Acta Scientiarum

http://periodicos.uem.br/ojs
ISSN on-line: 1807-8672
Doi: 10.4025/actascianimsci.v46i1.67242

Fermentation quality and nutritional value of marandu grass silage with dehydrated banana peel

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ABSTRACT. The objective of this study was to evaluate the fermentation profile and nutritional value of Marandu grass silage (*Urochloa brizantha* (Hoschst.Ex. A. Rich) R. D. Webster cv. Marandu Syn. *Brachiaria brizantha* (Hochst. Ex A. Rich) Stapf cv. Marandu} with different levels of inclusion of dehydrated banana peel. The experiment was conducted in a completely randomized design with marandu grass with five levels of dehydrated banana peel (0, 10, 20, 30 and 40% of natural matter) with eight replicates. The data collected were submitted to analysis of variance and, when the "F" test was significant, the inclusion levels of the pre-dried banana peel were analyzed utilizing orthogonal polynomials and linear and quadratic regression models. The mean values of N-NH3 were adjusted to the linear regression model ($p < 0.01$), while the pH values had the lowest value of 4.3 with the inclusion of 15% of banana peel. The mean values of the gas loss (PG, $P = 0.01$) and the dry matter recovery (RMS; $P = 0.01$) were adjusted to the quadratic regression model, with a minimum point of 16.15% for losses and 21% as the maximum point for dry matter recovery. The rate of degradation potential degradability of the dry matter (SD; $P = 0.74$) did not vary with the inclusion of the banana peel. The potential degradability standardized at 2, 5 and 8% was adjusted to the regressive linear regression model ($p < 0.01$), and for each percentage point of inclusion of the banana peel, there was a reduction of 0.23, 0.14 and 0.10%, respectively. The inclusion of 10 to 20% dehydrated banana peel in the marandu grass silage improves the fermentation profile and the nutritional value of the silage.

Keywords: effluents; dry matter; grasses; ruminal kinetics; waste.

Received on February 22 2023.
Accepted on August 16 2023

Introduction

Cattle production in Brazil relies on forage plants as the primary nutrient source, with Brachiaria grasses being the most widely cultivated. However, due to varying edaphoclimatic conditions in the central region of Brazil, consistent forage mass production is challenging. Consequently, ensiling excess roughage during the rainy season becomes a cost-effective strategy to sustain animal production (Orrico et al., 2017; Silva et al., 2018).

Brachiaria grasses offer substantial ensilage potential due to their high biomass productivity and excellent nutritional value for animals (Orrico Junior et al., 2017; Silva et al., 2018). Their adaptability and resilience to harsh environmental conditions make them popular forage choices in tropical regions.

Despite their merits, the persistent challenge in ensiling Brachiaria forages remains their low dry matter content (less than 25%) and limited non-fiber carbohydrates (Kung, Shaver, Grant, & Schmidt, 2018). This low dry matter content can lead to excess moisture during ensiling, hindering desirable fermentation and risking nutrient losses and spoilage. Furthermore, the scarcity of non-fiber carbohydrates can affect the energy density and overall nutritional quality of ensiled forage (Marques et al., 2021).

As banana production expands, a parallel rise in byproducts from this crop, including pseudostems, leaves, husks, stalks, and cores, emerges. These byproducts can serve as organic materials within the banana cultivation cycle or as valuable feed additives for ruminant animals (Pimentel et al., 2017; Carmo et al., 2018; Rigueira et al., 2021). The remaining banana pseudostem after harvest can generate about 3 tons of green matter per ton of harvested crop (de Oliveira Rabelo et al., 2020).

In this context, utilizing moisture-sequestering additives like sun-dried banana peel (Musa spp.) becomes a noteworthy conservation alternative. Typically discarded post-pulp extraction, banana peel offers a low-cost residue for grass ensilage (Monção et al., 2016; Brant et al., 2017). However, there is a knowledge gap concerning the optimal inclusion level of banana peel for ensiling and its effects on fermentation profile, chemical-bromatological composition, and ruminal kinetics of the ensiled mass (Mat et al., 2020).

Hence, this study aims to evaluate the fermentative profile and nutritional value of Marandu grass silage with dehydrated banana peel inclusion, addressing these concerns.

