Ciência Rural, Santa Maria, v.54:02, e20220513, 2024
http://doi.org/10.1590/0103-8478cr20220513
ISSNe 1678-4596
ANIMAL PRODUCTION

Nutritional value and fermentative characteristics of pearl millet silage with different levels of coffee husk

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ABSTRACT: The research was conducted to test the hypothesis that the inclusion of coffee husk (*Coffea* sp.) would improve the fermentative characteristics and quality of pearl millet silage (*Pennisetum glaucum*). Thus, the objective was to assess the effect of the inclusion of different levels of coffee husk in pearl millet silage on the chemical composition, fermentative characteristics and degradability *in situ* of silage. The experimental design used was completely randomized and the treatments consisted of the silage of the whole pearl millet plant with the inclusion of increasing levels of coffee husk: 0%, 7%, 14% and 21%, based on natural matter. After 60 days of fermentation, the silages were evaluated for chemical characteristics, fermentative, degradability *in situ* dry matter (DM) and neutral detergent fiber (NDF). The inclusion of coffee husk did not alter (P > 0.05) the contents of crude protein (11.94%), NDF (44.89%) and total digestible nutrients (65.09%). There were increases in the concentrations of DM and fiber in acid detergent, accompanied by a reduction in the concentrations of mineral matter and ether extract, as the proportion of coffee husks in silages increased. There was an increase in the lignin content up to the level of 7.59% inclusion of the coffee husk. There was no effect of the inclusion of the coffee husk on the pH of the silage (3.60). However, the inclusion of coffee husk resulted in a reduction in temperature, gas losses, and degradability *in situ* of silage DM and NDF. It is recommended to include coffee husk up to the level of 14.0% of the natural matter to improve the fermentation pattern and the quality of the pearl millet silage.
Key words: absorbent additives, *Coffea* sp., chemical composition, degradability *in situ*, preserved forage, *Pennisetum glaucum*.

Valor nutritivo e características fermentativas da silagem de milheto com diferentes níveis de casca de café

RESUMO: A pesquisa foi conduzida para testar a hipótese de que a inclusão de casca de café (*Coffea* sp.) melhoraria as características fermentativas e a qualidade da silagem de milheto (*Pennisetum glaucum*). Assim, objetivou-se avaliar o efeito da inclusão de diferentes níveis da casca de café na ensilagem de milheto sobre a composição química, características fermentativas e degradabilidade *in situ* da silagem. O delineamento experimental utilizado foi inteiramente casualizado e os tratamentos constituíram-se pela silagem da planta inteira de milheto com a inclusão de níveis crescentes de casca de café: 0%, 7%, 14% e 21%, com base na matéria natural. Após 60 dias de fermentação, as silagens foram avaliadas quanto às características químicas, fermentativas, degradabilidade *in situ* da matéria seca (MS) e da fibra em detergente neutro (FDN). A inclusão da casca de café não alterou (P > 0,05) os teores de proteína bruta (11,94%), FDN (44,89%) e nutrientes digestíveis totais (65,09%). Houve aumentos nas concentrações de MS e fibra em detergente ácido, acompanhados de uma redução nas concentrações de matéria mineral e extrato etéreo, à medida que se aumentou a participação da casca de café nas silagens. Houve um aumento no teor de lignina até o nível de 7,59% de inclusão da casca de café. Não houve efeito da inclusão da casca de café sobre o pH da silagem (3,60). Entretanto, a inclusão de casca de café acarretou na redução da temperatura, perdas por gases, degradabilidade *in situ* da MS e FDN da silagem. Recomenda-se a inclusão de casca de café até o nível de 14,0% da matéria natural para melhoria do padrão de fermentação e da qualidade da silagem de milheto.
Palavras-chave: aditivos absorventes, *Coffea* sp., composição química, degradabilidade *in situ*, forragem conservada, *Pennisetum glaucum*.

INTRODUCTION

One of the biggest challenges for ruminant production in tropical climate regions is to maintain a constant fodder supply throughout the year, as seasonal weather events affect forage plant growth (GURGEL et al., 2020; SILVA et al., 2022). In this sense, the silage of short-cycle forages that are resistant to water shortages is a possibility to have volume available for animals during periods of food shortages (BARCELOS et al., 2018; BRITO et al., 2020; OLIVEIRA et al., 2023; ALI et al., 2022).

