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Physical-chemical and microbiological quality of milk and cheese of goats fed with bidestilated glycerin

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Abstract

The objective of this study was to evaluate the effects of replacing corn with bidistilled glycerin from the biodiesel industry on the physicochemical, microbiological, and sensory quality of milk and goat cheese. Twelve Saanen multiparous goats weighing 40 ± 6 kg and 30 ± 5 days of lactation were used. The physicochemical parameters analyzed were: fat (%), non-fat solids (%), protein (%), lactose (%), salts (%), relative density at 15/15 °C (gmL^{-1}), index cryoscopic (°C), electrical conductivity ($mScm^{-1}$), pH and acidity. The milk from each treatment was used to make the rennet cheese. The physicochemical variables: pH, lipids, ESD, and cheese yield had a significant effect ($P < 0.05$) for the increasing use of bidistilled glycerin in the goat feeding. The pH, acidity, EST, ESD, and yield variables presented linear regressive effect and lipids quadratic regressive effect. 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. Bi-distilled glycerin, when inserted in the diets of dairy goats at increasing levels, promotes a reduction in the lipid content of milk, consequently affecting the cheese yield and the sensory softness parameter.

Keywords: glycerol; lipids; microbiological; rennet; softness.

Practical Application: Glycerin can be used in the diet without impairing the quality of cheese and milk.

1 Introduction

The increase in goat milk production and processing that has occurred in recente years is mainly due to new food trends (Barlowska et al., 2018). Goat rearing is a low cost alternative for dairy production in underdeveloped and developing countries (Schwarz et al., 2017). 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 (Kuznicka & Łapinska, 2014).

Milk and products made from goat's milk are appreciated by consumers because they bring health benefits (Popovic-Vranjes et al., 2017). 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-Ma lek et al., 2019), goat's milk yogurt (Beltran et al., 2018), goat's cheese (Barlowska 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. From a nutritional point of view, it is essential to look for alternatives to replace conventional foods to allow livestock production in non-grain producing regions (Souza et al., 2015), with rainfall irregularities. Thus alternative food sources are an option to reduce feed costs and increase livestock production, as well as decrease the deposition of organic waste in the environment. Crude glycerin (CG) is a by-product of biodiesel production resulting from the formation of triglyceride fatty acid methyl esters (Dasari et al., 2005). Approximately 10 liters of glycerine is produced per 100 liters of biodiesel (Wen, 2012). Glycerin contains glycerol (Dasari et al., 2005). The CG has high energy value (Donkin, 2008), therefore glycerin can be used as an energetic ingredient in animal feed in ruminant diets (Avila-Stagno et al., 2013; Chanjula et al., 2015) replacing cereals (which are generally more expensive than glycerin) (Terré et al., 2011).

Glycerol is directly absorbed by the ruminal epithelium, metabolized in the liver and directed to gluconeogenesis by the action of the glycerol kinase enzyme, which converts it to glucose. Part of the glycerol can be fermented to propionate in the rumen, which is metabolized to oxaloacetate via the Krebs cycle in the liver and can be used to form glucose by the gluconeogenic pathway. Thus, crude glycerin has the potential for application as a gluconeogenic substrate for ruminants (Krehbiel, 2008) and can provide energy for cellular metabolism (Goff & Horst, 2001). The CG is an attractive product in feedlot diets as it is said that CG is first converted to rumen propionate, thus acting as a precursor for glucose synthesis. (Rémond et al., 1993).

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Glycerin also contains methanol, diethylene glycol, phosphorus, potassium, and sodium chloride, which may compromise its use in animal feed (Terré et al., 2011).

The CG has been used in diets of beef cattle (Parsons et al., 2009) and dairy cows (Carvalho et al., 2011) and inclusions of 10 to 20% of dry matter in the diet have been used without negatively affecting the performance of lambs (Gunn et al., 2010). However, there is little information on the use of CG in feeding and dairy goat production responses. The study aimed to evaluate the effects of substitution of corn by bi-distilled glycerin from the biodiesel industry on the physicochemical, microbiological, and sensory quality of milk and goat cheese.

2 Materials and methods

2.1 Experiment location and animals

This project was submitted to the Animal Use Ethics Committee (CEUA) of the Federal University of Paraíba and approved according to protocol No. 052/2017. The experiment was conducted at the Federal University of Paraíba, Campus at Bananeiras- Paraíba, Brazil (altitude 552m, latitude 6° 41' 11", longitude 35° 37' 41"). The air temperature was 24.97 °C, and relative humidity was 76.48% in the stalls.

Twelve Saanen multiparous goats weighing 40 ± 6 kg and 30 ± five days of lactation were used. The animals were kept in a confinement system for 60 days, housed in a covered shed and kept in individual pens made of wood, provided with feeder and drinker.

2.2 Diets

The animals went through four periods of 15 days, twelve for adaptation to the diet, and three for data collection. During the adaptation and collection periods, daily offer and leftover food weighing were performed to calculate voluntary consumption and adjust the diet offered, in order to guarantee 10% leftovers based on a dry matter (DM). Water for animal consumption was offered on an ad libitum basis, and consumption was quantified daily during the data collection period. The animals were weighed at each period, at the beginning and after the collection period.

