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Production and quality of cheese and milk of goats fed with guava agroindustrial waste (*Psidium guajava L.*)

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Abstract

The objective of this study was carried out to evaluating the productive performance, the physical-chemical quality of the milk, the physical-chemical and sensorial quality of rennet cheeses obtained from the milk of goats submitted to diets with diferente levels of guava agroindustrial waste (GAW). The goats were randomly distributed in a Latin square (4x4) according to the substitution levels (0, 14, 28, and 42%) of inclusion GAW in the diet. The consumption of natural and dry matter increased with the increase in hay substitution. However, the physical-chemical requirements of milk and cheese were not altered.

Keywords: animal diet; goat milk; casein; cheese; cheese microbiology.

Practical Application: The guava agro-industrial waste (GAW) has the potential to be used in animal feed.

1 Introduction

Goat rearing is a low cost alternative for dairy production in underdeveloped and developing countries (Schwarz et al., 2017). The increase in goat milk production and processing that has occurred in recent years is mainly due to new food trends (Barlowska et al., 2018). There is a demand from the consumer to buy cheese made by traditional methods. The sensory qualities of cheese produced by traditional methods are differentiated from cheese produced on an industrial scale (Kuźnicka & Łapinska, 2014).

An analytical sensory evaluation and consumer testing provide reliable, valuable and the most meaningful information on the quality and acceptability of food. During the development of an innovative product process, information is always urgent. A quantitative descriptive analysis (QDA) is one of the most sophisticated tools that provides a multidimensional sensory 'image' of a product and could be useful during the comparison of samples (Mituniewicz-Malek et al., 2019)

Milk and products made from goat's milk are appreciated by consumers because they bring health benefits (Popovic-Vranjes et al., 2017). Fermented goat's milk drinks are potentially beneficial to health, with acceptable sensory characteristics, and can contribute to increasing the diversity of functional dairy products and, especially, can be considered a good alternative to cow's milk products for people with poor digestion (Mituniewicz-Malek et al., 2019). Consumers want products that have food quality and safety, sensory attractiveness and nutritional value (Linares et al., 2017). Products made from goat's milk, for example fermented goat's milk (Mituniewicz-Malek et al., 2019; Santos et al., 2019), goat's milk yogurt (Beltran et al., 2018; El-Shafei et al., 2020; Hadjimbei et al., 2020), goat's cheese (Barlowska et al., 2018; Moraes et al., 2018), meet consumer needs.

Goat's milk production depends on the animal's fitness, the nutritional value of the food, the level of dry matter intake by the animal, among others. Goat's milk has essential characteristics such as small fat globules which provide higher digestibility (Fangmeier et al., 2019) presence of iron insignificant amount (Idamokoro et al., 2017). For milk production to meet the growing demand for milk, it is necessary to use foods of high nutritional value such as corn and soybean meal and high-quality ingredients that increase the cost of production.

So replacing part of these ingredients with others is alternative that can improve the final price of the product and make the activity competitive (Freitas et al., 2009). The guava agro-industrial waste (GAW) has the potential to be used in animal feed (Costa et al., 2018, 2019), reducing feed cost and/or providing bioactive substances enabling beneficial effects on product quality and consumer health. Thus industry waste as a component of the diet has been the target of much research. GAW is mainly pulp seeds, which also have significant amounts of unsaturated fatty acid and fibrous matter (Uchôa-Thomaz et al., 2014). The protein content of GAW is about 7.9-9.6%, 10.5-16% fat and 53.6-67.7% crude fiber (Chang et al., 2014).

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Given the above, the objective of this research was to evaluate the productive performance, the physicochemical quality of milk, and the physicochemical and sensory quality of curd type cheese obtained from goat milk submitted to diets with different levels of substitution tifton grass hay by guava agroindustrial waste (GAW).

2 Materials and methods

2.1 Experiment site and animals

The experiment was conducted at the Goat and Sheep Production Sector of the Federal University of Paraíba (*Universidade Federal da Paraíba – UFPB*), located in Bananeiras, Paraíba State, Brazil, microregion of Brejo Paraibano, 6°45'00" S latitude and 35°38'00" W longitude, at an altitude of 520 m above sea level.

This study was certified by the Animal Ethics Committee of the Federal University of Paraiba (UFPB), Brazil (protocol no. 0390/16). Twelve Saanen multiparous goats weighing 40 ± 6 kg and 30 ± 5 days of lactation were used. The animals were identified, weighed and treated against ecto and endoparasites and then distributed in individual 1.46m^2 pens with free access to feeders and drinkers, where they received diets.

