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*Scientific Article*

# Productive performance of dairy cows fed millet or corn silage

# Desempenho de vacas leiteiras alimentadas com silagem de milheto ou de milho

Aníbal C. do Rêgo[1]*, Gustavo R. Siqueira[2], Mauro D. S.de Oliveira[2], Geraldo B. de S. Almeida[3], Marcus V. S. B. Cardoso[1], Flávio D. de Resende[2], Ricardo D. Signoretti[4]

[1]Department of Animal Science, Universidade Federal do Ceará, Fortaleza, CE, Brazil. [2]Department of Animal Science, Universidade Estadual de São Paulo, Jaboticabal, SP, Brazil. [3]Agroceres Multimix Animal Nutrition LTDA, Animal Nutrition – Cattle, Rio Claro, SP, Brazil.[4]Regional Pole Alta Mogiana, Agência Paulista de Tecnologia dos Agronegócios, Colina, SP, Brazil.

**ABSTRACT** – The objective of this study was to determine the effect of particle size and inoculation in millet silage compared to corn silage in diets of crossbred 3/4 Holstein × 1/4 Gir cows on diet intake and digestibility, as well as milk production and composition. Five cows were used, with 100 ± 26 d in lactation and a mean body weight (BW) of 509 ± 53 kg, in a 5 × 5 Latin square experimental design. Millet silage with 5 or 20 mm particle size, inoculated or not with *Propionibacterium acidipropionici* and *Lactiplantibacillus plantarum*, was evaluated in the diets, and compared with corn silage. Cows fed with corn silage showed a higher intake of dry matter (DM), organic matter (OM), total carbohydrates (TC), and neutral detergent fiber (NDF) than cows fed diets containing millet silage. The DM digestibility of the corn silage diet was higher than that of the diets containing millet silage. Cows fed a diet containing corn silage produced more milk than cows fed diets containing millet silage. Cows fed diets containing millet silage with 20 mm particle size compared to 5 mm showed better productive efficiency, 1.05 and 0.94 kg of milk/kg of DM intake, respectively. Cows fed diets containing corn silage produced more milk than cows fed diets containing millet silage.

**Keywords**: Ensiling. *Lactiplantibacillus plantarum*. *Pennisetum glaucum*. *Propionibacterium acidipropionici*. Particle size.

**RESUMO** – Objetivou-se com este trabalho determinar o efeito do tamanho de partículas e da inoculação em silagem milheto comparada à silagem de milho em dietas de vacas mestiças 3/4 Holandês × 1/4 Gir, sob o consumo e digestibilidade das dietas, bem como, a produção e composição do leite. Foram utilizadas cinco vacas, com 100 ± 26 dias em lactação e peso corporal (PC) médio de 509 ± 53 kg, em delineamento experimental em quadrado latino 5 × 5. Foram avaliadas nas dietas, silagem de milheto com 5 ou 20 mm de tamanho de partículas, inoculadas ou não com *Propionibacterium acidipropionici* e *Lacticplantibacillus plantarum*, e comparadas com silagem de milho. Vacas alimentadas com silagem de milho apresentaram maiores consumo de matéria seca (MS), matéria orgânica (MO), carboidratos totais (CT) e fibra em detergente neutro (FDN) do que vacas alimentadas com dietas contendo silagem de milheto. A digestibilidade da MS da dieta contendo silagem de milho foi maior do que das dietas contendo silagem de milheto. Vacas alimentadas com dieta contendo silagem de milho produziram mais leite do que as vacas alimentadas com dietas contendo silagem de milheto. Vacas alimentadas com dietas contendo silagem de milheto com 20 mm de tamanho de partículas comparadas as de 5 mm apresentaram melhor eficiência produtiva, 1,05 e 0,94 kg de leite $kg^{-1}$ de MS consumida, respectivamente. Vacas alimentadas com dietas contendo silagem de milho produziram mais leite do que vacas alimentadas com dietas contendo silagem de milheto.

**Palavras-chave**: Ensilagem. *Lacticplantibacillus plantarum*. *Pennisetum glaucum*. *Propionibacterium acidipropionici*. Tamanho de partícula.

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***Corresponding author:**
<anibalcr@ufc.br>

## INTRODUCTION

In Brazil, corn is the most widely used crop for silage production, mainly in the form of whole-plant corn silage (SILVESTRE; MILLEN, 2021; SANTOS et al., 2020; BERNARDES; RÊGO, 2014). Despite being a crop with good characteristics for silage production, soil and climate requirements can still limit cultivation in some regions. Thus, some forage crops, such as millet, may emerge as alternatives to corn in the diet of ruminant animals. On account of its short phenological cycle and high water stress tolerance (MAHAJAN et al., 2021; PIRES et al., 2024), this crop has great potential to be explored mainly in semi-arid regions, as well as in off-season periods in traditionally agricultural Brazilian areas.

In animal diets, millet grains can be used as feed, and the millet plant can be used for silage production. However, millet silage is poorly or not reported by producers (BERNARDES; RÊGO, 2014; SILVA et al., 2019). Thus, the impact of this food on the diet of ruminant animals needs to be better understood, especially in terms of animal performance. Several factors in silage management can interfere with the quality of the silage produced (e.g. theoretical particle size - TPS), among which those related to plant harvesting stand out (FERRARETTO; SHAVER; LUCK, 2018; MENDONÇA et al., 2020). Lower TPS (e.g., 5 mm) at the time of harvest facilitates the ensiling process, since compaction becomes more efficient and a greater amount of stored feed per area can be achieved inside the silo. On the other hand, higher TPS (e.g. 20 mm) can hinder the compaction process, reducing the amount of feed stored per area. Overall, the TPS can affect the compaction density in the silo (SILVA et al., 2015; RÊGO et al., 2016; KRUGER et al., 2020) and consequently result in changes in the nutritional characteristics of the feed.