Material and methods

The ruling of the Ethics Committee of Unimontes No.174, APPROVED on 09/28/2018. The experiment was carried out at the State University of Montes Claros, Campus Janaúba, MG, Brazil (15º 52 '38 "South and 43º 20' 05" West). The mean annual precipitation is 800 mm with an average annual temperature of 28°C, relative air humidity around 65% and, according to Koppen (1948) limatic classification, the predominant type of climate in the region is Aw.

The treatments consisted of the inclusion of dehydrated banana peel in the marandu grass silage in five levels (0, 10, 20, 30 and 40% of natural matter) with eight replications. The forage was collected in a pre-installed area at the Unimontes Experimental Farm after 60 days of standardization cut. It was done the manual cutting of the grass and later crushing in a shredder-chopper machine (JF, Model Z-6; Itapira, São Paulo State, Brazil) coupled to the TL75, 4x4 tractor (New Holland, Curitiba, PR, Brazil). The knives of the machine were set to grind the forage and obtain a particle size of 2 cm. The banana peel was collected fresh in the banana processing industry and dehydrated in the sun for 5 days. After drying, the banana peel was crushed in a shredder-chopper machine coupled to an electric motor (2 cm particle size).

Five hills were harvested with the forage, being the additive added in the respective proportions and homogenized before ensiling. For silage, experimental PVC silos of known weights, 50 cm long and 10 cm in diameter, were used. The bottom of the silos, they contained 10 cm of dry sand (300 g), separated from the forage by foam to quantify the produced effluent. After the complete homogenization of the forage with the additives, it was deposited in the silos and compacted with the aid of a wooden plunger. For each treatment the silage density was quantified and approximately 3 kg of the chopped material of each fresh forage was ensiled. After filling, the silos were closed with PVC caps fitted with Bunsen-type valves, sealed with adhesive tape and then weighed. The silos were stored indoors, kept at room temperature and opened 60 days after ensiling. After the opening, samples were collected in the middle of each silo.

For the determination of the pH of the silages, a program (digital model MA522, Marconi Laboratory Equipment, Piracicaba, São Paulo State, Brazil) was used according to the methodology described by Silva and Queiroz (2006). The analysis of ammoniacal nitrogen expressed as total nitrogen (NH_3, %/NT) was performed by sampling about 25g of silage, as proposed by Bolsen et al. (1992).

The losses of dry matter in the silages under the gas and effluent forms were quantified by weight difference. The loss of dry matter in the form of gases was calculated by the difference between the gross weight of the initial and final ensiled dry matter, about the amount of dry matter ensiled, minus the weight of the silo set and dry sand. Dry matter recovery was calculated by the difference between the initial and final dry matter content of the silo. All the formulas can be consulted in the methodology described by Jobim, Nussio, Reis, and Schmidt (2007).

The dehydrated banana peel, fresh marandu grass and silage samples were analyzed for dry matter (DM, 934.01), ashes (942.05), ether extract (EE; 920,39) and crude protein (PB, 978.04) as described by Association of Official Analytical Chemists (AOAC, 1995). Neutral detergent fiber (NDF) and acid detergent fiber (FDA) were determined by the sequential method, according to procedures described by Robertson and Van Soest (1991) using the TECNAL® TE-149 fiber determiner (Piracicaba, São Paulo State, Brazil) using alpha-amylase. Cellulose was solubilized in 72% sulfuric acid and lignin content was obtained as the difference (Goering & Van Soest, 1970). The total carbohydrate (TC) content was estimated by the equation: TC (%) = 100 [% Humidity + CP (%) + EE (%) + ashes (%)] and those of non-fibrous carbohydrates (NFC) according to Sniffen, O'connor, Van Soest, Fox, and Russell, (1992).

Total digestible nutrients (TDN) were estimated using the formula according to National Research Council (NRC, 2001). The chemical-bromatological composition of marandu grass and dehydrated banana peel before ensiling can be observed in Table 1.

Table 1. Chemical composition of marandu grass and dehydrated banana peel.

Item (g kg^{-1})	Marandu grass [1]	Dehydrated banana peel [2]
Dry matter	239.1	942.5
Ash	119.0	141.4
Crude Protein	122.6	119.1
Ether extract	18.2	75.8
Neutral detergent fiber	643.3	501.4
Acid detergent fiber	349.5	407.2
Lignin	42.5	111.0

[1] 60 days of regrowth; [2] Dehydrated in the sun for 120 hours.

