**Clinical evaluation and digestibility of banana (*Musa* spp.) compared to the Coast Cross hay (*Cynodon* sp.) as food for sheep.** Avaliação clínica e digestibilidade da banana (*Musa* spp.) comparada ao Coast Cross feno (*Cynodon* sp.) como alimento para ovelhas.

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**Resumo**

O objetivo deste trabalho foi realizar um ensaio alimentar para avaliar os aspectos nutricionais da parte aérea da banana em ovinos sadios. No primeiro ensaio, doze ovelhas foram utilizadas nos testes para determinar a digestibilidade da matéria seca da bananeira. No segundo foram utilizados seis ovinos com cânulas ruminais para avaliar o teor de matéria seca, proteína bruta, fibra em detergente neutro e ácido. Três tratamentos foram analisados: (A) talo mais folhas secas de bananeira, (B) talo seco de bananeira e (C) folhas secas de bananeira. As folhas e talos da bananeira mostrou-se como uma fonte alternativa para nutrição de ovinos, que em formulação adequada, não compromete a saúde animal.

**Palavras-chave**: Nutrição. Pequenos ruminantes. Sustentabilidade.

# Abstract

The objective of this work was to carry out a feeding trial to evaluate the nutritional aspects of the aerial part of the banana in healthy sheep. In the first trial, twelve ewes were used in the tests to determine the digestibility of banana dry matter. In the second, six sheep were used with ruminal cannulas to evaluate the content of dry matter, crude protein, neutral and acid detergent fiber. Three treatments were analyzed: (A) stalk plus dried banana leaves, (B) dried banana stalk and (C) dried banana leaves. The leaves and stems of the banana tree proved to be an alternative source of nutrition for sheep, which, when properly formulated, does not compromise animal health.

**Keywords**: Nutrition. Small ruminants. Sustainability.

**Introduction**

 The banana (*Musa spp.)* cultivation is among the expanding crops. It has been gaining prominence in the agricultural market, being that, the banana is one of the most produced and consumed fruits in the world (FAO, 2019). Casas et al. (2020) concluded that the use of banana residues, in cattle, did not affect ruminal and hepatic health, being able to provide these animals. Banana peel has the potential to be used in sheep feed. It is considerably rich in nutrients, phenols and tannins and its composition may be different, depending on the variety and its degree of ripening (RAMDANI et al., 2019).

 The aerial parts of the banana plants could be utilized as forage food. In addition to the economic advantage of using these plants, they contain secondary compounds known to exhibit different degrees of anthelmintic activity, because of tannins presence in this plant, which is of particular interest of the sheep industry (FERRÃO, 2013). Although the banana leaves have a higher PB content than the pseudostem, its digestibilityis lower, probably due to its high lignin content. Due to the low crude protein content in the pseudostem, when it is used as single food, the ingestion, growth and the milk production will be depressed, as a result of low nitrogen availability for ruminal fermentation and low dry matter intake. Banana peel, leaves and pseudostem can be a good food source for ruminants, may contribute to increasing weight gain and milk production, provided it is subjected to appropriate treatment and with supplementation (RUSDY, 2019).

The addition of banana leaf hay and pseudostem can replace hay of *Cynodon* sp. without changing the intake, digestibility of nutrients and the ruminal concentration of short-chain fatty acids. The lowest dry matter digestibility and organic were observed in diets with levels of banana leaf hay when compared to the same proportion of the pseudostem hay, probably due to higher concentration of lignin (88,1g Kg-1) in the leaf hay, although the ingestion did not differ between treatments. In study, the inclusion of 400g Kg-1 of leaf hay, reduced digestibility of NDF in relation to treatments containing *Cynodon* spp. hay or of pseudostem. These results can be explained by the high percentage of ADF and high lignin content in this treatment. The pH ruminal was kept close to neutral in all treatments. However, it is important to highlight that the average pH 7.0±0.15 may have been affected by the time of collection of rumen fluid (CARMO et al., 2018).

The inclusion of banana residue in the diet of growing lambs, increases the economic viability of the activity. The treatment with 40% of banana leaf hay and 60% of concentrate presented the best economic indicators, based on the highest net revenue, at the highest rate of return and e in the highest profitability for marketing live or slaughtered animals (GERASSEV et al., 2013). The objective of the work was to conduct a feeding trial to evaluate the nutritional aspects of the aerial portion of the banana (*Musa* spp.) in healthy sheep fitted with rumenal cannulae.

