Acta Scientiarum. Animal Sciences
ISSN: 1806-2636
eduem@uem.br
Universidade Estadual de Maringá
Brasil

Santos Brant, Lara Maria; Silveira Pimentel, Paulo Roberto; Sampaio Rigueira, João Paulo; Alves, Dorismar David; Alves Macedo Carvalho, Mateus; Sousa Alves, Wagner
Fermentative characteristics and nutritional value of elephant grass silage added with dehydrated banana peel
Acta Scientiarum. Animal Sciences, vol. 39, núm. 2, abril-junio, 2017, pp. 123-129
Universidade Estadual de Maringá
Maringá, Brasil

Acta Scientiarum

http://www.uem.br/acta
ISSN printed: 1806-2636
ISSN on-line: 1807-8672
Doi: 10.4025/actascianimsci.v39i2.33925

# Fermentative characteristics and nutritional value of elephant grass silage added with dehydrated banana peel

**Lara Maria Santos Brant[1*], Paulo Roberto Silveira Pimentel[1], João Paulo Sampaio Rigueira[2], Dorismar David Alves[2], Mateus Alves Macedo Carvalho[2] and Wagner Sousa Alves[2]**

*[1]Universidade Federal da Bahia, Avenida Ademar de Barros , 500, 40170-110, Salvador, Bahia, Brazil. [2]Universidade Estadual de Montes Claros, Janaúba, Minas Gerais, Brazil. *Author for correspondence. E-mail: lara_brantt@hotmail.com*

**ABSTRACT.** The aim of this study was to evaluate the fermentative losses and nutritional value of elephant grass silages with the increasing of inclusion levels of dehydrated banana peel. The experiment was conducted in a completely randomized design, with six treatments and four replications, being the silage exclusively from elephant grass, and five levels of inclusion of banana peel to the elephant grass silage, as the following - 5; 10; 15; 20 and 25%, being added based on natural matter. The addition of the banana peel in the silage reduced linearly ($p < 0.05$) the pH, the ammoniacal nitrogen and the losses of the fermentative process. In addition, the inclusion of banana peel increased linearly ($p < 0.05$) the dry matter and non-fibrous carbohydrates. On the other hand, the neutral detergent fiber and the acid detergent fiber were linearly reduced with the inclusion of the banana peel ($p < 0.05$), but there was no change in the dry matter digestibility *in situ*. The inclusion of dehydrated banana peel in elephant grass silage reduces the losses of the fermentation process with more consistent results at the 25% inclusion level, however, it reduces the silage nutritional value due to fibrous and protein quality.

**Keywords:** co-product, fermentation, *Musa*, *Pennisetum purpureum*.

## Características fermentativas e valor nutricional da silagem de capim-elefante aditivada com casca de banana desidratada

**RESUMO.** Objetivou-se com este estudo avaliar as perdas fermentativas e o valor nutricional das silagens de capim-elefante com níveis crescentes de inclusão da casca de banana desidratada. O experimento foi conduzido em delineamento inteiramente casualizado, com seis tratamentos e quatro repetições, sendo silagem exclusiva de capim-elefante e cinco níveis de inclusão da casca de banana à silagem de capim-elefante - 5; 10; 15; 20 e 25%, sendo adicionada com base na matéria natural. A adição da casca de banana na ensilagem reduziu linearmente ($p < 0,05$) o pH, nitrogênio amoniacal e as perdas do processo fermentativo. Ademais, a inclusão da casca de banana aumentou de forma linear ($p < 0,05$) a matéria seca e os carboidratos não fibrosos. Já a fibra em detergente neutro e em detergente ácido reduziu linearmente com inclusão da casca de banana ($p < 0,05$), mas não houve alteração na digestibilidade *in situ* da matéria seca. A inclusão de casca de banana desidratada na ensilagem do capim-elefante reduz as perdas do processo fermentativo com resultados mais consistentes no nível de 25% de inclusão, entretanto, reduz o valor nutricional por detrimento da qualidade fibrosa e proteica.

**Palavras-chave:** coproduto, fermentação, *Musa*, *Pennisetum purpureum*.

## Introduction

One of the main reasons that justify the production of forage grasses silages is the possibility of conserving the plant's surplus production during favorable growing seasons. This justification takes more relevance in regions where the pluviometric indexes are restrictive and/or with irregular distribution, such as the Brazilian semi-arid region.

Among the forage grasses used for silage production, elephant grass (*Pennisetum purpureum* Schum.) stands out due to its high dry matter production per cultivated area (Figueira, Neumann, Ueno, Galbeiro, & Bueno, 2016). However, when the grass presents adequate nutritive value for silage production, it also contains a higher moisture content, resulting in undesirable fermentation and thus it represents an obstacle to the use of elephant grass in the silage form (Zanine et al., 2016).

