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Sensory analysis of goat cheese feed with sorghum silage levels in forage cactus based diets

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Abstract:

The objective of this study was to evaluate the quality of milk and cheese and sensory analysis of cheese from goats that received a diet with different levels of sorghum silage in the diet. Twenty Anglonubian dairy goats were used, with an average age of 2 years, average live weight of 43.7 kg, distributed in a completely randomized design, with five replications. Moisture (P=0.001), total solids (P=0.001), fat (p=0.001), TDE (P=0.006) and protein (P=0.003) of goat cheese showed a significant difference due to the inclusion of silage from goat cheese. sorghum in the diet. The sensory attributes soft appearance (P<.0001), look (P<.0001), salty taste (P<.0001) and smooth texture (P=0.0430) showed a significant difference depending on the level of sorghum silage added to the diet. of goats. In the PC analysis, it is observed that three main components were needed to represent the variation of 64.84% of the data. PC 1 determined 29% of the data variation and was represented by the attributes with the highest averages: attractive aroma (5.87) and global acceptability (7.74). The inclusion of up to 45% of sorghum silage in the diet of goats increased milk and cheese fat, which favored high scores for the attributes of softness and global acceptance.

Keywords: goat; curd cheese; sensory; texture; moisture.

Practical Application: Forage sorghum is the most viable option to meet the demand of ranchers, due to its bromatological characteristics that allow adequate fermentation and consequence of food conservation in the form of silage.

1 Introduction

Animal production in the semiarid region is conditioned to the production and conservation of forage, since intra and inter-annual climatic variations define an oscillation in the supply of forage, which causes a deficit in the productive indexes of the herds due to the scarcity of food. In addition to the amount of forage, the quality also fluctuates over time, which makes it even more difficult to define feeding programs (Ramos et al., 2017). Pastures in dry season decline and become less nutritious with higher lignin content and little nutritional capacity. Therefore, for this period it is necessary to search for food alternatives, highlighting the use of silage. Among the silage alternatives, sorghum silage can be prepared, stored and supplied in times of lack of food (Carvalho et al., 2016).

Sorghum, in ensiled form, has good nutritional and agronomic quality when compared to corn silage, which is one of the most used in our country (Lopes et al., 2017). Forage sorghum is the most viable option to meet the demand of ranchers, due to its bromatological characteristics that allow adequate fermentation and consequence of food conservation in the form of silage. Its grains have good nutritional values, similar to corn, with an average composition of 70% carbohydrates, 12% protein, 3% fat, 2% fiber and 1.5% ash (Behling et al., 2017). According to the same author, the protein concentration can vary between 8.3 and 15.5%, and may exceed that found in corn grain (10%).

Animal nutrition plays a fundamental role in the milk production system, as in addition to being a crucial production tool, it influences quality and is associated with a considerable portion of the dairy herd (Lopes et al., 2017). Of the various factors associated with sensory attributes and milk quality, food has been fundamental in the handling of milk components (Pereira et al., 2010; Muniz et al., 2022). Due to substances present in forages with odoriferous properties, the pasture-based diet can modify the chemical composition and sensory properties of milk related to the fatty acid and enzyme composition of milk (Coulon & Priolo, 2002). Some substances that modify the sensory characteristics of milk are probably due to intense changes in food compounds during digestion and metabolism by microbial and enzymatic processes (Addis et al., 2006).

The objective of this study was to evaluate the quality of milk and cheese and sensory analysis of cheese from goats that received a diet with different levels of sorghum silage in the diet.

2 Materials and methods

2.1 Experiment location and animals

The experiment was conducted at the Federal University of Paraíba, Bananeiras Campus, Paraíba state, Brazil (altitude 552 m,

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latitude 6° 41' 11", longitude 35° 37' 41"). The air temperature was 24.97 °C, and relative humidity was 76.48% in the stalls.

Twenty Anglonubian dairy goats were used, with an average age of 2 years, average live weight of 43.7 kg, distributed in a completely randomized design, with five replications. Each animal was housed in an individual "Tie Stall" stall, equipped with a feeder and a drinker. The experiment lasted a total of 21 days, with 14 days of adaptation to experimental diets and facilities and seven days of data collection. All animals were vaccinated against Clostridiosis and treated against endo and ectoparasites before the start of the experiment.

