DOI: 10.5433/1679-0359.2016v37n6p4203

Ensiling of elephant grass with soybean hulls or rice bran[1]

Ensilagem de capim elefante acrescida de casca de soja ou farelo de arroz

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Abstract

The goal was to evaluate the chemical composition and fermentation pattern of elephant grass (*Pennisetum purpureum* Schum. cv. Roxo) silage with different levels of soybean hulls or rice bran. Two trials were conducted, comprising of a completely randomized design, with four replicates each. Treatments consisted on the addition of 0%, 5%, 10%, and 15% of soybean hulls or rice bran to unwilted green elephant grass forage. Large PVC silos were used adopting a density of 600 kg of green mass m^{-3}. The silos were opened 40 days after ensiling. The results revealed that the inclusion of 10% soybean hulls increased elephant grass forage dry matter (DM) content to 31%, but did not alter the water soluble carbohydrate (WSC) content or buffering capacity. The resultant silages exhibited good fermentation patterns in terms of pH (less than 3.97) and NH_3-N (4.07% total N) levels. The inclusion of rice bran increased both DM and WSC content in the forage, improving the fermentation pattern of silages ($P < 0.05$). This too was verified by a pH lower than 3.92 and a maximum NH_3-N of 4.23% of the total N. The inclusion of 10% rice bran to the elephant grass improved the nutritional value of the forage to be ensiled and, hence, of the produced silage.

Key words: Additive. Ammonia nitrogen. pH. *Pennisetum purpureum*. Silage. Water soluble carbohydrates.

Resumo

Objetivou-se avaliar a composição bromatológica e o padrão de fermentação da silagem de capim-elefante (*Pennisetum purpureum* Schum. cv. Roxo) aditivada com níveis de casca de soja e de farelo de arroz. Foram realizados dois experimentos para avaliar o uso de aditivos na ensilagem de capim elefante. Utilizou-se delineamento experimental inteiramente casualizado, com quatro repetições. Os tratamentos consistiram na adição de 0, 5, 10 e 15% do aditivo na massa verde de forragem de capim-elefante picada e sem emurchecimento. Foi utilizado silos de PVC, adotando densidade de 600 kg de massa verde m^{-3}, com abertura do silo 40 dias após a ensilagem. A inclusão de 10% de casca de soja aumentou o teor de matéria seca (MS) da forragem de capim-elefante para 31%, porém não

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[1] Parte da dissertação de mestrado do primeiro autor, apresentada ao Programa de Pós-Graduação em Ciência Animal, Universidade Federal de Mato Grosso, UFMT, Cuiabá, MT, Brasil.

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Received: Dec. 01, 2014 – Approved: Aug. 15, 2016

alterou os teores de carboidratos solúveis (CHOS) e poder tampão. As silagens de capim-elefante obtidas apresentaram bom padrão fermentativo, com valores de pH inferior a 3,97 e de N-NH_3, 4,07% do N total. A inclusão de farelo de arroz proporcionou melhoria no padrão fermentativo das silagens produzidas, verificado pelo pH inferior a 3,92 e N-NH_3 máximo de 4,23% do N total. A inclusão de 10% de farelo de arroz na ensilagem do capim-elefante melhorou o valor nutritivo da forragem a ser ensilada e, consequentemente, da silagem produzida.

Palavras-chave: Aditivo. Carboidratos solúveis. Nitrogênio amoniacal. *Pennisetum purpureum*. pH. Silagem.

Introduction

Forage availability for ruminants is greatly influenced throughout the year by weather conditions. Silage production is therefore a viable alternative for maintaining animal production by minimizing the effects of seasonal forage production. Among grasses with potential for silage production, elephant grass (*Pennisetum purpureum*) stands out with production that ranges from 15 to 30 t of dry matter (DM) ha^{-1} yr^{-1}. In the Midwest region of Brazil, 70% of the annual production of elephant grass occurs during the rainy season (October to April) (PACIULLO et al., 2008).