Several studies (Lukkananukool et al., 2013, Epifanio, Costa, Severiano, Bento, & Perim, 2014, Figueredo et al., 2014, Menezes et al., 2016, Guerra et al., 2016) have been carried out with the objective of evaluating treatments that benefit the fermentative process and the reduction of losses of tropical grass silages, among which the use of additives was highlighted. In this sense, the adsorbent additives, characterized by reducing or eliminating effluent production, may assume relevance in the production of forage grass silages with high moisture content.

Dehydrated banana peel (*Musa spp*.) can be a viable alternative as an additive in forage grass silages with high moisture content, since it has a high content of dry matter, 91.64% (Souza et al., 2016), and a high nutritional value, being a rich source of carbohydrates, mainly pectin, ranging from 10 to 21% DM (Mohapatra, Mishra, & Sutar, 2010). Also, it has soluble carbohydrates, which can reach 32.4% DM (Emaga, Andrianaivo, Wathelet, Tchango, & Paquot, 2007).

The co-products used in animal feed, besides reducing the demand for food commonly used in human nutrition, they ensure the ecologically correct disposal of this material. It is likely to notice the possibility of using dehydrated banana peel as an additive to elephant grass silage helps to consolidate the concept of sustainability into the production chain of ruminants of livestock interest.

In this regard, the objective of the study was to evaluate the fermentative losses and the nutritional value of elephant grass silage added with dehydrated banana peel.

## Material and methods

The experiment was conducted in the Departamento de Ciências Agrárias, of Universidade Estadual de Montes Claros (Unimontes), Campus Janaúba, northern region of Minas Gerais. The forage used was elephant grass, Purple cultivar, from an area established at the Experimental Farm of Unimontes, Janaúba Campus. The design was completely randomized, with six treatments (silage exclusively from elephant grass and five levels of inclusion of dehydrated banana peel to elephant grass silage - 5; 10; 15; 20 and 25%, based on natural matter), with four replicates in each treatment.

The forage was submitted to a standardization cut at an average height of 10 cm of the soil, and after a regrowth period of 60 days it was collected manually and chopped in a stationary forage harvester, adopting the fragment's size of approximately 1 to 2 cm.

Immediately after chopping the elephant grass, the material was homogenized and mixed with the banana peel, according to the inclusion levels evaluated in the ensiling.

The banana peel, obtained after the removal of the pulp, was previously dehydrated by sun exposure. When it was breakable, the banana peel was disintegrated in a stationary forage machine, in order to favor the homogenization of the material in elephant grass ensilage.

The chemical-bromatological composition of elephant grass and dehydrated banana peel are presented in Table 1.

**Table 1.** Chemical-bromatological composition of elephant grass and dehydrated banana peel.

| Item | Elephant grass | Dehydrated banana peel |
|---|---|---|
| Dry matter (DM) | 15.63 | 89.67 |
| Mineral matter[1] | 11.94 | 12.66 |
| Neutral detergent insoluble ash (NDIA)[1] | 2.48 | 3.00 |
| Acid detergent insoluble ash (ADIA)[1] | 1.03 | 2.34 |
| Crude protein[1] | 6.80 | 6.12 |
| Neutral detergent insoluble protein (NDIP)[2] | 20.21 | 49.63 |
| Acid detergent insoluble protein (ADIP)[2] | 12.16 | 33.92 |
| Ether extract[1] | 1.69 | 7.12 |
| Neutral detergent fiber corrected for ash (NDFa)[1] | 67.29 | 38.32 |
| Acid detergent fiber corrected for ash (ADFa)[1] | 46.26 | 30.62 |
| Hemicellulose [1] | 26.12 | 14.7 |
| Cellulose [1] | 35.17 | 18.40 |
| Lignin[1] | 9.01 | 13.35 |
| Non-fiber carbohydrates (NFC)[1] | 12.28 | 35.78 |

[1]% of DM; [2]% of crude protein.

It was used experimental PVC silos with dimensions of 50 cm in height and 10 cm in diameter, with Bunsen valve in the lid. At the bottom of the silos, 0.4 kg of dry sand was added to drain the effluents produced, as well as a foam to avoid the contact of the forage with the sand. The set consisting of silo, lid, sand and foam were previously weighed in order to estimate the empty weight of the silo.

The silages were put in the silos and compacted with the help of a wooden plunger until it reach the density of $550\pm20$ kg $m^3$. After the ensilage was complete, the silos were sealed and stored at room temperature. The opening of the silos occurred 60 days after ensilage, and they were previously weighed to determine the losses by gases. After opening the silos, the silage, silo, foam and sand were weighed to quantify losses by effluents. Losses through gas, effluents and dry matter recovery rate were calculated using the equations proposed by Gandra et al. (2016).

When the silage was removed from each silo, the material was homogenized, and a part was pressed with the aid of a hydraulic press, for extraction of the broth and immediate determination of the hydrogen ionic potential (pH) with a digital potentiometer (Wilson & Wilkins, 1972). The ammoniacal nitrogen ($N\text{-}NH_3$) was also quantified in the broth, by distillation with magnesium oxide and calcium chloride, using boric acid solution and titration with hydrochloric acid at 0.1 N (Association of Official Analytical Chemistry [AOAC], 1980).