Four crossbred steers, cannulated in the rumen and with an average weight of 500 ± 50 kg, were used to evaluate the kinetics of ruminal degradation. The animals received 3.0 kg of concentrate *plus* dehulled banana peel, divided twice in the morning and afternoon. In addition to the concentrate, the animals received bulk, in the same proportion, with marandu grass and elephant grass silage (*Pennisetum purpureum* Schum.) For 14 days before the experiment.

The *in situ* degradability technique was used using non-woven fabric (TNT, weight 100), 60 µm porosity bags according to Casali et al. (2009), with several samples following the ratio of 20 mg of MS cm^{-2} of bag surface area (Nocek, 1988).

The bags were placed in filo bags along with 100 grams of lead. The bags were tied with nylon thread, leaving a free length of 1 m so that they had free movement in the solid and liquid phases of the rumen. The bags were deposited in the ventral sac region of the rumen for 0, 3, 6, 12, 24, 48, 72, 96 and 120 hours, with the end of the nylon thread remaining attached to the cannula. The bags were placed in reverse order, starting with the time of 120 hours. The zero-time samples were washed in ice water (20°C) along with the other samples. Subsequently, the samples were placed in a forced ventilation oven at 55°C until reaching constant weight.

Residues remaining in the TNT collected in the rumen were analyzed for DM and NDF contents. The data obtained were adjusted to non-linear regression by the Gauss-Newton method (Neter, Wasserman, & Kutner, 1985), using SAS software (SAS Institute Inc., Cary, NC), according to the equation proposed by Ørskov and Mcdonald (1979)): $Y = a + b\ (1-e^{-ct})$, where: Y = cumulative degradation of the nutrient component analyzed after time t; a = degradation curve intercept when t = 0, which corresponds to the water-soluble fraction of the analyzed nutrient component; b = degradation potential of the water-insoluble fraction of the analyzed nutrient component; a + b = potential degradation of the nutrient component analyzed when time is not a limiting factor; c = rate of degradation per fermentative action of b; t = incubation time.

After calculating, the coefficients a, b and c were applied to the equation proposed by Ørskov and Mcdonald (1979): $DE = a + (b \times c / c + k)$, where: DE = effective ruminal degradation of the analyzed nutrient component; k = rate of feed passage. Rumen particle passage rates estimated at 5% h^{-1}, as suggested by Agricultural and Food Research Council (AFRC, 1993), were assumed. The degradability of NDF was estimated using the model of Mertens and Loften (1980): $Rt = Bx\ e^{-ct} + I$, where Rt = the fraction degraded at time t; B = insoluble fraction potentially degradable; and Ip = the indigestible fraction.

After adjusting the NDF degradation equation, the fractions were standardized as proposed by Waldo, Smith, and Cox, (1972) using the following equations: $Bp = B / (B + I) \times 100$ and $Ip = I / (B + I) \times 100$, where BP = the standard potentially degradable fraction (%); Ip = the standard indigestible fraction (%); B = the insoluble fraction potentially degradable; and I = the indigestible fraction. The effective degradability of the NDF was calculated using the model $DE = Bp \times c / (c + k)$, where Bp is the standardized potential of the degradable fraction (%).

A completely randomized design with five levels of inclusion of dehydrated banana peel and the control treatment with eight replicates (experimental unit) were used for fermentation profile and chemical-bromatological composition evaluations. The ruminal degradability assay was carried out in a randomized complete block design with subdivided plots, with the plots and incubation times being the subplots. The weight variation of cattle was the blocking factor.

The data collected were submitted to analysis of variance and, when the "F" test was significant, the inclusion levels of the pre-dried banana peel were analyzed utilizing orthogonal polynomials and linear and quadratic regression models were tested using the PROC REG of SAS (SAS Institute Inc., Cary, NC). For all statistical procedures, $\alpha = 0.05$ was adopted as the maximum tolerable limit for type I error.

Results and discussion

The inclusion of the banana peel during the ensiling of the marandu grass modified the fermentative characteristics of the silage (Table 2, $p < 0.01$), except for the effluent losses ($P = 0.77$), an average of 1.91 kg t^{-1}. The averages for pH, gas losses and dry matter recovery (DMR) were adjusted to the quadratic regression model, with the minimum points with the inclusion of 15% for pH and 21% for DMR and a maximum point for gas losses. Ammoniacal nitrogen (N-NH_3) linearly reduced 0.06% of the total nitrogen (NT) for each percentage unit of banana peel included in the silage.

Table 2. Fermentation characteristics of marandu grass silages with levels of dehydrated banana peel.

