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Chemical and bromatological characteristics of elephant grass silages with the addition of dried cashew stalk

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ABSTRACT - The objective of this study was to evaluate the nutritive value of elephant grass (*Pennisetum purpureum*, Schum.) silages with the addition of 0, 4, 8, 12 and 16% dried cashew stalk (*Anacardium occidentale* L.) - DCS, based on the fresh matter. A randomized complete design with four replications was used. Twenty 210 L plastic drums were used as experimental silos. The levels were determined of the dry matter (DM), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), hemicellulose, ether extract (EE), total carbohydrates (TC), non-fibrous carbohydrates (NFC), neutral detergent insoluble nitrogen (NDIN,% total N), acid detergent insoluble nitrogen (ADIN, % total N), pH values, ammonia nitrogen (in percentage of the total nitrogen, $N\text{-}NH_3$, % total N), lactic acid, acetic acid, butyric acid and propionic acid. Adding DCS resulted in higher values of DM, CP, EE, NFC, NDIN (% total N), ADIN (% total N), pH, lactic acid and propionic acid. On the other hand, with increasing DCS levels, a linear decline was observed in values of NDF, ADF, hemicellulose, ammonia nitrogen (% total N) and butyric acid. DCS did not show effect on the TC and acetic acid in the silages. As a result, up to 16% dehydrated cashew stalk may be added to elephant-grass silages, based on the fresh matter, to increase CP and NFC levels and decrease NDF and ADF and improve the fermentation patterns. It should be taken into account that higher NDIN and ADIN values may interfere in nitrogen availability and therefore in further DM intake.

Key Words: *Anacardium occidentale*, fermentation, industrial by-products, nutritive value, *Pennisetum purpureum*

Características bromatológicas e fermentativas da silagem de capim-elefante com adição do pedúnculo de caju desidratado

RESUMO - Este trabalho foi conduzido para avaliar o valor nutritivo de silagens de capim-elefante (*Pennisetum purpureum*, Schum.) com 0, 4, 8, 12 e 16% de pedúnculo de caju (*Anacardium occidentale* L.) desidratado, com base na matéria natural. Utilizou-se o delineamento inteiramente casualizado com quatro repetições. Como silos experimentais, foram utilizados tambores plásticos de 210 L. Determinaram-se a composição nutricional, os valores de pH e os teores de nitrogênio amoniacal, ácido lático, acético, propiônico e butírico. A inclusão de pedúnculo de caju desidratado na ensilagem de capim-elefante promoveu aumento das concentrações de matéria seca (MS), proteína bruta (PB), extrato etéreo (EE), carboidratos não-fibrosos (CNF), nitrogênio insolúvel em detergente neutro (NIDN, % do N total), nitrogênio insolúvel em detergente ácido (NIDA, % do N total), pH e ácidos lático e propiônico. Por outro lado, os teores de FDN, FDA, hemicelulose, $N\text{-}NH_3$ (% do N total) e ácido butírico diminuíram de forma linear conforme aumentaram os níveis do subproduto na ensilagem. O pedúnculo de caju desidratado não influenciou os teores de carboidratos totais e ácido acético das silagens. Esse subproduto pode ser ensilado com o capim-elefante até o nível de 16%, uma vez que aumenta os teores de PB e CNF e reduz os teores de FDN e FDA, melhorando o padrão de fermentação das silagens.

Palavras-chave: *Anacardium occidentale*, fermentação, *Pennisetum purpureum*, subprodutos agroindustriais, valor nutritivo

Introduction

The use of silage can be an alternative to raise food stuff offer, especially in the dry period, and reduce the effects of seasonality of plant production on animal production. Elephant grass is the most used the tropical grass and in spite of the technological alternatives for the use other species of the *panicum*, *Brachiaria* and

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Cynodon genus, its use is still important in some regions. According to FAEMG (2005), most of the producers on dairy farms in Minas Gerais state opt for sugarcane followed by elephant grass plantations as alternatives for bulk supplementation in the dry periods of the year.

However, to fully exploit elephant grass in the period of food shortage, some conservation practices need to be used, normally ensilage, to ensure the preservation of the forage quality. There is some difficulty when ensilaging elephant grass in reaching the point of equilibrium between productivity and forage quality because when the plants reach between 1.60 and 1.80 m in height, the moisture contents are high, normally around 80% (Vilela et al., 2002).