Diets were adjusted to meet the requirements of the National Research Council (2007) for lactating goats producing 2.0 kg milk/day and 4% fat, with a 55:45 forage: concentrate ratio. The experimental diet was offered ad libitum at 07:30 a.m. and 04:30 p.m. as a complete mixture. Tifton hay, ground corn grain, soybean meal, vitamin/mineral supplement, urea, and bidistilled glycerin levels (0, 6, 12, and 18%) were used to replace corn in the diets, as described in Table 1.

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.

Table 1. Percentage and bromatological composition of experimental diets.

Ingredient (g kg^{-1} DM)	Levels of inclusion (%)			
	0.0	6.0	12.0	18.0
Glycerin	0.0	60.0	120	180
Soybean meal	95.0	95.0	95.0	95.0
Ground corn	335	273	211	149
Tifton hay	550	550	550	550
Urea	0.0	2.0	4.0	6.0
Mineral supplement[1]	15.0	15.0	15.0	15.0
Calciticlimestone	5.0	5.0	5.0	5.0
Chemical composition				
Dry matter, DM (g kg^{-1} as fed)	881	876	848	823
Crude protein. CP (g kg^{-1} DM)	113	119	107	89.6
Ethereal extract. EE (g kg^{-1} DM)	128	135	165	210
Neutral detergent fiber. NDF (g kg^{-1} DM)	905	784	709	638
Fiber in acid detergent. FAD (g kg^{-1} DM)	282	270	254	238
Metabolizable energy. ME (Mcal/kg DM)	3.62	3.66	3.62	3.54

[1]Composition of mineral supplement per kg: P: 70 g; Ca: 140 g; Na: 148 g; S: 12 g; Mg: 1.320 mg; F: 700 mg; Zn: 4.700 mg; Mn: 3.690 mg; Fe: 2.200 mg; Co: 140 mg; I: 61 mg; Se: 15 mg; Monensinasódica: 100 mg.

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 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.

- Acquisition of the raw material: the milk came from each treatment (0, 6, 12 and 18%) replacing corn with glycerin;
- Filtration: A 120 mesh nylon filter was used to prevent any impurities from entering the milk;
- Pasteurization was performed slowly at 65 °C for 30 minutes;
- Cooling: After pasteurization, the milk was cooled in order to reach the ideal temperature for the placement of the rennet (36 °C) ;
- Addition of Ingredients: Lactic yeast (*Streptococcus lactis* and *Streptococcus cremoris*) were added to fresh milk in the ratio of 10 mL for each 10 L of milk and calcium chloride (5 mL for each 10 L);
- Coagulation: liquid rennet was added, and 10 mL was added for each 10 L of milk, measuring at process temperature, at about 36 °C, where coagulation occurred within 30 minutes;
- Cutting and Stirring: After coagulation, lyras were used, passing them vertically (two way) and horizontally (one way) to standardize the size of the curd grains;
- Homogenization: The curd grains were well homogenized in order to reduce the waste of the production process;
- Mass heating: after homogenization, the mass was put to rest for about 5 minutes; it was then heated under stirring at 41 °C, making it consistent and firm;
- Dough Cooling: After heating, the dough was expected to cool to 36 °C and then to desorse, aiming an adequate firmness;
- Desorption: consisted of the removal of serum from the mass, performed with the aid of buckets;
- Pasta Collection: The pasta was placed in polypropylene forms;
- Weighing: The mass was weighed to precisely 1 kg, with the aid of a semi-analytical scale, model ESSE-15, brand GURAL (BR), aiming at the homogeneity of the weight of the studied cheeses;
- Salting: The salt was added in the proportion of 0.3% about the mass used in the cheese formulations;
- Forming: Polypropylene plastic forms (with desorption) were used to remove the serum;
- Pressing: with the aid of a manual press manufactured by BIASINOX (BR), a pressure weighing 5 kg was used, adapting it to the cheese desorption process;
- Vacuum Packaging: the cheeses were packed in high-density polyethylene plastic bags, with vacuum closure, through the aid of a SELOVAC (BR) sealer, model 200 B;
- Cheese Making: Cheese with about 1 kg of dough was obtained;
- Storage or Curing: The cheeses were kept for 2 (two) days refrigerated at 10 °C to achieve a pleasant sensory quality (ripening or curing);
- Packaging: The cheeses were refrigerated at a temperature of 10 °C at the Dairy Research and Development Laboratory.

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:

$$\text{Cheese yield} = \frac{\text{10 L of milk used}}{\text{Weight in grams of cheese produced}} \quad (1)$$

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 (Albuquerque et al., 2019).

2.7 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 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 (Albuquerque et al., 2019).

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. (2006) 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) (Albuquerque et al., 2019).

2.8 Statistical analysis

The 4x4 Latin Square design with a triple (4 treatments and 4 periods) was used in a rotating experiment. Data were subjected to an analysis of variance (ANOVA), and the averages were compared by Tukey test at 5% probability, through the PROC GLM and regression of the PROC REG of the SAS statistical package (SAS Institute, 2001). The means of the sensorial attributes were compared by the test Ryan-Einot-Gabriel-Welsch at 5% probability.