2.2 Diet

The diets consisted of forage cactus, sorghum silage and concentrate, the treatments being represented by the different levels of sorghum silage in the dry matter of the ration (7.5; 15; 30 and 45%) (Table 1) based on the dry matter dry. Diets were formulated according to National Research Council (2001) recommendations for dairy goats with an average milk production of 2.0 kg/day.

Feed was provided in two equal daily portions, at 08:00 and 16:00 hours, being weighed and adjusted, allowing for leftovers of up to 10% after morning and afternoon milking. The samples were analyzed according to the Association of Official Analytical Chemists (2012) for dry matter (DM) (934.01 method), mineral matter (MM) (942.05 method), crude protein (CP) (954.01 method), extract ethereal (EE) (920.39 method) (Table 2).

2.3 Physical-chemical of milk

Milking was performed manually, throughout the experiment, occurring twice a day at the times of (6:00 a.m. and 3:00 p.m.), including adaptation periods and data collection, and the dairy control was performed by weighing. Before milking, the goats' udders were washed with chlorinated water and dried with paper towels and then tested for mastitis (black bottom mug test). After each milking was done post-dipping, the goats' roofs were dipped in a 2% iodine solution.

The samples of the morning production were conditioned in a refrigerated environment (4 °C) to be later mixed to the milk samples of the afternoon, forming a sample composed of goat per day. From the whole milk milked per animal (kg day^{-1}), an aliquot of 200 mL was taken (with the participation of the samples proportional to the morning and afternoon milking), for analysis of the physicochemical characteristics. After being placed in identified plastic bottles, the samples were slowly pasteurized at 65 °C for 30 minutes (Brasil, 2001) and finally frozen at -4 °C (in a freezer) for further analysis.

Physicochemical requirements for fat (%), protein (%), lactose (%), extrato seco evaluated according to the Master Complete® Milk Analyzer (AKSO®, São Leopoldo, Rio Grande do Sul, Brasil), under specific technical conditions.

2.4 Phyysical-chemical and sensory analysis cheese

For the elaboration of artisanal raw coalho cheese, samples of 10 liters of goat's milk from each experimental treatment were used. After milking the milk was strained and immediately refrigerated at 5-7 °C for one day. Subsequently, the milk was heated to 32-37 °C and the liquid coagulant was added at a rate of 1 mL for every 1 L of milk. The clotting power of the rennet used was 1:3,000/75 IMCU. After the addition of rennet, the milk was homogenized and allowed to clot for 40 minutes. Then the curd was cut, stirred, heated to 45 °C, partially removed the whey, added sodium chloride to the mass in a proportion of 1%, pressed into round plastic molds, and kept for 24 hours at an average temperature of 10-12 °C. After the elapsed time, the cheeses were removed, packaged, labeled and kept under the same refrigeration temperature (Brasil, 2001; Nassu et al., 2001).

It was performed at the Laboratory of Product Performance and Sensory Analysis at the UFPB. In all tests, samples were randomly placed in trays with randomized three-digit codes. The samples were split into equal portions of 5g into polystyrene plates, marked with a random 3-digit code. In order to avoid the possible effects of the order of presentation, the samples were presented to panel members following different orders (MacFie et al.,

Table 1. Ingredient proportions of experimental cactus-based diets used for lactating goats based on dry matter.

Ingredient (% Dry Matter)	Níveis de inclusão da silagem de sorgo (%)			
	7.5	15.0	30.0	45.0
Silage sorghum	75	150	300	450
Cactus pear	591.70	516.70	366.70	216.60
Ground corn	159.30	159.30	159.30	159.30
Soybean meal	174.00	173.40	172.30	171.20
Urea	0.00	0.60	1.70	2.90

Table 2. Bromatological composition of ingredients used in the composition of experimental diets for lactating goats based on dry matter.

Ingrediet (g kg)	Dry matter	Organic matter	Mineral matter	Crude protein	Ether extract
Silage sorghum	272.60	919.20	80.80	82.20	28.60
Cactus pear	115.00	870.90	129.10	58.30	14.10
Ground corn	888.20	948.70	15.30	88.00	34.80
Soybean meal	893.10	929.80	70.02	446.80	11.20

1989). Sensory analysis was performed in individual booths having controlled environmental conditions, at a temperature around 23 °C (International Organization for Standardization, 1988). The panel included nine UFPB agricultural science students who were duly selected and trained (International Organization for Standardization, 1993). The tests took place in 2 sessions and nine trained tasters. Consumers evaluated the cheese samples and were asked to mark the option that best suited the product in relation to overall acceptance using a 9-point unstructured hedonic scale (Oliveira et al., 2017). The tasters described how much they liked or disliked the attributes: odor, appearance, taste, texture, and overall impression. A scale of 5 points recommended by Meilgaard et al. (2007) was used to evaluate the intention of purchasing: 1 (Certainly I would buy it); 2 (Probably I would buy it); 3 (Maybe I would buy it/Maybe I wouldn't buy it); 4 (Probably I wouldn't buy it) and 5 (Certainly I wouldn't buy it) (Lima et al., 2021).