One sample of the silage was collected to determine the water activity (AW) using the AquaLab 4TE DUO equipment (Tolentino et al., 2016). The remaining silage from each silo was pre-dried in a forced ventilation oven at 55°C for 72 hours. Then, the pre-dried silage was grinded through a 1-mm screen in a Wiley millfor further chemical-bromatological analysis.

The analyzes were performed according to the analytical procedures of the National Institute of Science and Technology in Animal Science (INCT-CA; Detmann et al., 2012). It was determined the levels of dry matter (DM) (INCT-CA G-003/1), crude protein (CP) (INCT-CA M-001/1), ether extract (EE) (INCT-CA G-005/1), mineral matter (MM) (INCT-CA N-001/1), neutral detergent fiber (NDF) (INCT-CA F-002/1), neutral detergent fiber corrected for ash (NDFa) (INCT-CA M-002/1) and neutral detergent insoluble protein (NDIP) (INCT-CA N-004/1), acid detergent fiber (ADF) acid detergent fiber corrected for ash (ADFa) (INCT-CA M-003/1), acid detergent insoluble protein (ADIP) (INCT-CA N-005/1) and lignin (LIG) (INCT-CA F-005/1). The hemicellulose levels (HEM) were calculated through the difference between the NDF and ADF, and the cellulose (CEL) through the difference between ADF and lignin.

The content of non-fiber carbohydrates (NFC) was obtained by the equation proposed by Detmann and Valadares Filho (2010), as it follows Equation 1:

$$NFC = 100 - MM - EE - NDFa - CP \quad (1)$$

The dry matter digestibility was evaluated by the *in situ* incubation method (DISDM) for a period of 48 hours, using two crossbred Holstein-Zebu steers with rumen cannula. The samples used in the ruminal incubation were sieved with 5 mm sieves and packed in bags (7.5 x 7.5 cm), made with a nonwoven fabric (100 g $m^2$) according to Casali et al. (2008), in order to maintain a ratio close to 20 mg of MS $cm^2$ of bag surface area (Nocek, 1988). After 48 hours of ruminal incubation, all bags were washed manually under running water until they became translucid, and then, the bags were dried in forced ventilation oven at 55ºC for 72 hours, and later weighed for determination of *in situ* dry matter digestibility.

The collected data were submitted to analysis of variance by the SISVAR program (Ferreira, 2011) and when significant, the means of the treatments were submitted to regression analysis at the 5% probability level.

## Results and discussion

The dry matter content of elephant grass silages increased linearly ($p < 0.05$) as the dehydrated banana peel was added (Table 2). For each 1% of banana peel addition to silage, it was observed a 0.40% elevation in dry matter content.

**Table 2.** Mean values of dry matter (DM), pH, ammoniacal nitrogen ($NH_3$ $N^{-1}$ total; % of the total nitrogen), water activity (Aw), losses through effluent (EL; kg $t^{-1}$ of green matter), losses through gas (GL; % of DM) and dry matter recovery rate (DMRR) of the elephant grass silage added with dehydrated banana peel.

| Item | Levels of banana peel (%) | | | | | | CV | Value-p |
|---|---|---|---|---|---|---|---|---|
| | 0 | 5 | 10 | 15 | 20 | 25 | | |
| DM | 19.1 | 23.4 | 25.1 | 27.3 | 30.6 | 34.9 | 2.72 | < 0.01 |
| pH | 4.67 | 4.34 | 4.06 | 4.06 | 4.07 | 4.03 | 1.87 | < 0.01 |
| $NH_3$ N-total$^{-1}$ | 4.29 | 4.27 | 4.02 | 3.95 | 3.76 | 2.58 | 7.21 | < 0.01 |
| Aw | 0.97 | 0.96 | 0.96 | 0.95 | 0.95 | 0.94 | 0.19 | < 0.01 |
| EL (kg $t^{-1}$ GM) | 50.9 | 46.6 | 35.2 | 36.5 | 11.7 | 10.2 | 13.9 | < 0.01 |
| GL (% DM) | 0.18 | 0.17 | 0.14 | 0.08 | 0.05 | 0.03 | 6.48 | < 0.01 |
| DMRR | 91.9 | 93.6 | 94.2 | 95.5 | 96.8 | 97.9 | 1.07 | < 0.01 |
| | Regression Equations | | | | | | | |
| DM | $\hat{Y} = 19.270272+0.403554*X$ | | | | | | $R^2 = 97.48\%$ | |
| pH | $\hat{Y} = 4.488190-0.015123*X$ | | | | | | $R^2 = 80.32\%$ | |
| $NH_3$ N-total$^{-1}$ | $\hat{Y} = 4.538826-0.038611*X$ | | | | | | $R^2 = 82.74\%$ | |
| Aw | $\hat{Y} = 0.966237-0.000548*X$ | | | | | | $R^2 = 95.17\%$ | |
| EL (kg $t^{-1}$ GM) | $\hat{Y} = 53.754256-1.168053*X$ | | | | | | $R^2 = 90.38\%$ | |
| GL (% DM) | $\hat{Y} = 0.193249-0.004505*X$ | | | | | | $R^2 = 96.71\%$ | |
| DMRR | $\hat{Y} = 92.050504+0.155913*X$ | | | | | | $R^2 = 99.15\%$ | |

CV = coefficient of variation.