Lavezzo (1985) suggested that for silage production, elephant grass should be harvested within 50 to 60 days of its development, when there is a good correlation between plant growth and nutritional value. However, the plant DM content is usually low at this age (15% to 20%), which is not recommended for the ensiling process.

Despite the fact that buffering capacity (BC) and water soluble carbohydrate content (WSC) of elephant grass do not limit the ensiling process, Weissbach (1996) reported that a minimum dry matter content is required to avoid undesirable fermentations, which occurs when the ratio between the WSC and BC decreases.

Alternative methods for increasing DM and WSC content of ensiling materials have been widely studied throughout Brazil. Forage wilting, and/or the inclusion of additives has been successfully used in the production of elephant grass silage (CARVALHO et al., 2007, SILVA et al., 2007). Of all the additives with potential use in elephant grass ensiling, soybean hulls and rice bran have interesting features such as high DM content.

Soybean (*Glycine max* (L.) Merr.) hulls are a by-product of grain processing. Approximately 2% of processed grain results in soybeans hulls which ranges from 0% to 3% according to Andrade and Quadros (2011).

Rice bran is derived from the processing of rice, with integuments being removed during the milling process, when the cereal is prepared for human consumption. The bran represents approximately 8% of the processed rice (LACERDA et al., 2010).

Given that soybean hulls and rice bran are readily available in Mato Grosso state, Brazil, the goal was to evaluate both the chemical composition of silage and the fermentation pattern at ensiling of elephant grass (*Pennisetum purpureum* Schum. Cv. Roxo) when different quantities of soybean hulls or rice bran were added to the grass.

Materials and Methods

Trials were conducted at the Experimental Farm of Mato Grosso Federal University in Santo Antônio do Leverger-MT. This is located 141 m above sea level, at latitude 15°51′S and longitude 56°04′W, at micro-region of Cuiaba (FERREIRA, 2001). The climate, according to the Koppen classification system, is Cwa, indicating it is a tropical, seasonal climate with two well-defined seasons. The region experiences a rainy summer season from October to March, and dry winters (April to September). The average annual rainfall is 1500 mm, with most of the precipitation occurring during December, January and February (FERREIRA, 2001).

The predominant soil type at the farm consisted of moderate halic plinthisol Tb, with a plateau landscape and medium texture that facilitates water infiltration, soil aeration, root penetration and radicular system development.

Elephant grass was planted with 1.0 m spacing between grooves. The trial commenced in December 2007, after uniformity cut. Maintenance fertilization was applied at approximately 100 kg N ha^{-1} and 100 kg K_2O ha^{-1}.

The experimental area consisted of 16 rows, each one measuring 30 m in length, and 1.0 m apart, covering a total area of 480 m². A 2.0 m border was set aside around the entire perimeter of the study plot, reducing the usable area to 14 central rows, each of them with 26 m length. The total area was reduced to 364 m².

Two trials were conducted to evaluate additives used in elephant grass ensiling, one with soybean hulls and another with rice bran. The experimental design was completely randomized, with four replicates. Treatments consisted on inclusion of 0%, 5%, 10%, and 15% soybean hull or rice bran additives to unwilted green, chopped elephant grass forage.

Harvesting was conducted 60 days after regrowth, during which the elephant grass had an average height of 1.50 m. All grasses were cut at 10 cm above ground with the use of a machete. The forage was chopped to approximately 20 mm in length using a stationary forage cutter. The additives (soybean hulls and rice bran) were manually homogenized to forage mass according to the treatments mentioned above. Chemical analysis (SILVA; QUEIROZ, 2002) of the soybean hulls showed 90.29% DM, 8.14% crude protein (CP), 62.99% neutral detergent fiber (NDF), and 44.61% acid detergent fiber (ADF), while rice bran with hulls showed 91.14% DM, 9.05% CP, 51.28% NDF, and 30.35% ADF.