2.5 Statistical analysis

Data were subjected to an analysis of variance (ANOVA), and the Tukey test compared the averages at 5% probability through the PROC GLM of the SAS statistical package (Statistical Analysis System Institute, 2010). The test Ryan-Einot-Gabriel-Welsch compared the means of the sensorial attributes 5% probability level. After standardization, a multivariate analysis test was carried following the recommendations previously established by Sneath & Sokal (1973) to allocate the animals into groups according to similarity and verify the original variables' discriminant capacity. The principal component analysis (PCA) allowed the assessment of overall variance, and, on the other hand, the discriminant analysis described the variation among the different groups and identified the variables with greater discriminatory power between groups. PCA was performed by the PRINCOMP (Statistical Analysis System Institute, 2010) procedure, separately for each population

3 Results

The physicochemical characteristics of the milk showed no significant difference (P<0.05) as a function of the level of inclusion of sorghum silage in the diet of goats (Table 3).

Moisture (P=0.001), total solids (P=0.001), fat (p=0.001), TDE (P=0.006) and protein (P=0.003) of goat cheese showed a significant difference due to the inclusion of silage from goat cheese. sorghum in the diet (Table 4). Ash showed no significant difference (P>0.05). Moisture increased with the inclusion of silage, where the highest values were at levels of 15, 30 and 45%. Total solids, fat and TDE had the highest values at the 45% level, whereas the protein decreased with the inclusion of silage, presenting the lowest value at the 45% level (Table 4).

The sensory attributes soft appearance (P<.0001), look (P<.0001), salty taste (P<.0001) and smooth texture (P=0.0430) showed a significant difference depending on the level of sorghum silage added to the diet. of goats (Table 5). The smooth appearance, look and salty taste had the highest scores at the 45% level. In the smooth texture, the levels of 15, 30 and 45% presented statistically equal scores. The level of 45% was the one that presented cheese with the highest fat content (Table 4), which may have reflected on the taste of the evaluators. Even though there was no statistical difference, the level of 45% of silage inclusion was the one that presented the highest score for global acceptability (Table 5).

In the PC analysis, it was observed that three main components were needed to represent the variation of 64.84% of the data,

Table 3. Physicochemical characteristics of goat milk fed with sorghum silage.

Variable	Inclusion sorghum silage (%)				SEM	P-value
	7.5	15	30	45		
Fat	2.91c	3.34b	3.67b	4.16a	0.86	0.019
Total solids	8.78	9.04	8.88	9.40	0.66	0.483
Density	31.51	31.94	31.61	32.92	2.26	0.792
Protein	3.24	3.33	3.28	3.47	0.25	0.479
Lactose	4.81	4.94	4.87	5.14	0.36	0.524
Solubility	0.73	0.75	0.74	0.76	0.06	0.658

SEM = standard error of the mean. Different letters on the line differ from each other by Tukey's test at the 5% probability level.

Table 4. Physicochemical characteristics of cheese from goats fed sorghum silage.

Variable	Inclusion sorghum silage (%)				SEM	P-value
	7.5	15	30	45		
Moisture	46.02b	51.76a	52.22a	52.74a	0.36	0.001
Total solids	47.26b	47.78b	48.24b	53.98a	0.36	0.001
Ash	6.20	6.34	6.25	7.34	0.29	0.055
Fat	15.58b	16.43b	16.43b	20.96a	0.45	0.001
TDE	32.96b	34.39b	34.06b	38.83a	2.29	0.006
Protein	53.19a	53.83a	52.87a	42.51b	1.45	0.003

TDE = total dry extract; SEM = standard error of the mean. Different letters on the line differ from each other by Tukey's test at the 5% probability level.

Table 5. Attributes of goat cheese fed diets containing increasing levels of sorghum silage.

