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Potential for using dehydrated banana peel as an additive in grass silage

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Abstract

Among the techniques for conserving forage for herbivore feeding, the production of grass silage has been widely used in recent times in tropical regions, however, the low content of dry matter and carbohydrates in these forages can hamper the fermentation of ensiled biomass. In this regard, the dehydrated banana peel presents itself as an alternative as an additive in the production of grass silage. Given the above, the objective of this review was to present the main aspects of the use of dehydrated banana peel as an additive in the production of grass silage. The review was developed through the search for selected terms, such as: "grass silages", "banana residues", "additives". The terms were searched in the Google Scholar, Scielo, PubMed, Elsevier, Science Direct, Capes Periodical databases. The banana peel has bromatological characteristics that make it a good alternative for use in the feeding of ruminants, with carbohydrate values of up to 32.4% of dry matter, as well as a source of protein, ether extract, minerals, and essential amino acids. Because it presents good nutritional values compared to citrus and cassava peel, the banana peel has been used in the feeding of ruminants by small producers in tropical regions, where the use of by-products has the purpose of having lower feeding costs. The use of dehydrated banana peel is an alternative to be used as an additive in the production of grass silage and ruminant feed due to its nutritional characteristics.

Keywords: Alternative foods. Byproducts. Fermentation. Ruminants.

Potencial de uso da casca de banana desidratada como aditivo na silagem de capins

Resumo

Dentre as técnicas para conservação de forragem para alimentação de herbívoros, a produção de silagem de capins vem sendo bastante utilizada nos últimos tempos em regiões tropicais, entretanto, o baixo teor de matéria seca e carboidratos nessas forrageiras podem dificultar a fermentação da biomassa ensilada. Neste aspecto, a casca de banana desidratada apresenta-se como uma alternativa como aditivo na produção de silagem de capins. Diante do exposto,

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objetivou-se com esta revisão, apresentar os principais aspectos do uso da casca de banana desidratada como aditivo na produção de silagem de capins. O desenvolvimento da revisão foi através da busca de termos selecionados, tais como: “capim-marandu”, “silagens”, “resíduos de banana”, “aditivos”. Os termos foram buscados nas bases de dados Google Scholar, Scielo, PubMed, Elsevier, Science Direct, Periódicos Capes. A casca de banana apresenta características bromatológicas que a torna uma boa alternativa para uso na alimentação de ruminantes, com valores de carboidratos de até 32,4% da matéria seca, além de fonte de proteína, extrato etéreo, minerais e aminoácidos essenciais. Por apresentar bons valores nutricionais comparados à casca de citros e mandioca, a casca de banana vem sendo utilizada na alimentação de ruminantes por pequenos produtores de regiões tropicais, onde que o uso de subprodutos tem a finalidade de se ter menores custos com alimentação. A utilização da casca de banana desidratada pode ser uma alternativa a ser utilizada como aditivo na produção de silagem de capins e alimentação de ruminantes devido às características nutricionais.

Palavras-chave: Alimentos alternativos. Fermentação. Subprodutos. Ruminantes.

Introduction

Forage production in Brazil is characterized by great production in summer and seasonality in winter, which can compromise animal production, in this scenario, it is necessary to make use of techniques that conserve forage for supply to animals in the period of low availability of food. Among the various forage conservation techniques for feeding herbivores, the production of silage is one of the most used for allowing the conservation of forage plants for long periods without major losses of nutritional value.

For the production of silage, several forage plants can be used, however, corn and sorghum are the most cultivated. In recent years, interest in growing other grasses that are normally used for grazings, such as those of the genus Brachiaria and Panicum, has grown. The use of grass for silage production mainly aims to take advantage of excess production during the rainy season for use in the dry season. Despite the high biomass production of tropical grasses, these at the time of harvest have characteristics that are not ideal for obtaining silage with a good fermentative pattern, such as the high water content and low soluble carbohydrate content, this hinders the production of lactic acid by acid lactic bacteria favoring secondary fermentation, in addition to increasing nutrient losses from effluents, decreasing the nutritional value of silage.