A sample of the chopped forage (500 g) was collected during ensiling, and was placed in paper bags and dried in a forced-air oven at 55°C for 72 h. Pre-dried samples were weighed, and then ground in a Wiley mill until the samples could pass through a 20 mesh steel sieve. Each of these samples was stored in polyethylene containers for analysis of DM (SILVA; QUEIROZ, 2002) and WSC (SILVEIRA, 1975). A second sample (500 g) was frozen in plastic bags for BC determination following the method described by Playne and McDonald (1966).

Each experimental silo (plot) consisted of a PVC pipe of 10 cm diameter and 50 cm length, with the capacity to condition 2.50 kg of forage (density of 600 kg of green forage m^{-3}). Timber sockets were used to compress the matter inside the silos. These were sealed with PVC caps with Bunsen valves that allowed fermentation gases to escape. Then, the caps were sealed with tape.

Silos were opened 40 days after ensiling. The upper and lower 5 cm portions of matter inside the silos were discarded. The remaining silage was divided into two portions. The first (500 g) was transferred to plastic bags and frozen to measure pH, in accordance with Silva and Queiroz (2002) and ammonia nitrogen content ($N\text{-}NH_3$), according to Tosi (1973). The second part (500g) was placed in paper bags and dried for 72 h in a forced-air oven at 55°C. Pre-dried samples were weighed, ground in a Wiley mill until they could pass through a 20 mesh steel sieve, and stored in polyethylene containers for chemical analysis.

The DM and CP contents were determined according to methods described by Silva and Queiroz (2002). Levels of NDF and ADF were determined according to methods by Van Soest et al. (1991), using tissue non-tissue bags (TNT-100 g m^{-2}). Indigestible NDF (iNDF) content was determined using methods described by Cochran et al. (1986).

The total digestible nutrient content (TDN) was estimated according to the following formula by Undersander et al. (1993):

$$\text{TDN (\%DM)} = 88.9 - [\text{ADF (\%DM)} \times 0.779].$$

All data were analyzed by analysis of variance and regression, using SAEG, version 9.1 (RIBEIRO JÚNIOR; MELO, 2008) software. Probabilities less than 5% were considered statistically significant.

Results and Discussion

The chemical composition of elephant grass forage with soybean hulls or rice bran is shown in Table 1.

Table 1. Average content of dry matter (DM), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), total digestible nutrients (TDN), water soluble carbohydrates (WSC), buffering capacity (BC) and *in vitro* dry matter digestibility (IVDMD) of elephant grass forage with soybean hulls or rice bran added to it.

Variables	Additive level (%)				Regression equation[1]	R^2	CV (%)
	0	5	10	15			
				Soybean hulls			
DM (%)	17.87	26.92	31.62	26.18	$\hat{Y} = 17.7278 + 2.5022 X^{**} - 0.1152 X^{2**}$	0.99	8.15
CP (% DM)	5.16	7.42	7.83	8.18	$\hat{Y} = 5.2509 + 0.4766 X^{**} - 0.01914 X^{2**}$	0.97	6.01
NDF (% DM)	68.35	67.3	66.15	66.08	$\hat{Y} = 68.1661 - 0.15915 X^{*}$	0.91	1.85
ADF (% DM)	40.4	42.91	43.29	43.98	$\hat{Y} = 40.5273 + 0.4941 X^{**} - 0.0181 X^{2*}$	0.96	1.67
TDN (% DM)	59.59	57.08	56.7	56.01	$\hat{Y} = 59.427 - 0.4941 X^{**} + 0.0181 X^{2*}$	0.96	1.24
WSC (% DM)	14.03	13.94	15.2	13.59	$\bar{y} = 14.19$	-	6.45
BC[2]	8.41	9.43	8.99	9.93	$\bar{y} = 9.19$	-	13.21
IVDMD (% DM)	59.72	72.59	70.7	81.16	$\hat{Y} = 59.7236 + 1.249 X^{**}$	0.84	20.83
				Rice bran			
DM (%)	17.87	28.42	28.89	32.39	$\hat{Y} = 20.2912 + 0.8805 X^{*}$	0.82	13.75
CP (% DM)	5.16	7.35	7.12	7.36	$\hat{Y} = 5.305 + 0.422 X^{**} - 0.0196 X^{2*}$	0.99	10.07
NDF (% DM)	68.35	64.84	61.46	61.4	$\hat{Y} = 68.5124 - 1.0014 X^{**} + 0.0344 X^{2*}$	0.98	2.09
ADF (% DM)	40.4	39.19	37.23	37.45	$\hat{Y} = 40.195 - 0.2161 X^{**}$	0.86	3.66
TDN (% DM)	59.59	60.8	62.76	62.54	$\hat{Y} = 59.805 + 0.216 X^{**}$	0.86	2.3
WSC (% DM)	14.03	13.85	15.55	16.41	$\hat{Y} = 13.6396 + 0.17709 X^{*}$	0.86	3.82
BC[2]	8.41	8.24	7.22	11.98	$\hat{Y} = 8.7469 - 0.5453 X + 0.0492 X^{2*}$	0.83	23.29
IVDMD (% DM)	59.72	59.47	50.69	54.08	$\bar{y} = 55.99$	-	34.26