The dry matter levels ranged from 19.09 to 34.89%, in the silage exclusively from elephant grass and in the silage added with 25% of banana peel, respectively, indicating that the banana peel, due to its high content of dry matter (89.67% - Table 1), is an efficient additive to raise the dry matter content of elephant grass silages.

The forage dry matter concentration is one of the most important factors to obtain silage with a good fermentation standard. Among the evaluated levels, the treatments with 20 and 25% inclusion of the banana peel presented values of 30.63 and 34.89% of dry matter, value within the range of 30 to 35%. This inhibits the growth of undesirable bacteria that produce butyric acid, acetic acid, ammonia and carbonic gas, thus facilitating a more efficient fermentation process (McDonald, Henderson, & Heron, 1991).

The pH was influenced by the addition of banana peel to the elephant grass silage ($p < 0.05$), showing a linear decreasing effect, as for each 1% inclusion of banana peel to elephant grass silage, there was a reduction of 0.02% in the silage pH (Table 2).

The lowest pH value in the silages with banana peel can be explained by the higher non-fibrous carbohydrate content in the banana peel (35.78% - Table 1) than in elephant grass (12.28% - Table 1). The silages with inclusion of up to 10% of banana peel presented pH values within the range of 3.8 to 4.1, which restrict the growth of undesirable microorganisms such as enterobacterias and clostridium (Arriola, Kim, & Adesogan, 2011). However, it is worth mentioning that the pH drop rate is more important than the final pH, because it is directly proportional to the decrease of the undesirable microorganism's activity in the silo (McDonald et al., 1991).

Regarding the ammoniacal nitrogen content, as a percentage of total nitrogen, it was influenced by the addition of banana peel ($p < 0.05$), presenting a linear decreasing effect, with a reduction of 0.04 for each 1% of banana peel added to silage (Table 2).

The ammoniacal nitrogen is an important feature in the evaluation of silage, since it indicates the amount of degraded protein during the fermentation phase (Pires et al., 2013). According to Costa et al. (2016), the concentration of ammoniacal nitrogen in the silages should be less than 10% of the total nitrogen in the silage, thus conferring good quality to the product. It is possible that the reduction in the ammoniacal nitrogen content is associated with the high dry matter content of the silages with banana peel, because, according to Ribeiro et al. (2014), the highest ammoniacal nitrogen content observed for elephant grass silage, without addition of additive, is associated with the higher moisture content in the ensiled mass, which refers to the low osmotic pressure. This may lead to a higher development of protein-degrading bacteria, such as those of the genus *Clostridium*. Besides the dry matter content, the low pH of the silages with banana peel may also have contributed to the low production of ammoniacal nitrogen, since the growth of these degrading bacteria is limited in low pH conditions (Dunière, Sindou, Chaucheyras-Durand, Chevallier, & Thévenot-Sergentet, 2013).

The water activity and the effluent production were influenced by the addition of banana peel ($p < 0.05$), presenting a linear decreasing effect, with reduction of 0.005 and 1.17 kg $t^{-1}$ GM, respectively, for each 1% of banana peel added to the silage (Table 2).

In regard to the water activity, the lower values observed in the silages with banana peel can be explained by the higher dry matter content of the banana peel (89.67% - Table 1), since according to Tolentino et al. (2016), as the addition of solutes in silages occurs, the lower the water activity will be. The reduction provided by the inclusion of the banana peel is relevant, since the growth of Clostridium bacteria is inhibited with Aw below 0.94 (McDonald et al., 1991), value obtained in the highest level of banana peel inclusion.

The lower effluent production in the silages with banana peel is due to the fact that the banana peel has a high content of dry matter (89.67% - Table 1), which allowed the absorption of the excess moisture from the elephant grass, resulting in lower moisture content of the ensiled mass. In accord with Gebrehanna, Gordon, Madani, VanderZaag, and Wood (2014), the increase in losses by effluents raises the losses of nutrients by leaching with the effluent produced during the ensilage, representing losings in the silage nutritive value.

The loss by gas was influenced by the addition of banana peel to elephant grass silage ($p < 0.05$), presenting a linear decreasing effect of 0.04% reduction for each 1% of banana peel added to the silage (Table 2). Perhaps, the increase in the dry matter content of the ensiled material, as it increases the inclusion of banana peel, may justify this behavior. Losses by gas can be attributed to the incidence of undesirable fermentations caused by the development of gas-producing microorganisms (Santos et al., 2014), which presents their growth associated with the high moisture content of the ensiled material.