For the production of tropical grass silage so that there are a good fermentation pattern and reduction of losses, it is necessary to use additives. The use of additives, in addition to reducing losses in the silage production process, can improve nutritional value, increase food consumption and digestibility (Bernardes *et al.*, 2005). Among the various industrial residues that can be used as an additive in the production of silage, the banana peel has great potential. The banana is the most produced fruit worldwide and its industrialization generates a large amount of waste (pseudostem, leaves, and peels) (Mohapatra *et al.*, 2010), when this waste is incorrectly disposed of, it can become a source of pollution, an alternative to dispose of the banana peel residue would be used in the feeding of ruminants, where it can be supplied fresh or dehydrated to the animals.

The banana peel has in its composition characteristics that can correct the nutrient deficiency of tropical grasses since they present in their composition good values of carbohydrates (32.4% of DM) that are mostly soluble, in addition to being a source of ethereal extract, minerals, and essential amino acids (Emaga *et al.*, 2011; Mohapatra *et al.*, 2010). Given the above, the objective of this review was to present the main aspects of grass silage with dehydrated banana peel.

Material and methods

This bibliographic review was carried out following the proposal of Dane (1990), where terms were selected, such as: “marandu grass”, “silages”, “banana residues”, “additives”. The terms were searched in the following databases Google Scholar, Scielo, PubMed, Elsevier, Science Direct, Capes Periodicals. It is worth mentioning that restrictive measures were not adopted during the search for scientific papers.

After analyzing the archives of the scientific databases, criteria for the exclusion of repeated articles that did not fit the theme were applied. After the relevance test for use in the study, they were tabulated in an Excel spreadsheet® with the information that is relevant, for exploration in the literature review.

Results and discussion

Tropical grass silage

Animal production based on a pasture of tropical grasses, has as an obstacle the seasonality of production in the dry period, that to maintain a high productive standard in the period of food deficit it is necessary to make use of techniques/strategies that allow meeting the dietary requirements of the animals. In this respect, silage is an alternative for the conservation of roughage for use in the period of food deficit (Faria *et al.*, 2010).

Silage of tropical grasses is a recommended alternative to conserve surplus production in the rainy season and supplement animals in the dry season (Arruda *et al.*, 2010). Also, according to the authors, this strategy allows to rationalize and intensify the management of pastures in the rainy season.

Frame 1 – Periodic portals used in the research.

Database	**Email address**
Google Scholar	https://scholar.google.com.br/?hl=pt
Scielo	https://scielo.org/pt
PubMed	https://pubmed.ncbi.nlm.nih.gov
Elsevier	https://www.elsevier.com/pt-br
Science Direct	https://www.sciencedirect.com
Capes Periodicals	https://sucupira.capes.gov.br/sucupira/public

The grasses present advantageous characteristics for silage production, such as flexibility of harvest, low risk of losses, and high production of dry matter (Corrêa *et al.*, 2001). Tropical forage plants change and with maturity, dry matter production increases, however, it loses nutritional value, whereas, in young plants, the biomass of these forages has a high moisture content, high buffering capacity, and low concentration of soluble carbohydrates (Randa *et al.*, 2017). These characteristics can harm the silage production process (Bernardes *et al.*, 2018).

According to Wilkinson (1983), the dry matter content, amount of soluble carbohydrates, and the buffering power of the material have a direct effect on the adequate fermentation of the ensiled material. The growth of bacteria of the genus Lactobacillus depends directly adequate levels of soluble carbohydrates in the ensiled mass so that they establish, grow, and produce lactic acid since it is responsible for silage stabilization (Valença *et al.*, 2016; Van Soest, 1994).

The high moisture content of grasses at harvest can be corrected by using wilt or using additives (Bernardes *et al.*, 2005). According to the authors, depending on the additive used, better quality silage can be produced, with better digestibility and potential for ingestion.

Use of additives in grass silages

According to McDonald *et al.* (1991), silage additives can be classified into five main groups: fermentation stimulators, partial or total fermentation inhibitors, aerobic deterioration inhibitors, nutritional, and absorbents.

The use of additives in the production of silage helps to reduce losses and can also improve the nutritional value of ensiled mass (Bernardes *et al.*, 2005). In small-scale silage production, Gusmão *et al.* (2018) recommend the use of residues from the food industry that act as moisture-scavenging additives.

Different moisture-sequestering additives can be used to improve the fermentative profile of tropical grasses, such as manioc bran (Pires *et al.*, 2010), dehydrated banana peel (Brant *et al.*, 2017), coffee peel (Bernardino *et al.*, 2005), among others, as long as they have a high DM content and these are added in adequate amounts so that the silage dry matter content is between 28 and 34% as recommended by Borreani *et al.* (2018), thus avoiding compression problems and subsequent losses.