The pearl millet (*Pennisetum glaucum*) is an alternative for livestock farmers to produce preserved fodder in the form of silage in regions or periods of low rainfall (GUIMARÃES JUNIOR et

Received 09.15.22 Approved 04.21.23 Returned by the author 06.16.23
CR-2022-0513.R1
Editors: Leandro Souza da Silva Denise Montagner

al., 2010; JACOVETTI et al., 2018; CARVALHO et al., 2018). Because, it is a plant with high drought resistance, adaptability to low fertility soils, high fodder production, and high nutrient extraction capacity, given the deep root system that the culture has (PINHO et al., 2014). The main limiting factor for the production of the pearl millet silage is the high moisture content of the material to be silaged. At the appropriate time for harvesting, when the grains are in the pasty-farinaceous stage, the plant has dry matter contents between 20% and 25% (PINHO et al., 2014; JACOVETTI et al., 2018), which can result in undesirable fermentation and increased effluent losses during silage, reducing final silage quality (KUNG JUNIOR et al., 2018; OLIVEIRA et al., 2023). Therefore, it is necessary to use techniques such as the inclusion of moisture absorbing additives, as an alternative to enable improvement in the fermentative profile of pearl millet silages.

Coffee husk (*Coffea sp.*) has been considered an absorbent additive option in silages of non-graniferous grasses (FARIA et al., 2007; FARIA et al., 2010; BARCELOS et al., 2018). In Brazil, the coffee production estimate for 2022 is 53.43 million 60 kg bags of processed product, considering the 1:1 ratio for processed coffee:coffee husk, this production will generate 3.2 million tons of coffee husk (CONAB, 2022). Among their characteristics, they can present approximately 10.0% crude protein and 55.0% digestibility of dry matter (BARCELOS et al., 2018). In addition, this residue reaches dry matter contents of 85.0%. Thus, the use of this by-product as additives reduces the moisture of the silage material, allowing a adequate fermentative process (BARCELOS et al., 2018).

It should be noted that the amount of coffee husk added to the silage must be evaluated safely, mainly due to the high fiber values in acid detergent and lignin, which can negatively affect the digestibility of nutrients (BERNARDINO et al., 2005; FARIA et al., 2007; BARCELOS et al., 2018). Therefore, the hypothesis tested was that ensiling pearl millet with coffee husk in moderate levels of inclusion results in silages with reduced losses and high nutritional value.

Thus, the objective was to evaluate the effect of the inclusion of different levels of coffee husk in the ensiling of whole plant of pearl millet on the chemical composition, fermentative characteristics, and degradability *in situ* of silages.

MATERIALS AND METHODS

The experiment was conducted at the Technology and Innovation Center of the company Agroceres Multimix Nutrição Animal LTDA®, located in the municipality of Patrocínio, Minas Gerais - Brazil (18º56'38 S, 46°59'34 W and 947 meters altitude), during the months from April to August 2019. The climate of the region, according to the Köppen classification, is of type Cwa, with an average annual temperature of 21.4 °C and an average rainfall of 1350 mm per year, with a water surplus between the months of October and April.

The soil of the area used for the cultivation of pearl millet (*Pennisetum glaucum*) is classified as Red Oxisol (SANTOS et al., 2018). Before sowing, soil was collected for chemical characterization (Table 1). Based on the results, it was not necessary to use limestone, so the soil was prepared with two ploughs and two harrows.

For the preparation of the silage, the pearl millet cultivar BRS-1501 was used, which was sown manually in April 2019, at a depth of 2 cm, with row spacing of 50 cm, adopting 20 seeds per linear meter. 100 kg ha^{-1} of nitrogen (N) was applied, divided into 20 kg at sowing and 80 kg at cover when the plants reached five expanded leaves. Control of diseases and insect pests was not necessary, and weed removal was performed manually to avoid bush interference.