Ruminants are animals that are greatly influenced in their dietary intake by the feed they are fed. Silage is a feed that is highly dependent on the chemical and physical characteristics of the raw material, which will modulate the course of fermentation of the feed during storage, directly reflecting the nutritional profile of the final product. These physical and nutritional changes in the feed and its inclusion in the diet can lead to possible changes in forage intake by the animals (NASROLLAHI; IMANI; ZEBELI, 2015), ingestive behavior and animal performance (e.g., milk production) (GRANT; FERRARETTO, 2018).

During ensiling, processes such as respiration, proteolytic activities, and clostridial fermentation, among others, can negatively affect conservation efficiency (BORREANI et al., 2018). In conjunction with this, WPCS are highly susceptible to aerobic spoilage (OLIVEIRA et al., 2017). Inoculation with lactic acid bacteria (LAB) at the time of ensiling, such as *L. plantarum*, can stimulate fermentation due to the high production of lactic acid and rapid pH lowering (OLIVEIRA et al., 2017). In addition, propionic acid bacteria (PAB), such as *P. acidipropionici*, can produce propionic acid, which is associated with increased aerobic stability in silages (MUCK et al., 2018). However, the possible effects of inoculation on intake and performance of animals when fed inoculated silage are still little explored.

In view of this, this study aims to determine the effect of particle size and inoculation in millet silage compared to corn silage on the intake and digestibility of diets, in addition to the production and composition of milk from Holstein × Gir cows.

## MATERIAL AND METHODS

The present experiment was conducted in the Dairy Cattle Sector of the São Paulo Agribusiness Technology Agency (APTA), Colina, São Paulo. Five 3/4 Holstein × 1/4 Gir crossbred cows were used, with approximately 100 ± 26 d of lactation at the beginning of the experiment and an average body weight (BW) of 509 ± 53 kg, producing 15.2 ± 2.3 kg of milk day$^{-1}$, arranged in a 5 × 5 Latin square experimental design. Five diets were evaluated: millet silage with 5 mm particle size without bacterial inoculant (5S), millet silage with 5 mm particle size with bacterial inoculant (5C), millet silage with 20 mm particle size without bacterial inoculant (20S), millet silage with 20 mm particle size with bacterial inoculant (20C), and corn silage with 5 mm particle size without bacterial inoculant (CS). WPCS was used as a control in the experiment because it is a standard feed in the diets of ruminant animals in different production systems.

The corn hybrid used was Biomatrix 810 and the cultivar of pearl millet used was ADR 7010. Corn and pearl millet were harvested by forage harvester with a JF 192 Z6® model. The harvest of pearl millet was performed 80 days after sowing, and corn crop was harvested 95 days after sowing. TPS was obtained by changing the gears of the forage harvester to 5 and 20 mm for pearl millet and 5 mm for corn crop. One surface silo (dimensions: 20 m x 6 m x 1 m) was made for each silage, totalizing five surface silos. Compaction was done using one tractor with uninterrupted movements.

The inoculation process was carried out only for pearl millet silage during the silo filling. The inoculant used was corn Biomax® (Lallemand Nutrition®), consisting of strains of *L. plantarum* and *P. acidipropionici*. The inoculant was diluted in water (100 g of the product per 100 liters of water) and applied to the forage in order to reach $10^5$ cfu/g forage of each microorganism. The silos remained closed for approximately 120 d and samples were collected to determine the nutritional composition of the silages.

The diets were formulated following the proportion of 60 kg DM of roughage to 40 kg DM of concentrate. The proportions of each dietary constituent can be seen in Table 1, and the composition of the silages and ingredients can be seen in Table 2.

**Table 1**. Experimental diet composition.

| Feed (g DM kg$^{-1}$) | Diet[2] | | | | |
|---|---|---|---|---|---|
| | 5S | 5C | 20S | 20C | CS |
| Millet silage | 600.0 | 600.0 | 600.0 | 600.0 | - |
| Corn silage | - | - | - | - | 600.0 |
| Ground corn | 274.9 | 274.9 | 274.9 | 274.9 | 274.9 |
| Soybean meal | 104.6 | 104.6 | 104.6 | 104.6 | 104.6 |
| Urea | 5.6 | 5.6 | 5.6 | 5.6 | 5.6 |
| Ammonium sulfate | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |
| Mineral supply[1] | 14.2 | 14.2 | 14.2 | 14.2 | 14.2 |

[1]Composition per kilogram of product: calcium – 250 g, phosphorus – 50 g, sulfur – 35 g, magnesium – 50 g, copper – 600 mg, zinc - 2,260 mg, manganese - 2,390 mg, cobalt – 36 mg, iodine – 45 mg, selenium – 18 mg, monensin 650 mg, vitamin A – 3600000 Ul kg$^{-1}$, vitamin D – 355000 Ul kg$^{-1}$, vitamin E – 1100 Ul kg$^{-1}$; DM = dry matter. [2]5S = millet silage with a 5 mm particle size without bacterial inoculant; 5C = millet silage with a 5 mm particle size with bacterial inoculant; 20S = millet silage with a 20 mm particle size without bacterial inoculant; 20C = millet silage with a 20 mm particle size with bacterial inoculant; CS = corn silage.