2.2 Diets

The treatments comprised diets with a 55:45 forage to concentrate ratio, with diferente levels of Tifton grass hay being replaced with GAW. That is, the forage feeds contained 0, 14, 28 e 42% of GAW on a dry matter basis (Table 1).

Table 1. Percentage and bromatological composition of experimental diets.

Ingredient	Levels of inclusion (%)			
(g kg^{-1} DM)	0	14	28	42
Guava agro-industrial waste (GAW)[1]	0.00	140	280	420
Tifton hay	500	360	220	80
Ground corn	360	360	360	360
Soybean meal	120	120	120	120
Mineral supplement[2]	15.0	15.0	15.0	15.0
Calcitic limestone	5.0	5.0	5.0	5.0
Chemical composition (g kg $^{-1}$ DM)				
Dry matter. DM (g kg^{-1} as fed)	872	882	891	901
Crude protein. CP	132	133	134	135
Ethereal extract. EE	24.9	37.6	50.3	63.0
Neutral detergent fiber. NDF	496	492	489	486
Fiber in acid detergent. FAD	251	277	303	328
Calcium	6.6	6.0	5.4	4.9
Phosphorus	4.1	3.9	3.7	3.5
Total Carbohydrates. TC	817	804	791	778
Non-fibrous carbohydrates. NFC	321	311	301	292
Metabolizable energy. ME (Mcal/kg DM)	2.09	2.41	2.32	2.23

[1]GAW composition; DM, 908; CP, 91.8; EE, 107; NDF, 730; ADF, 620; Ash, 21.3; TC, 779; NFC, 48.7; Tannin, 6.60; [2]Composition of mineral supplement per kg; P, 70.0 g; Ca, 140 g; Na, 148 g; S, 12.0 g; Mg, 1.32 mg; F, 700 mg; Zn, 4.70 mg; Mn, 3.69 mg; Fe, 2.20 mg; Co, 140 mg; I, 61.0 mg; Monensinasódica, 100.0 mg.

The GAW was weighed and placed on canvas in the sun for the drying procedure. The diets were adjusted to meet the requirements recommended by the National Research Council (2007) for lactating goats with production of 2.0 kg milk/day and 4% fat. The diets were offered ad libitum at 7:30 am and 4:30 pm, in the form of complete mixture, in two daily meals immediately after the milkings.

The animals underwent four 17-day periods, fourteen for diet adaptation, and three for data collection, totaling 68 days of confinement. During the adaptation and collection periods, daily offer and leftover food weighing were performed to calculate voluntary consumption and adjust the offered food, in order to guarantee 10% leftovers based on dry matter (DM).

Water was offered to each goat daily using 5 L (liter) buckets placed next to feeding troughs. Average daily water intake (ADWI) was measured to the nearest 10 mL. Loss of water due to evaporation was assessed by measuring the volume of water lost from a similar bucket placed beyond the reach of sheep (Mdletshe et al., 2017).

2.3 Milk production and physicochemical analysis 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. Milk (kg/day) during the three days of collection of each period (all experimental period). 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. Milk samples from each animal were collected twice a day, at regular times, during the three days of data collection of each period respecting the proportion of milk milked (morning/afternoon).

Vials and glassware were sanitized at 105 °C for one h, to avoid contamination by milk residues from the previous milking. 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 (%), non-fat solids (%), protein (%), lactose (%), salts (%), relative density at 15/15 °C (g mL^{-1}), cryoscopic index (°C), electrical conductivity (mS cm^{-1}) and pH were evaluated according to the Master Complete® Milk Analyzer (AKSO®, São Leopoldo, Rio Grande do Sul, Brasil), under specific technical conditions. The titratable acidity (g of lactic acid 100 mL^{-1}) was performed by titration method, being analyzed the acidity in lactic acid by the protocol 947.05 (Association of Analytical Chemists, 2010).

2.4 Formulation and the cheese-making process

The curd cheeses were prepared according to the technique developed by the cheese makers in the Milk and Derivatives sector, coming from Campus III, Bananeiras-PB. The following ingredients were used for cheese preparation: 10 liters of milk; 10 mL of milk yeast; 5 mL of calcium chloride; 10 mL of liquid rennet and 30 grams of sodium chloride (Lima et al., 2020).