The experimental design used was completely randomized with four treatments and six replications. The treatments consisted of the silage of the whole millet plant with the inclusion of increasing levels of coffee husk: 0%, 7%, 14% and 21%, based on the fresh matter. Pearl millet cutting

Table 1 - Chemical characteristics of the soil of the experimental area in the layer of 0 – 20cm deep.

pH*	Ca^{2+}	Mg^{2+}	K^{+}	Al^{3+}	H+Al	S	T	M	V	P
5.40	----------cmolc.dm-³----------							----------%----------		----mg.dm-³----
	0.60	4.20	2.50	-	1.60	7.30	7.30	-	82.00	86.00

*pH ($CaCl^2$); S: sum of bases (Ca + Mg + K); T: cation exchange capacity at pH 7.0 [S+(H+Al)]; V: Saturation by bases [(S/T) * 100]; M: Saturation by aluminum [(Al/T) * 100].

was carried out manually 10 cm from the ground, 72 days after sowing, at a time when the grains were in the pasty-farinaceous stage. The material was chopped into particles of approximately two centimeters in forage harvester model JF C120© coupled to a tractor. The coffee husk was obtained from a producer in the region, consisting of the exocarp, mesocarp and endocarp.

In natura samples of the pearl millet and the coffee husk were collected to determine the contents of dry matter (DM), crude protein (CP), mineral matter (MM) ether extract (EE), neutral detergent fiber (NDF), acid detergent fiber (ADF), lignin, calcium (Ca) and phosphorus (P) by near infrared spectroscopy (NIRS), according to the methodology proposed by MERTEN et al. (1985). For the estimation of total digestible nutrients (TDN), the following equation proposed by CAPPELLE et al. (2001) was used: TDN (%) = 99.39 – 0.7641*NDF. Non-fibrous carbohydrates (NFC) were calculated by the following equation (SNIFFEN et al., 1992): NFC (%) = 100 - (NDF + CP + EE + MM) (Table 2).

Twenty-four experimental silos (six per treatment) cylindrical PVC tubes with 10 cm in diameter and 40 cm in length were used, with PVC lids equipped with a Bunsen valve to allow the escape of gases from the fermentation. The compaction was performed with wooden tampers, adopting a specific mass of 200 kg DM/m^3. Subsequently, the silos were weighed and kept in a covered area at room temperature.

The silos were weighed before opening, which occurred after 60 days of fermentation, to quantify gas losses and dry matter recovery index, according to equations described by JOBIM et al. (2007):

Gas losses (%) = [(WS initial – WS final) / MS initial] × 100

In which, *WS* is the weight (kg) of the silo at the time of silage (initial), *WS* is the weight (kg) of the silo at the time of opening (final), and *MS* represents the mass of silage fodder (kg of DM).

Dry matter recovery (%) = (FM at opening × DM at opening)/(FM at closing × DM at closing) × 100

Where, *FM at opening* and *DM at opening* represent, respectively, the forage mass and the DM of the forage at the opening of the silo; *FM and DM* are the values referring to the forage mass and DM of fodder at the ensiling moment in the closing of silo, respectively.

At the time of opening the silo, the temperature in the 20 cm deep layer was measured with a digital thermometer. The contents referring to the three centimeters of the upper and lower parts of each experimental silo were discarded and the rest of the content was homogenized (initial, intermediate and final part). After this procedure, the silage samples were collected, packed in plastic bags and sent to the laboratory to determine the contents of DM, MM, CP, EE, NDF, ADF, lignin, Ca, P, TDN and NFC in a manner analogous to the evaluations performed on the material *in natura*.

The pH of the silage was determined after diluting nine grams of fresh silage in 60 mL of distilled water. After 30 minutes of rest, an electrode was introduced into the solution waiting for a stabilization of 15 seconds for each sample (JOBIM et al., 2007).

To determine the *in situ* degradability of DM and NDF, samples were dried and then ground in a mill with a 2.0 mm sieve (AOAC, 1990). Subsequently, five grams of each sample were weighed in duplicate and placed in *nylon* plastic bags (NOCEK & RUSSELL, 1988).

For the degradability test, two castrated and rumen fistulated male bovines were used. Three days before the first incubation, the animals were adapted, being offered 10 kg of pearl millet silage with inclusion of 7% of the coffee husk and two kg of commercial concentrate (14% CP) per animal. After adaptation to the diet, the samples were incubated *in situ* for 24, 48 and 72 hours. After the incubation period, the *nylon* were removed and washed under running water until the water was clear, and then subjected to drying in an oven at 65 °C for a period of 72 hours. Finally, the bags of *nylon* were weighed again to determine the degradability of DM.

Table 2 - Chemical composition of ingredients *in natura* used for the manufacture of silages.