In addition to improving the fermentation pattern of silage, the use of residues as moisture-sequestering additives can reduce losses during the ensiling process, in this sense, Negrão *et al.* (2016) observed a reduction in effluent losses in *Brachiaria decumbens* silage when added with 40% rice bran.

With the increasing use of by-products as an additive for silages, new residues from food processing are being sought, and in this aspect, the banana peel appears as an alternative, since the processing of this fruit generates great production of residues and this one has in its composition high content of dry matter and non-fibrous carbohydrates, ether extract, and protein with averages of (87.76, 31.46, 6.25 and 8.28 respectively) that can assist the silage fermentation process (Monção *et al.*, 2014). Brant *et al.* (2017), observed that the inclusion of 25% of the banana house in elephant grass silage reduced losses during the fermentation process.

Use of banana peel

The banana is the second most-produced fruit in the world, however, its production generates a large amount of waste (pseudostem, leaves, and peels) with great potential for use both in the production of biofuels and in animal feed (Mohapatra *et al.*, 2010). In 2016, banana production in Brazil was estimated at 6,764,324 tonnes, where the state of Minas Gerais was responsible for 11% of national production, occupying third place in the country (EMBRAPA, 2016).

Of the total banana production in Brazil, it is estimated that only 2.5 to 3% are industrialized, and of this total 40% is transformed into waste (peels), which can cause problems to the environment if not disposed of correctly. Thus, the banana peel can be used in animal feed, as a by-product, especially in periods of food deficit (Monção *et al.*, 2014; Emaga *et al.*, 2011).

The banana peel has bromatological characteristics that make it a good alternative for use in the feeding of ruminants, with carbohydrate values of up to 32.4% of dry matter, where these are mostly soluble carbohydrates (Emaga *et al.*, 2011), in addition to a source of protein, ether extract, minerals, and essential amino acids (leucine, valine, threonine, and phenolphthalein) (Mohapatra *et al.*, 2010).

As it presents good nutritional values compared to citrus and cassava peel, the banana peel has been used in the feeding of ruminants by small producers in tropical regions, where the use of by-products has the purpose of having lower feeding costs, increasing the productivity and profitability of meat and milk production (Oliveira *et al.*, 2012).

The form of supply of this product can be made in natural or dehydrated in the sun, with or without some type of treatment (Conte, 2017). The results with the use of banana peel in animal feed are positive. Souza *et al.*, (2016) evaluating ways of treating banana peels, sun-dried peels for 7 days treated or not with lime and calcium oxide on the performance of dairy cows concluded that the use of sun-dried peel in 20% of the diet did not affect milk production.

According to Pimentel *et al.* (2016), the use of banana peel to replace sorghum silage by up to 60% in the feeding of F1 Holstein x Zebu cows during lactation did not influence milk production with an average of 16.49 kg and observed an increase in consumption and feed efficiency of dry matter.

Antunes *et al.* (2017) reports that the inclusion of banana peel in diets in place of sorgum silage did not influence fat and protein contents, thus maintaining its quality. Thus, it is evident that the chemical composition of banana peel is satisfactory for maintaining milk quality, since it has about 8% of ethereal extract, 8% of crude protein, non-fibrous carbohydrates around 13% that contribute to the energy supply to rumen microorganisms that, together with dietary protein, can produce adequate amount of microbial protein of high biological value (Monção *et al.*, 2014, Antunes *et al.*, 2017). Emaga *et al.*, (2011) evaluated the in vitro digestibility of banana peel and observed a value of 86%, thus showing the great potential of this by-product.

Evaluating milk quality, Melo *et al.*, (2018) substitution of up to 60% of sorb silage by banana peel in the diet of lactating cows may be an alternative for milk production and processing, when considering the improvement in the nutritional value of the milk lipid fraction and the increase in the contents of conjugated linoleic acid. Ferreira *et al.*, (2016) reported that the use of banana peel dried in the sun in 20% of the diet does not alter milk production, however, reduces the digestibility of DM and nutrients, which may limit the weight gain of animals.