Attributes	Inclusion of sorghum silage (%)				SEM	P-value
	7.5	15.0	30.0	45.0		
Appearance						
Soft	2.22c	3.08bc	4.18b	9.11a	1.56	<.0001
Whitish	3.76	3.13	3.25	2.58	1.44	01098
Look	1.89c	3.47b	3.50b	6.31a	2.02	<.0001
Aroma						
Typical of cheese	4.16	3.42	4.25	2.94	2.16	0.2194
Typical of butter	3.79	3.66	3.53	3.08	2.00	0.7335
Attractive	5.89	5.95	5.89	5.75	2.72	0.9968
Flavor						
Salty	2.55b	2.68b	2.56b	5.89a	2.00	<.0001
Sweet	3.50	3.52	2.22	3.83	2.10	0.1096
Typical of cheese	4.71	4.66	5.41	4.78	2.42	0.7598
Typical of butter	3.34	3.68	4.36	3.89	3.34	0.5610
Texture						
Soft	4.36b	4.92ab	5.24ab	6.44a	2.43	0.0430
Homogeneous	5.16	6.21	4.28	6.81	3.76	0.1946
Global Acceptability	6.03	7.11	8.33	9.50	7.23	0.5035

Same letters on the line do not differ from each other by the Ryan–Einot–Gabriel–Welsch test ($P < 0.05$). SEM = standard error of the mean.

we had 13 attributes and only 6 showed greater discriminatory power in the first three PC. PC 1 determined 29% of the data variation and was represented by the attributes with the highest averages: attractive aroma (5.87) and global acceptability (7.74). The second PC contributed with 26.19% of the data variation and was represented by the attributes smooth appearance, look and salty taste, while the third PC was represented by the smooth texture and explained 9.12% of the data variation (Table 6).

4 Discussion

The fat content of milk follows the requirements of IN 62 (Brasil, 2011), which establishes the minimum standard of 3.0% fat in raw milk. Milk fat content, composition and yield depend on several factors, including the composition of the diet you receive (Burin, 2016). Diet is critical because it determines changes in rumen fermentation, modifying the production of different fatty acids and, therefore, the fat content. With an increase in EE, it is therefore expected to increase the percentage of milk fat, as it is considered that the synthesis of lipids in the mammary gland may be affected by the input of triglycerides provided to the animals in the diet (Naumann et al., 2017). Coutinho et al. (2022) evaluated the use of glycerin levels (0, 6, 12 and 18%) in the diet of goats and observed that milk fat varied with the inclusion of glycerin, with an average value of 2.17%.

Lactose content is generally slightly lower in goat milk (4.16 g/100 mL) (Clark & Mora García, 2017), but in this study, the lactose content had an average value of 5%. Lactose did not change what was expected, because according to the literature, this is the milk component that least changes due to diet, having an essential role in the osmotic regulation of milk (Fonseca & Santos, 2000). Santos et al. (2022) evaluated the use of different levels of the guava by-product (0,14, 28 e 42%) in the feeding of goats and observed that the lactose in milk did not change, Beltrão et al. (2022) evaluated the use of flaxseed oil (0,1, 2, e 3%) in the feeding of goats and observed that lactose in milk increased as a function of the inclusion of oil and fat did not change.

The moisture content of the cheese at different levels is within the classification of the Technical Regulation on Identity and Quality of Requeijão (Brasil, 2001), which classifies curd cheese as having a high moisture content, when the moisture content varies from 46.0 at 54.9%. This high moisture content determined in the cheese was also observed by This high moisture content determined in the cheese was also observed by Beltrão et al. (2022) who observed moisture in the cheese ranging from 51.10 to 56.43%, as well as Santos et al. (2022) who observed moisture in cheese ranging from 55.07 to 55.35% and can be characterized as moist cheese, which would be those with averages ranging from (39% > Moisture <46%), (46% > moisture < 55%). This fact can be explained by the information presented by Santos et al. (2011), that this high moisture content is possibly due to the greater presence of whey and denatured proteins, which tend to increase the water retention capacity of the cheese. Santos et al. (2011) reported that the high moisture content can be a negative characteristic, as moisture interferes with the water activity and metabolic actions of microorganisms throughout the ripening process, with its possible consequences on pH, texture, flavor and aroma.