Item	Inclusion of banana peel (% NM)					SEM	P-value	
	0	10	20	30	40		Linear	Quad
pH[1]	4.6	4.2	4.3	4.4	4.6	0.03	0.01	<0.01
N-NH_3, % TN[2]	7.9	6.1	5.8	5.4	5.2	0.50	<0.01	0.11
Gases (% DM)[3]	11.78	16.95	15.4	11.99	8.9	1.35	0.01	0.01
Effluents (kg t^{-1})	2.23	1.65	2.11	1.81	1.76	0.27	0.38	0.77
DMR (%)[4]	88.22	83.04	84.58	88.0	91.05	1.35	0.01	<0.01

TN - Total nitrogen; P – Probability; NM – Natural matter; N- NH_3- Ammoniacal nitrogen; DM- Dry matter; DMR- Dry matter recovery. SEM – Standard error of the mean; Equations: [1]$Y= 4.60 –0.03^*X+0.001^*X^2$, $R^2= 0.87$; [2]$Y= 7.40-0.06^*X$, $R^2= 0.81$; [3] $Y= 12.53+0.42^*X–0.013^*X^2$, $R^2= 0.87$; [4]$Y= 87.47-0.42^*X+0.01^*X^2$, $R^2= 0.87$. * significant by the t test at 5% probability.

The inclusion levels of banana peel influenced linearly the DM content, ashes, ether extract (EE) and lignin of the marandu grass silage ($p < 0.01$; Table 3). Regarding the organic matter, the effect was linearly decreasing with an increase of bark levels, in which the addition of 1% of bark during silage provided a decrease of 0.14%. The NDF contents of the marandu grass silage reduced ($p < 0.01$) linearly from 65.8% to 54.92%.

Table 3. Chemical-bromatological composition of marandu grass silage associated with increasing levels of dehydrated banana peel.

Item (g kg de MS^{-1})	Inclusion of banana peel (% MN)					SEM	P-value	
	0	10	20	30	40		Linear	Quadratic
MS[1]	240	303	369	417	510	66	<0,01	0,08
Ashes[2]	119	148,2	156	170	180	22	<0,01	<0,01
OM[3]	880	851	843	829	819	22	<0,01	<0,01
CP	85	96	84	87	81	41	0,20	0,21
EE[4]	56	62	91	71	101	48	<0,01	0,98
NDF[5]	658	619	599	562	549	70	<0,01	0,20
ADF	386	361	339	349	345	10	0,06	0,05
Celulose[6]	352	307	268	282	299	105	<0,01	<0,01
Hemicel[7]	271	258	259	213	203	117	<0,01	0,36
TC[8]	739	692	668	670	636	69	<0,01	0,05
NFC	80	73	68	107	96	91	0,11	0,60
TDN[9]	612	619	667	648	695	80	<0,01	0,66
Lignin[10]	51	92	97	114	126	45	<0,01	<0,01

Dry matter base (DM); MN – Natural matter; OM – Organic matter; CP – Crude protein; NDF – Neutral detergent fiber; ADF – Acid detergent fiber; Hemicel – Hemicellulose; TC - Total carbohydrates; NFC – Non-fibrous carbohydrates; TDN- Total digestible nutrients; SEM – Standard error of the mean; * Significant by the T test at 5% probability. Equations: [1]$Y= 237+6.5^*X$, $R^2= 0.99$; [2]$Y= 125+1.44^*X$, $R^2= 0.94$; [3]$Y= 874-1.44^*X$, $R^2= 0.94$; 4$Y= 56.5+1.0^*X$, $R^2= 0.68$; 5$Y= 653-2.75^*X$, $R^2= 0.97$; 6$Y= 354 – 63.9+1.2^*X^2$, $R^2= 0.96$; 7$Y= 277 – 1.81^*X$, $R^2= 0.87$; 8$Y= 727 – 2.28^*X$, $R^2= 0.89$; 9$Y= 609+1.94^*X$, $R^2= 0.81$; 10$Y=62.1+1.72^*X$, R2=0.89.

There was no effect of the inclusion of the banana peel for the CP and ADF, with an average of 8.5 and 35.5%, respectively. The averages of the cellulose contents were adjusted to the quadratic model of regression, which is the minimum point of 26.62%. Hemicellulose and TC linearly reduced 1.81 and 2.28 g kg^{-1} with the inclusion of every 1% of the banana peel. The NFC were not altered in the silage (mean of 84.8 g kg^{-1}; $P = 0.60$). Total digestible nutrients and lignin increased by 1.94 and 1.72 g kg^{-1} for each percentage point of inclusion of the banana peel.

