

Assessing cattle feed preferences to Crescentia cujete silages by cafeteria test

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Abstract

The aim of this study was to determine the animal preference and intake pattern of tropical cattle fed two calabash tree fruit silages: i) ground ripe calabash tree fruit (FS) and ii), a ground calabash tree fruit mixed to a composed foliage at 30:70 fruit-to-roughage ratio (FFS). We verified whether the silage alternative with the best ensilability and preservation features evaluated in a previous study is that with the greater animal preference. Eight Gyr breed cows (451.6 ± 9.5 kg BW; 3–4-years old) were involved in a short-term 21-day cafeteria test (i.e., 14 and 7 days for adaptation and data collection, respectively). First consumed silage (FCS) and number of times the animal consumed each silage (CONS) were measured, whereas individual fresh matter intake of each silage (FMI), total time spent eating (TSE), fresh matter intake rate (IRFM) and dry matter intake rate (IRDM) were calculated and statistically analysed as a completely randomized design with two experimental treatments and seven replicates. Significant statistical differences were observed in all the variables evaluated except on CONS and IRFM. The cows consumed FFS in 100% of the times they were exposed to this silage, compared to 93.9% when consuming FS. Under the conditions of this study, our findings suggest that ensiled mixture of calabash tree fruit and foliage in a 30:70 fruit-to-roughage ratio positively influenced the preference and intake pattern by beef cows when compared to a calabash tree fruit silage without additives or forages in the mixture.

Introduction

Feed intake and consumption patterns are of particular relevance in cattle production, as they directly impact the performance and profitability of the production system while reducing its environmental footprint (Kenny et al., 2018; Ojo et al., 2024; Maree et al., 2025). The preferences of ruminants on specific feedstuffs have been demonstrated to result in an increased feed intake with a positive influence on the animal performance (Baumont, 1996; Coleman & Moore, 2003). Furthermore, during scarcity periods, when animals are confronted to a lack of feed options, or under intensive or high-input farming systems on which animals' ability to select feed is reduced, this decision belongs to the farmers. Hence, understanding animal preferences behavior in order to promote a higher feed intake and, consequently, the best possible performance is becoming increasingly imperative (Villalba et al., 2010; Roura & Navarro, 2018).

Despite a reported less preference of ruminants for silages in comparison to both fresh or succulent forages and some grains (Baumont, 1996; Kung et al., 2018; Monllor et al., 2020), silage and hay are frequently the only available options to farmers for feeding their herds during the dry season in tropical conditions (Ribeiro et al., 2015; Haselmann et al., 2020).

In a previous and related study, Rojas-Meza et al. (2026) assessed the feasibility of silage as conservation technique for calabash tree (*Crescentia cujete*) fruit without or with adding several additives (i.e., common salt or tropical forages in the mixture), for their further use in tropical cattle feeding. Results reported that despite its low DM content ($\sim 20\%$), calabash tree fruit without any

additives presented the best results with adequate ensilability features and optimal preservation, followed by the ground fruit mixed with the foliage of the same tree in a fresh basis of 30:70 fruit-to-roughage ratio. Although this study demonstrated the feasibility of the silage technique for the conservation of this feed resources using different mixtures, the preference and consumption pattern of any of those feedstuffs by ruminants is still unknown.

Hence, the aim of this trial was to determine the preference and consumption pattern of tropical cattle by comparing two different silage alternatives through a multiple-choice feeding test (the so-called cafeteria test), and verify whether the alternative with better ensilability and preservation features correspond to that of greater animal preference.

Materials and methods

Study area

The cafeteria test was performed under productive on-farm conditions i.e., the facilities of the farm “El Porvenir”, which is located in the Colombian Caribbean region (10°05'58"N 73°23'55"W, altitude 80 m) in a tropical dry forest agroecological zone with 1300 mm of total annual rainfall, 65% of average relative humidity and 28.8°C (min: 24.0°C; max: 34.3°C) of average annual air temperature (Rojas-Meza et al., 2026).