The energetic and protein characteristics of the diet that the animal receives are those that exert the most significant influence on the protein level of the milk, above the genetic condition. The non-degradation of the protein ingested in the rumen is the factor that significantly changes the protein contente expressed in the milk (Naumann et al., 2017). The average protein percentage observed in this study was 2.98%. This result is in line with current legislation for the chemical composition of goat milk, which limits the minimum protein content to 2.8% (Brasil, 2001).

Table 6. Principal component (PC) for the sensory attributes of goat cheese fed sorghum silage.

Attributes	PC1	PC2	PC3
Appearance			
Soft	0.3933	**-0.8255**	0.1447
Whitish	-0.1846	-0.3099	0.3585
Look	0.2756	**-0.7798**	0.0771
Aroma			
Typical of cheese	-0.5242	-0.5814	-0.1870
Typical of butter	-0.4063	-0.2888	-0.3542
Attractive	**-0.7078**	-0.1752	-0.2596
Flavor			
Salty	0.0744	**-0.8509**	0.1074
Sweet	-0.6909	-0.1299	-0.0414
Typical of cheese	-0.6443	-0.4731	0.3091
Typical of butter	-0.6602	-0.3609	0.3269
Texture			
Soft	-0.6656	0.0347	**-0.7657**
Homogeneous	-0.5629	0.6015	0.0280
Global Acceptability	**-0.7068**	0.3843	0.0177
Eigenvalue (λ)	3.7994	3.4439	1.1866
Accumulated variance (%)	29.2265	55.7182	64.8463

Freire et al. (2022a), Santos et al. (2022) observed a fat content of 20% for the curd cheese obtained with only goat's milk, a value higher than that of this research in the levels of silage inclusion of 7.5, 15 and 30%, only the level of 45% showed a higher value. (20%). According to data described by the Ministry of Agriculture (Brasil, 2001), when the gross value in dry extract varies from 25 to 44.9%, cheeses are classified as semi-fat.

Quantitative descriptive analysis (QDA) is a tool for measuring and optimizing the sensory attributes of different products (El-Shafei et al., 2020; Hadjimbei et al., 2020; Lima et al., 2021; Freire et al., 2022a). QDA qualifies the type and quantifies the intensity of sensory properties immediately after sensory stimulation (Stone & Sidel, 2004). Silva et al. (2018) evaluated the effect of sodium reduction and flavor enhancement on the dynamic and static sensory profile of dish probiotic cheese using the methods of temporal sense dominance (TDS) and quantitative descriptive analysis (QDA).

According to Lima et al. (2021) the softness sensory attribute had a significant effect ($P < 0.05$) for the increasing levels of bidistilled glycerin in the goat diet; the softness decreased as the glycerin level increased. For the tasters, meat tenderness decreased by 25% with the inclusion of glycerin. The softness attribute showed a difference, which may be associated with milk fat content, which was influenced by dietary glycerin levels. Goat cheese is softer than beef cheese, resulting from the higher proportion of smaller fat globules in goat milk (Freire et al., 2022b).

A multivariate statistical procedure that considers consumers' individuality and not just the group's average and even surpasses its competitors (Stone & Sidel, 2004) can contribute to developing adequate technologies to the sector. The technique is likely to obtain a graphical representation of the differences in acceptance between the samples on a two-dimensional scale, allowing each consumer's identification and preferences concerning the evaluated foods (Granato et al., 2012). The sensory characteristics analyzed contributions to improving the quality of the food and its maintenance, favoring consumer loyalty to a specific product in an increasingly demanding Market (Teixeira, 2009).

Muniz et al. (2022) observed that three main components were needed to explain 69% of the total variation in milk's sensory attributes from cows supplemented with tannic acid levels. Of the 13 attributes considered in the sensory analysis, 7 were important in the first 3 PCs, considering that their correlation was 69%. The first main componente (PC1) explained that 29.5% of the total variance was composed of cow odor and milk production traits. The first and second principal component (PC2) explained that 51.4% of the total variance and the PC2 was made up of the following variables: forage bush odor, after the test: intensity and protein. The three first principal components (PC1, PC2, and PC3) explained 69% of the total variance of the attributes.

5 Conclusions

The inclusion of up to 45% of sorghum silage in the diet of goats increased milk and cheese fat, which favored high scores for the attributes of softness and global acceptance. Thus, sorghum silage is an excellent forage to be used in the semi-arid region in the feeding of goats in the period of scarcity.

The multivariate technique proved to be effective in reducing the attributes used in the sensory analysis.

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