The inclusion of banana peel increased linearly the readily soluble fraction (fraction a; $p < 0.01$) and the effective degradability ($p < 0.01$) of the silage dry matter (Table 4).

The water-insoluble but a potentially degradable fraction (fraction b; $p < 0.01$) of the dry matter increased by 0.31% for each inclusion unit of the banana peel. The degradation rate of the "b" fraction "c" ($P = 0.09$), potential degradability (PD; $P = 0.74$) and undegradable fraction (UF; $P = 0.16$) of the dry matter were not altered with inclusion of banana peel, with averages of 2.2% h^{-1}, 79.97 and 23.02%, respectively.

Table 4. Rumen kinetics of the dry matter of the marandu grass silage with the inclusion of dehydrated banana peel.

Item	Inclusion of banana peel (% NM)					SEM	P-value	
	0	10	20	30	40		Linear	Quadr
Fraction a[1]	27.56	31.05	32.22	35.32	35.73	0.65	<0.01	0.09
Fraction b[2]	49.78	48.07	46.35	41.42	37.35	2.03	<0.01	0.30
c, %/h	2.00	2.00	2.00	2.00	3.00	<0.01	0.06	0.09
PD	77.34	79.13	73.57	76.74	73.08	1.78	0.06	0.74
ED[3]	43.00	45.18	46.49	47.62	49.42	0.70	<0.01	0.73
UF	22.65	20.87	21.42	23.25	26.91	2.27	0.13	0.16

c- Rate of degradation "c" of fraction b; PD - Potential degradability; ED- effective degradability; UF- undegradable fraction; Equations: [1]Y= 28.25+0.21*X, R^2= 0.94; [2]Y= 50.89–0.31*X, R^2= 0.94; [3]Y= 43.29+0.15*X, R^2= 0.98. * Significant by the t test at 5% probability.

The inclusion of different levels of dehydrated banana peel in the marandu grass silage had no significant effect on the degradation rate of neutral detergent fiber fraction b (P = 0.81), with an average of 3% h^{-1} (Table 5). Standard potential degradability and effective degradability at 2, 5 and 8% presented a linear decreasing effect (p < 0.01). For each percentage point of banana peel inclusion, there was a reduction of 0.37, 0.23, 0.14 and 0.10%, respectively. The standardized undegradable fraction of NDF adjusted to the linear regression model.

Table 5. Rumen degradability of dry neutral detergent fiber of marandu grass silage with the inclusion of dehydrated banana peel.

Item	Inclusion of banana peel (% NM)					SEM	P-value	
	0	10	20	30	40		Linear	Quad
[1]Bp, %	65.58	62.66	51.11	55.23	50.48	1.25	<0.01	0.03
c, %/h	3.00	3.00	3.00	3.00	3.00	<0.01	0.81	0.84
[2]ED 2% h^{-1}	38.04	34.93	29.85	29.37	28.89	1.37	<0.01	0.08
[3]ED 5% h^{-1}	23.50	21.30	18.86	17.99	17.94	1.09	<0.01	0.17
[4]ED 8% h^{-1}	17.03	15.35	13.85	13.04	13.07	0.87	<0.01	0.23
Ip, %	34.42	37.34	48.89	44.78	49.52	1.25	<0.01	0.03

Bp - potentially degradable fraction standardized; c - Rate of degradation "c" of fraction b; ED - effective degradability; Ip - undegradable fraction standardized. Equations: [1]Y= 64.53-0.37*X, R^2= 0.76; [2]Y= 36.98-0.23*X, R^2= 0.86; [3]Y= 22.80-0.14*X, R^2= 0.88; [4]Y= 16.51-0.10*X, R^2= 0.89; [5]Y= 33.74+0.71*X-0.008*X^2, R^2= 0.81. * Significant by the t test at 5% probability.

The concentration of soluble carbohydrates, DM content and buffering capacity are factors that influence the pH of the ensiled mass. According to Kung et al. (2018), pH values between 4.3 and 4.7 characterize well-conserved silage for grasses, and values above these may indicate butyric fermentation. According to the authors, the rate of pH reduction during fermentation may affect the microorganisms that grow and dominate the ensiled mass influencing pH and stability. The pH value observed is characterized by marandu grass silage with banana peel with good conservation capacity up to 15%, observing from this point there is an increase in pH value.