Fermentative profile

The fermentative pattern is an important aspect to be evaluated in the production of silage, where the pH and ammoniacal nitrogen are considered important parameters to be observed. According to Borreani *et al.*, (2018) and Ferraretto *et al.*, (2018), pH values between 3.8 and 4.2 characterize well-preserved silage, and values above these may indicate butyric fermentation, whereas ammoniacal nitrogen must have values below 10% of DM to qualify silage with good fermentation standard (Arruda *et al.*, 2010). At the time of harvest, the plants may present unfavorable characteristics for ensiling, such as high humidity and low content of soluble carbohydrates, being factors that make it difficult to reduce the pH of the ensiled material, causing secondary fermentation (Evangelista *et al.*, 2004; Bergamaschine *et al.*, 2006).

In the ensiling process, secondary fermentation occurs mainly when forage plants have dry matter content below 21%, soluble carbohydrates below 2.2% in the natural matter, and low carbohydrate / buffering ratio, requiring the use of techniques to correct such deficiency (McDonald *et al.*, 1991).

The fermentation of soluble carbohydrates occurs through the action of hetero and homofermentative microorganisms, and soluble sugars are fermented to volatile fatty acids, carbon dioxide, water, and heat (Muck, 2010). Lactic acid plays a fundamental role in the anaerobic conservation of ensiled biomass and the production of this acid depends directly on the number of soluble carbohydrates in the forage (Senger *et al.*, 2005).

Banana peel is a viable option as an additive for silage production, when dehydrated it can increase the dry matter content of grass biomass, improving the fermentation profile and consequently reducing losses. The main aspects of a good fermentation pattern can be observed by the pH, ammonia nitrogen combined with the dry matter content, in grass silages with banana peel additives. These values are shown in table 1.

Brant *et al.* 2017 shows that the inclusion of dehydrated banana peel in elephant grass silage reduces losses from the fermentation process with more consistent results at the 25% inclusion level.

Table 1 – Fermentative characteristics of banana peel and grass silages with banana peel additives.

Food	Inclusion %	pH	NH_3	DM	Author
fresh banana peel	-	3.9	-	10.20	Salim et al 2021
Banana Peel + inadequate fruits	-	3.61	-	10.43	Conte 2017
Banana peel+brachiaria grass	20	4.3	5.8	36.9	Marques 2018
Banana peel + elephant grass	20	4.07	3.76	30.6	Brant et al 2017
Banana Peel + Alfalfa	20	5.4	50.6%	27.2	Elahi et al 2019

Fermentative losses

During the production of silage, losses occur in the ensiled material, which can be in the form of effluents or gases and the values will vary according to the composition of the forage (dry matter, soluble carbohydrates, and buffering capacity). The losses by effluent correspond to the loss of intracellular content, such as nitrogen compounds, organic acids, minerals, and soluble carbohydrates, thus increasing the components of the cell wall, which have low nutritional quality (Faria *et al.*, 2010).

According to Loures *et al.*, (2003), the effluent exposed to the environment can become a contaminant to watercourses, since these have a high biochemical demand for oxygen. For Nússio *et al.*, (2002), the use of forages with a higher dry matter content and the mixture of drier crops with material with a higher water content helps to reduce losses by effluents. According to Pereira and Bernardino (2004), one way to control effluent losses is through the wilting of plants and the use of absorbent additives.

According to Brant *et al.*, (2017), the use of dehydrated banana peel in elephant grass silage can reduce losses by gases and effluents during the fermentation process due to its capacity to increase the dry matter content of the silage, where every 1% of inclusion of banana peel in silage there was an increase of 0.4% in dry matter content. Also, according to the authors, the increase in the levels of banana peel in the ensiled mass had a decreasing linear effect on the values of pH and ammoniacal nitrogen. Andrade *et al.*, (2010) evaluating losses, fermentative characteristics, and nutritional value of elephant grass silage containing agricultural by-products, found that cassava, cocoa, and coffee husks in doses of 14.2; 26.3 and 30%, respectively, acted efficiently as moisture-sequestering additives in elephant grass silage, in addition to improving the fermentative characteristics of silages with lower pH and ammonia nitrogen values.