[1] **; *: Significant at probability levels of 1% and 5% for F-test. [2]: eq.mg HCl 100 g^{-1} DM.

A quadratic effect ($P < 0.05$) of soybean hull levels was observed on DM content of elephant grass forage before ensiling, with a maximum estimated value of 31.31% when using 10.86% of soybean hulls. Muck (1988) reported that an ideal fermentation inside the silo is expected when the forage to be ensiled has a DM content between 28% and 35%. The addition of 10.86% of soybean hull therefore promoted the appropriate DM content in the forage to obtain good silage.

With regard to the DM content of forage prior to ensiling, there was a significant increase of 0.88% in the DM content for every 1% of rice bran added ($P < 0.05$). The addition of rice bran also enhanced the nutritive value of ensiled forage (Table 1). The addition of 8.75% of rice bran to elephant grass during ensiling resulted in a forage DM content of 28%, which is the minimum required to obtain good silage according to Muck (1988). Additives such as these reduce DM losses, limit secondary fermentation, improve aerobic stability and increase the nutritional value of silage (HENDERSON, 1993). Ribeiro et al. (2009) reported that the use of citrus pulp and soybean hulls on marandu palisade grass silage (*Brachiaria brizantha* cv. BRS Marandu), resulted in an increase in the DM content of the forage, in which the high DM content additives were included.

There was no significant increase ($P > 0.05$) in WSC content or BC of elephant grass forage due to the addition of soybean hull. The mean values were 14.19% and 9.19 eq.mg HCl 100 g^{-1} DM, respectively. In contrast, the addition of rice bran to chopped elephant grass resulted in a significant linear increase ($P < 0.05$) in the WSC content of material, with a 0.177% increase for every 1% of rice bran added (Table 1). The WSC content is considered an indicator of the quality of the forage to be used for ensiling, with a minimum concentration of 2.5 to 3.0% required (HAIGH, 1990). Despite some elephant grass cultivars possessing a WSC content greater than 16% of DM (Taiwan A-148), reasonable silages have been produced when the cultivar used has a WSC content below 13% to 15%. This was according to Machado Filho and Muhlbach (1986).

The addition of 10% rice bran to elephant grass forage increased the DM content by 29% and WSC by 15.41%. Zanine et al. (2010) tested the effects of cassava scrapings on elephant grass ensiling and reported an increase on DM and WSC content in the forage with additive inclusion, similar to the rice bran at this work.