Thus several techniques have been assessed to overcome the problem of high moisture. The addition of absorbent products has been studied as a suggestion to raise the dry matter content of the silage mass of tropical grasses (Evangelista et al., 2000; Neiva et al., 2006; Cysne et al., 2006; Pompeu et al., 2006; Coan et al., 2007; Sá et al., 2007; Candido et al., 2007; Ferreira et al., 2007; Tavares et al., 2009; Ribeiro et al., 2009). The absorbent materials assessed include the by-products of fruit processing or harvesting, materials that are normally lost in the processing industries.

One of the fruits with greatest by-product availability in Brazil is the cashew. The cashew tree (*Anacardium occidentale* L.) is native to Brazil and found in several states in the Northeast (Silva, 1993). Cashew penduncle production in the Northeast is approximately two million tons per year (Holanda et al., 1996) and is hardly used by the producers.

In the face of the availability and the possibility of using by-products to raise the DM content of elephant grass forage for silage, the present study was carried out to assess the bromatological and fermentative characteristics of elephant grass silage with the addition of dried cashew stalk.

Materials and Methods

Five levels of dried cashew (*Anacardium occidentale* L.) stalk addition were studied based on the natural material, at elephant grass (*Pennisetum purpureum*, Schum.) ensilage.

Elephant grass was used to make the experimental silage from a field established on the Fazenda Experimental Vale do Curu, in Pentecoste, Ceará, Brazil. The grass was cut manually at approximately 70 days growth, processed in a stationary forage chopper and mixed with the dried cashew stalk.

The dried cashew stalk used came from the cashew nut harvest, when it was discarded. The material was dried until it reached about 15% moisture. The cashew stalk was obtained from the CIONE (Companhia de Óleos Nordeste) in Fortaleza, Ceará, Brazil and dried in a forced air circulation chamber at 45 ^{o}C. After drying, the dried cashew stalk was ground in a grinder with a 1.0 cm diameter sieve.

At ensilage, the elephant grass presented 16.80% dry matter (DM), 88.05% organic matter (OM), 5.58% crude protein (PC), 76.57% neutral detergent fiber (NDF), 47.62% acid detergent fiber (ADF), 28.95% hemicellulose, 4.30% ether extract (EE), 78.17% total carbohydrates (TC), 1.60% non-fibrous carbohydrates (NFC), 16.38% neutral detergent insoluble nitrogen (NIDN)(% total nitrogen) and 6.5% acid detergent insoluble nitrogen (NIDA)(% total N). The dried cashew stalk presented 86.02% DM, 94.80% OM, 8.67% PC, 31.53% NDF, 26.48% ADF, 5.05% hemicellulose, 5.29% EE, 80.84% TC, 49.31% NFC, 34.19% neutral detergent insoluble nitrogen (NIDN)(% total nitrogen) and 11.05% NIDA (% total N) based on the DM.

Plastic 210L drums were used as the experimental silos and 126 kg forage were placed in each silo that were compacted by men to a density of 600 kg/m^3. After weighing and homogenizing the elephant grass with the dried cashew stalk, the material was compacted inside the silo and the silos were closed with plastic sheeting fastened with rubber straps.

During the apparent digestibility experiment with sheep, that lasted 21 days, samples were removed daily from each silo to supply the animal corresponding to the respective experimental treatment and replication. After homogenization, a 100g sub-sample was removed. The sub-samples were placed in plastic bags and stored at -10 ^{o}C and were thawed were thawed at the end of the 21 days and an 800 g compound sample was removed for later analyses.

In the Animal Nutrition Laboratory at the Animal Science Department at UFC, the samples were pre-dried in a forced air chamber at 55 ^{o}C and ground in a grinder with a 1 mm diameter mesh sieve for later determination of the composition of the dry matter (DM), organic matter (OM), crude protein (PC), neutral detergent fiber (NDF), acid detergent fiber (ADF), ether extract (EE), neutral detergent insoluble nitrogen (NIDN) (% total nitrogen) and acid detergent insoluble nitrogen (NIDA)(% total N) following methodology reported by Silva & Queiroz (2002). The total carbohydrate values were obtained by difference, according to the methodology reported by Sniffen et al. (1992), where CT (%) = 100 - (%CP + %EE + %ashes). The nonfibrous carbohydrate (NFC) contents were calculated by the difference between the total carbohydrates and NDF, according to Hall (2001).