At the end of the cheese processing, they were kept in a suitable container and relocated to the cold room located in the same processing laboratory. These, in turn, underwent the maturation process for two to three days, at a temperature of 10 ± 1 °C, as recommended by the Technical Regulation of rennet cheese identity and quality (Brasil, 2001). After this maturation period, the cheeses were vacuum packed and refrigerated until microbiological laboratory, physicochemical, and sensory analyzes.

2.5 Yield and physicochemical analysis of cheese

After processing, the yield of each type of cheese was expressed (in g of cheese/10 L of milk) as the weight of fresh cheese in grams obtained from 10 liters of milk used, according to the Equation 1:

$$Cheese\ yeld\ = 10\ L\ of\ milk\ used\ /\ weight\ in\ grams\ od\ cheese\ produced \quad (1)$$

Water activity (aW) was determined by the Aqualab apparatus (model 4TE – Decagon Devices, Inc., Pullman, WA). The pH was measured with the aid of the brand pH meter. Tecnal (model Tec-2). The total acidity titratable (Association of Analytical Chemists, 2010, method 947.05), humidity (Association of Analytical Chemists, 2010, method 925.09), ashes (Association of Analytical Chemists, 2010, method 923.03), protein (Association of Analytical Chemists, 2010, method 991.23), fat (Association of Analytical Chemists, 2010, method 920.39) and the total dry extract (TDE) (Association of Analytical Chemists, 2010, method 925.23).

2.6 Microbiological analysis of cheese

According to the recommendations of RDC Resolution No. 12 of January 2, 2001 (Brasil, 2001), and the samples were analyzed according to the methodology described by the American Public Health Association (2001) for determination of total coliforms, thermotolerant coliforms, *viable aerobic mesophilic* bacteria, coagulase-positive *Staphylococcus,* and *Salmonella* sp. The analyses of total and thermotolerant coliforms were performed following the technique of the most probable number. The analysis of viable aerobic mesophilic bacteria was performed by the depth plate technique using Plate Count Agar and incubation at 35 ± 2 °C for a period of 48 hr. Coagulase positive Staphylococcal analyses were performed by direct plate counting. The plates were incubated in an oven at 36 °C for 48 hr, and then the plates were collected for counting the colonies. For the analysis of *Salmonella sp*. the procedure was as follows: a pre-enrichment of the samples with lactose broth and incubation at 42 ± 2 °C for 24 hr was carried out, and then a selective enrichment with Tetrionate and Selenite cystine broth followed by incubation in xylose lysine deoxycholate Agar and Enteric Agar was done.

2.7 Instrumental color of cheese

For color analyzes, the samples were defrosted overnight at 4 °C and readings were taken after 50 min at room temperature. The determination of the color was obtained through the Colorimeter (Minolta, Model CR-400, Japan), using the CIE system L*, a*, b*, determining the coordinates L* (luminosity), a*) and b* (yellow index), illuminant C, observer angle 0 ° (Miltenburg et al., 1992). Measurements were made in triplicate with the previously calibrated apparatus using the outside and inside of the cheese piece immediately after unpacking.

2.8 Cheese sensory analysis

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 5 g 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., 1989). Sensory analysis was performed in individual booths having controlled environmental conditions, at a temperature around 23 °C (International Stardards Organisation, 1988). The evaluation was conducted with 9 consumers, men and women, including untrained students, being selected based on the interest and habits of consuming goat dairy products. The age range of the consumers was 18 to 25 years. 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 (Barbosa et al., 2016; Cardello, 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).

2.9 Statistic analysis

Data were subjected to analysis of variance (ANOVA), and the mean was compared by the Tukey test at 5% probability using GLM of the SAS® program. For sensorial analysis, the mathematical model was: $Y_{ijk} = \mu + T_i + e_{ijk}$, where Y_{ijk} is the dependent variable, μ is the mean, Ti is the fixed effect of the treatment at i levels from 1 to 4, and e_{ijk} is the error. The Ryan-Einot-Gabriel-Welsch test at a significance level of 5% was used for sensory analysis. Data were submitted to regression analysis, at a 5% error probability, performed with REG procedure of the software SAS (Statistical Analyses System, 2001).

3 Results

Performance variables had no significant effect (P>0.05) for the inclusion of GAW (Table 2). The average milk yield of goats evaluated in this research was 2.77 kg day^{-1}. There was a linear increase (P<.0001) in natural matter intake with increased levels of Tifton hay replacement by GAW. Natural matter intake values increased from 2.32 to 3.09 kg/day with the inclusion of GAW.