A quadratic response ($P < 0.05$) to rice bran levels on forage BC was observed. The addition 8.99% of rice bran resulted in the lower BC value of 7.17 eq.mg HCl 100 g^{-1} DM. Adding more rice bran increased the BC, which was possibly due to the higher crude protein content of rice bran, which can act as a buffering agent in the forage (JOBIM et al., 2007). Elephant grass forage BC, with or without the addition of soybean hulls or rice bran, was always lower than 15 eq.mg HCl 100 g^{-1} DM (FERRARI JUNIOR; LAVEZZO, 2001). Lavezzo (1985) reported that the ideal fermentation can be achieved when the forage to be ensiled has a DM content ranging between 28% and 34%. Under these conditions, a WSC content of 6% to 8% would be sufficient to allow lactic fermentation. This is provided when BC is not high.

There was a linear effect ($P < 0.05$) of soybean hull levels on forage NDF. For every 1% of soybean hull added to chopped elephant grass forage there was 0.15% decrease in NDF content (Table 1). A quadratic effect ($P < 0.05$) due to soybean hull levels on forage ADF content was also observed, with a maximum estimated value of 43.89% when using 13.65% of soybean hulls. The opposite occurred to the TDN content in forage in which soybean hulls were added. There was a significant quadratic effect ($P < 0.05$) due to soybean hull levels on the CP content of forage (Table 1). The maximum estimated value of 8.21% CP was achieved when 12.45% of soybean hulls was added. These results are due to the chemical composition of soybean hulls.

A quadratic effect ($P <0.05$) due to rice bran levels on forage NDF (Table 1) was also observed. A minimum estimated value of 61.22% of NDF occurred following the inclusion of 14.55% rice bran. These decreases may have been due to the lower NDF content of rice bran (31.28%) compared to the elephant grass (68.51%). Rice bran exerted a linear effect on forage ADF levels ($P <0.05$), resulting in a decrease of 0.21% for every 1% of rice bran added to elephant grass forage prior to ensiling (Table 1). A quadratic effect due to rice bran levels on forage CP content was similarly observed. The addition of up to 10.76% of rice bran induced an increase in elephant grass forage CP content of 7.57%. This was due to the higher CP content in rice bran (9.05%).

The results of the chemical composition and fermentation characteristics of elephant grass silage with soybean hulls and rice bran are shown in Table 2.

Table 2. Average content of dry matter (DM), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), total digestible nutrients (TDN), water soluble carbohydrates (WSC), ammonia nitrogen (AN), pH and *in vitro* dry matter digestibility (IVDMD) of elephant grass silage with soybean hulls or rice bran added to it.

Variables	Additive level (%)				Regression equation[1]	R^2	CV (%)
	0	5	10	15			
				Soybean hulls			
DM (%)	23.75	29.78	29.49	32.92	$\bar{Y} = 29.74$	-	16.57
CP (% DM)	4.42	6.19	7.09	7.51	$\hat{Y} = 4.44817 + 0.4064 X^{**} - 0.01356 X^{2*}$	0.99	9.72
NDF (% DM)	65.75	61.88	61.52	62.76	$\bar{Y} = 62.98$	-	3.93
ADF (% DM)	41.14	39.48	41.61	42.62	$\bar{Y} = 41.22$	-	5.32
TDN (% DM)	58.85	60.51	58.38	57.36	$\bar{Y} = 58.78$	-	3.73
WSC (% DM)	8.67	6.27	7.13	5.17	$\hat{Y} = 8.2643 - 0.19307 X^{**}$	0.71	17
AN (% total N)	4.15	4.3	3.84	3.98	$\bar{Y} = 4.07$	-	13.31
pH	3.92	3.95	3.93	3.97	$\hat{Y} = 3.9297 + 0.00245 X^{*}$	0.55	0.63
IVDMD (% DM)	60.83	77.96	87.73	69.57	$\hat{Y} = 60.8396 + 6.0113 X^{*} - 0.3527 X^{2**}$	0.95	27.78
				Rice bran			
DM (%)	23.75	26.52	29.86	35.03	$\hat{Y} = 25.322 + 0.5631 X^{*}$	0.84	14.39
CP (% DM)	4.42	5.75	5.97	6.41	$\hat{Y} = 4.4079 + 0.3704 X^{**} - 0.0176 X^{2**}$	0.99	7.93
NDF (% DM)	65.75	62.39	60.86	58.4	$\bar{Y} = 59.74$	-	14.26
ADF (% DM)	41.14	39.03	38.08	37.13	$\hat{Y} = 40.7998 - 0.2598 X^{**}$	0.95	2.02
TDN (% DM)	58.85	60.96	61.91	62.86	$\hat{Y} = 59.2002 + 0.259 X^{**}$	0.95	1.28
WSC (% DM)	8.67	7.94	8.91	9.03	$\bar{Y} = 8.64$	-	15.68
AN (% total N)	4.15	4.49	3.93	4.34	$\bar{Y} = 4.23$	-	12.24
pH	3.92	3.85	3.85	3.8	$\hat{Y} = 3.9167 - 0.0079 X^{**}$	0.93	0.59
IVDMD (% DM)	60.83	54.19	51.49	49.3	$\hat{Y} = 53.9525 - 0.309 X^{*}$	0.93	13.27