The pH was determined according to Silva & Queiroz (2002) and the N-NH_3 (% total nitrogen) content according to methodology developed by Bolsen et al. (1992) and adapted by Cândido (2000).

Juice was collected from the silage using a hydraulic press to determine the organic acids. Fifty mL juice were collected, stored in recipients containing 10 mL 25% orthophosphoric solution and after buffering were placed in a freezer at -10 ^{o}C for later analysis.

The concentrations of organic acids (lactic, acetic, propionic and butyric) were determined in the laboratory. Approximately 5 mL of the frozen sample were transferred to 10 mL centrifuge tubes (Sigma Laboratory Centrifuges 4k15) and centrifuged at 5000 rpm at 10 ^{o}C for 15 minutes. The organic acids were determined by a high precision liquid chromatography (HPLC) according to methodology by Matthew et al. (1997), and approximately 2 mL were filtered from the supernatant of each silage juice sample through cellulose acetate membrane with 0.45 µm porosity.

The HPLC analyses were carried out using a Phenomenex, Rezex 8mµ 8% H^+ column, 300 mm long and 7.8 mm wide, H_2SO_4 aqueous solvent solution at 8 mM and 0.5 mL/minute elution rate. The equipment was calibrated by injecting standard solutions containing 10-50 mM lactic acid/L, 10-60 mM acetic acid/L, 15-150 mM propionic acid and 10-50 mM butyric acid where the standards were also filtered through cellulose acetate membrane with 0.45 µm porosity. The peaks of organic acid concentration in the silage juice samples were obtained from the areas in relation to the calibration curve for each standard injected, using Origin 6.0 Profissional software.

A randomized complete design with four replications was used and the data obtained were first analyzed to meet the assumptions of normality, additivity and homocedasticity. The data obtained for EE, pH and $N\text{-}NH_3$ (% total nitrogen) were transformed to (1/EE), ($pH^{-0.5}$) and (1/root $N\text{-}NH_3$), respectively, for regression analysis.

The data for the silage bromatological and fermentative characteristics were submitted to analyses of variance and regression. The models were chosen based on the significance of the linear and quadratic coefficients, by the Student t test at the levels of 1 and 5% probability. The PROC REG procedure of the SAS software (2001) was adopted as a tool to help in the statistical analyses.

Results and Discussion

The addition of dried cashew stalk raised ($P<0.01$) the dry matter contents of the silages (Table 1), that increased 0.36 percentage points for every 1% of dried cashew stalk included in the silage. The increase in the dry matter content of the silage with the addition of dried cashew stalk was due to the reduced moisture obtained by drying this by-product, according to the chemical composition presented previously.

A similar value was observed in the present study with the addition of 16% dried cashew stalk (23.72% dry matter) to that reported by Ferreira et al.(2004), who assessed elephant grass silages and observed a maximum 23.75% dry matter content with 18.33% dried cashew stalk bagasse. However, Gonçalves et al. (2007) ensilaged elephant grass and brachiaria grass with increasing levels of dried cashew stalk and observed increase in the dry matter contents ($P<0.01$) of 0.65 and 0.58 percentage points for each 1% addition of the by-product, respectively.

Although these data proved that the edition of dried cashew stalk during elephant grass ensilage raised the dry matter content of the silages produced, the maximum content obtained (23.72% dry matter) at the level of 16% addition was below the minimum characteristic of good-quality silage, that is between 30 and 35% dry matter (McDonald et al., 1981) a fact explained by the high moisture content contained in the elephant grass, that presented only 16.80% dry matter at cutting. The addition of 16% dried cashew stalk resulted in an increase of 5.76 percentage points in the dry matter contents of the silage.

The effect of raising the dry matter contents in the silages on Clostridia bacterial growth does not occur only after these levels are reached. According to Muck (1988), as dry matter content increases the water activity decreases progressively, causing proportional reduction in microorganism growth, especially the Clostridium genus. Thus, the addition of dried cashew stalk favored the fermentation progress even if the dry matter contents considered ideal were not reached.