# Materials and methods

 This work was approved by the Ethics Committee for Animal Experimentation at the University of Santo Amaro. Twelve castrated sheep Suffolk were used in the tests, aged between two and three years and weighing 55 kg on average. Six animals, two to three years of age, were cannulated. All animals were individually examined once a week according to the specific and general physical examination criteria published by Rosenberger (1979). Blood samples were collected before and after treatments.

 The experiment was divided in two trials. In the first one, twelve animals (six fistulated and six not fistulated) were studied in a completely randomized design (GOMES, 1985) to determine the apparent digestibility of three treatments: 15, 25 and 35% dry matter from the banana plant (leaf + stalk) in a standard mixture of concentrated (40% soybean meal, 57% corn meal and 3% mineral salt) and hay coast-cross, which is a maintenance diet. The provided samples were minced, exposed to room temperature for a pre-drying and subsequently crushed and placed in an oven at 36° C for 48 hours.

 The technical evaluation of digestibility was performed after total faeces samples were collected from twelve confined sheep for 5 consecutive days with the goal of determining the following parameters: dry matter, crude protein, crude fiber, ether extract and nitrogen free extract (NFE). All the procedures were performed according to AOAC (2000).

 Hepatic and renal functions were analysed. Serum urea levels were quantified (mg / dL) according to the methodology described by Talke and Schubert (1965) using a Diasys® commercial kit (DiaSys. Europe). Serum creatinine levels were determined based on the method of Jaffe modified, according to the technique described by Lustgarten and Wenk (1972). Serum albumin levels were measured by the bromocresol green method in accordance with the technique recommended by Doumas and Bigges (1972). The enzymatic activity of serumaspartate aminotransferase was determined using the kinetic methodology recommended by the International Federation of Clinical Chemistry with a Biosystems® commercial kit. The enzymatic activity of serum gamma glutamyl was quantitated according to the kinetic methodology recommended by the International Federation of Clinical Chemistry using a Diasys® commercial kit. All the assays were performed on an automatic biochemical analyser (AMS®, model Liasys®) (Figure 1).



Figure 1 - Trail one.

 In the second trial six fistulated animals were used. The *in situ* nylon bag technique was utilized (ORSKOV, 1982; LUCCI, 1997): five grams of sample (a) banana leaf, (b) dried banana stalk and (c) dried banana leaf) was placed in each bag, which was incubated in the rumen of the fistulated sheep for 0, 6, 12, 24, 48, 72 and 96 h. The feed consisted of coast-cross hay (roughage) and concentrate with 20% protein. All the animals (1-6) received three nylon bags with the respective treatment (A, B or C).

 Ruminal fluid samples were executed at times 0, 1, 2, 3, 4, 6, 8 and 24 hours after feeding, for analysis of NH3 concentrations (crop 1 and 2 hours), and determination of pH (crop 0, 1 and 2 hours). The following degradability parameters were analysed: dry matter (DM), crude protein (AOAC, 2000), acid detergent fiber (ADF) and neutral detergent fiber (NDF) (VAN SOEST; WINE, 1968; UDÉN et al., 2005) (Figure 2 ).



Figure 2 - Trail two.

Statistical analysis

 *In situ* digestibility analysis: the degradability data were adjusted using the Orskov et al. (1980) model, and the effective degradability (dge) was calculated based on the Orskov et al. (1980) equation with a passage rate of r = 0.2.

 A statistical analysis was performed on the Latin square design (GOMES, 1985) with three treatments: (A) stalk plus dried banana leaf, (B) dried banana stalk and (C) dried banana leaf. The feed consisted of coast-cross hay (roughage) and concentrate with 20% protein. All the animals (1-6) received three nylon bags with the respective treatment (A, B or C). The effective degradability data for dry matter (DM), crude protein (CP), acid detergent fiber (ADF) and neutral detergent fiber (NDF) were subjected to statistical regression analyses, as proposed by Gomes (1985), with the regressions considered statistically significant when p ≤ 0.05. The variance of the treatments was split into linear regression (1 degree of freedom) and deviation from regression (1 degree of freedom).