**Table 2**. Nutritional composition of the silages and ingredients used in the diets.

| Nutrients | Silages[3] | | | | | GC[4] | Soybean meal |
|---|---|---|---|---|---|---|---|
| | 5S | 5C | 20S | 20C | CS | | |
| DM[1] (g FM kg$^{-1}$) | 284.9 | 282.9 | 283.7 | 287.1 | 294.5 | 878.5 | 885.9 |
| OM[2] (g DM kg$^{-1}$) | 905.3 | 917.7 | 927.7 | 925.6 | 952.2 | 969.0 | 927.8 |
| CP[2] (g DM kg$^{-1}$) | 68.5 | 69.5 | 68.3 | 69.4 | 70.2 | 90.7 | 489.6 |
| INDP[2] (g DM kg$^{-1}$) | 26.7 | 29.9 | 27.8 | 36.6 | 26.3 | 37.8 | 34.5 |
| EE[2] (g DM kg$^{-1}$) | 27.4 | 29.0 | 29.9 | 29.2 | 30.5 | 42.1 | 17.6 |
| TC[2] (g DM kg$^{-1}$) | 809.4 | 819.2 | 829.5 | 827.0 | 851.5 | 836.2 | 420.6 |
| NDF[2] (g DM kg$^{-1}$) | 615.7 | 619.4 | 616.2 | 606.8 | 589.7 | 148.8 | 154.9 |
| aNDFp[2] (g DM kg$^{-1}$) | 553.6 | 557.8 | 564.3 | 539.0 | 550.9 | 134.8 | 132.3 |
| ADF[2] (g DM kg$^{-1}$) | 485.3 | 474.0 | 488.1 | 492.3 | 442.5 | 41.3 | 96.1 |
| NFC[2] (g DM kg$^{-1}$) | 193.7 | 199.8 | 213.3 | 220.2 | 261.8 | 687.4 | 265.7 |
| LIG[2] (g DM kg$^{-1}$) | 53.5 | 56.2 | 55.7 | 55.9 | 50.8 | 19.0 | 17.6 |
| MM[2] (g DM kg$^{-1}$) | 94.7 | 82.3 | 72.3 | 74.4 | 47.8 | 31.0 | 72.2 |
| pH | 4.80 | 4.69 | 4.60 | 4.70 | 4.20 | - | - |

[1]g kg$^{-1}$ of fresh matter; [2]DM = dry matter; FM = fresh matter; OM = organic matter; CP = crude protein; INDP = indigestible neutral detergent protein; EE = ethere extract; TC = total carbohydrates; NDF = neutral detergent fiber; aNDFp = NDF corrected for ash and protein; ADF = acid detergent fiber; NFC = non-fibrous carbohydrates; LIG = lignin; MM = mineral matter; [3]5S = millet silage with 5 mm particle size without bacterial inoculant; 5C = millet silage with 5 mm particle size with bacterial inoculant; 20S = millet silage with 20 mm particle size without bacterial inoculant; 20C = millet silage with 20 mm particle size with bacterial inoculant; CS = corn silage; [4]GC = ground corn grain.

The animals were housed in individual pens with concrete floors and wood sawdust, with free access to the drinking fountain and feeding trough. The diet was provided *ad libitum* twice a day immediately after milking, at 06:00 h. and 17:00 h., with half of the diet being provided at each time. The experiment consisted of five periods, lasting 21 d each, with 14 d of adaptation and 7 d of sample collection.

To determine the intake of DM and nutrients, the quantities of feed provided and leftovers were weighed daily, and the difference obtained was the amount ingested. In estimating the apparent digestibility of DM and nutrients, indigestible neutral detergent fiber (iNDF) was used as an internal indicator, in samples of the feed provided, leftovers, and feces, adopting the *in situ* incubation procedure for 264 h (INCT; method INCT-CA G-009/1; DETMANN et al., 2021).

Thus, while the sampling of the feed provided was carried out separately by ingredient, the sampling of the leftovers was carried out after the total weighing. Both were carried out during the seven days of collection. Feces were collected directly from the rectum on the 16th and 20th days of each experimental period, always before morning and afternoon milking. The silage, leftovers, and feces samples were pre-dried in an oven with forced ventilation at 55 ºC for 72 h, and along with other ingredient samples, they were processed in a knife mill with 2 mm mesh sieves for subsequent incubation (INCT; method INCT-CA G-009/1; DETMANN et al., 2021). Then, for 7 days, the samples were incubated in the rumen of two Red Angus cows, previously adapted to a diet containing millet silage as roughage. In order to determine iNDF, the bags were subjected to treatment with neutral detergent (INCT; method INCT-CA F-001/2; DETMANN et al., 2021), for one hour, in an ANKOM fiber analyzer equipment (ANKOM Technology, Fairport, NY, USA).

The feed provided, leftovers, and feces were analyzed according to the standard analytical procedures of the Brazilian National Institute of Science and Technology in Animal Science (INCT-CA; DETMAN et al., 2021) for DM (dried overnight at 105 ºC; method INCT-CA G-003/1), ash (MM; complete combustion in a muffle furnace at 600 °C for 4 h; method INCT-CA M-001/2), crude protein (CP; Kjeldahl procedure; method INCT-CA N-001/2), ether extract (EE; Randall procedure; method INCT-CA G-005/2), neutral detergent fiber corrected for ash and protein (aNDFp; using autoclave for 60 min with a heat-stable α-amylase, omitting sodium sulfite and correcting for residual ash and protein; method INCT-CA F-002/2), acid detergent fiber (ADF; method INCT-CA F-004/2), and lignin (LIG; acid hydrolysis procedure; method INCT-CA F-005/2). For the determination of pH values in silage samples, an aqueous extract composed of 30 g of fresh samples and 270 g of distilled water was prepared and read using a pH meter (Potentiometer DIGIMED® DM 20, Digicrom Instruments, SP, Brazil). Neutral detergent insoluble protein was determined according to INCT (method INCT-CA N-004/2; DETMANN et al. 2021). Total carbohydrate (TC) concentrations were obtained by difference, as follows the Equation 1:

$$TC\,(g\,kg^{-1}) = 100 - (CP(g\,kg^{-1}) + EE(g\,kg^{-1}) + MM(g\,kg^{-1})) \qquad (1)$$