	DM[1]	MM	CP	EE	NDF	ADF	TDN	Lignin	NFC	Ca	P
Pearl Millet	18.36	8.96	13.92	4.81	50.93	34.12	60.47	2.94	21.38	0.42	0.25
Coffee Husk	86.14	7.59	12.08	3.51	44.92	34.37	65.06	10.02	31.90	0.27	0.12

DM: dry matter (% of natural matter)[1]; MM: mineral matter; CP: crude protein; EE: ether extract; NDF; neutral detergent fiber; ADF: acid detergent fiber; NFC: Non-fibrous carbohydrates; TDN: total digestible nutrients; Ca: calcium; P: phosphorus.

The samples of the silage and the residue obtained after the incubation periods were sent to the laboratory for determination of NDF by near infrared spectroscopy (NIRS). With this information, the NDF degradability calculation was performed:

Degradability in situ (%) = (Weight of incubated nutrient (g) – Weight of residual nutrient (g) – Weight of blank (g)) / (Weight of incubated nutrient (g)) × 100

The data related to the fermentative characteristics and chemical composition of the silage were submitted to the analysis of variance taking into account the following model: $Yij = \mu + Ni + \varepsilon ij$, Yij: value observed at coffee husk inclusion level i, in repetition j; μ = overall average effect; Ni: effect of coffee husk inclusion level (i = 0, 7, 14 and 21% of coffee husk); εij: random error, associated with each observation i and j.

For the *in situ* degradability data of DM and NDF, a mixed model was considered, with fixed effects of incubation time (24, 48 and 72 hours), the levels of coffee husk used (0, 7, 14 and 21% of coffee husk) and the interaction between them, in addition to the random effect of the animals.

When significant by the F test, the effect of coffee husk inclusion levels was analyzed by first degree regression: $yij = \beta 0 + \beta 1^{*}x + \varepsilon ij$, and second degree: $yij = \beta 0 + \beta 1^{*}x + \beta 2^{*}x^{2} + \varepsilon ij$; yij: observed value; $\beta 0$, $\beta 1$ e $\beta 2$: parameters of the equation; X: coffee husk inclusion levels; εij: random error, associated with each observed value i and j. The equation that showed significant effect ($P < 0.05$) and higher coefficient of determination (R^2). The means of incubation time were compared by Tukey Test ($P < 0.05$).

For the analysis of variance and regression, Sisvar software version 5.6 was used (FERREIRA, 2014).

RESULTS

The inclusion of coffee husk did not alter the contents of CP (P = 0.1820), NDF (P = 0.8148), TDN (P = 0.8153), and NFC (P = 0.5013) of the silages (Table 3). However, there was an effect of the inclusion of coffee husk on the DM, ADF, MM, EE, Ca, and P contents of the silages, which by a first-degree linear equation were adjusted (Table 3). According to the adjusted equation, with the increase in coffee husk level, there is an estimated increase of 0.062% and 0.09% in the DM and ADF contents of the silages, respectively. On the other hand, a reduction in the MM (β1 = 0.05%), EE (β1 = 0.08%), Ca (β1 = 0.004%) and P (β1 = 0.002%) contents of the silages in response to the inclusion of the coffee husk.

For the lignin content of the silage, there was a significant effect of the inclusion of coffee husks. Data for this variable were adjusted using a second-degree linear equation, which allowed estimating minimum values of 6.10% with the inclusion of 7.59% (Table 3).

There was no effect of the inclusion of the coffee husk on the pH of the silages (Table 4). However, each level of inclusion of the coffee husk

Table 3 - Chemical composition of pearl millet silage with different levels of coffee husk.

Variables (% of DM)	Coffee husk inclusion levels (%)				SEM	P-Value		Equation	R^2
	0	7	14	21		L	Q		
DM[1]	19.16	22.63	27.77	31.84	0.38	<0.001	0.439	y = 18.88 + 0.062x	0.95
MM	8.41	8.34	7.67	7.50	0.13	<0.001	0.696	y = 8.49 – 0.05x	0.90
CP	11.69	12.10	11.97	11.98	0.13	0.234	0.137	y = 11.94	-
EE	5.24	3.62	3.33	3.50	0.47	0.017	0.073	y = 4.75 – 0.08x	0.65
NDF	44.45	45.02	44.76	45.33	0.66	0.438	0.998	y = 44.89	-
ADF	32.96	33.67	34.07	34.94	0.48	0.008	0.867	y = 32.96 + 0.09x	0.98
Lignin	6.55	6.18	6.37	7.60	0.14	<0.001	<0.001	$y = 6.58 – 0.12x + 0.008x^2$	0.99
NFC	30.21	30.90	32.28	31.70	0.52	0.083	0.002	y = 31.28	-
TDN	65.42	64.99	65.19	64.76	0.51	0.438	0.998	y = 65.09	-
Ca	0.39	0.38	0.34	0.31	0.01	<0.001	0.355	y = 0.39 – 0.004x	0.97
P	0.20	0.19	0.18	0.16	0.003	<0.001	0.154	y = 0.20 – 0.002x	0.98