3 Results and discussion

Milk fat from goats fed increasing levels of bidistilled glycerin had a significant effect ($P < 0.05$), as well as increasing linear regressive effect (0.001) (Table 2).

The average for the fat percentage of the milk analyzed in this study was 2.17% below the recommended by the Brazilian Table of Composition of Feeding a (Universidade Estadual de Campinas, 2012), which establishes a minimum value of 3.8% for goat milk. Morgan et al. (2003) and Costa et al. (2007) state that variable milk fat is the factor that is most influenced by food. Therefore, the fat content may have been reduced because some diet components have higher digestibility due to the rapid metabolism of rumen glycerol, and factors such as purity of glycerin used, quality of other ingredients and physiological situation of animals may also influence in these results (Chanjula et al., 2015).

The NGS represents the solid fraction of milk, basically represents the levels of lactose, protein, and salts, the value for this variable is within the standards of the legislation, which

Table 2. Mean values of physicochemical variables of bidistilled glycerin fed goat's milk.

Variable	Levels of inclusion (%)				SEM	*P* value	
	0.0	6.0	12.0	18.0		Linear	Quad
Fat (%)	2.51[a]	2.18[ab]	2.05[b]	1.95[b]	0.40	0.001[1]	0.310
DDE (%)	8.36	8.21	8.24	8.19	0.37	0.332	0.616
Density (g cm^3)	1.03	1.03	1.03	1.03	0.00	0.814	0.734
Protein (%)	3.07	3.04	2.93	3.00	0.20	0.252	0.385
Lactose (%)	4.59	4.46	4.40	4.60	0.34	0.926	0.099
Crysoscopic index	-0.52	-0.53	-0.52	-0.52	0.02	0.457	0.943
pH	6.58	6.60	6.59	6.58	0.11	0.929	0.647
Condutivity	5.34	5.30	5.30	5.33	0.05	0.661	0.050

SEM = Standard error means; DDE = Degreased dry extract; Quad= quadratic; [a,b]Means followed by different lowercase letters in the same row indicate significant differences according to Tukey's at a 5% significance level; [1]Y=2,44 - 0,03x (R^2 = 0,92).

determines on average 8.20% for NGS (Brasil, 2000) as well as the density of milk that is within the established by the legislation, ranging from 1,028 to 1,034 as being the most suitable for goat milk (Brasil 2000).

The average value of the protein found in this study was 3.01%, which is compatible with the legislation that prescribes a minimum value of 2.8% (Brasil, 2000). The percentage of milk protein can be explained by the fact that diets are isoproteic, even with different levels of glycerin as an energy source. Lactose is also within the value recommended by the legislation of at least 4.3% (Brasil, 2000). The lactose content is generally slightly lower in goat milk (4.16 g/100 mL) (Clark & Mora García, 2017). The cryoscopic index variable indicates that diets with bidistilled glycerin did not interfere with milk freezing temperature. Salt concentrations were also not modified by diets containing different levels of glycerin. The average salt found for this experiment was 0.67%, slightly lower than the legislation (0.70%) on goat milk composition (Brasil, 2000).

According to Boza & Sanz Sampelayo (1997), there is a relationship between the pH value and the protein content of milk and the different combinations of its phosphates, and this, in turn, is usually related to the pH of goat milk. There was no change in milk protein levels; therefore, there was no change in pH.

The physicochemical variables: pH, fat, degreased dry extract, and cheese yield had a significant effect (P<0.05) for the increasing use of bidistilled glycerin in goat feeding (Table 3). The pH, acidity, TDE, degreased dry extract and yield variables presented linear regressive effect and lipids quadratic regressive effect.

This high moisture content determined in cheese was also observed by Silva et al. (2010), which obtained moisture contents ranging from 45.5 to 51.5%, and can be characterized as medium humidity cheese that would be those with averages ranging from (39% > Humidity <46%), to high humidity (46% > humidity <55%). This fact can be explained by the information presented by Cunha et al. (2002), that possibly this high moisture content is due to the higher presence of whey and denatured proteins, which tend to increase the water retention capacity of cheese.

Santos et al. (2011) reported that high moisture content might be a negative feature, as moisture interferes with water activity and metabolic actions of microorganisms throughout maturation, with its possible consequences on pH, texture, taste, and aroma.

The water activity of the water-soluble extract was 0.97, higher than the values that favor the development of microorganism, which is 0.60, according to Franco & Landgraf (2008). High water activity values make cheese more susceptible to the development of spoilage and pathogenic microorganisms. For this reason, attention should be paid to controlling this variable from the beginning of manufacturing to the final consumer (Teixeira, 2016).

As the lipid content decreased in goat milk, this also occurred in cheese. As glycerin increased in the diet, the value of lipids decreased, showed a reduction of approximately 23%. The lipid concentration in cheese reduced by 20% very similar to what happened in milk. The lowest lipid values are observed when the glycerin level was 12.96%. The cheese fat content may be influenced by the composition of the milk to which cheese originated (Souza et al., 2011).