The dry matter recovery rate was influenced by the inclusion of banana peel ($p < 0.05$), with increasing linear effect, when for each 1% inclusion of the banana peel there was an increase of 0.16% of dry matter recovery.

The higher dry matter recovery rate in the silages with banana peel was probably due to the lower occurrence of enterobacteria, which is justified by the higher dry matter content and the higher pH retention in the silages with banana peel (Zanine et al., 2016), associated to the fact that silages with banana peel have lower effluent production.

The mineral matter contents were not influenced by the addition of banana peel to the elephant grass silage ($p > 0.05$) (Table 3), presenting an average value of 12.53%. These results indicate that the mineral matter contents of banana peel and elephant grass are equivalent. However, the neutral detergent insoluble ash (NDIA) and acid detergent insoluble ash (ADIA) were influenced by the addition of banana peel ($p < 0.05$), presenting linear increasing effect, with increases of 0.56 and 0.48% for each 1% inclusion, respectively (Table 3). These results can be explained by the higher NDIA and ADIA contents in the banana peel than in the elephant grass.

**Table 3.** Mean values of the chemical-bromatological composition of the elephant grass silage added with banana peel.

| Item | Levels of banana peel (%) | | | | | | CV | Value-P |
|---|---|---|---|---|---|---|---|---|
| | 0 | 5 | 10 | 15 | 20 | 25 | | |
| MM | 12.0 | 12.1 | 12.5 | 13.0 | 12.8 | 12.9 | 3.85 | 0.1313 |
| NDIA | 0.79 | 1.03 | 1.63 | 1.79 | 1.99 | 2.14 | 19.6 | 0.0206 |
| ADIA | 0.45 | 0.54 | 1.04 | 1.23 | 1.37 | 1.60 | 11.9 | < 0.01 |
| EE | 2.46 | 3.45 | 4.72 | 5.00 | 5.08 | 5.68 | 9.61 | < 0.01 |
| CP | 6.56 | 6.50 | 6.50 | 6.58 | 6.55 | 6.51 | 2.55 | 0.9831 |
| NDIP | 21.7 | 26.7 | 28.2 | 28.9 | 32.1 | 36.4 | 6.53 | < 0.01 |
| ADIP | 12.3 | 16.3 | 21.4 | 26.0 | 29.9 | 31.5 | 8.91 | < 0.01 |
| NDFap | 68.6 | 65.1 | 63.2 | 59.7 | 55.6 | 50.2 | 1.84 | < 0.01 |
| ADFap | 46.3 | 44.1 | 43.2 | 41.7 | 38.9 | 35.1 | 3.58 | < 0.01 |
| HEM | 26.4 | 25.2 | 25.4 | 22.0 | 22.5 | 20.1 | 4.58 | < 0.01 |
| CEL | 39.9 | 36.3 | 33.0 | 33.4 | 28.4 | 24.1 | 3.58 | < 0.01 |
| LIG | 6.65 | 8.73 | 9.79 | 10.1 | 11.1 | 12.2 | 12.5 | < 0.01 |
| NFC | 10.4 | 12.8 | 13.2 | 15.8 | 19.7 | 24.8 | 9.31 | < 0.01 |
| DISDM | 48.8 | 47.1 | 49.4 | 50.7 | 53.7 | 51.5 | 5.02 | 0.0945 |
| Regression Equations | | | | | | | | |
| NDIA | $\hat{Y} = 0.857744+0.056220*X$ | | | | | | $R^2 = 94.29\%$ | |
| ADIA | $\hat{Y} = 0.436333+0.048285*X$ | | | | | | $R^2 = 94.29\%$ | |
| EE | $\hat{Y} = 2.880909+0.080980*X$ | | | | | | $R^2 = 89.39\%$ | |
| NDIP | $\hat{Y} = 22.540034+0.344125*X$ | | | | | | $R^2 = 94.51\%$ | |
| ADIP | $\hat{Y} = 12.787382+0.539158*X$ | | | | | | $R^2 = 98.20\%$ | |
| NDFap | $\hat{Y} = 69.279006-0.710463*X$ | | | | | | $R^2 = 97.78\%$ | |
| ADFap | $\hat{Y} = 46.755957-0.277882*X$ | | | | | | $R^2 = 94.78\%$ | |
| HEM | $\hat{Y} = 26.683197-0.164055*X$ | | | | | | $R^2 = 89.05\%$ | |
| CEL | $\hat{Y} = 39.821852-0.390539*X$ | | | | | | $R^2 = 94.95\%$ | |
| LIG | $\hat{Y} = 7.245714+0.133917*X$ | | | | | | $R^2 = 94.95\%$ | |
| NFC | $\hat{Y} = 9.282832+0.544322*X$ | | | | | | $R^2 = 92.24\%$ | |

CV = coefficient of variation.