Non-fibrous carbohydrate (NFC) levels were determined by subtracting NDF from TC, according to the following Equation 2, where:

$$NFC(g\,kg^{-1}) = 100(g\,kg^{-1}) - \left(NDF(g\,kg^{-1}) + CP(g\,kg^{-1}) + EE(g\,kg^{-1}) + MM(g\,kg^{-1})\right) \qquad (2)$$

Total digestible nutrients (TDN) were calculated according to the following Equation 3:

$$TDN = CPdigestible + NDFdigestible + (EEdigestible \times 2.25) + NFCdigestible \quad (3)$$

The cows were mechanically milked twice a day, at 06:00 h and 17:00 h, with a daily weighing of the milk production (MP), during the collection period. MP was divided by the DM intake in order to obtain the productive efficiency (PE) of the animals. Milk production was corrected (CMP) to 3.5 g kg$^{-1}$ of milk, according to the following Equation 4, where:

$$CMP = (0.432 + 0.1625 \times milk\ fat\ concentration) \times milk\ (kg) \quad (4)$$

The samples used to analyze the milk composition were obtained on the 16$^{th}$ and 19$^{th}$ day of each experimental period, with each sample coming from the two daily milkings. Analyses of milk fat (MF), crude protein (CP), lactose (LA), total solids (TS), defatted dry extract (DDE), somatic cell count (SCC), nitrogen (N), and urea nitrogen (UN) were carried out in the Milk Clinic Laboratory at ESALQ-USP.

Analysis of the data variance was carried out using the statistical program SAS, and the means of the parameters relating to the intake, digestibility, production, and milk composition were compared at a 5% significance level, using four orthogonal contrasts: corn silage versus millet silage; millet silage with 5 mm particle size versus millet silage with 20 mm particle size; millet silage with 5 mm particle size without inoculant versus millet silage millet with 5 mm particle size with inoculant; and millet silage with 20 mm particle size without inoculant versus millet silage with 20 mm particle size with inoculant.

## RESULTS AND DISCUSSION

Cows fed the diet containing corn silage had higher (P<0.05) intake of DM, OM, TC, and NDF compared to cows fed diets containing millet silage, both in kg BW day$^{-1}$ and g BW kg$^{-1}$ (Table 3).

**Table 3**. Average nutrient intake of diets.

| Variable[1] | Diets[2] | | | | | CV (%) | Contrast (P-value)[3] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 5S | 5C | 20S | 20C | CS | | 1 | 2 | 3 | 4 |
| DMI (kg day$^{-1}$) | 15.39 | 15.30 | 14.32 | 13.78 | 16.90 | 3.9 | <0.01 | <0.01 | 0.81 | 0.18 |
| DMI (g BW kg$^{-1}$) | 30.2 | 30.1 | 28.3 | 27.2 | 33.1 | 3.8 | <0.01 | <0.01 | 0.85 | 0.09 |
| OMI (kg day$^{-1}$) | 14.08 | 14.10 | 13.26 | 12.75 | 15.86 | 5.9 | <0.01 | <0.01 | 0.95 | 0.16 |
| OMI (g BW kg$^{-1}$) | 27.6 | 27.8 | 26.2 | 25.1 | 31.0 | 5.1 | <0.01 | <0.01 | 0.78 | 0.09 |
| CPI (kg day$^{-1}$) | 2.24 | 2.15 | 2.14 | 2.06 | 2.28 | 5.6 | 0.05 | 0.10 | 0.28 | 0.34 |
| CPI (g BW kg$^{-1}$) | 4.4 | 4.2 | 4.2 | 4.0 | 4.5 | 6.3 | 0.09 | 0.16 | 0.37 | 0.26 |
| EEI (kg day$^{-1}$) | 0.45 | 0.47 | 0.45 | 0.43 | 0.48 | 6.6 | 0.14 | 0.16 | 0.52 | 0.15 |
| EEI (g BW kg$^{-1}$) | 0.89 | 0.92 | 0.90 | 0.85 | 0.95 | 6.6 | 0.15 | 0.21 | 0.47 | 0.16 |
| TCI (kg day$^{-1}$) | 11.36 | 11.47 | 10.65 | 10.24 | 12.89 | 5.1 | <0.01 | <0.01 | 0.71 | 0.19 |
| TCI (g BW kg$^{-1}$) | 22.3 | 22.6 | 21.0 | 20.2 | 25.3 | 5.5 | <0.01 | <0.01 | 0.61 | 0.14 |
| NDFI (kg day$^{-1}$) | 6.21 | 6.13 | 5.47 | 5.25 | 6.35 | 5.8 | <0.01 | <0.01 | 0.71 | 0.29 |
| NDFI (g BW kg$^{-1}$) | 12.2 | 12.0 | 10.8 | 10.3 | 12.4 | 6.2 | <0.01 | <0.01 | 0.68 | 0.26 |
| NFCI (kg day$^{-1}$) | 5.15 | 5.36 | 5.18 | 5.09 | 6.56 | 6.9 | <0.01 | 0.50 | 0.41 | 0.71 |
| NFCI (g BW kg$^{-1}$) | 10.1 | 10.6 | 10.3 | 10.1 | 12.8 | 7.6 | <0.01 | 0.63 | 0.39 | 0.73 |
| TDNI (kg day$^{-1}$) | 9.10 | 9.01 | 8.36 | 8.42 | 10.92 | 7.1 | <0.01 | 0.04 | 0.31 | 0.53 |