[1] **; *: Significant at probability levels of 1% and 5% for F-test.

Soybean hulls, when added to elephant grass, linearly reduced ($P < 0.05$) the silage WSC content, with every 1% of soybean hull added decreasing it by 0.19% (Table 2). Rice bran also promoted a decrease in WSC content in the silage (8.64%) compared to the forage (14.19%). The difference in WSC content between silage and forage suggests that this fraction was consumed during the fermentation process by lactic acid bacteria. Ferrari Junior and Lavezzo (2001) reported a similar increase in consume of WSC contained in elephant grass silage when mixed with cassava meal. Despite the low WSC content in elephant grass forage, the fermentation process provided satisfactory silage with suitable values of pH and $N\text{-}NH_3$.

With regard to silage DM content, there was a significant increase of 0.56% for every 1% of rice bran added ($P < 0.05$). This indicated that rice bran possesses adequate moisture absorption capacity.

Both soybean hulls and rice bran had an effect on silage pH. There was an estimated increase of 0.002 pH units for every 1% of soybean hulls added. A decrease of 0.0079 pH units resulted for every 1% of rice bran added to elephant grass forage (Table 2). Since good silage has pH values ranging from 3.8 to 4.2 (MCDONALD et al., 1991), the addition of soybean hulls or rice bran to forage promoted an ideal acidity level.

To assess the efficiency of the fermentation process, pH levels should not be the only parameters measured. The $N\text{-}NH_3$ content, which is a product of undesirable fermentation by bacteria of the *Clostridium* genus, should also be considered. The addition of soybean hulls did not significantly ($P > 0.05$) affect the $N\text{-}NH_3$ content of silage. According to McDonald et al. (1991), a good silage should contain, a maximum of 11% of $N\text{-}NH_3$ total N^{-1}. Based on these figures, it is clear that elephant grass silages treated with soybean hulls and rice bran presented desirable fermentations.

According to Pahlow et al. (2003), silage with low pH values inhibited proteolytic bacteria, reducing proteolysis and, consequently, N-NH_3 production. The results suggest that the inclusion of soybean hulls and rice bran increase silage DM content, promoting the development of lactic acid bacteria over enterobacteria and *Clostridium*, which results in lower pH and N-NH_3 levels in the silages.

The forages used in this study, both additivated and control treatments, were generally well conserved, presenting good fermentation profiles, with ideal pH and N-NH_3 values, as according to McDonald et al. (1991). It should be noted, however, that silage without any additives, produced unpleasant odors, which are characteristic of undesirable fermentations. They also presented mould and were, therefore, considered unfit for animal consumption.