There was a linear increase in the content of ether extract ($p < 0.05$), with the inclusion of banana peel in elephant grass silage, estimating an increase of 0.08% for each 1% inclusion of banana peel (Table 3). This increase is due to the fact that the banana peel has a higher content of ether extract (7.12% - Table 1), when compared to the elephant grass (1.69% - Table 1), thus providing an improvement in the energy supply of the silages with banana peel, since ether extract provides more energy than carbohydrates and proteins. Although there was an increase in the ether extract contents with the banana peel inclusion, the values remained below the limit of 6 to 7% recommended by the National Research Council (NRC, 2001).

There was no influence in the crude protein contents of the elephant grass by the addition of dehydrated banana peel (Table 3). This fact is associated with the banana peel presenting crude protein content close to the value found in elephant grass, 6.12 and 6.80% (Table 1), respectively. The mean crude protein content of the silages was 6.55%, below the minimum required for a good ruminal functioning (Lazzarini et al., 2013).

The levels of neutral detergent insoluble protein (NDIP) and acid detergent insoluble protein (ADIP) in elephant grass silage were influenced by the addition of dehydrated banana peel ($p < 0.05$). There was a linear increase for these two variables, with increases of 0.34 and 0.54% in the NDIP and ADIP contents, respectively, for each 1% inclusion of the banana peel (Table 3), being explained by the higher values of these components in banana peel when compared to elephant grass (Table 1).

From the nutritional aspect, high levels of NDIP and ADIP are not desirable, since NDIP has a slow rate of ruminal degradation, compromising the access of microorganisms to nitrogenous compounds (Wang et al., 2016). However, the ADIP, because it is composed of nitrogen associated with lignin, tannin-protein complexes and *Maillard* reaction compounds, is highly resistant to microbial enzymes and highly indigestible along the gastrointestinal tract of the animals (Costa et al., 2016).

The levels of neutral detergent fiber corrected for ash and protein (NDFap) and acid detergent fiber corrected for ash and protein (ADFap) were influenced by the addition of banana peel to elephant grass silage (Table 3). For each 1% inclusion of banana peel to the silage, there was a reduction of 0.74% of NDFap and 0.49% of ADFap. This decrease can be explained by the lower levels of NDFap (38.32% - Table 1) and ADFap (30.62% - Table 1) in the peel of dehydrated banana in relation to elephant grass (67.29 and 46.26% - Table 1, respectively).

The reduction of the fibrous fraction of the silages added with banana peels is interesting, since forages with high NDF contents limit the dry matter consumption by the animal, because it takes space for a longer time in the digestive tract (Riaz, Südekum, Clauss, & Jayanegara, 2014). According to Van Soest (1994), NDF values greater than 60% correlate negatively with dry matter consumption by ruminants. From the regression equation (Table 3), it can be estimated that with up to 13.81% of inclusion of banana peel to elephant grass silage, it is possible to reach NDFap levels below 60%. In relation to ADFap, it correlates negatively with fiber quality, since according to Gonçalves et al. (2010), high levels of ADF difficult food degradation and the digestion by bacteria.

As banana peel was added, there was a decreasing linear behavior for hemicellulose and cellulose ($p < 0.05$), presenting a reduction of 0.16 and 0.39% for each 1% inclusion of the banana peel, respectively (Table 3).

The fibrous carbohydrates are potentially degradable fractions during the ensiling process and, at low concentrations of soluble carbohydrates in tropical grasses, microorganisms can use fibrous carbohydrates, especially hemicellulose, as an alternative substrate for the fermentation of silage (Arroquy, Cornacchione, Colombatto, & Kunst Jr., 2014). Since the banana peel presents a high content of soluble carbohydrates (Emaga et al., 2007), the reduction of hemicellulose and cellulose in the present study can be related to the lower content of these compounds in the banana peel in relation to the elephant grass (Table 1).

It was observed an increasing linear effect for lignin ($p < 0.05$), presenting an increase of 0.13% for each 1% of banana peel added to the silage, with estimated values ranging from 7.24 to 12.26%, in the silage exclusively from elephant grass and in the silage with 25% of banana peel, respectively (Table 3). The increase in the amount of lignin can be explained by the higher contents of this compound in the banana peel (13.35% - Table 1) in relation to elephant grass (9.01% - Table 1).

There was an increasing linear behavior for the non-fibrous carbohydrate content ($p < 0.05$), showing an increase of 0.54% for each 1% addition of dehydrated banana peel to elephant grass silage (Table 3). The estimated value of non-fibrous carbohydrates was 11.06% in the silage exclusively from elephant grass, increasing to 25.20% at the highest inclusion level of banana peel evaluated. This result can be explained by the high levels of pectin (Mohapatra et al., 2010) and soluble carbohydrates (Emaga et al., 2007) present in banana peel compared to elephant grass, thus justifying the higher levels of non-fibrous carbohydrates in silages with banana peel.

The *in situ* digestibility of the dry matter was not influenced by the inclusion of banana peel in the silage ($p > 0.05$). Probably because the increase in the non-fibrous carbohydrate content concomitantly with the elevation of the lignin contents, in the silages with banana peel, has generated a balance in the dry matter digestibility.