Table 2. Average performance values of dairy goats fed diets containing guava agro-industrial waste (GAW).

Variable	Levels of inclusion (%)				SEM	*P-value*	
	0	14	28	42		Linear	Quadratic
MP (kg day^{-1})	2.70	2.66	2.80	2.90	0.45	0.923	0.747
NMI (kg day^{-1})	2.32	2.57	2.88	3.09	0.25	<.0001[1]	0.860
DMI (kg day^{-1})	2.02	2.26	2.56	2.90	0.23	<.0001[2]	0.593
FE (MP/DMI)	1.33	1.17	1.08	0.99	0.16	0.0003[3]	0.652

SEM = Standard error mean; MP = milk production; NMI = natural matter intake; DMI = dry matter intake; FE = feed efficiency. [1]Y=2.32+0.02x (R^2=0.99); [2]Y=1.99+0.02x (R^2=0.99); [3]Y=1.30-0.008 (R^2=0.97).

Table 3. Average values of physiological characteristics of milk from dairy goats fed diets containing guava agro-industrial waste (GAW).

Variables	Levels of inclusion (%)				SEM	*P-value*	
	0	14	28	42		Linear	Quadratic
Protein (%)	2.91	2.96	3.00	3.03	0.12	0.438	0.894
Fat (%)	2.75	2.80	2.74	2.63	0.33	0.628	0.450
NGS (%)	8.05	8.18	8.26	8.30	0.34	0.374	0.670
Lactose (%)	4.43	4.48	4.56	4.56	0.17	0.352	0.674
Salt (%)	0.67	0.68	0.69	0.70	0.02	0.356	0.705
Density (g cm^{-3})	1.02	1.03	1.03	1.04	0.02	0.594	0.319
CI (°C)	-0.50	-.051	-0.52	-0.52	0.02	0.408	0.668
pH	6.31	6.37	6.38	6.31	0.08	0.130	0.116
Acidity (%)	0.14	0.14	0.15	0.15	0.01	0.977	0.663
Condutivity (mS cm^{-1})	5.43	5.40	5.39	5.38	0.05	0.277	0.612

SEM: Standard error mean; NGS = non greasy solids; CI = Crysoscopic index.

Table 4. Microbiological evaluation of milk curd cheese from goats fed diets containing guava agro-industrial waste (GAW).

Microorgnism	Levels of inclusion (%)			
	0	14	28	42
Coliform 35 °C (MPN g^{-1})	<3.0	<3.0	<3.0	<3.0
Coliform 45 °C (MPN g^{-1})	<3.0	<3.0	<3.0	<3.0
Mesophiles (UFC g^{-1})	<400	<100	<100	<100
Staphylococcus spp. (UFC g^{-1})	<100	<100	<100	<100
Salmonell spp (25 g)	Absent	Absent	Absent	Absent

Dry matter intake was influenced by diets containing different GAW inclusion levels, and the values were better adjusted to the linear regression model (P<.0001).

A decreasing linear effect (P = 0.0003) was observed with increasing GAW levels for food efficiency. The physicochemical variables of milk had no significant effect (P>0.05) for the inclusion of GAW in the diet of goats (Table 3).

Microbiological analysis of curd-type cheese produced from GAW fed goats is of adequate microbiological quality for the investigated microorganisms (Table 4).

The physicochemical variables of rennet cheese had no significant effect (P>0.05) for the inclusion of GAW in the diet (Table 5).

Sensory attributes had no significant effect (P> 0.05) on the inclusion of GAW in the goat diet (Table 6). The attributes texture, flavor, and overall evaluation were the ones that got the highest grades.

4 Discussion

The fact that all diets were made for lactating goats with 2.0 kg of milk production day^{-1} and with equal amounts of protein and NDF may have contributed to the goats producing the same amount of milk in all diets. The DM intake values ranged from 2.02 (0% GAW) to 2.90 kg/day (42% GAW), representing a 43.56% increase in consumption. Even though diets with higher levels of GAW inclusion have high levels of EE, this did not increase milk fat content.

Milk production did not accompany the increase in DM intake since the increase in milk intake generally increases milk production by increasing the intake of milk constituent nutrients in the diet. The level of intake of DM and energy during lactation is positively related to milk production, and any improvement in nutritional management, particularly in forage (roughage) and feed quality, leads to an increase in production (Linn et al., 2007; Oliveira et al., 2014).