The ‘cafeteria test’

Eight dried Gyr breed adult cows (3–4 years old; 451.6 ± 9.5 kg BW; at maintenance), were chosen from a commercial beef herd to carry out the cafeteria test, which is defined as a trial where animals are “briefly exposed” to different feedstuffs choices e.g., forages from several plant species (Salem et al., 1994). The trial lasted 21 consecutive days, including 14 days for the adaptation of the observer and animals (to the feed, the pens, and the daily routine), and 7 days for data collection. The voluntary preference by cows was determined by comparing the two offered different silage options: i) ground ripe calabash tree fruit with 90 conservation days (**FS**) and ii), foliage and ground ripe calabash tree fruit mixture at 30:70 fruit-to-roughage ratio on a fresh basis, also with 90 conservation days (**FFS**). The two offered silages were prepared at the facilities of the “El Porvenir” farm previously to the experiment, and the start of the experimental period was carefully scheduled in a synchronized manner i.e., at the same time the silages completed the 90 days conservation period.

In the farm, the beef herd was managed following a rotational grazing schedule under an intensive silvopastoral system composed by Tanzania grass (*Megathyrsus maximus* cv. *Tanzania*) and *Leucaena* shrubs (*Leucaena leucocephala* – with a tree density around 10000 trees/ha). The silages were prepared with the foliage and fruits harvested from the *Crecentia kujete* plantation established since several years ago in the same farm.

Once chosen, the experimental cows were kept separately from the original herd but grazing under the same conditions i.e., in paddocks next to the area where the cafeteria test was carried out. The protocol was as following: the cows were daily collected from the paddocks at 17:00 h and held in a collective pen with only access to drinking water. The next day at 07:00 h, 1000 g of each silage was weighed on an electronic scale SF-400 (accuracy of ± 0.01 g) and distributed separately at the same time into an individual pen using a two-sections divided feeder (the section where each silage was offered was alternated daily in order to avoid any bias by position). Immediately, a cow was transferred from the collective pen to an individual one and exposed to feed during a 10 minutes period. A digital chronometer (Pulivia Stopwatch YS-802C) was used for manual monitoring of the following indicators of preference and voluntary intake: the first consumed silage (**FCS**), the number of times the animal consumed each silage (**CONS**) and the time spent eating on each consumption (**TSE**).

In order to standardize the exposure time to each animal and clearly determine the number of visits the animal made for each silage along time, the starting point of the 10 minutes period exposition of each animal to the silages was defined according to Nedelkov et al. (2019) i.e., the moment “when the muzzle of the animal crossed by the first time the imaginary plane of the opening of any feeder section”. According to the same authors, each consumption event was defined to begin “when the animal’s tongue or its muzzle touched the silage and it began to move its jaws” and stopped “when chewing of the consumed silage ceased while the animal’s head was raised out of a feeder or another eating event began”. Finished the test time, the animal was released and the refusals were completely removed and weighed in order to determine the individual fresh matter intake of each silage (**FMI**), calculated as the difference between the initial and final weight. The individual dry matter intake (**DMI**) was then calculated ($\text{FMI} \times \% \text{DM}$) based on the chemical nutritional composition reported for each evaluated silage by Rojas-Meza et al. (2026). At the end of the trial, the total time spent eating for each 10-minutes interval (registered in seconds) was summed and converted into minutes for each silage (**TSE**, min.), whereas the fresh matter intake rate (**IRFM**; FMI/TSE) and the dry matter intake rate (**IRDM**; DMI/TSE) were calculated for the subsequent statistical analysis.

This procedure was repeated with each of the remaining animals, one after one, in the different individual pens. Once the daily tests were completed by all animals (after 90 min.), they were headed back to the paddocks where they spent the rest of the day until 17h, the time when were conducted again to the collective pen until the next day test.

Data regarding chemical nutritional composition, as well as the organic acids and ammoniacal nitrogen concentration of silages were obtained from Rojas-Meza et al. (2026).

Statistical analysis

Due to the refusal of one of the eight cows in the sample to consume one of the two experimental feeds during the experimental phase, the statistical analyses were performed with the data obtained only from the remaining seven animals. In order to compare cattle preference and feed intake patterns between

the two silages, the variables FMI (g), DMI (g), TSE (min.), CONS (number), IRFM (g/min.), and IRDM (g/min.) were analysed using a paired two-sample *t*-test. Each cow was offered both silages simultaneously during seven consecutive days, and the median value across days was computed for each variable and animal to represent its overall response. This approach reduces the influence of day-to-day variability while maintaining one observation per animal. Normality of the difference vector between silages was assessed using the Shapiro–Wilk test.