## Conclusion

The addition of dehydrated banana peel in elephant grass silage reduces the losses of the fermentation process, with more consistent results at the 25% inclusion level, however, it reduces the nutritional value of the silage due to fibrous and protein quality.

## Referências


Arriola, K. G., Kim, S. C., & Adesogan, A. T. (2011). Effect of applying inoculants with heterolactic or homolactic and heterolactic bacteria on the fermentation and quality of corn silage. *Journal of Dairy Science, 94*(3), 1511-1516.

Arroquy, J. I., Cornacchione, M. V., Colombatto, D., & Kunst Jr., C. (2014). Chemical composition and *in vitro* ruminal degradation of hay and silage from tropical grasses. *Canadian Journal of Animal Science, 94*(4), 705-715.

Association of Official Analytical Chemistry [AOAC]. (1980). *Official methods of analysis* (13th ed.). Washington, DC: AOAC.

Casali, A. O., Detmann, E., Valadares Filho, S. D. C., Pereira, J. C., Henriques, L. T., Freitas, S. D., & Paulino, M. F. (2008). Influência do tempo de incubação e do tamanho de partículas sobre os teores de compostos indigestíveis em alimentos e fezes bovinas obtidos por procedimentos *in situ*. *Revista Brasileira de Zootecnia, 37*(2), 335-342.

Costa, R. F., Pires, D. A. D. A., Moura, M. M. A., Sales, E. C. J. D., Rodrigues, J. A. S., & Rigueira, J. P. S. (2016). Agronomic characteristics of sorghum genotypes and nutritional values of silage. *Acta Scientiarum. Animal Sciences, 38*(2), 127-133.

Detmann, E., & Valadares Filho, S. C. (2010). On the estimation of non-fibrous carbohydrates in feeds and diets. *Arquivo Brasileiro de Medicina Veterinária e Zootecnia, 62*(4), 980-984.

Detmann, E., Souza, M. A., Valadares Filho, S. C., Queiroz, A. C., Berchielli, T. T., Saliba, E. O. S., ... Azevedo, J. A. G. (2012). *Métodos para análise de alimentos - Instituto Nacional de Ciência e Tecnologia de Ciência Animal, INCT*. Visconde do Rio Branco, MG: Suprema.

Dunière, L., Sindou, J., Chaucheyras-Durand, F., Chevallier, I., & Thévenot-Sergentet, D. (2013). Silage processing and strategies to prevent persistence of undesirable microorganisms. *Animal Feed Science and Technology, 182*(1), 1-15.

Emaga, T. H., Andrianaivo, R. H., Wathelet, B., Tchango, J. T., & Paquot, M. (2007). Effects of the stage of maturation and varieties on the chemical composition of banana and plantain peels. *Food Chemistry, 103*(2), 590-600.

Epifanio, P. S., Costa, K. A. P., Severiano, E. C., Bento, J. C., & Perim, R. C. (2014). Fermentative and bromatological characteristics of *Piatapalisade* grass ensiled whit levels of meals from biodiesel industry. *Semina: Ciências Agrárias, 35*(1), 491-504.

Ferreira, D. F. (2011). *Sisvar sistema de análise de variância. Versão 5.3* [Software]. Lavras, MG: UFLA.

Figueira, D. N., Neumann, M., Ueno, R. K., Galbeiro, S., & Bueno, A. V. I. (2016). Produção e composição química do capim elefante cv. Pioneiro manejado em diferentes alturas de resíduo no ano de implantação da cultura. *Semina: Ciências Agrárias, 37*(2), 1017-1028.

Figueredo, R. S., Costa, K. A. P., Epifanio, P. S., Severiano, E. C., Cruvinel, W. S., Moreira, T. S., & Guimarães, K. C. (2014). Silage quality of *Piatapalisa* degrass with palm kernel cake. *Semina: Ciências Agrárias, 35*(1), 505-518.

Gandra, J. R., Oliveira, E. R., Takiya, C. S., Goes, R. H. T. B., Paiva, P. G., Oliveira, K. M. P., ... Haraki, H. M. C. (2016) Chitosan improves the chemical composition, microbiological quality, and aerobic stability of sugar cane silage. *Animal Feed Science and Technology, 214*(1), 44-52.

Gebrehanna, M. M., Gordon, R. J., Madani, A., VanderZaag, A. C., & Wood, J. D. (2014). Silage effluent management: a review. *Journal of Environmental Management, 143*(1), 113-122.

Gonçalves, J. R. S., Pires, A. V., Susin, I., Lima, L. G. D., Mendes, C. Q., & Ferreira, E. M. (2010). Substituição do grão de milho pelo grão de milheto em dietas contendo silagem de milho ou silagem de capim-elefante na alimentação de bovinos de corte. *Revista Brasileira de Zootecnia, 39*(9), 2032-2039.