[1]DMI = dry matter intake; OMI = organic matter intake; CPI = crude protein intake; EEI = ether extract intake; TCI = total carbohydrate intake; NDFI = neutral detergent fiber intake; NFCI = non-fibrous carbohydrates intake; BW = body weight; [2]5S = millet silage with a 5 mm particle size without bacterial inoculant; 5C = millet silage with a 5 mm particle size with bacterial inoculant; 20S = millet silage with a 20 mm particle size without bacterial inoculant; 20C = millet silage with a 20 mm particle size with bacterial inoculant; CS = corn silage; [3]Contrast 1 = corn silage (CS) versus millet silage; contrast 2 = millet silage with 5 mm particle size versus millet silage with 20 mm particle size; contrast 3 = millet silage with 5 mm particle size without inoculant (5S) versus millet silage with 5 mm particle size containing inoculant (5C); contrast 4 = millet silage with 20 mm particle size without inoculant (20S) versus millet silage with 20 mm particle size containing inoculant (20C); CV = coefficient of variation; P = probability.

Animals fed a diet containing corn silage had higher (P<0.05) NDF intake than animals fed diets containing millet silage. Animals fed diets containing millet silage with 5 mm particle size had greater (P<0.05) amounts of DM, OM, TC, and NDF intake in kg BW day$^{-1}$ and g BW kg$^{-1}$ compared to animals fed diets containing millet silage with 20 mm particle size. The presence or absence of inoculant in the silages did not affect (P>0.05) the intake of DM, OM, TC, and NDF in the diets in kg BW day$^{-1}$ and g BW kg$^{-1}$.

In the study, 600 g DM kg$^{-1}$ from the diets analyzed are composed of silages from C4 plants, which normally, in this quantity, can cause physical limitations in DM intake due to the chemical characteristics of these plants regarding fiber concentration. With few exceptions, DM intake increases when NDF concentration decreases in diets containing more than 250 g NDF kg$^{-1}$. Likewise, NFC, which has a high degradation rate, contributes to shorter feed retention time in the rumen and greater intake. Thus, the higher DM intake of the diet containing corn silage compared to diets containing millet silage can be explained by the concentration of NDF and NFC. Corn silage had a lower concentration of NDF (589.7 g DM kg$^{-1}$) and a higher concentration of NFC (262 g DM kg$^{-1}$), improving the intake when compared to millet silages that had higher NDF concentration (614.5 g DM kg$^{-1}$) and lower NFC (227 g DM kg$^{-1}$) (Table 2). When comparing a diet containing corn silage with a diet containing millet silage in a forage:concentrate ratio of 53:47, Amer and Mustafa (2010) observed no difference in DM intake in kg BW day$^{-1}$ and g BW kg$^{-1}$ in cows with approximately 38 kg of MP day$^{-1}$. These authors observed DM intake of 24.1 and 23.6 kg day$^{-1}$ in diets containing millet and corn silage, respectively.

The DM intake in the diets may have improved the NDF intake. Unlike the present study, Amer and Mustafa (2010) observed higher NDF intake in kg BW day$^{-1}$ and g BW kg$^{-1}$ for cows fed millet silage compared to corn silage. Mertens (1997) suggested that, in cases where intake is limited by physical obstacles, NDF intake remains close to 11.0 g BW kg$^{-1}$ for lactating cows, as in the present study, in which intake values ranged from 10.3 to 12.2 g BW kg$^{-1}$. Regarding the OM and TC intake, it is possible that they were influenced by the DM intake.

The diets containing silage with smaller particles may have contributed to the supposed increase in the feed passage rate. In a meta-analysis on the effect of forage particle size on nutrient intake in dairy cows, Nasrollahi, Imani, and Zebeli (2015) observed that DM and NDF intakes increased with reducing particle size. These authors also observed that DM intakes increased mainly in studies with diets containing more than 500 g DM kg$^{-1}$ of forage and when they contained silage. Zebeli et al. (2009) worked with three theoretical particle sizes of corn silage (5.5, 8.1 and 14 mm) in lactating cows' diets and observed a linear decrease in DM and NDF intake with the increase in particles, mainly justified by distension of the reticule-rumen wall and consequent retention of digesta. Regarding the higher OM and TC intakes from diets containing silages with 5 mm particle size, it is likely that these were driven by the DM intakes from the respective diets. In a meta-analysis on the effects of inoculants in silage diets for dairy cows, Oliveira et al. (2017) observed variations in intake responses. When evaluating whether or not corn silage should be inoculated with homofermentative and heterofermentative bacteria in the diets of lactating cows, Arriola et al. (2011) also did not observe differences in the DM and NDF intake in the diets.

The CP intake in kg day$^{-1}$ was higher ($P<0.05$) in cows fed a diet containing corn silage compared to those fed millet silage, while CP intake in g BW kg$^{-1}$ did not differ ($P>0.05$) among the diets studied. The cut size of the particles and the presence or absence of inoculant in the millet silage did not interfere ($P>0.05$) with the CP intake in the diets, both in kg BW day$^{-1}$ and g BW kg$^{-1}$. Cows fed a diet containing corn or millet silage did not differ in EE intake ($P>0.05$) in kg BW day$^{-1}$ and g BW kg$^{-1}$. The particle size and the presence or absence of inoculant in the millet silage also did not interfere ($P>0.05$) with the EE intake of the diets. The NFC intake in kg BW day$^{-1}$ and g BW kg$^{-1}$ was higher ($P<0.05$) for cows fed a diet containing corn silage compared to cows fed diets containing millet silage. The particle size and the presence or absence of inoculant in the millet silage did not interfere ($P>0.05$) with the NFC intake of the diets.