The addition of dried cashew stalk increased ($P<0.01$) the silage crude protein contents (Table 1). For each 1% addition of the by-product, the crude protein contents increased 0.12 percentage point, with a variation of 6.14% without adding dried cashew stalk and up to 8.06% with the addition of 16% dried cashew stalk. This beneficial effect of adding dried cashew stalk on the silage crude protein content was due to the greater content of this nutrient compared to that in elephant grass.

The results observed in the present study confirmed those obtained by Ferreira et al. (2004) and Gonçalves et al. (2004, 2006 and 2007), who observed increase in the dry matter contents of tropical grass silage with the addition of cashew bagasse, Caribbean Cherry, urucum and dried cashew stalk, respectively. The neutral detergent fiber and acid detergent fiber contents of the silages were affected ($P<0.1$) and decreased linearly with increased dried cashew stalk levels (Table 1). For each 1% of added dried cashew stalk, the neutral detergent fiber decreased 0.71 percentage point, with a variation of 72.66 and 61.30% at the levels of 0 and 16% dried cashew stalk, respectively.

This effect of the levels of dried cashew stalk addition on the neutral detergent fiber content in the silage was related to the low content of this nutrient (31.53%) in the by-product. However, the data obtained in the present study differed from those obtained by Gonçalves et al. (2007) who did not observe alterations in the neutral detergent fiber contents of elephant grass silages containing dried cashew stalk. The high neutral fiber detergent contents (73.14%) observed in the dried cashew stalk used by these authors justified the difference in the results.

The reduction in the neutral detergent fiber content in the silages improved their nutritional characteristics, because, according to Van Soest (1994), starting at 70% of this nutritional fraction, food intake is limited by the physical effect of filling the rumen. In the present study, with the addition of 3.80% dried cashew stalk, the neutral detergent fiber contents remained below the value reported by Van Soest (1994) as limiting for forage ingestion.

For each 1% addition of dried cashew stalk, a reduction of 0.51 percentage points was observed in the acid detergent fiber contents, that ranged from 46.66 to 38.50%, respectively, at the levels of 0 and 16% dried cashew stalk. The decrease in the acid detergent fiber contents was caused by the dried cashew stalk ADF content (26.48%) that was lower than that of the elephant grass (47.62) at ensilage.

The hemicellulose content of the silages was affected ($P<0.01$) by the dried cashew stalk levels and presented a decreasing and linear response (Table 1). For each 1% of dried cashew stalk added, the hemicellulose content decreased 0.20 percentage point, with a variation of 26 and 18% between the levels of 0 and 16% dried cashew stalk. This decrease in the hemicellulose contents may be associated to the small hemicellulose content of the dried cashew stalk (5.05%) compared to that of the elephant grass (28.95%) at ensilage, and to the use of the hemicellulose by the fermentative bacteria in the ensiling process (McDonald, 1981; Crestana et al., 2001).

The levels of dried cashew stalk had a linear effect ($P<0.01$) on the ether extract contents of the silages (Table 1), so that For each 1% addition of the by-product, there was an increase of 0.13 percentage points in the ether extract contents of the silages, probably as a result of the greater ether extract content of the dried cashew stalk (5.29%) compared to that of the elephant grass (4.30%).

Gonçalves et al. (2006) observed increased ether extract contents and reported a 0.03 percentage point increase for each 1% urucum by-product added. Sá et al. (2007) worked with dried mango by-product and observed an increase of 0.07 percentage point in the ether extract contents of the silages for each 1% addition of the by-product.

Adding dried cashew stalk did not alter the total carbohydrate contents of the silages ($P<0.05$) whose average content was 78.56% (Table 1), a fact explained by the dried cashew stalk total carbohydrate content (80.84%) that was close to that of the elephant grass (78.17%) and did not interfere in the total carbohydrate contents of the silages up to the level used.