Apparent digestibility factors and metabolism

 Analytical methods: twelve animals were used in a completely randomized design as Gomes (1985), in order to study the apparent digestibility in three treatments: 15%, 25% e 35% of dry matter of banana leaves (stalk plus dried banana leaf) in a standard mixture of concentration and coast cross.

A) 15% of banana leave and 85% of standard mixture;

B) 25% of banana leave and 75% of standard mixture;

C) 35% of banana leave and 65% of standard mixture;

 The statistical analysis was performed using SAS software. The significant differences that reached 5% probability were analysed by searching for linearity in the responses obtained with different treatments.

# Results

 Among the three treatments, dried banana stalk had the highest degradability of dry matter (56.73%). The degradability of dry leaf and dry stalk plus dry leaves was 28.67%, and 35.77%, respectively (Table 1). The NDF content (Table 1a) was significantly different between the treatments. Treatments A (1%) and C (0.96%) were equal, and treatment B exhibited the best digestibility (0,02%).

**Table 1 -** *in situ* digestibility of dry banana leaves fed to sheep.

|  |  |  |  |
| --- | --- | --- | --- |
| TreatmentVariable | (A)% | (B)% | (C)% |
| Dry Matter | 35.7 | 56.7 | 28.6 |
| Crude Protein | 11.0 | 6.0 | 14.0 |

 The ADF (Table 1a) differed between all treatments (P ≤ 0.05). The degradability of dry leaves (treatment C) was the best (0,030%), followed by treatment A (0,050%). Treatment B was the worst in terms of ADF degradation (0,047%). The apparent digestibility results are presented for all treatments in Table 2: 15, 25 and 35% of dry matter of the banana plant (leaf + stalk) added to a standard mixture of concentrate and coast-cross hay.

**Table 1a -** *in situ* digestibility of dry banana plants leaves fed to sheep.

|  |  |  |  |
| --- | --- | --- | --- |
| Treatment | (A)% | (B)% | (C)% |
| NDF | 1.00 a | 0.02 b | 0.96 a |
| ADF | 0.05 a | 0.047 b | 0.030 c |

 There was no change in hepatic or renal function in the animals that received feed supplemented with banana leaves. All the values were within the normal limits. The pH measurements indicated severe ruminal alkalosis in the animals, with a pH between 7.5 and 9.0.

**Table 2 -** the apparent digestibility of dry banana leaves in sheep.

|  |  |  |  |
| --- | --- | --- | --- |
| Leaf concentration (%) | 15%\* | 25%\*\* | 35%\*\*\* |
| Dry matter | 61.70 a | 63.39 a | 41.05 b |
| Crude protein | 67.55 a | 67.27 a | 53.99 b |
| Crude fiber | 61.41 a | 56.59 a | 21.99 b |
| NNE | 73.05 a | 72.52 a | 59.73 b |

The same lowercase letters in the same row represent data that are not significantly different, and different lowercase letters in the same row indicate significant differences (P ≤ 0.05).

\*Treatment (A)/ \*\* Treatment (B)/ \*\*\*Treatment (C)

# Discussion

 Among the three treatments, dried banana stalk had the highest degradability of dry matter (56.73%). The degradability of dry leaf and dry stalk plus dry leaves was 28.67%, and 35.77%, respectively (Table 1). There are two possible explanations for these data: the leaves are covered with waxes and lipids; and a higher proportion of the fiber in the stems is hemicellulose, whereas the leaves are rich in cellulose. These hypotheses suggest the need to analyze the leaves and stems separately to determine the lipid components in the leaves and the cellulose and hemicellulose content of the stalk and leaf fibers. These data, together with the tannin concentrations in the stalks and leaves, would clarify the results of this experiment. The NDF content (Table 1a) was significantly different between the treatments. Treatments A (1%) and C (0.96%) were equal, and treatment B exhibited the best digestibility (0,02%).

 The ADF (Table 1a) differed between all treatments (P ≤ 0.05). The degradability of dry leaves (treatment C) was the best (0,030%), followed by treatment A (0,050%). Treatment B was the worst in terms of ADF degradation (0,047%). Another explanation for the best NDF degradation of treatment B relates to the higher concentration of hemicellulose in the stalk. The good ADF degradation of treatments A and C may be due to the amounts of cellulose and lignin present in the leaves. The clinical evaluations of the animals showed no changes.