DM: dry matter (% of natural matter)[1]; MM: mineral matter; CP: crude protein; EE: ether extract; NDF; neutral detergent fiber; ADF: acid detergent fiber; NFC: Non-fibrous carbohydrates; TDN: total digestible nutrients; Ca: calcium; P: phosphorus; SEM: standard error of the mean; p-value: probability of significant effect for the linear (L) and quadratic (Q) equations; R^2: Coefficient of determination. y = dependent variable; x = coffee husk inclusion levels (0, 7, 14, 21 %).

Table 4 - Fermentative characteristics of pearl millet silage with different levels of coffee husk.

Variables	--------Coffee husk inclusion levels (%)-------				SEM	-----P-Value------		------Equation-------	--R^2--
	0	7	14	21		L	Q		
Temperature (ºC)	19.50	19.17	19.17	18.67	0.27	0.049	0.757	y = 19.50 – 0.017x	0.88
pH	3.60	3.54	3.49	3.55	0.10	0.619	0.514	y = 3.54	-
Recovery of DM (%)	93.97	94.77	95.44	96.20	0.58	0.008	0.906	y = 93.92 + 0.109x	0.99
Gas losses (%)	6.74	5.60	4.47	3.30	0.40	<0.001	0.964	y = 6.74 – 0.163x	0.99

DM: dry matter; SEM: standard error of the mean; P-value: probability of significant effect for the linear (L) and quadratic (Q) equations; R^2: Coefficient of determination. y = dependent variable; x = coffee husk inclusion levels (0, 7, 14, 21%).

resulted in an estimated reduction of 0.017 ºC in temperature and 0.163% in silage gas losses. There was an estimated increase of 0.109% in the recovery of dry matter due to the increase in the share of coffee husks in pearl millet silage (Table 4).

There was no interaction between coffee husk inclusion levels and incubation time for in situ degradability of DM (P = 0.1538) and NDF (P = 0.0982). However, there was an isolated effect of coffee husk inclusion levels on the in situ degradability of DM and NDF, with an estimated reduction in these parameters of 0.184% and 0.679%, respectively (Figure 1).

There was an effect of incubation time on the in situ degradability of DM (P = 0.0001) and NDF (P = 0.0001). For DM degradability, the highest values were recorded at 72 hours after incubation. The highest values for NDF degradability were obtained at 48 and 72 hours after incubation (Figure 1).

