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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

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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 (CaCl²); 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.