Cows fed a diet containing corn silage had higher ($P<0.05$) TDN intake (10.92 kg day$^{-1}$) when compared to cows fed diets containing millet silage (8.72 kg day$^{-1}$). Cows fed diets containing millet silage with 5 mm particle size consumed greater ($P<0.05$) amounts of TDN (9.06 kg day$^{-1}$) than cows fed diets containing millet silage with 20 mm particle size (8.39 kg day$^{-1}$). The use or not of the inoculant in millet silage had no effect ($P>0.05$) on the TDN intake of the diets.

Amer and Mustafa (2010) observed no difference in CP intake in kg day$^{-1}$ in the study with a comparison of the use of corn silage versus millet silage in the diets of lactating cows. The higher NDF intake for cows fed corn silage can be justified by the higher NDF concentration in corn silage compared to millet silage (Table 2). The greater DM and NDF intake may help explain the greater TDN intake from corn silage.

The apparent DM digestibility of the diet containing corn silage (66.2%) was higher ($P<0.05$) in comparison to the diets containing millet silage (61.8%) (Table 4). Particle size and the use or not of the inoculant did not influence ($P>0.05$) the apparent DM digestibility of diets containing millet silage. The apparent OM digestibility was higher ($P<0.05$) in the diet containing corn silage when compared to diets containing millet silage. Particle size and the use or not of the inoculant did not influence ($P>0.05$) the apparent OM digestibility in diets with millet silage.

The greater DM apparent digestibility from the diet containing corn silage may justify the greater DM intake by animals when fed with this silage. Although this study did not measure the proportion of grains in the millet and corn plants, it is a point that must be taken into consideration, as it is directly related to the quality of the silage. It is likely that the grain proportion of the corn plant was higher than that of the millet plant and influenced the NFC and NDF concentration in this silage. In a study evaluating corn silage and two silages of millet cultivars, Brunette, Baurhoo, and Mustafa (2014) observed no difference in DM digestibility between diets containing corn silage (70.43%) or millet silage (66.02% and 67.34%). Arriola et al. (2011) did not observe a difference in the DM digestibility of inoculated or not inoculated corn silages, similar to what was observed in the present study. The OM apparent digestibility, when compared with the DM apparent digestibility, can explain the influence that DM has on OM.

No differences ($P>0.05$) were observed in the apparent digestibility of CP, EE, TC, NDF, and NFC between the diet containing corn silage and the diets containing millet silage. Considering the type of silage (corn or millet), there were no differences ($P>0.05$) in the CP, EE, TC, NDF, and NFC apparent digestibility between diets containing millet silage with 5 mm or 20 mm particle size, as well as silages containing or not inoculant. The diet containing corn silage had a higher ($P<0.05$) TDN concentration than the diets containing millet silage. Particle size and the use or not of inoculant did not influence ($P>0.05$) TDN concentration in diets containing millet silage.

**Table 4**. Average apparent digestibility coefficients of feed.

| Variable[1] | Diet[2] | | | | | CV (%) | Contrast (P_value)[3] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 5S | 5C | 20S | 20C | CS | | 1 | 2 | 3 | 4 |
| DMDC | 60.2 | 61.9 | 61.7 | 63.6 | 66.2 | 5.3 | 0.01 | 0.20 | 0.31 | 0.27 |
| OMDC | 56.8 | 59.2 | 58.4 | 61.0 | 62.4 | 5.0 | 0.03 | 0.23 | 0.23 | 0.19 |
| CPDC | 68.1 | 67.8 | 68.6 | 68.8 | 69.4 | 8.9 | 0.62 | 0.70 | 0.90 | 0.93 |
| EEDC | 83.7 | 83.5 | 81.3 | 85.0 | 83.7 | 7.3 | 0.86 | 0.76 | 0.91 | 0.13 |
| CTDC | 51.1 | 54.5 | 51.5 | 55.5 | 55.5 | 8.4 | 0.32 | 0.75 | 0.26 | 0.19 |
| NDFDC | 47.4 | 44.6 | 51.0 | 50.9 | 51.8 | 11.2 | 0.17 | 0.17 | 0.44 | 0.45 |
| NFCDC | 72.1 | 71.9 | 72.1 | 71.0 | 74.3 | 11.0 | 0.21 | 0.14 | 0.97 | 0.41 |
| TDN (g $kg^{-1}$) | 565.2 | 586.7 | 587.1 | 585.3 | 616.8 | 5.02 | 0.03 | 0.45 | 0.29 | 0.90 |

[1]DMDC = DM apparent digestibility coefficient; OMDC = organic matter of apparent digestibility coefficient; CPDC = crude protein apparent digestibility coefficient; EEDC = ether extract apparent digestibility coefficient, TCDC = total carbohydrates apparent digestibility coefficient; NDFDC = neutral detergent fiber apparent digestibility coefficient; NFCDC = non-fibrous carbohydrates apparent digestibility coefficient; TDN = total digestible nutrients; [2]5S = millet silage with a 5 mm particle size without bacterial inoculant; 5C = millet silage with a 5 mm particle size with bacterial inoculant; 20S = millet silage with a 20 mm particle size without bacterial inoculant; 20C = millet silage with a 20 mm particle size with bacterial inoculant; CS = corn silage; [3]Contrast 1 = corn silage (CS) versus millet silage; contrast 2 = millet silage with 5 mm particle size versus millet silage with 20 mm particle size; contrast 3 = millet silage with 5 mm particle size without inoculant (5S) versus millet silage with 5 mm particle size containing inoculant (5C); contrast 4 = millet silage with 20 mm particle size without inoculant (20S) versus millet silage with 20 mm particle size containing inoculant (20C); CV = coefficient of variation; P = probability.