Total dry extract values are inversely proportional to the moisture content, noting that when the moisture content increases the total dry extract, which is represented by the sum of fat, protein, ash salts and others, less the humidity decreases. Therefore, the control of total dry extract should be recommended, as it is one of the most critical factors in the physicochemical characterization of cheese (Teixeira, 2016).

The fat percentage in dry extract is one of the most expressive ways to quantify the fat contained in the different types of cheese. For this variable, the average lipid value in the defatted dry extract was 35.32%, lower than the values established by current legislation for curd cheese (Brasil, 2000). This influence may be related to the lipid content of milk used to obtain cheese. In addition to being associated with the high humidity presented

Table 3. Average values of the physicochemical variables of bidistilled glycerin fed goats cheese.

Variable	Levels of inclusion (%)				SEM	*P* value	
	0.0	6.0	12.0	18.0		Linear	Quad
pH	5.70^{c}	5.93^{bc}	6.09^{ab}	6.22^{a}	0.17	<.0001[1]	0.447
Acidity (%)	0.21	0.20	0.17	0.17	0.03	0.011[2]	0.459
Moisture (%)	53.47	52.83	52.70	51.84	1.28	0.110	0.875
Ash (%)	5.67	6.28	6.11	6.21	0.41	0.057	0.124
aW	0.97	0.97	0.97	0.97	0.00	0.612	0.708
Fat (%)	13.97^{a}	11.31^{b}	11.38^{b}	11.21^{b}	0.94	0.001	0.004[3]
DDE (%)	46.15	47.17	47.30	48.16	2.57	0.044[4]	0.907
Lactose (%)	1.08	1.15	0.92	1.14	0.22	0.892	0.489
MSE (%)	32.56^{b}	35.86^{ab}	35.92^{ab}	36.95^{a}	1.36	0.003[5]	0.233
Yield (L kg^{-1})	11.02	12.02	12.20	12.50	0,85	0,002[6]	0,334

SEM = Standard error means; TDE = Total dry extract; DDE = Degreased dry extract; aW = activity water; Quad = Quad; ^{a,b,c} Means followed by different lowercase letters in the same row indicate significant differences according to Tukey's at a 5% significance level; [1]Y=5,73 + 0,03x (R^2 = 0,98); [2]Y=0,208 - 0,002 (R^2 = 0,89); [3]Y=13,82 - 0,45x + 0,02x^2 (R^2 = 0,92); [4]Y=46,27 + 0,10x (R^2 = 0,93); [5]Y=33,33 + 0,22x (R^2 = 0,89); [6]Y= 11,24 + 0,08x (R^2 = 0,86).

by the cheese, since the low moisture content has an increase in dry extract. According to data described by the Ministry of Agriculture (Brasil, 2000), when the gross value in dry extract varies from 25 to 44.9%, cheeses are classified as semi-fat.

The increase in the yield value of cheese can be explained by several factors starting from the manipulation of the raw material. In this case, the low lipid content found in milk may have influenced the requirement for more milk to produce cheese. We are thus presenting a difference between the lowest treatment and the largest of 1.483 liters, causing an average loss of $ 3.75 per kilo of cheese considering the price of goat milk liter at $2.50.

Cheeses from goat milk-fed with a higher level of bidistilled glycerin presented higher pH (6.22%) with an increase of approximately 9%. Several factors can affect cheese pH, including moisture content, the type of curd used for curd formation and microorganisms that use lactose for lactic acid production (Santos et al., 2011), moreover, pH values may influence microbial cheese activity, texture, and maturation through chemical reactions that are catalyzed by enzymes from the rennet composition used in cheese making (Robinson & Wilbey, 2002). However, despite being an essential variable in cheese, there are no reference values for pH pre-established by Brazilian legislation. It was found in this case that the values obtained were lower than those observed by Santos et al. (2011), who obtained a pH value of 6.36 for cheese made from Saanen goat's milk. Lactic acid production at the beginning of fermentation decreases pH and inhibits undesirable microorganisms such as *Salmonella* sp., *Yersinia enterocolitis* and *Escherichia coli* (Balduino et al., 1999).

As for microbiological analyzes, no microbial growth was observed in goat cheese fed increasing levels of bidistilled glycerin (Table 4).

Cheeses from goats fed increasing levels of bidistilled glycerin did not influence moisture content (average value of 52.71%). These values are within the classification established by the Curd Cheese Identity and Quality Technical Regulation (Brasil, 2001), which classifies high moisture content curd cheese when the averages range from 46.0 to 54.9%, but this high humidity did not cause proliferation of microorganisms.

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 (Table 5).

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 (Silanikove et al., 2010). Results not found in this search. We can conclude that the decrease in milk lipid reflected in the physical part of cheeses from different glycerin levels, especially in softness.

Quantitative descriptive analysis (QDA) is a tool for measuring and optimizing the sensory attributes of different products (Ferrão et al., 2018). 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). They concluded that QDA revealed that the addition of yeast increased the flavor and the oregano extract increased the salinity of low sodium dish cheeses.