Guerra, D. G. F., Maia, I. D. S., Braga, A. P., Assis, L. D. S., Lucena, J. A., Bidler, D. C., ... Pinto, M. M. F. (2016). Chemical composition of elephant grass silages supplemented with different levels of dehydrated cashew bagasse. *Semina: Ciências Agrárias, 37*(2), 997-1005.

Lazzarini, Í., Detmann, E., Paulino, M. F., Valadares Filho, S. D. C., Valadares, R. F. D., Oliveira, F. A., ... Reis, W. L. S. D. (2013). Nutritional performance of cattle grazing on low-quality tropical forage supplemented with nitrogenous compounds and/or starch. *Revista Brasileira de Zootecnia, 42*(9), 664-674.

Lukkananukool, A., Paengkoum, P., Bureenok, S., Paengkoum, S., Yuangklang, C., & Kawamoto, Y. (2013). Effect of forage species and additives on quality of tropical forage silage. *Journal of Animal and Veterinary Advances, 12*(2), 153-159.

McDonald, P., Henderson, A. R., & Heron, S. (1991). *The biochemistry of silage* (2nd ed.). Marlow, OK: Chalcombe.

Menezes, D. R., Barbosa, A. L., Rodrigues, R. T. S., Lista, F. N., Nascimento, T. V. C., Moraes, S. A., & Busato, K. C. (2016). *In vitro* gas production and degradation kinetics of elephant grass silage with dried tamarind residue. *Journal of Animal and Feed Sciences, 25*(1), 259-265.

Mohapatra, D., Mishra, S., & Sutar, N. (2010). Banana and its by-product utilization: an overview. *Journal of Scientific e Industrial Research, 69*(5), 323-329.

National Research Council [NRC]. (2001). *Nutrient requirements of dairy cattle* (7th ed.). Washington, DC: National Academy Press.

Nocek, J. E. (1988). *In situ* and other methods to estimate ruminal protein and energy digestibility: a review. *Journal of Dairy Science, 71*(8), 2051-2069.

Pires, D. A. A., Rocha Júnior, V. R., Sales, E. C. J., Reis, S. T., Jayme, D. G., Cruz, S. S., & Esteves, B. L. C. (2013). Características das silagens de cinco genótipos de sorgo cultivados no inverno. *Revista Brasileira de Milho e Sorgo, 12*(1), 68-77.

Riaz, M. Q., Südekum, K. H., Clauss, M., & Jayanegara, A. (2014). Voluntary feed intake and digestibility of four domestic ruminant species as influenced by dietary constituents: A meta-analysis. *Livestock Science, 162*(1), 76-85.

Ribeiro, L. S. O., Pires, A. J. V., Carvalho, G. G. P., Pereira, M. L. A., Santos, A. B., & Rocha, L. C. (2014). Características fermentativas, composição química e fracionamento de carboidratos e proteínas de silagem de capim-elefante emurchecido ou com adição de torta de mamona. *Semina: Ciências Agrárias, 35*(3), 1447-1462.

Santos, E. M., Pereira, O. G., Garcia, R., Ferreira, C. L. L. F., Oliveira, J. S., & Silva, T. C. (2014). Effect of regrowth interval and a microbial inoculant on the fermentation profile and dry matter recovery of guinea grass silages. *Journal of Dairy Science, 97*(7), 4423-4432.

Souza, C. F., Rocha Júnior, V. R., Reis, S. T. D., Antunes, C. R., Rigueira, J. P. S., Sales, E. C. J. D., & Souza, G. R. (2016). Casca de banana em dietas para vacas mestiças em lactação. *Revista Brasileira de Saúde e Produção Animal, 17*(1), 86-100.

Tolentino, D. C., Rodrigues, J. A. S., Pires, D. A. D. A., Veriato, F. T., Lima, L. O. B., & Moura, M. M. A. (2016). The quality of silage of different sorghum genotypes. *Acta Scientiarum. Animal Sciences, 38*(2), 143-149.

Van Soest, P. J. (1994). *Nutritional ecology of the ruminant* (2nd ed.). Ithaca, NK: Cornell University.

Wang, Y., Jin, L., Wen, Q. N., Kopparapu, N. K., Liu, J., Liu, X. L., & Zhang, Y. G. (2016). Rumen degradability and small intestinal digestibility of the amino acids in four protein supplements. *Asian-Australasian Journal of Animal Sciences, 29*(2), 241-249.

Wilson, R. F., & Wilkins, R. J. (1972).The ensilage of autumn-sown rye. *Grass and Forage Science, 27*(1), 35-42.

Zanine, A. D. M., Bonelli, E. A., Souza, A. L. D., Ferreira, D. D. J., Santos, E. M., Ribeiro, M. D., ... Pinho, R. M. A. (2016). Effects of *Streptococcus* bovis isolated from bovine rumen on the fermentation characteristics and nutritive value of tanzania grass silage. *The Scientific World Journal, 2016*(1), 1-6.

*Received on October 18, 2016.*
*Accepted on November 28, 2016.*