The NDF apparent digestibility value (51.8%) is close to that observed (52.7%) by Brunette, Baurhoo, and Mustafa (2014), who evaluated corn silage in the diet of dairy cows. Arriola et al. (2011) did not observe a difference in CP digestibility between inoculated or not inoculated corn silages. However, the same authors observed a decrease in NDF digestibility when using strains of homo and heterofermentative bacteria. The authors justified this decrease in digestibility by the greater deterioration of the inoculated silage in the silo, a fact that did not occur in the present study. The higher TDN concentration in diets with corn silage was probably influenced by the apparent digestibility of DM, although no difference was found in the apparent digestibility of the constituents that make up this fraction.

Cows fed the diet containing corn silage produced ($P<0.05$) more milk (18 kg $day^{-1}$) than cows fed diets containing millet silage (14.5 kg $day^{-1}$) (Table 5). Likewise, CMP was higher ($P<0.05$) in cows fed diets containing corn silage (17.4 kg $day^{-1}$) in comparison to those fed millet silage (15.1 kg $day^{-1}$). Although animals fed diets containing millet silage with 5 mm particle size had higher DM intake in comparison to animals fed silage with 20 mm particle size, this did not influence ($P>0.05$) MP and CMP. This could be observed in the lower ($P<0.05$) PE of cows fed diets containing millet silage with 5 mm particle size when compared to those fed silage with 20 mm particle size, 0.94 and 1.05 kg of milk $kg^{-1}$ of DM intake, respectively. The use or not of bacterial inoculation in millet silages did not influence ($P>0.05$) MP, CMP, and PE.

The increases in MP and CMP reflect the greater digestibility and greater DM intake of the diet containing corn silage in contrast to millet silage. Amer and Mustafa (2010) observed no difference in the MP of cows fed corn or millet silage (38 kg $day^{-1}$). In a test with three theoretical particle sizes of corn silage (5.5, 8.1, and 14 mm) in diets of lactating cows, Zebeli et al. (2009) observed a similarity in MP and CMP among the treatments. These authors justified that, despite changes in diet intake, the absence of changes in MP may be a result of the short period over which the animals were subjected to each diet (23 d). Arriola et al. (2011) observed no difference in corrected or uncorrected milk production in diets containing corn silage, inoculated or not, similar to what was observed in the present study. According to Muck et al. (2018), the observed results of the effect of inoculants on responses in animals still need to be elucidated.

Fat concentration in milk was higher ($P<0.05$) in cows fed a diet containing millet silage in comparison to diets containing corn silage. Corn silage had higher NFC concentration and lower NDF concentration than millet silage. Still regarding the fat concentrations in milk in g of milk $kg^{-1}$ and g $day^{-1}$, they were not ($P>0.05$) influenced by particle size nor by the use or not of inoculant in millet silage. Regarding the higher fat concentration in the milk of cows that were fed millet silage, the difference in milk fat can be explained by a probable lower acetate:propionate ratio in the rumen when the animals received diets containing corn silage, justified by the difference in the chemical composition of silage, especially in terms of plant carbohydrates. The amount of fat produced per day was not influenced by the silage supplied, because although cows fed corn silage had a lower concentration of fat in their milk, this was balanced by the higher production. As in the present work, Zebeli et al. (2009) observed no difference in the concentration and fat production of milk from cows fed diets containing corn silage with three theoretical particle sizes (5.5, 8.1, and 14 mm).

**Table 5**. Average composition and milk production of cows fed with different diets.

| Variable[1] | Diets[2] | | | | | CV (%) | Contrast (P_value)[3] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 5S | 5C | 20S | 20C | CS | | 1 | 2 | 3 | 4 |
| MP (kg day$^{-1}$) | 14.8 | 14.0 | 14.7 | 14.6 | 18.0 | 6.3 | <0.01 | 0.55 | 0.25 | 0.90 |
| CMP (kg day$^{-1}$) | 15.3 | 14.7 | 15.4 | 15.1 | 17.4 | 7.5 | 0.01 | 0.66 | 0.42 | 0.70 |
| PE (kg milk kg$^{-1}$ DM) | 0.96 | 0.91 | 1.03 | 1.06 | 1.06 | 6.4 | 0.05 | <0.01 | 0.45 | 0.51 |
| Fat (g kg$^{-1}$) | 37.6 | 38.2 | 37.9 | 37.0 | 33.0 | 7.3 | 0.00 | 0.73 | 0.75 | 0.57 |
| Fat (g day$^{-1}$) | 552 | 533 | 559 | 542 | 593 | 9.5 | 0.10 | 0.75 | 0.59 | 0.64 |
| Protein (g kg$^{-1}$) | 31.1 | 31.3 | 30.3 | 29.2 | 31.6 | 4.4 | 0.14 | 0.04 | 0.86 | 0.21 |
| Protein (g day$^{-1}$) | 457 | 436 | 445 | 427 | 567 | 4.6 | <0.01 | 0.33 | 0.15 | 0.21 |
| Lactose (g kg$^{-1}$) | 43.2 | 43.6 | 43.6 | 43.2 | 44.3 | 2.9 | 0.18 | 0.99 | 0.60 | 0.63 |
| Lactose (g day$^{-1}$) | 640 | 613 | 641 | 614 | 801 | 7.3 | <0.01 | 0.66 | 0.39 | 0.76 |
| TS (g kg$^{-1}$) | 122.4 | 123.3 | 118.1 | 116.6 | 119.3 | 2.2 | 0.54 | <0.01 | 0.63 | 0.39 |
| TS (g day$^{-1}$) | 1804 | 1724 | 1735 | 1706 | 2148 | 6.5 | <0.01 | 0.42 | 0.31 | 0.71 |
| DDE (g kg$^{-1}$) | 83.8 | 84.2 | 83.2 | 82.1 | 85.5 | 2.2 | 0.04 | 0.12 | 0.72 | 0.34 |
| SCC (1000 mL$^{-1}$) | 460 | 573 | 556 | 922 | 598 | 58.5 | 0.87 | 0.20 | 0.63 | 0.14 |
| UN | 9.9 | 9.60 | 10.28 | 10.08 | 8.32 | 10.7 | 0.01 | 0.37 | 0.65 | 0.77 |
| N (g kg$^{-1}$) | 5.0 | 5.0 | 4.9 | 4.7 | 5.1 | 4.4 | 0.14 | 0.03 | 0.86 | 0.24 |
| BW (kg) | 511 | 508 | 508 | 510 | 510 | 0.9 | 0.78 | 0.73 | 0.38 | 0.42 |