Seeking to assess the potential use of banana peel in silage, Conte (2017), evaluating the silage of banana peel and fruits called unsuitable for the industrialization of bananas (selected by the processing industry), the author found values of loss by gases, effluent losses and dry matter recovery of 8.7, 782 and 676.9g/kg respectively, which can be considered high values compared to other silages, which may be due to the low dry matter of the banana peel in this experimental condition. However, when evaluating the use of dehydrated banana peel as an additive in elephant grass silage, Brant *et al.*, (2017), observed that the inclusion of dehydrated banana peel increased the dry matter of elephant grass silage, with a decreasing linear effect on gas and effluent losses and increasing linear effect for dry matter recovery, with values of 10.02, 0.03 and 97.9% respectively. Marques (2018), evaluating the inclusion of dehydrated banana peel in Marandu grass silage, observed an effect similar to that found by Brant *et al.*, (2017), with values of 8.9, 1.76 and 91.5% for losses by gases, effluents and dry matter recovery respectively, at the 40% inclusion level.

Digestibility of banana peel

Tropical grasses show great variation in their composition, requiring the evaluation of their composition and the evaluation of fractions is the main point for estimating the energy content (Detmann *et al.*, 2004). Knowledge of the composition of food (energy value and digestibility) is of paramount importance for the correct formulation of rations that meet the needs of maintenance and production of animals (Muniz *et al.*, 2012), and knowledge of digestive dynamics has a role important for efficient feeding programs and the development and selection of forage plants with higher value (Ladeira *et al.*, 2001).

According to Ítavo *et al.* (2002), ruminal degradation of cellulose and hemicellulose is the main source of energy for maintaining, growing, and producing cattle. In tropical conditions, forage grasses have a different composition from temperate grasses (Van Soest, 1994).

The evaluation of food digestibility can be done by different methods, however, the estimation of rumen degradation rates provides a closer estimate of the actual digestive parameters of food (Muniz *et al.*, 2012). The in-situ technique or the nylon bag suspended in the rumen allows the food to have a simulation of the rumen environment that is closer to the real one, despite not predisposing the food to chew rumination and passage (Carvalho *et al.*, 2006). In situ degradation evaluates food infractions such as the soluble fraction (a), potentially degradable fraction (b), the degradation rate of fraction b (c), potential degradability (DP), and the effective degradability (DE) of the fractions of matter dry and neutral detergent fiber (Salman *et al.*, 2010).

The estimation of fiber degradation in neutral detergent (NDF) is expressed in a complementary way by indigestible NDF, however, the method does not consider the physical replenishment to the rumen environment (Muniz *et al.*, 2012). The NDFi content estimation adopted by the Cornell Net Carbohydrate and Protein System (CNCPS) and the National Research Council (NRC) has lignin as the main limitation of the digestion of forage plants (Cassida *et al.*, 2007). neutral can be increased by using plants with a lower concentration of lignin or indigestible NDF, in addition to the cultivation of selected forages, harvesting the material at the ideal point of maturity, or making use of additives (Grant *et al.*, 2018).

According to a work carried out by Monção *et al.*, (2014), evaluating the inclusion of calcium oxide in the dehydration of banana peel, they found values of 58.18% for the in vitro degradability of dry matter when the peel did not undergo any treatment. In the same sense, work carried out by Souza *et al.*, (2016), evaluating the inclusion of banana peel in the diet of cows, with the treatments of sorghum silage, silage + banana peel, silage + banana peel with limestone and silage + banana peel with calcium oxide, observed that the total apparent digestibility of dry matter was similar between sorghum silage and silage + banana peel with calcium oxide

Seeking to evaluate the inclusion of banana peel in Marandu grass silage, Marques (2018), evaluating the doses of 10, 20, 30 and 40% of inclusion of dehydrated banana peel in Marandu grass silage, observed greater effective degradability of the matter. dry at a dose of 40% inclusion, which demonstrates that the inclusion of banana peel in grass silage can contribute to increasing non-structural carbohydrates in the ensiled mass, improving degradability. According to Padam *et al.* (2012) and Monção *et al.* (2014), characterized the banana peel as a good energy source to be used in animal nutrition.

The use of by-products/waste from banana production as raw material, in addition to economic benefits, would represent a reduction in environmental impacts, as they are discarded into the environment and promote additional costs for processing companies (Lousada junior *et al.*, 2005). Pimentel *et al.* (2017), when replacing sorghum silage by up to 60% with sun-dried banana peel, they found no differences in milk production and production corrected for 3.5% fat, which had an average of 16.49 kg/day.

Conclusion

Banana peel is an option for strategic use in grass silage, its inclusion in the silage can improve the fermentation pattern and reduce losses, and the use of grass silage with banana peel can be an alternative to be used in ruminant feeding due to its nutritional characteristics combined with its low cost in regions of greater availability.

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