Adding dried cashew stalk raised the nonfibrous carbohydrate contents of the silages ($P<0.01$) that increased as a result of the increase of 0.66 percentage point in the total carbohydrate contents for each 1% addition of the by-product at ensilage (Table 1). Adding dried cashew stalk raised the nonfibrous carbohydrate contents from 6.28, at

Table 1 - Chemical composition of the elephant grass silages containing dried cashew stalk

Item	Dried cashew stalk level (%)					Regression	R^2	CV (%)
	0	4	8	12	16			
Dry matter	17.21	20.10	21.18	22.65	23.20	$\hat{Y}$ = 17.96+0.36x**	0.91	3.17
Crude protein	5.88	6.95	7.15	7.71	7.97	$\hat{Y}$ = 6.14+0.12x**	0.81	4.81
Neutral detergent fiber	73.92	69.04	65.99	63.51	62.54	$\hat{Y}$ = 72.66-0.71x**	0.89	2.13
Acid detergent fiber	48.54	42.07	42.95	39.98	39.42	$\hat{Y}$ = 46.66-0.51x**	0.72	4.25
Hemi cellulose	25.38	26.96	23.04	23.52	23.12	$\hat{Y}$ = 26.00-0.20x**	0.40	5.58
Ether extract	2.34	2.58	2.76	3.41	4.63	1/EE($\hat{Y}$) = 0.44-0.013x**	0.88	8.08
Total carbohydrates	78.39	78.60	79.70	78.79	77.32	$\hat{Y}$ = 78.56±0.53	-	0.67
Non-fibrous carbohydrates	4.46	9.56	13.70	15.28	14.78	$\hat{Y}$ = 6.28+0.66x**	0.79	17.14
Neutral detergent insoluble nitrogen	35.62	37.98	44.38	45.33	48.64	$\hat{Y}$ = 35.71+0.83x**	0.80	5.70
Acid detergent insoluble nitrogen	18.26	18.02	24.72	27.17	29.63	$\hat{Y}$ = 17.18+0.80x**	0.83	8.85

**($P<0.01$).

the 0% level, to 16.84% at the 16% level of dried cashew stalk, showing an increase of 10.56 percentage points. This result was attributed to the greater nonfibrous carbohydrate content of the by-product (49.31%) compared to that of the elephant grass (1.60%) at ensilage. Another factor that may also have contributed to raising the nonfibrous carbohydrates of the silages was the breakdown of chemical links in the structural carbohydrates, especially hemicellulose (Tosi et al., 1999). The nonfibrous carbohydrates can serve as a substrate for the bacteria of the *Lactobacillus* genus to improve silage fermentation (Ferreira et al., 2004), and, if present at high levels, increase the silage intake, digestibility and energetic density. The neutral detergent insoluble nitrogen (% total nitrogen) of the silages was influenced by the addition of dried cashew stalk (Table 1). The increase was 0.83 percentage point at the concentration of neutral detergent insoluble nitrogen (% total nitrogen) for each 1% addition of dried cashew stalk to the silage. In spite of the similarity in the neutral detergent insoluble nitrogen (% total nitrogen) contents of the elephant grass (61.81%) and the dried cashew stalk (64.19%), the concentration of this nitrogen fraction decreased during the ensilage process, that probably because the enzymes produced in the ensilage process acted on the nitrogen linked to the cell wall constituents. According to Van Soest (1994), the neutral detergent insoluble nitrogen (% total nitrogen), when soluble in acid detergent, can present considerable digestibility, but this nitrogen presents slower digestion rates. Certainly, this slow nitrogen availability, along with the low crude protein content, will limit the use of these silages.

The dried cashew stalk levels had an increasing linear effect ($P<0.01$) on the acid detergent insoluble nitrogen (% total N) of the silages (Table 1). The dried cashew stalk presented greater nitrogen content (51.05%) compared to the elephant grass (20.65%) at ensilage. Thus, the acid detergent insoluble nitrogen contents in the silages increased linearly. For each 1% dried cashew stalk added, the acid detergent insoluble nitrogen contents of the silages increased 0.80 percentage point.

The pH values were influenced ($P<0.01$) by the dried cashew stalk levels (Table 2). The increase of 1% dried cashew stalk resulted in a decrease of 0.03 percentage point in the pH value of the silages. The pH of all the silages studied was considered adequate for good fermentation but the pH value is a parameter of little importance when assessed alone because for a silage to be considered of good quality, a rapid fall in the pH is necessary so that the $N\text{-}NH_3$ and butyric acid contents do not increase (Whittenbury et al., 1967).

The results obtained were in line with those by Gonçalves et al. (2007), who observed a 0.03 percentage point decrease in the pH of for each 1% dried cashew stalk added to the elephant grass silage. The $N\text{-}NH_3$ (% total nitrogen) contents also decreased linearly ($P<0.01$) with the addition of dried cashew stalk to the silages (Table 2). For each 1% dried cashew stalk added, a 1.02 percentage point decrease was observed in the $N\text{-}NH_3$ contents. High $N\text{-}NH_3$ (>12%) content is associated to protein breakdown and indicates poor quality silage (McDonald, 1981) that shows proteolysis in the silage.