Table 4. Microbiological evaluation of curd cheese made from goat milk fed with biddestylated glycerin.

Microorganisms	Levesl of inclusion (%)			
	0.0	6.0	12.0	18.0
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
Viable *Mesophiles* (CFU g^{-1})	$<1 \times 10^2$	$<1 \times 10^2$	$<1 \times 10^2$	$<1 \times 10^2$
Staphylococcus spp. (CFU g^{-1})	$<1 \times 10^2$	$<1 \times 10^2$	$<1 \times 10^2$	$<1 \times 10^2$
Salmonell spp.	Absent	Absent	Absent	Absent

Table 5. Effect of glycerin addition on dairy goat feeding on sensory attributes of curd cheese.

Attributes	Levels of inclusion (%)				SEM	*P* value
	0.0	6.0	12.0	18.0		
Appearance	7.69	7.59	7.71	7.63	1.60	0.987
Aroma	6.04	6.03	6.39	6.11	1.99	0.856
Flavor	6.82	6.72	6.81	6.47	1.82	0.838
Softness	6.84^{a}	5.87^{ab}	5.64^{ab}	5.14^{b}	2.32	0.019

SEM = Standard error means; Means followed by different lowercase letters in the same row indicate significant differences according to the Ryan–Einot–Gabriel–Welsch test at a 5% significance level.

Descriptive analysis is a recognized and established method used by the dairy industry. It employs a trained panel to identify and quantify the intensity of each sensory descriptor, providing a complete sensory profile (Drake, 2007). Using intensity scales to describe a large set of attributes can be tedious for consumers and can result in high variability in scale use and low discrimination between samples (Bruzzone et al., 2015). In addition to needing a considerable amount of sessions to ensure reliable results (Torres et al., 2017).

Check-all-that-apply (CATA) questions are one of the rapid approaches that have recently been introduced in sensory analysis (Meyners et al., 2013); they are easy to implement and not tedious for consumers (Jaeger & Ares, 2014). Previous studies have shown that sensory characterization performed by trained assessors and by consumers, using CATA questions provided very similar results (Oliveira et al., 2017).

Torres et al. (2017) concluded the CATA questionnaire proved effective tool for characterizing different samples of requeijão cremoso, showing results that correlated well with conventional descriptive analysis by trained assessors. Multidimensional alignment and multidimensional scaling based on phi coeficiente values were important and useful alternatives for obtaining a deeper understanding of the CATA findings, adding information to the traditional analysis. Adoption of these methods should be encouraged for the processed cheese industry when it conducts sensory profiling with consumers and using CATA questionnaire.

Focus Groups is based on data collection through a group discussion about the research objective, it encourages participants to express their perception on the subject (Jervis & Drake, 2014). The word association technique encopasses terms that help describe consumers' expectations of a particular product (Eldesouky et al., 2015), so the results obtained by this method can be used to develop or adjust new products (Soares et al., 2017). Judacewski et al. (2019) evaluated the study of Brazilian consumers' perceptions of white mold-matured cheeses using the word association technique and concluded that the use of the word association technique made it possible to evaluate the perception of Brazilian consumers (and non-consumers) regarding cheese ripened to the surface by white mold.

4 Conclusions

Bi-distilled glycerin, when inserted in the diets of dairy goats at increasing levels, promotes a reduction in the lipid content of milk, consequently affecting the cheese yield and the sensory softness parameter.

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References

Albuquerque, G. N., Costa, R. G., Barba, F. J., Gómez, B., Ribeiro, N. L., Beltrão, E. M. Fo., Sousa, S., Santos, J. G., & Lorenzo, J. M. (2019). Effect of organic acids on the quality of sheep "buchada": from food safety to physicochemical, nutritional, and sensorial evaluation. *Journal of Food Processing and Preservation*, 416(3), e13877. http://dx.doi.org/10.1111/jfpp.13877.

American Public Health Association – APHA. (2001). *Standard methods for the examination of waste and wastewater* (18th ed.). Washington: APHA/AWNA/WEF.

Association of Analytical Chemists – AOAC. (2010). *Official methods of analysis of AOAC International* (19th ed., 1219 p.). Washington: AOAC International.

Avila-Stagno, J., Chaves, A. V., He, M. L., Harstad, O. M., Beauchemin, K. A., McGinn, S. M., & McAllister, T. A. (2013). Effects of increasing concentrations of glycerol in concentrate diets on nutrient digestibility, methane emissions, growth, fatty acid profiles, and carcass traits of lambs. *Journal of Animal Science*, 91(2), 829-837. PMid:23148243.

Balduino, R., Oliveria, A. S., & Hauly, M. C. O. (1999). Cultura lática mista com potencial de aplicação como cultura iniciadora em produtos cárneos. *Food Science and Technology (Campinas)*, 19, 356-362.

Barlowska, J., Pastuszka, R., Rysiak, A., Król, J., Brodziak, A., Kedzierska-Matysek, M., Wolanciuk, A., & Litwinczuk, Z. (2018). Physicochemical and sensory properties of goat cheeses and their fatty acid profile in relation to the geografic region of production. *International Journal of Dairy Technology*, 71(3), 699-708. http://dx.doi.org/10.1111/1471-0307.12506.