Data regarding nutritional intake proportion (**IP**) were calculated from the total of 49 consumptions events by treatment as follows: $[(all\ observed\ consumptions - times\ animal\ did\ not\ consume)/all\ observed\ consumptions] \times 100$; (variable expressed in percentage). For each animal, the proportion of trials in which FFS was chosen first (**First consumption**) was computed as an individual measure of preference. These proportions were then analyzed as a single sample to evaluate whether the median preference differed from 0.5, with 0.5 representing the absence of systematic preference between feeds. Because the data did not meet the assumptions of normality and the number of animals was limited, a non-parametric Wilcoxon signed-rank test was applied. Confidence intervals for the median proportion were obtained by nonparametric bootstrap resampling (2000 iterations).

Finally, a principal component analysis (PCA) was performed using the *prcomp* function in a complementary manner to summarize and illustrate graphically the results of the main statistical analysis. All procedures were performed using R Studio Software version 3.6.0 (2024; R Core Team) with a significance level established at 5%.

Results

The results of the variables related to the preference and intake patterns on tropical beef cattle, assessed by cafeteria test, are presented in Table 1. Except for IRFM, significant differences ($P < 0.05$) were found in all parameters, with higher FMI, DMI, TSE, CONS and IRDM observed in FFS compared to FS.

Table 1

Preference and intake pattern of calabash tree fruit silage without (FS) and with calabash tree foliage (FFS) in the ensiled mass by tropical beef cows assessed through a short-term cafeteria test

Item	Silage		MD	95% CI	t-value	Effect, P-value
	FS	FSS				
FMI (g)	363.9 ± 103.1	918.9 ± 14.4	541.3	[312.5–770.1]	5.79	0.0012
DMI (g)	71.5 ± 20.3	262.9 ± 4.1	189.4	[145.2–233.7]	10.47	< 0.0001
TSE (min)	1.87 ± 0.6	4.75 ± 0.4	2.94	[1.02–4.87]	3.74	0.01
CONS (times)	3.57 ± 0.4	4.71 ± 0.5	1.43	[0.70–2.16]	4.80	0.003
IRFM (g/min)	199.7 ± 21.7	211.4 ± 19.4	-0.72	[-56.8–55.3]	-0.03	0.976
IRDM (g/min)	41.6 ± 4.3	57.2 ± 5.5	17.53	[3.98–31.08]	3.17	0.019
IP (%)	93.9	100	ND	ND	ND	ND
First consumption (%)	14.3	85.7	ND	[0.714–1.00]*	ND	0.021**
FMI: Fresh matter intake; DMI: Dry matter intake; TSE: Time spent eating; CONS: average of times each silage was consumed by the animals; IRFM: Fresh matter intake rate; IRDM: Dry matter intake rate; IP: Intake proportion; First consumption: Estimated percentage of times the animal chose each food item at first consumption; FS: ground ripe calabash tree fruit silage with 90 conservation days; FSS: foliage and ground ripe calabash tree fruit mixture at 70:30 roughage-to-fruit ratio on a fresh basis, also with 90 conservation days; MD: Mean of the calculated difference between treatments; 95% CI: 95 percent confidence interval of MD; t-value: value of the t-test statistic; P-value: statistical significance of treatment; Mean by treatment: Estimated marginal means ± standard error; *Bootstrap confidence interval calculations based on 2000 bootstrap replicates for the most preferred feed (FFS); **P value by Wilcoxon signed rank test with continuity correction.						

The results of the PCA are presented using a biplot (Fig. 1) with 88.8% of the total variance of data described by the analysis (PC1 accounting for 58.1% and PC2 for 30.7% of the total variance), indicating this method PCA effectively summarizes the structure of our results.