The reduction of NDF with the increase in the inclusion of GAW may have influenced the increase in DM intake, because in ruminants, one of the main characteristics of food linked to consumption control is the NDF content and quality, which will determine the potential of volume occupancy in the rumen per unit of food consumed (Van Soest, 1994). Another important fact that should be taken into consideration is the mechanism of controlling the intake of rumen-filled DM. The rumen has pressure sensors on its wall that activate when the compartment is at its maximum capacity to hold the food. The diet containing the maximum hay replacement level (42%) has a lower volume when compared to the Tifton hay-only diet (control, 0% GAW). Thus the animal fed diets containing higher levels of GAW

Table 5. Average physiochemical characteristics of goat's milk curd cheese fed diets containing guava ago-industrial waste (GAW).

Variable	Levels of inclusion (%)				SEM	*P-value*	
	0	14	28	42		Linear	Quadratic
aW	0.98	0.98	0.98	0.98	0.00	0.982	0.734
Moisture (%)	55.07	55.20	55.10	55.35	1.75	0.991	0.952
Protein (%)	20.43	20.73	21.95	21.33	1.34	0.343	0.523
Fat (%)	13.25	13.32	12.84	14.43	1.28	0.410	0.247
FDE (%)	29.33	29.72	28.58	32.43	2.38	0.335	0.152
TDE (%)	44.93	44.80	44.90	44.65	1.75	0.990	0.951
Ash (%)	4.77	4.61	4.87	4.72	0.30	0.993	0.975
pH	6.15	6.18	6.24	6.16	0.09	0.748	0.855
Acidity (%)	0.24	0.26	0.23	0.30	0.06	0.800	0.691
Yield	11.27	10.36	11.10	10.33	1.09	0.735	0.904
Instrumental colour							
Lightness (L*)	83.33	83.64	83.15	83.48	1.11	0.993	0.996
Redness (a*)	0.05	-0.13	-0.03	0.43	0.82	0.567	0.421
Yellowness (b*)	14.28	14.49	14.23	13.42	0.68	0.380	0.151

SEM = Standard error mean; FDE = fat in the dry extract; TDE = total dry extract; Yield = Lmilk/kg cheese.

Table 6. Sensory evaluation of milk curd cheese from goat's fed diets containing guava agro-industrial waste (GAW).

Attributes	Levels of inclusion (%)				SEM	*P-value*
	0	14	28	42		
Colour	4.46	4.89	4.60	4.29	1.66	0.489
Odour	4.51	4.14	4.49	4.46	1.74	0.794
Tenderness	7.23	7.03	6.89	7.14	1.71	0.852
Flavour	6.69	6.26	6.46	6.31	1.70	0.726
Evaluation global	6.66	7.09	7.26	7.06	1.88	0.726

SEM = Standar error mean. Different letters in the line differ from each other by the Ryan-Einot-Gabriel-Welsch.

consumed a higher amount of DM to activate the mechanism of ingestion of MS and to cease ingestion. The results obtained in this research for DM consumption contradict the values found by Azevêdo et al. (2011), who did not observe an increase in dry matter intake as GAW inclusion levels increased in ruminant diets.

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 content 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).

Milk fat content, composition, and yield depend on several factors, including the composition of the diet it receives (Cannas et al., 2008). Diet is fundamental because it determines the changes in rumen fermentation, modifying the production of different fatty acids and, thus the fat content. With increased EE it was therefore expected to increase the percentage of milk fat, as it is considered that lipid synthesis in the mammary gland may be affected by the input of triglycerides provided by animal diet (Naumann et al., 2017).

Therefore, the explanation for not increasing the milk fat percentage would be the increase of the food passage rate, affected by some components of the GAW, decrease the utilization of the triglycerides present in the food, reducing the lipogenesis in the mammary gland (Naumann et al., 2017). The average fat produced in milk in this experiment was 2.72%, but for legislation, the minimum fat content is not fixed, and values below 2.9% are allowed by proving that the average fat content of a given herd does not reach this level (Brasil, 2001).

Acidity is correlated with pH. Thus, with no change in pH, the acidity also remained unchanged. However, other factors may influence the acidity of milk. The determination of acidity is of great importance in the control of technological processes during the elaboration of various dairy products (Thamer & Penna, 2006). Acidity values are advocated by legislation that limits the range from 0.13 to 0.18 (% lactic acid) (Brasil, 2001). Thus, the acidity values obtained in this research (0.15% lactic acid) are adequate, indicating good hygienic conditions of milk.

