of variation.

The average disappearance of potentially degradable fractions, soluble fractions and the rates of solids passing through the rumen at 2, 5 and 8% h^{-1} of hay DM and CP of the five forage plants studied are described in Table 4. Based on ruminal degradation data of forage hay DM and CP it is possible to determine estimates of the different degradabilities.

In the DM soluble fraction ("a" in g kg^{-1} DM) Ervanço, Spiny Amaranth, Hairy Woodrose and Malva hay obtained 31.0, 26.2, 22.1 and 9.7 g kg^{-1} DM more than Mucuna. This fraction represents the zero time and may be related to sugar solubilization and soluble nitrogenated compounds (PIRES et al., 2010) that for some forage species represent energy reserves. The greatest degradation potential is related to starch concentrations, nitrogen compounds and structural carbohydrates, while fraction C may be related to CP and NDF contents. According to Bezerra et al. (2015) the soluble fraction of DM "a" represents the food fraction to be readily available to the rumen microorganisms.

Spiny Amaranth and Malva hay have values of 335.4 and 193.2 g kg^{-1} DM of slowly degraded fraction "b", respectively (Table 4), which is greater than that observed in Ervanço hay. A smaller slowly degraded fraction "b" has a degradation rate in g kg^{-1} of DM per hour, of the forage plants DM indicated a better use of the forage by the animal. The measurement of degradability in the rumen without considering the rate of solids passing by it may overestimate the extent of degradation because the food particles are subject to passing through to the next compartment before being completely degraded.

Table 4. Average of the kinetic fractions estimates of the ruminal degradation *in situ* of native forage species hay of semiarid region of Bom Jesus, Piauí, Brazil.

Variables	Spiny Amaranth	Malva	Mucuna	Hairy Woodrose	Ervanço
		Dry matter (g kg^{-1} of DM)			
Soluble fraction (a)	91.0	74.5	64.8	86.9	95.8
Slowly degraded fraction (b)	486.8	344.6	204.5	301.9	151.4
Degradation rate (c)	32.3	33.4	36.9	31.8	25.6
Potential degradability	577.9	419.1	269.3	388.8	247.2
Effective degradability	361.0	327.0	250.0	263.0	210.0
($2h^{-1}$)					
($5h^{-1}$)	399.0	277.0	260.0	213.0	182.0
($8h^{-1)}$	561.0	260.0	296.0	198.0	167.0
		Crude protein			
Soluble fraction (a)	383.2	70.6	-	155.8	-
Slowly degraded fraction (b)	111.3	571.5	-	259.2	-
Degradation rate (c)	37.4	29.7	-	36.5	-
Potential degradability	494.5	642.1	-	415.0	-
Effective degradability					
($2h^{-1}$)	457.0	550.0	-	382.0	-
($5h^{-1}$)	446.0	479.0	-	366.0	-
($8h^{-1}$)	449.0	440.0	-	368.0	-

For soluble fraction “a” in g kg^{-1} of CP, Spiny Amaranth and Hairy Woodrose hay obtained 312.6 and 85.2 g kg^{-1} of CP, respectively, in the DM more than that observed for Malva. However, for the potentially degradable portion of fraction “b” in g kg^{-1}, Malva and Hairy Woodrose hay showed greater values at 460.2 and 147.9 g kg^{-1} CP, respectively, in the DM, than the ones obtained in Spiny Amaranth hay. Malva and Hairy Woodrose hay was 26% and 23% more than Spiny Amaranth hay for fraction “c” g kg^{-1} of CP (Table 4). The understanding of the action of microorganisms in rumen microbial protein synthesis, as well as the non-degraded fraction in the rumen, aims to improve animal husbandry production rates.

Spiny Amaranth and Malva hay showed potential degradability (PD) and effective degradability (ED) values of 2, 5 and 8 h^{-1} g kg^{-1} of DM, respectively, which are greater than the other forage plants studied. Hairy Woodrose showed the lowest value. Regarding the observed CP effective degradability (ED) in g kg^{-1} of 2, 5 and 8 h^{-1} for Malva and Spiny Amaranth, it can be a negative point for these forage plants, because when the protein degradation is too fast, ruminal microorganisms may not use all the released amino acids and ammonia (BRODERICK, 1995).

Conclusion

Mucuna species have better forage potential to be hayed in the semiarid region of Brazil when compared to Spiny Amaranth, Hairy Woodrose, Malva and Ervanço.

The assessed forages species have chemical composition appropriate characteristics for the plant and produced hay.

The nutritional quality and efficient use in rumen was greater for Malva and Spiny Amaranth hay regarding the degradability of dry matter and crude protein.

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