Vectors corresponding to CONS, DMI, FMI, and TSE variables showed high relationship with major preference and feed intake. In contrast, vectors corresponding to IRFM and IRDM were related to relative feed intake (g/min.). The IRDM was the assessed variable with highest value on PC1 and PC2 components, which means a higher relationship with both preference (expressed as feed intake) and relative intake (expressed in g DM/min.). The separation of data into two groups (green triangles for FS and blue circles for FFS; Fig. 1) and the location of their centroids (lower left quadrant for FS and upper right quadrant for FFS) denote a clear difference in favor of FFS with regard to preference and, consequently, higher feed intake by animals.

Discussion

The higher fresh and DMI observed in FFS compared to FS could be probably associated to physicochemical features of the silages. The FS with a low DM content (~ 20%), exhibited a muddy consistency. Conversely, FFS with high foliage content (70% of the mixture on a fresh basis), showed a more solid, dry and pasty consistency, which is characteristic of forages. Similarity of FFS to forage could initially motivate higher feed intake, influenced by the ruminant herbivorous behavior (Cannas et al., 2009; Favreau-Peigné et al., 2013; Riaz et al., 2014; Distel & Villalba, 2018). Additionally, the 14-hour fasting period to which animals were submitted prior exposure to silages during the short-time test, could probably induce the preference of animal by a feedstuff with a higher dry matter and fiber content as FFS (Baumont, 1996; Meier et al., 2012).

Another aspect that could be related to higher feed intake is that, although both feeds were ensiled, according to Rojas-Meza et al. (2026) FS presented lower pH (3.75 vs. 4.45) and a higher content on volatile compounds as ammoniacal nitrogen ($\text{NH}_3\text{-N}$; 12.8 vs. 7.8% of total N), lactic (8.7 vs. 3.3 g/kg DM) and acetic (2.8 vs. 1.7 g/kg DM) acid concentration, when compared to FFS. According to several authors (Rapisarda et al., 2012; Gerlach et al., 2021), these compounds resulting from the conservation process of silages, are negatively correlated to feed intake in ruminants, which is consistent with the lower preference and feed intake observed for FS in the current study. The above could be decisive on the preference and intake pattern of animals considering that in this trial, silages were offered in their original form, which could increase the consumption-depressing effect of the volatile compounds when compared to the mixture of silages and either, hay or fresh chopped grass in a forage-based diet, thus reducing the concentration of these compounds and, consequently, their negative effect on feed intake (Brüning et al., 2018; Bandla et al., 2024). A higher content of ammoniacal nitrogen and organic acids in the silages could also explain why the animals spent more time consuming FFS compared to FS.

According to Monllor et al. (2020), the energy content of the feedstuff is strongly correlated to a higher preference and DMI by ruminants. In this trial, and contrary to the authors statement, FS with a higher energy concentration (19.8 vs. 18.2 MJ of gross energy/kg DM in FFS) showed a lesser preference and consequently a lower feed intake. This can be explained as a derivative consequence, not only of a higher volatile compound concentration on FS but also by its higher total condensed tannins concentration (2.6 vs. 1.1 g/kg DM in FFS) that could probably reduce the preference and intake by the animal (Hernández-Orduño et al., 2015; López Benavides et al., 2022). It is likely that total condensed tannins content, as well as $\text{NH}_3\text{-N}$ and organic acids contents may be more decisive to define the preferences and intake pattern in ruminants than gross energy concentration, especially when the differences in energy content are not very pronounced, as is the case in our study.

Results on intake rate of fresh matter (IRFM) did not show significant statistical differences (Table 1). This could probably suggest that, although animals spent more time consuming FFS and consumed a greater total amount of this feed compared to FS, they did not consume FFS more eagerly to the point of increasing the amount consumed/min compared to FS. Notwithstanding this observation, IRDM on FFS

was found to be significantly higher ($P = 0.019$) compared to FS. This can be attributed to a higher DM content of FFS (28.6%) vs. 19.7% of DM observed in FS, as reported by Rojas-Meza et al. (2026). This higher DM content in FFS could enable the animals to consume a greater quantity of DM either by unit of time or unit of consumed fresh matter, despite the not statistically differences on IRFM found in both silages (Table 1).