There was a quadratic effect ($P < 0.05$) due to the addition of soybean hull levels on silage CP content (Table 2). This resulted in a maximum estimated value of 7.49% CP content when 14.98% of soybean hulls were added. This suggests a little loss of CP, which can be attributed to the possible reduction by proteolytic microorganisms. This was in addition to heterofermentative bacteria, which develop at the beginning of the fermentation process, when the decrease in pH is less pronounced. High moisture content and low soluble carbohydrate concentration can also be considered conditioning factors for the development of the afore-mentioned microorganism (PAHLOW et al., 2003). The low CP content observed in silages without additive was likely due to the loss of soluble nitrogen compounds in the effluent. According to Pinho et al. (2008), grass ensiling without additives is subject to significant losses by effluent, which can contain large amounts of organic compounds, including proteins. For silages with increasing levels of soybean hulls compared to the forages, the decrease in CP content can be attributed to the dilution effect, as a result of additive DM proportion.

A quadratic effect ($P < 0.05$) due to rice bran levels on silage CP content was observed, with a maximum value of 6.36% CP resulting from the addition of 10.53% of rice bran to elephant grass forage. This was possibly due to the higher CP content in rice bran (9.05%). The levels observed in this study were similar to those reported by Rodrigues et al. (2005), who added citrus pulp with 6.79% CP to forage. They showed that a higher CP content was achieved when the forage was treated with 7.61% of the additive.

The reduction in silage NDF content (62.98%), when compared to ensiled forage with added soybean hulls is interesting, since the ruminant intake is usually limited by NDF content ranging from 1.0 to 1.4% of body weight (MERTENS, 1987). The decrease of NDF on diets containing a high proportion of roughage may contribute to an increase in DM intake, with incremental increase in energy on the ruminant diet (JUNG; ALLEN, 1995).

A linear effect ($P < 0.05$) due to the addition of rice bran was observed on silage ADF content. A decrease in ADF content occurred following an increase in rice bran levels, with an estimated reduction of 0.25% on silage for every 1% of rice bran added to elephant grass forage prior to ensiling (Table 2). The linear reduction in ADF content of silage may have been due to a direct response to lower levels of ADF in rice bran (30.35%) compared to elephant grass forage at ensiling (40.19%). Zanine et al. (2010) tested the effects of adding cassava scrapings to elephant grass ensiling and observed a similar response.

There was an increase of 0.22% and 0.26% TDN in the forage (Table 1) and silage of elephant grass, respectively, (Table 2) for every 1% of rice bran added to the forage. The increase in energy following rice bran inclusion was due to its chemical composition. There was an increase in CP and WSC, with a concomitant decrease in NDF and

ADF that correlated with energy increments (Table 2). The addition of 15% of rice bran to chopped elephant grass forage provided silage with 62.86% TDN. This was similar to levels reported by Pereira et al. (2008) for corn silage (63.7% NDT), which is considered the standard silage.

For soybean hulls, ADF and TDN levels of 41.21% and 58.78%, respectively were observed. These results were also reported by Bernardino et al. (2005), who evaluated the addition of coffee hulls at levels of 0%, 10%, 20%, 30%, and 40% on elephant grass forage with 12.4% of DM content. They showed that silage ADF levels were not affected by the addition of coffee hulls, which was due to similar ADF content between ensiled elephant grass and the additive.

Conclusions

It is therefore concluded that the inclusion of 10% of soybean hulls increased the dry matter content of elephant grass forage (31%), but did not alter the water soluble carbohydrates content or the buffering capacity. The addition of rice bran increased the content of dry matter and water soluble carbohydrate of the elephant grass forage for ensiling, improving the fermentation pattern of produced silages, resulting in ideal values of pH and ammonia nitrogen. The inclusion of 10% of rice bran on elephant grass ensiling eliminated the need for wilting and also improved the nutritional value of the silage. The elephant grass silage produced in the present study exhibited good fermentation, with ideal pH and ammonia nitrogen values.

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