 The apparent digestibility results are presented for all treatments in Table 2: 15, 25 and 35% of dry matter of the banana plant (leaf + stalk) added to a standard mixture of concentrate and coast-cross hay. As the quantity of leaves added to the standard feed increased, the total digestibility decreased to a greater degree, what was measured by rates of CP, CF, NFE and DM. There was a decrease in digestibility in the range of 25% to 35%, since in the range of 15% to 25% was not observed a significant difference, as showed in table 2. It was assumed that the greater tannin concentration in the leaves impaired digestibility (EGGUM; CHRISTENSEN, 1975; MEHANSHO et al., 1987).

 Palatability was reduced with the dry banana leaf, which was not the case when the animals were fed with fresh leaves. According to Patra and Saxena (2010), high tannin concentrations adversely affect nutrition in grazing ruminants. Tannins have an astringent flavor, which alters the palatability of the diet and reduces feed intake. The dried leaves have a higher tannin concentration because of water loss during the drying process. Chung et al. (1998a) reported that tannins are also nutritionally undesirable compounds because of their ability to precipitate proteins, inhibit digestive enzymes and affect the utilization of vitamins and minerals. The ingestion of tannins on a large scale can result in adverse health effects. However, small quantities of banana (*Musa* spp.) leaves have a different effect than the findings reported by Chung et al. (1998a), since physical and clinical examinations did not uncover any deleterious effects of *Musa* spp (HOSTE; TORRES-ACOSTA, 2011).

 Tannins form complexes that are insoluble and indigestible in the rumen and intestine; these complexes inhibit microbial enzymes involved in fiber degradation (SMITH; MACKIE, 2004; WALLER, 2006). Tannins are also responsible for decreased growth rate, food absorption, energy metabolism and protein digestibility. Eggum and Christensen (1975), Kumar et al. (2012), discovered that the addition of tannic acid to the diet of rats decreased the digestibility of protein and amino acids and the use of metabolic proteins. Mehansho et al. (1987) demonstrated that tannins can bind to epithelial cells and cause subsequent precipitation of proteins that penetrate the cells surface, causing damage to the liver. Furthermore, tannins reduce the amount of vitamin A in the liver and interfere with the use of vitamin B12 Chung et al. (1998b), Krishnan et al*.* (2014), they also form insoluble complexes with divalent iron, making it less absorbable. Interestingly, tannins have astringent properties, antidiarrheal activity, antimicrobial ([SCALBERT,](http://www.sciencedirect.com/science/article/pii/S0377840101002346%22%20%5Cl%20%22BIB53) [1991](http://www.sciencedirect.com/science/article/pii/S0377840101002346%22%20%5Cl%20%22BIB53)), antifungal activity ([HART; HILLIS, 1972](http://www.sciencedirect.com/science/article/pii/S0377840101002346%22%20%5Cl%20%22BIB21)) and antiseptic effects. They also have the ability to form waterproof layers over exposed skin and mucous membranes, and they are haemostatic (precipitate alkaloids).

 There was no change in hepatic or renal function in the animals that received feed supplemented with banana leaves. All the values were within the normal limits. The pH measurements indicated severe ruminal alkalosis in the animals, with a pH between 7.5 and 9.0. However, these animals did not exhibit any clinical symptoms. It was not possible to perform ammonia tests due to reagent problems.

 This project was the first to study banana plant leaves and stalks as an alternative feed source for sheep. Further studies should be performed to establish acceptable standards for the safe amounts of secondary compounds, such as tannins, and to standardize the methods for quantifying these secondary compounds.

# Conclusion

 Banana plant (*Musa* spp.) leaves and stalks can be used as an alternative source of nutrition for ruminants in a program that emphasizes sustainability, since these biomass residues are used judiciously. The indiscriminate use of banana leaves can result in low digestibility and consequently, economical losses to the farmer. However, in a proper nutritional formulation, banana leaves and stalks can substantially benefit the producers and will not impinge on animal health.

# Conflicts of interest

 The authors declare no conflicts of interest regarding the work presented here.

**Authors' contribution**

 Bruno Leonardo Mendonça Ribeiro - execution of the experiment; Mariane Ferreira Franco - writing and execution of the experiment; Eduardo Carvalho Marques - execution of the experiment; Lucas Alencar Fernandes Beserra - work corrections; Gisela Gregoria Choque - work corrections; Lilian Gregory - guidance, corrections and revision of the text.

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