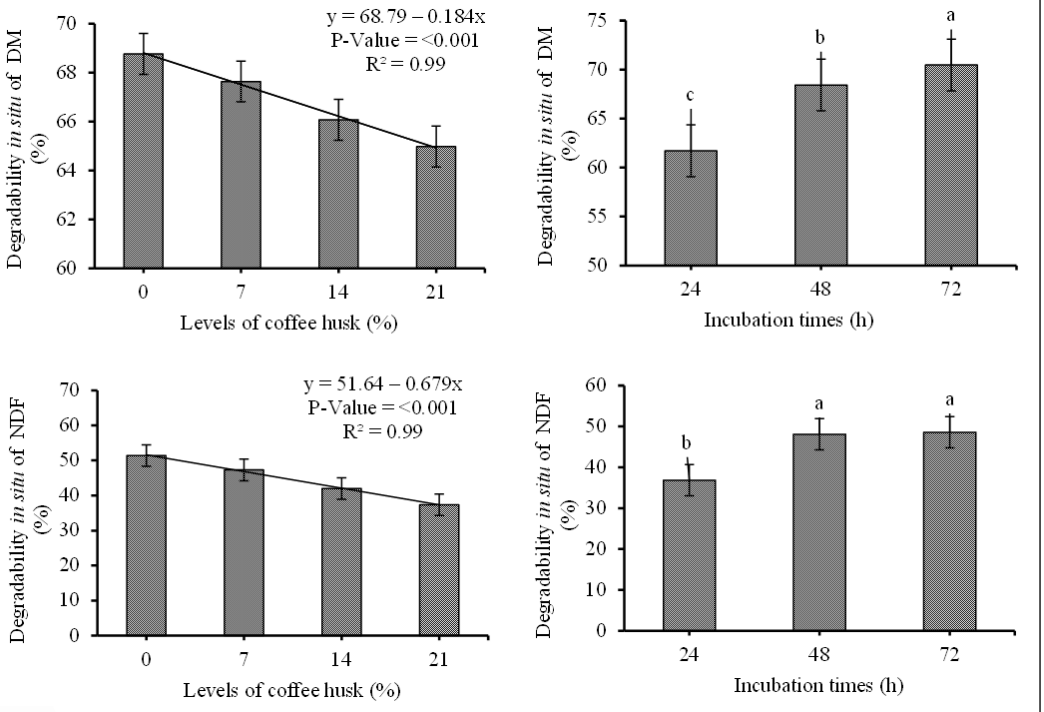

Figure 1 - Degradability *in situ* of the dry matter (DM) and neutral detergent fiber (NDF) of pearl millet silage with different levels of coffee husk and incubation times. y = dependent variable; x = coffee husk inclusion levels (0, 7, 14, 21%). [a, b, c] distinct letters indicate significant differences (P < 0.05) by the Tukey Test.

DISCUSSION

The inclusion of the coffee husk up to the level of 21% was not sufficient to alter the CP, NDF, TDN, and NFC contents of the pearl millet silage, which can be attributed to the fact that the coffee husk did not present a discrepant difference in the concentrations of these nutrients compared to the whole pearl millet plant (Table 2). In addition, when silage processing is carried out according to the established basic procedures, no significant change in the concentration of these nutrients in the silage is detected (ZARDIN et al., 2017; OLIVEIRA et al., 2023). However, the inclusion of the coffee husk promoted increases in the DM of the silage, so that at the highest level of inclusion of coffee husk (21%), the highest DM content of the silage was obtained with 31.83%, a value within the ideal range (30 to 35% of DM) for adequate fermentation of the material (JOBIM et al., 2007). This result is justified by the fact that the coffee husk has approximately 86% of DM (Table 2).

The major limiting factor for pearl millet silage production is the low DM content of the material at the ensiling moment (JACOVETTI et al., 2018). The high water concentration inside the silo increases the activity of Clostridium, which leads to undesirable fermentation, significantly increasing losses (BARCELOS et al., 2018; KUNG JUNIOR et al., 2018) and compromising the nutritional quality of silage (XIE et al., 2012; WILKINSON & MUCK, 2019). Therefore, absorbent additives can be an alternative to improve the fermentative process of materials with higher moisture contents (GURGEL et al., 2019; OLIVEIRA et al., 2023).

The inclusion of coffee husk increased the ADF concentrations and reduced the EE, MM, Ca, and P contents of the silage. In addition, there was an estimated reduction in lignin content when the coffee husk was included in moderate proportions (7.60%), and subsequent increments in the inclusion of the residue increased silage lignin concentrations. Thus, the inclusion of higher amounts of coffee husks, despite increasing the DM of preserved fodder, reduces the quality of the final product (Figure 1). The greater participation of structural carbohydrates associated with lignin decreases cell wall degradation rates (FARIA et al., 2020; KARLS et al., 2022; ALI et al., 2022), in addition to changing forage consumption by animals (GORNIAK et al., 2013).

Working with elephant grass silages (*Pennisetum purpureum* Schum) cultivar from Minas, cut at 70 days of age, and receiving 0, 6, 12, 18, and 24% ground coffee husk based on DM, BARCELOS et al. (2018) reported that coffee husk promoted a reduction in MM and EE contents, as well as increases in DM, lignin, and ADF of silage. These results were justified by the different concentrations of these components in coffee husk compared to elephant grass. This fact can be corroborated with the data of this research in which coffee husks presented higher levels of ADF, lignin, and DM compared to pearl millet (Table 2).

Coffee husk has been considered efficient moisture sequestering additive in reducing the pH of grass silage (FARIA et al., 2007; BARCELOS et al., 2018). However, in addition to DM content, intrinsic plant characteristics such as soluble carbohydrate concentration and buffer capacity determine forage fermentability (GURGEL et al., 2019). Pearl millet, despite having a low DM content, has adequate concentrations of soluble carbohydrates (JACOVETTI et al., 2018). These characteristics associated with correct compaction of the silo, allowed a reduction of the pH to adequate levels (3.60), regardless of the inclusion of coffee husk in the silage.