The addition of 3.5% dried cashew stalk was sufficient to reduce the $N\text{-}NH_3$ contents below critical levels (<12% total N) as reported by McDonald (1981). Although the addition of dried cashew stalk was not sufficient to reach the ideal dry matter contents for good fermentation, that is, 28 to 34%, according to McCullough (1977), the fermentation characteristic improved substantially, suggesting that the high nonfibrous carbohydrate content of dried cashew stalk was sufficient for rapid pH reduction and good silage fermentation.

Ferreira et al. (2004) reported that elephant grass silage with dried cashew stalk bagasse reduced the $N\text{-}NH_3$ contents to levels below 12%, with the minimum percentage of 2.75% with the addition of 44.11% cashew bagasse.

The dried cashew stalk favored a 0.34 percentage point increase ($P<0.01$) in the lactic acid contents for every 1% dried cashew stalk added (Table 2). The additive was efficient in producing the quantity of lactic acid necessary to quickly reduce the pH of the ensiled material. The maximum content obtained with the addition of 10% dried

Table 2 - Fermentation characteristics of elephant grass silages with the addition of dried cashew stalk

	Dried cashew stalk level (%)					Regression	R^2	CV (%)
	0	4	8	12	16			
pH	4.22	3.68	3.67	3.62	3.69	$(pH^{-0,5})$ $(\hat{Y})$ = 0.50+0.002x**	0.35	2.59
N-ammoniacal $N\text{-}NH_3$ (% N total)	23.14	9.57	6.41	3.71	3.07	(1/root $N\text{-}NH_3$) $(\hat{Y})$ = 0.22+0.02x**	0.94	8.26
Látic acid	2.81	7.00	7.97	7.81	9.26	$\hat{Y}$ = 4.23+0.34x**	0.57	24.05
Acetic acid	1.41	0.72	1.26	1.09	0.77	$\hat{Y}$ = 1.05±0.43	-	17.05
Propionic acid	0.63	0.70	0.97	2.17	4.53	$\hat{Y}$ = -0.06+0.23x**	0.64	55.78
Butyric acid	0.74	000	0.00	0.00	0.00	$(\hat{Y})$ = 0.15	-	2.17

*($P<0.05$). **($P<0.01$).

cashew stalk was higher than that reported by Roth & Heinrichs (2006). The high H+ disassociation power contained in lactic acid (Moisio & Heikonen, 1994) contributed to the decrease in the silage pH, especially for the elephant grass silage, that because of its high water content at ensilage, presented high buffering power.

Dried cashew stalk did not influence (P>0.01) the acetic acid content of the silages, whose average was around 1.05 ± 0.43%, a value below the maximum excepted of 2%, to consider a silage of good quality (Roth & Undersander, 1995). It is important to remember that, as the pH values and lactic acid levels were adequate, the acetic acid levels around 1% dry matter can even favor greater aerobic stability after opening the silo.

For each 1% dried cashew stalk added to the elephant grass at ensilage, there was a 0.23 percentage point increase in propionic acid in the silage (Table 2). All the silages presented a quantity of propionic acid greater than the limit (0.5%) suggested by Roth & Undersander, 1995. As the main fermentation characteristics of the silages were within the desirable standard, the rise in the propionic acid contents may have resulted from the dried cashew stalk itself, because during the drying process, some fermentation process may have occurred.

Butyric acid was detected only in the untreated elephant grass silage, so dried cashew stalk addition was efficient in controlling clostridium fermentations starting at the lower level of addition (4% dried cashew stalk). According to McDonald (1981) and Roth & Undersander (1995), butyric acid levels lower than 1% indicate desirable fermentation, resulting from the low activity of the bacteria of the Closstridium genus that present proteolytic activity.

Conclusions

Dried cashew stalk can be ensiled with elephant grass up to the level of 16%, because it increases the crude protein and nonfibrous carbohydrate contents and reduces the neutral detergent fiber and acid detergent fiber contents that improve the fermentation standard of the silages. However, the impact of adding the byproduct on the final cost of the silage should be assessed.

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