Beltran, M. C., Morari-Pirlog, A., Quintanilla, P., Escriche, I., & Molina, M. P. (2018). Influence of enrofloxacin on the coagulation time and the quality parameters of goat's Milk yoghurt. *International Journal of Dairy Technology*, 71(1), 105-111. http://dx.doi.org/10.1111/1471-0307.12388.

Boza, J., & Sanz Sampelayo, M. R. (1997). Aspectos nutricionales de la leche de cabra. *Anales de la Academia Ciencias Veterinárias de Andalucia Oriental*, 10, 109-139.

Brasil. Ministério da Agricultura. Secretaria Nacional da Agricultura. (2000). Regulamento Técnico de Produção, identidade e qualidade do leite de cabra (Instrução Normativa n° 37, de 8 de novembro de 2000). *Diário Oficial [da] República Federativa do Brasil*. Retrieved from www.Agricultura.gov.Br\das\dipoa\legislacaoespecificaleite.htm

Brasil. Ministério da Saúde. Agência Nacional de Vigilância Sanitária. (2001). Regulamento Técnico sobre os padrões microbiológicos para alimentos (Resolução RDC n. 12, de 02 de janeiro de 2001). *Diário Oficial [da] República Federativa do Brasil*.

Bruzzone, F., Vidal, L., Antúnez, L., Giménez, A., Deliza, R., & Ares, G. (2015). Comparison of intensity scales and CATA questions in new product development: Sensory characterisation and directions for product reformulation of milk desserts. *Food Quality and Preference*, 44, 183-193.

Carvalho, E. R., Schmelz-Roberts, N. S., White, H. M., Doane, P. H., & Donkin, S. S. (2011). Replacing corn with glycerol in diets for transition dairy cows. *Journal of Dairy Science*, 94(2), 908-916. http://dx.doi.org/10.3168/jds.2010-3581. PMid:21257059.

Chanjula, P., Pakdeechanuan, P., & Wattanasit, S. (2015). Effects of feeding crude glycerin on feedlot performance and carcass characteristics in finishing goats. *Small Ruminant Research*, 123(1), 95-102. http://dx.doi.org/10.1016/j.smallrumres.2014.11.011.

Clark, S., & Mora García, M. B. (2017). A 100-year review, advances in goat milk research. *Journal of Dairy Science*, 100(12), 10026-10044. http://dx.doi.org/10.3168/jds.2017-13287. PMid:29153153.

Costa, R. G., Beltrão Filho, E. M., Queiroga, R. C. R. E., Medeiros, A. N., Oliveira, C. J. B., & Guerra, I. C. D. (2007). Características físico-químicas do leite de cabra comercializado no estado da Paraíba, Brasil. *Revista do Instituto Adolfo Lutz*, 66, 136-141.

Cunha, C. R., Spadoti, L. M., Zacarchenco, P. B., & Viotto, W. H. (2002). Efeito do fator de concentração do retentado na composição e proteólise de queijo Minas Frescal de baixo teor de gordura fabricado por ultrafiltração. *Food Science and Technology (Campinas)*, 1(1), 82-87. http://dx.doi.org/10.1590/S0101-20612002000100015.

Dasari, M. A., Kiatsimkul, P. P., Sutterlin, W. R., & Suppes, G. J. (2005). Low-pressure hydrogenolysis of glycerol to propylene glycol. *Applied Catalysis A, General*, 281(1-2), 225-231. http://dx.doi.org/10.1016/j.apcata.2004.11.033.

Donkin, S. S. (2008). Glycerol from biodiesel production: the new corn for dairy cattle. *Revista Brasileira de Zootecnia*, 37(spe), 280-286. http://dx.doi.org/10.1590/S1516-35982008001300032.

Drake, M. A. (2007). Invited review: sensory analysis of dairy foods. *Journal of Dairy Science*, 90(11), 4925-4937. http://dx.doi.org/10.3168/jds.2007-0332. PMid:17954731.

Eldesouky, A., Pulido, A. F., & Mesias, F. J. (2015). The role of packaging and presentation format in consumers' preferences for food: an application of projective techniques. *Journal of Sensory Studies*, 30(5), 360-369. http://dx.doi.org/10.1111/joss.12162.

Ferrão, L. L., Ferreira, M. V. S., Cavalcanti, R. N., Carvalho, A. F. A., Pimentel, T. C., Silva, H. L. A., Silva, R., Esmerino, E. A., Neto, R. P. C., Tavares, M. I. B., Freitas, M. Q., Menezes, J. C. V., Cabral, L. M., Moraes, J., Silva, M. C., Mathias, S. P., Raices, R. S. L., Pastore, G. M., & Cruz, A. G. (2018). The xylooligosaccharide addition and sodium reduction in requeijão cremoso processed cheese. *Food Research International*, 107, 137-147. http://dx.doi.org/10.1016/j.foodres.2018.02.018. PMid:29580471.

Franco, B. D. G. M., & Landgraf, M. (2008). *Microbiologia dos alimentos* (182 p.). São Paulo: Atheneu.