The pH in silages is considered one of the most important indicators of fermentation quality (WILKINSON & DAVIES, 2013). In this sense, the pH observed (3.60) is suitable for forage conservation, since pH values between 3.6 and 4.2 are considered ideal (MCDONALD, 1991). However, the high moisture content in the silage allows the presence of Enterobacteria and Clostridium (KÖNIG et al., 2018). These microorganisms, despite not being able to develop in acidic environments, are able to resist such conditions, due to water activity in the silo (BRITO et al., 2020), which can lead to qualitative and quantitative losses of silages.

Despite pH adequate in all silages, there was a reduction in gas losses and temperature with the inclusion of coffee husk, which may be associated with greater activity of Enterobacteria and Clostridia in silages with less proportion of coffee husk. When fermentation occurs by homofermentative bacteria, hexoses are used as a substrate, producing only lactic acid, without loss of dry matter (FILYA & SUCU, 2010). However, when fermentation occurs by heterofermentative bacteria, acetic acid, carbon dioxide, ethanol, and heat are produced, favoring gas losses (KUNG JUNIOR et al., 2018) and increases in temperatures. The reduction of gas losses allowed a greater recovery of DM with the inclusion of 21% of coffee husk in the silage (96.19%).

The *in situ* degradability of DM and NDF reduced as the share of coffee husk in silage increased. This reduction can be attributed to the

higher concentrations of ADF and lignin in the silages that received higher levels of coffee husk. Similar results were found by BERNARDINO et al.(2005) and BARCELOS et al. (2018), who observed a linear decrease in the degradability of elephant grass silage with the addition of coffee husk. In both studies, the authors stated that the high lignin content of the coffee husk is the predominant factor in the reduction of silage degradability.

The degradability as a function of time denotes the need for a longer stay of the fodder in the rumen. The kinetics of ruminal degradation of food depends on a sequence of processes. Soon after incubation, the food is partially solubilized (ÍTAVO et al., 2016), and compounds of higher solubility are rapidly fermented (GURGEL et al., 2021). However, greater exposure of fodder to ruminal microbiota is necessary for fermentation of the less soluble parts to occur (SILVA et al., 2017). Therefore, depending on the time the fodder stays in the rumen, the percentage of the degraded substrate is obtained by summing up the rapidly soluble fraction and the potentially degraded fraction (ORSKOV & MCDONALD, 1979).

The inclusion of coffee husk in pearl millet ensiling showed promise. Therefore, there was an increase in the DM content of the silage, which reduced losses during the fermentation process. However, high levels of the coffee husk (< 14%) promoted excessive increases in lignin and ADF levels, and consequently, a 4.0% reduction in DM degradability and a 20.1% reduction in NDF degradability. Thus, the tested hypothesis that ensiling pearl millet with moderate levels of coffee husk inclusion would result in silages with reduced losses and high nutritional value was confirmed by the results obtained.

CONCLUSION

Coffee husk proved to be an efficient absorbent additive in increasing DM content and reducing pearl millet silage losses. However, high levels of coffee husk reduce the degradability of conserved fodder. It is recommended to include coffee husk up to the level of 14.0% of the fresh matter to improve the fermentation pattern and the quality of the pearl millet silage.

ACKNOWLEDGMENTS

The authors thank the Instituto Federal de Educação, Ciência e Tecnologia do Sudeste de Minas Gerais – Campus Rio Pomba and Conselho Nacional de Desenvolvimento Científico e Tecnológico (Process No: 150305/2022-2) for the financial support to the project. The authors also thank the company Agroceres Multimix Nutrição Animal LTDA® for providing its infrastructure for conducting this research.

DECLARATION OF CONFLICT OF INTEREST

The authors declare no conflict of interest. The founding sponsors had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, and in the decision to publish the results.

AUTHORS' CONTRIBUTIONS

All authors contributed equally for the conception and writing of the manuscript. All authors critically revised the manuscript and approved of the final version.

BIOETHICS AND BIOSSECURITY COMMITTEE APPROVAL

The Ethics Committee on the Use of Animals of the Instituto Federal de Educação, Ciência e Tecnologia do Sudeste de Minas Gerais, under license No. 08/2019, approved all experimental protocols.

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