[1]MP = milk production; CMP = corrected milk production; PE = productive efficiency; TS = total solids; DDE = defatted dry extract; SCC = somatic cell count; UN = urea nitrogen; N = nitrogen; BW = body weight; [2]5S = millet silage with a 5 mm particle size without bacterial inoculant; 5C = millet silage with a 5 mm particle size with bacterial inoculant; 20S = millet silage with a 20 mm particle size without bacterial inoculant; 20C = millet silage with a 20 mm particle size with bacterial inoculant; CS = corn silage; [3]Contrast 1 = corn silage (CS) versus millet silage; contrast 2 = millet silage with 5 mm particle size versus millet silage with 20 mm particle size; contrast 3 = millet silage with 5 mm particle size without inoculant (5S) versus millet silage with 5 mm particle size containing inoculant (5C); contrast 4 = millet silage with 20 mm particle size without inoculant (20S) versus millet silage with 20 mm particle size containing inoculant (20C); CV = coefficient of variation; P = probability.

Regarding protein in milk, no difference (P>0.05) was observed when the animals were fed diets containing corn or millet silage. Daily milk protein production was higher (P<0.05) in cows fed corn silage. Cows fed diets containing millet silage with 5 mm particle size had a higher (P<0.05) amount of protein in their milk than cows fed diets containing millet silage with 20 mm particle size. The type of silage in the diet (corn or millet) did not influence (P>0.05) the protein in milk in g kg$^{-1}$, as well as the use or not of inoculant. In diets containing millet silage, lactose in g of milk kg$^{-1}$ was not influenced (P>0.05) by the type of silage in the diet, particle size, and use or not of inoculant. Cows fed a diet containing corn silage were able to produce more (P<0.05) lactose per day (801 g day$^{-1}$) than cows fed the other diets. Particle size and use or not of inoculant in millet silage did not affect (P>0.05) the amount of lactose produced per day. In a meta-analysis on the effect of forage particle size, Nasrollahi, Imani, and Zebeli (2015) observed that protein production in milk increases with reducing particle size. These authors argue that the improvement in milk protein production with the decrease in forage particle size may be due to the improvement in the cows' energy supply due to the increase in dry matter intake, especially in diets with a high forage:concentrate ratio.

No difference (P>0.05) was observed in the amount of TS in the milk of cows fed diets containing corn or millet silage, the second one containing or not inoculant. However, in cows fed diets containing millet silage with 5 mm particle size, the milk had a higher (P<0.05) amount of TS than the milk of those fed with millet silage with 20 mm particle size. Considering the amount of TS produced on the day, cows fed corn silage had greater (P<0.05) production than those fed millet silage. The DDE concentration in g of milk kg$^{-1}$ was higher (P<0.05) in cows fed a diet containing corn silage in comparison to cows fed diets containing millet silage. No difference (P>0.05) was observed in DDE concentration in the different diets with millet silage. Likewise, no difference was observed between the somatic cell count (SCC) in the milk of cows fed different diets. The greater amount of TS produced by cows is related to the greater milk production in animals that consumed corn silage, that is, even though there was no difference in the TS concentration in milk in the different diets, MP improved the TS production per day. Arriola et al. (2011) also observed no difference in the SCC of milk from cows fed diets containing silage inoculated with homo and heterofermentative bacteria.

Cows fed corn silage had lower (P<0.05) UN values in milk compared to cows fed millet silage. Cows fed diets containing millet silage with 5 mm particle size showed higher nitrogen concentration in g of N kg$^{-1}$ of milk than diets containing silage with 20 mm particle size. No difference was observed in the concentration of nitrogen in the milk of cows fed with corn silage or millet silage, nor in cows fed with millet silage containing or not inoculant. Likewise, no difference (P>0.05) was observed in the BW of the animals on the different diets. As concerns to the UN concentration, lower levels of this component in milk are generally attributed to the balance of rumen degradable protein (RDP) and energy.

## CONCLUSION

Replacing millet silage with different TPS with WPCS in the diets did not improve nutrient intake and digestibility and did not increase the animals' milk production. The use of the inoculant in millet silages does not affect nutrient intake and digestibility, and the production and composition of milk.

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