Teixeira (2016) observed values of 0.98 for aW, the latter evaluated goat cheeses seasoned with Cumaru. According to Teixeira (2016), high aW values make cheese more susceptible to the development of spoilage and pathogenic microorganisms. Already the average moisture content (55.18%) is above the classification according to the Technical Regulation of Identity and Quality of Curd Cheese (Brasil, 2001), which classifies the curd type cheese in high moisture content, when The moisture content ranges from 46.0 to 54.9%. The high moisture content determined in cheese can be explained by the information presented by Cunha et al. (2002), which is possibly due to the more significant presence of whey and denatured proteins, which tend to increase the water retention capacity of cheese. The high presence of whey and denatured proteins in goat's milk rennet cheeses may be justified by the use of heat in the pasteurization process.

Possibly the fact that the milk obtained from GAW-fed goats had the same fat contente did not affect the fat content of the cheese. Souza et al. (2011) describe that milk fat contente may be influenced by the composition of the milk to which it originated. The values for fat content recorded in this study were lower than those obtained by Santos et al. (2011) who observed the fat content of 18.00% for curd type cheese obtained with goat milk only, but were similar to those obtained by Teixeira (2016) who observed the fat content of 12.64% for goat cheese spicy with Cumaru.

Several factors can affect cheese pH, including cheese moisture content, the type of curd used for curd formation, and microorganisms that use lactose to produce lactic acid (Santos et al., 2011). The lactose content is generally slightly lower in goat milk (4.16 g/100 mL) (Clark & Mora García, 2017). According to Balduino et al. (1999), lactic acid production at the beginning of fermentation decreases pH and inhibits undesirable microorganisms such as Salmonella sp., Yersinia enterocolytic, and Escherichia coli. The average cheese yield was 10.77 liters of milk for each kilo of cheese produced. Curd-type cheese made in almost all of the Northeastern Brazilian territory generally has a yield of 10 (ten) liters of milk for each kilo of cheese (Teixeira, 2016). Possibly the same fat content for the milk used in cheese making is the factor that determined the non-modification in cheese yield.

The cheeses presented an average value of 83.40 for luminosity. According to Santos et al. (2011) studies indicate that goat's milk cheese may be associated with a whiter color due to the conversion of β-carotene into vitamin A by these animals. According to Marino et al. (2010) the parameter L* indicates the luminosity and refers to the object's ability to reflect or transmit light, ranging from zero to 100. The higher the value of L*, the brighter the object.

The instrumental color parameter a* was also not influenced by the different kinds of milk used in cheese production. The instrumental color parameter a* indicates the intensity of the red and green colors. The value of the instrumental color parameter a* obtained in this research was 0.08 very close to zero, indicating little or no intensity of red color because the curd type cheese has a soft color due to its physicochemical properties. A value of 14.1 was verified for instrumental color parameter b*, indicating that the cheeses had a slight color intensity to yellow, due to the pigmentation of milk lipids.

The texture attribute received the highest marks awarded by the evaluators. Silanikove et al. (2010) mention that the texture of goat cheese is softer than bovine cheese, resulting from a higher proportion of smaller fat globules in goat milk. Several factors may interfere with cheese texture; for example, fat plays an essential role in the cheese texture, the presence of compounds, or even the biochemical transformations that result in the formation of other flavoring compounds such as ketones, methyl ketones, and lactones.

The color attribute was the second, in ascending order, which received the lowest scores. This attribute probably received a score below 7.0, probably due to its white color, proven by instrumental calorimetry, since goat milk does not present the carotenoid pigments present in bovine milk, which gives the production of derivatives a more yellowish color (Garcia et al., 2008). Goat milk has peculiar sensory characteristics, which are often considered pleasant or not, becoming factors of refusal and direct implication in its acceptability (Bernard et al., 2009).

Similar to the odor attribute, fat also plays a vital role in the taste of cheeses, by the presence of compounds or even by the biochemical transformations that result in the formation of other flavoring compounds, such as ketones, methyl ketones and lactones (Lima et al., 2011). Even with low marks in some attributes (color and odor), goat curd cheese scored above 7.0 for overall evaluation, obtaining good acceptance by the evaluators. The grades of texture and flavor attributes were probably the ones that most influenced the grades for overall cheese evaluation.

5 Conclusion

The replacement of Tifton hay by GAW did not affect milk production and physicochemical composition, but increased the consumption of natural and dry matter, decreasing feed efficiency. The use of goat milk receiving up to 42% inclusion of GAW in the diet does not change the physicochemical composition, yield, instrumental color, and sensory characteristics of cheese.

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