The high content of dry matter may have influenced the pH, since it impairs the compaction of the silage and, consequently, the lactic fermentation, responsible for controlling the undesirable fermentation microorganisms (Kung et al. 2018).

The value of ammoniacal nitrogen is an important factor to evaluate the fermentation process since it can demonstrate if there was crude protein degradation. The values verified based on the dry matter are below 10% that qualifies silage with good fermentative standard (Kung et al. 2018).

Brant et al. (2017) investigated using dehydrated banana peel as an additive in elephantgrass silage, they found that including 5 to 25% banana peel-maintained ammonia nitrogen levels within acceptable limits for proper silage fermentation. As per the authors' findings, the escalation of banana peel levels in the ensiled mass exhibited a linearly decreasing effect on pH and ammoniacal nitrogen values. However, there is no literature available on the utilization of banana peel in Marandu grass ensiling, underscoring the significance of this research.

The silage gases losses are caused by the action of enterobacteria, yeasts and heterofermentative bacteria is the bacteria of the genus Clostridium spp are the main responsible for losses through the butyric fermentation. The lowest values of gas losses were observed with the inclusion level of 16.15% of the banana peel in the marandu grass silage. The high content of dry matter can impair the compaction of the ensiled mass, increasing the amount of air in the silo, which can hinder the action of the lactic acid bacteria, which increases the loss of silage (Marques et al., 2021).

The effluent losses of the marandu grass silage reduced 24.44% with the inclusion of 40% of the dehydrated banana peel. This reduction highlights the potential of dehydrated banana peel as an absorbent additive. Effluent losses can directly influence the nutritional value of the silage, because, during the process, losses of carbohydrates and proteins occur, being the main cause of these losses the high moisture content of the forage at the time of harvest (Marques et al., 2021). The inclusion of 40% of banana peel in the marandu grass silage had the highest recovery of DM, 91.1% of the natural matter.

The dry matter content of the silage significantly increased, reaching 51% with the exclusive use of marandu grass and 40% inclusion of banana peel. This highlights the effectiveness of banana peel as an additive in enhancing the matter content of marandu grass silage due to its high dry matter content. According to Kung et al. (2018), recommended dry matter levels for effective silage production range between 25 and 35%.

Maintaining optimal dry matter content is crucial for high-quality silage, as values below 25% can lead to effluent losses, while exceeding 35% can compromise proper compaction of the ensiled mass. Consequently, a 10% inclusion of dehydrated banana peel emerges as the optimal choice.

The amount of NDF decreased by 11.6% with the inclusion of the banana peel. This reduction occurred due to the dilution effect since the banana peel has a lower NDF content compared to the marandu grass. The lignin content increased with the inclusion of banana peel. Thus, there was a reduction of the insoluble fraction, but the potential of the dry matter (fraction b) and a potential fraction of NDF (Bp).

According to Van Soest (1994), lignin when present in the cell wall may limit ruminal degradation due to the formation of steric-type bonds with hemicellulose. Due to the presence of carbohydrates such as pectin, starch and sugars in the banana peel, there was a 22.85% increase in the "a" fraction of the silage dry matter, which is an important source of energy for ruminal microorganis---ms (Van Soest, Robertson, & Lewis, 1991).

In a study by Souza et al. (2016), which assessed various treatments of banana peel including sun-drying for 7 days, with or without limestone and calcium oxide, on dairy cow performance, it was determined that incorporating 20% sun-dried peel into the diet had no significant impact on milk production. Furthermore, a range of inclusion levels revealed effects on both fermentation and nutritional properties.

A 10% inclusion enhanced pH, fermentation, and nutrients, while higher levels risked pH issues. Peel aided compaction, reducing effluent, and boosting recovery, but elevated lignin. A 10% inclusion seemed best, balancing quality and further research on livestock impact. As a consequence, the effective degradability of DM increased with the inclusion of banana peel, with values of 43% for control marandu grass silage and 49.42% for marandu grass silage with 40% inclusion.

Conclusion

The inclusion of 10 to 20% dehydrated banana peel in the marandu grass silage improves the fermentation profile and the nutritional value of the silage.

Acnowledgements

The authors thank the Foundation for Research Support of the State of Minas Gerais (FAPEMIG), the Embrapa Gado de Leite and the National Council for Scientific and Technological Development (CNPq). This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brazil (CAPES) - Finance Code 001.

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