Goff, J. P., & Horst, R. L. (2001). Oral glycerol as an aid in the treatment of of ketosis/fatty liver complex. *Journal of Dairy Science*, 84, 153.

Gunn, P. J., Neary, M. K., Lemenager, R. P., & Lake, S. L. (2010). Effects of crude glycerin on performance and carcass characteristics of finishing whether lambs. *Journal of Animal Science*, 88(5), 1771-1776. http://dx.doi.org/10.2527/jas.2009-2325. PMid:20154165.

International Organization for Standardization – ISO. (1988). *ISO 8589: Sensory analysis. The general guidance for the design of test rooms*. Geneva: ISO.

International Organization for Standardization – ISO. (1993). *ISO 8586-1: Sensory analysis methodology. The general guidance for the selection and training and monitoring of assessors. Part 1. Selected assessors*. Geneva: ISO.

Jaeger, S. R., & Ares, G. (2014). Lack of evidence that concurrent sensory product characterization using CATA questions bias hedonic scores. *Food Quality and Preference*, 35, 1-5. http://dx.doi.org/10.1016/j.foodqual.2014.01.001.

Jervis, M. G., & Drake, M. A. (2014). The use of qualitative research methods in quantitative science: A review. *Journal of Sensory Studies*, 29(4), 234-247. http://dx.doi.org/10.1111/joss.12101.

Judacewski, P., Los, P. R., Lima, L. S., Alberti, A., Zielinski, A. A. F., & Nogueira, A. (2019). Perceptions of Brazilian consumers regarding white mould surface-ripened cheese using free word association. *International Journal of Dairy Technology*, 72(4), 585-590. http://dx.doi.org/10.1111/1471-0307.12649.

Krehbiel, C. R. (2008). Ruminal and physiological metabolism of glycerin. *Journal of Dairy Science*, 86, 392.

Kuznicka, E., & Łapinska, A. (2014). Goat cheese on an organic farm in Grzybow as na example of organic products, direct sales and local markets. *Wiadomosci Zootechniczne*, 2, 75-82.

Linares, D. M., Gomez, C., Renes, E., Fresno, J. M., Tornadijo, M. E., Ross, R. P., & Stanton, C. (2017). Lactic acid bacteria and bifidobacteria with potential to design natural biofunctional health-promoting dairy foods. *Frontiers in Microbiology*, 8, 846. http://dx.doi.org/10.3389/fmicb.2017.00846. PMid:28572792.

MacFie, H. J., Bratchell, N., Greenhoff, K., & Vallis, L. V. (1989). Designs to balance the effect of the order of presentation and first-order carry-over effects in hall tests. *Journal of Sensory Studies*, 4(2), 129-148. http://dx.doi.org/10.1111/j.1745-459X.1989.tb00463.x.

Meilgaard, M. C., Carr, B. T., & Carr, B. T. (2006). *Sensory evaluation techniques* (4th ed.). Boca Raton: CRC Press. http://dx.doi.org/10.1201/b16452.

Meyners, M., Castura, J. C., & Carr, T. (2013). Existing and new approaches for the analysis of CATA data. *Food Quality and Preference*, 30(2), 309-319. http://dx.doi.org/10.1016/j.foodqual.2013.06.010.

Mituniewicz-Malek, A., Zielinska, D., & Ziarno, M. (2019). Probiotic monocultures in fermented goat Milk beverages- sensory quality of final product. *International Journal of Dairy Technology*, 72(2), 240-247. http://dx.doi.org/10.1111/1471-0307.12576.

Morgan, F., Massouras, T., Barbosa, M., Roseiro, L., Ravasco, F., Kandarakis, I., Bonnin, V., Fistakoris, M., Anifantakis, E., Jaubert, G., & Raynal-Ljutovac, K. (2003). Characteristics of goat milk collected from small and medium enterprises in Greece, Portugal, and France. *Small Ruminant Research*, 47(1), 39-49. http://dx.doi.org/10.1016/S0921-4488(02)00252-3.

National Research Council – NRC. (2007). *Nutrient requirements of small ruminants* (pp. 362). Washington: National Academy of Sciences.

Oliveira, E. W., Esmerino, E. A., Carr, B. T., Pinto, L. P. F., Silva, H. L. A., Pimentel, T. C., Bolini, H. M. A., Cruz, A. G., & Freitas, M. Q. (2017). Reformulating Minas Frescal cheese using consumers' perceptions: insights from intensity scales and check-all-that-apply questionnaires. *Journal of Dairy Science*, 100(8), 6111-6124. http://dx.doi.org/10.3168/jds.2016-12335. PMid:28551189.

Parsons, G. L., Shelor, M. K., & Drouillard, J. S. (2009). Performance and carcass traits of finishing heifers fed crude glycerin. *Journal of Animal Science*, 87(2), 653-657. http://dx.doi.org/10.2527/jas.2008-1053. PMid:18849392.