The percentage proportion of animals consuming each silage was calculated from the 49 observations on the seven cows along seven trial days. Although a descriptive approach was employed, it was possible to show that in all exposures to silages, the animals always (100%) consumed FFS to a greater or lesser extent, compared to 93.9% of animals consuming FS. This suggests a higher preference for FFS instead FS. This is consistent with the results of the Wilcoxon test ($P = 0.021$), revealing a significant effect of silage on the preference by the animals of their "first consumption" event. The FS was firstly consumed by the animals in a range of 0 to 28.6% of the times (mean value of 14.3%), whereas FFS was firstly consumed between 71.4 and 100% (mean value of 85.7%) of the times (Table 1).

Several studies evaluating different fruit + forage silages in ruminants reported an increase on feed intake in silages made from a mixture of forage and fruit when compared to those with only forage, fruit or when the later represent the major proportion of the ensiled mass. Abdelazeem et al., (2020) assessing persimmon skin ensiled with and without natural absorbents (i.e. wheat bran or kraft pulp) in based festuca hay diets for ewes, reported that animals fed diets without and with 12 and 25% of persimmon skin silage did not differ on DM intake, whereas diet including 20% of persimmon skin silages with a 40% of kraft pulp as absorbent fiber reduce the time spent eating by the animals with no significant differences on DM, CP and NDF intake, indicating a higher DM intake rate (g/min). Yang, et al., (2022) evaluating corn silage without and with 25 and 50% of ensiled pineapple peel in goats reported a higher feed intake and daily weight gain by animals fed the mixture of 50% corn silage and 50% pineapple peel silage. Research conducted by Dadashi, et al., (2023) comparing feed intake of corn silage (forage) against orange pulp ensiled only with wheat straw or wheat straw + sugar beet in sheep, reported a higher feed intake (g/d) in sheep fed corn silage, followed by those fed orange pulp ensiled with wheat straw + sugar beet, being the silage of orange pulp and wheat straw, which showed the lowest feed intake.

In another research, Firmino, et al., (2023) studied the effect of including melon fruit at 70, 140 and 210 g/kg of Canarana grass silage on Santa Inês lambs feeding. Results showed a decrease on DM, CP and ME intake while melon fruit inclusion was increasing. Gómez-Trinidad, et al., (2024) reported higher DM intake by crossed calves fed a diet containing 60% of waste papaya silage compared with a diet based on Pangola grass with corn and soybean grain without including papaya silage. Nevertheless, De Araújo, et al., 2025 did not report significant differences on DM intake by sheep when comparing a sorghum silage vs. a 70:30 fruit-to-roughage ratio silage made from mango fruit waste and *Gliricidia sepium* forage.

Conclusion

The prospective results of this study under tropical farming conditions suggest that the addition of calabash tree foliage in a 30:70 fruit-to-roughage ratio in the mixture, modified the physicochemical features of the silage and, consequently, the final products of fermentation after the conservation process. These alterations led to a positive influence on the palatability and preference of this silage by the beef cows, which was reflected in a higher consumption of FFS when compared to a calabash tree fruit silage without additives or added forages in the mixture. Although further research using short and long-term trials is required, the approach used in this study may impact the farmers feeding management practices using this feed resources.

Declarations

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Author contributions: All authors contributed to the study's conception and design. Material preparation, field execution and data collection were performed by Diego A. Rojas-Meza and Leonardo Manzano-García. Data Analysis were performed by Diego A. Rojas-Meza and Guillermo Antonio Correa-Londoño. The first draft of the manuscript was written by Diego A. Rojas-Meza, and the previous versions of the manuscript were commented by Jordi Bartolomé Filella and Eliel González-García. All authors read and approved the final manuscript.

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Data availability: The datasets generated during and/or analyzed during the current study are not publicly available due to privacy or ethical restrictions, but are available from the corresponding author upon reasonable request.

Ethics approval: Since this was an observational study, the Research Ethics Committee from Autonomous University of Barcelona has confirmed that no ethical approval is required.

Competing interests: The authors have no relevant financial or non-financial interest to disclose

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Figures

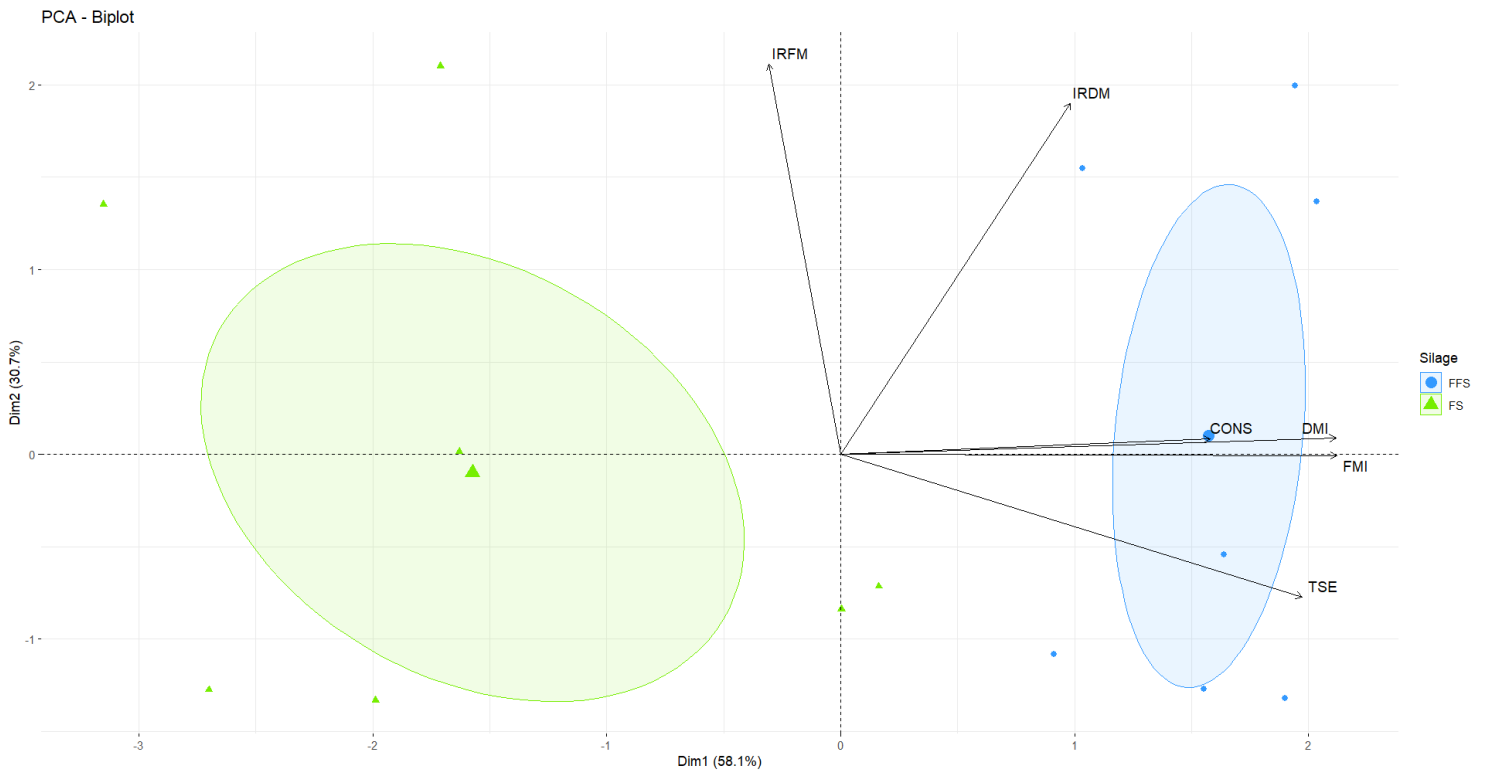


Figure 1

Biplot representation of the preference by tropical beef cattle (Gyr cows) when offered two silage alternatives (FS vs. FFS) in a cafeteria test; **FMI**: Fresh matter intake; **DMI**: Dry matter intake; **TSE**: Time spent eating; **CONS**: average of times each silage was consumed by the animals; **IRFM**: Fresh matter intake rate; **IRDM**: Dry matter intake rate; **FS**: ground ripe calabash tree fruit silage with 90 conservation days; **FFS**: foliage and ground ripe calabash tree fruit mixture at 70:30 roughage-to-fruit ratio on a fresh basis, also with 90 conservation days.