Popovic-Vranjes, A., Pihler, I., Paskas, S., Krstovic, S., Jurakic, Z., & Strugar, K. (2017). Production of hard goat cheese and goat whey from organic goat's milk. *Mljekarstvo*, 67, 177-187. http://dx.doi.org/10.15567/mljekarstvo.2017.0302.

Rémond, B., Souday, E., & Jouany, J. P. (1993). In vitro and in vivo fermentation of glycerol by ruminal microbes. *Animal Feed Science and Technology*, 41(2), 121-132. http://dx.doi.org/10.1016/0377-8401(93)90118-4.

Robinson, R. K., & Wilbey, R. A. (2002). *Fabricación de queso* (2. ed., 488 p.). Zaragoza, Espanha: Editorial Acribia, S. A.

Santos, B. M., Oliveira, M. E. G., Sousa, Y. R. F., Madureira, A. R. M. F. M., Souza, E. L., & Queiroga, R. C. R. E. (2011). Caracterização físico-química e sensorial de queijo de coalho produzido com mistura de leite de cabra e de leite de vaca. *Revista do Instituto Adolfo Lutz*, 70, 302-310.

SAS Institute. (2001). *SAS/STAT User's Guide: Statistics. Version 9* (2nd ed.). Cary: SAS Institute Inc..

Schwarz, D. G. G., Lima, M. C., Barros, M., Valente, F. L., Scatamburlo, T. M., Rosado, N., Oliveira, C. T. S. A. M., Oliveira, L. L., & Moreira, M. A. S. (2017). Short communication: Passive shedding of Mycobacterium avium ssp. paratuberculosis in commercial dairy goats in Brazil. *Journal of Dairy Science*, 100(10), 8426-8429. http://dx.doi.org/10.3168/jds.2017-12918. PMid:28755949.

Silanikove, N., Leitner, G., Merin, U., & Prosser, C. G. (2010). Recent advances in exploiting goat's milk: quality, safety, and production aspects. *Small Ruminant Research*, 89(2-3), 110-124. http://dx.doi.org/10.1016/j.smallrumres.2009.12.033.

Silva, H. L. A., Balthazar, C. F., Silva, R., Vieira, A. H., Costa, R. G. B., Esmerino, E. A., Freitas, M. Q., & Cruz, A. G. (2018). Sodium reduction and flavor enhancer addition in probiotic prato cheese: contributions of quantitative descriptive analysis and temporal dominance of sensations for sensory profiling. *Journal of Dairy Science*, 101(10), 8837-8846. http://dx.doi.org/10.3168/jds.2018-14819. PMid:30077456.

Silva, R. R., Prado, I. N., Silva, F. F., Almeida, V. V. S., Santana Júnior, H. A., Queiroz, A. C., Carvalho, G. G. P., & Barroso, D. S. (2010). Comportamento ingestivo diurno de novilhos Nelore recebendo níveis crescentes de suplementação em pastejo de capim-braquiária. *Revista Brasileira de Zootecnia*, 39(9), 207-2080. http://dx.doi.org/10.1590/S1516-35982010000900028.

Soares, E. K. B., Esmerino, E. A., Ferreira, M. V. S., da Silva, M. A. A. P., Freitas, M. Q., & Cruz, A. G. (2017). What are the cultural effects on consumers' perceptions? A case study covering coalho cheese in the Brazilian northeast and southeast área using word association. *Food Research International*, 102, 553-558. http://dx.doi.org/10.1016/j.foodres.2017.08.053. PMid:29195985.

Souza, E. L., Costa, A. C. V., Garcia, E. F., Oliveira, M. E. G., Souza, W. H., & Queiroga, R. C. R. E. (2011). Qualidade do queijo de leite de cabra tipo coalho condimentado com cumaru (*Amburana cearensis* A. C. Smith). *Brazilian Journal of Food Technology*, 14(03), 220-225. http://dx.doi.org/10.4260/BJFT2011140300026.

Souza, L. L., Azevêdo, J. A. G., de Araújo, G. G. L., Santos-Cruz, C. L., Cabral, Í. S., Almeida, F. M., Oliveira, G. A., & Oliveira, B. S. (2015). Crude glycerin for Santa Inês and F1 Dorper × Santa Inês lambs. *Small Ruminant Research*, 129, 1-5. http://dx.doi.org/10.1016/j.smallrumres.2015.06.006.

Stone, H., & Sidel, J. L. (2004). *Sensory evaluation practices* (3rd ed.). Academic Press, Cambridge, MA

Teixeira, J. L. P. (2016). *Qualidade do queijo de leite caprino tipo coalho condimentado com cumaru (Amburana cearensis A. C. Smith)* (Dissertação de mestrado). Pós-graduação em Tecnologia Agroalimentar, Centro de Ciências Humanas, Sociais e Agrárias, Universidade Federal da Paraiba, João Pessoa.

Terré, M., Nudda, A., Casado, P., & Bach, A. (2011). The use of glycerininrations for light lamb during the fattening period. *Animal Feed Science and Technology*, 164(3-4), 262-267. http://dx.doi.org/10.1016/j.anifeedsci.2010.12.008.

Torres, F. R., Esmerino, E. A., Carr, B. T., Ferrão, L. L., Granato, D., Pimentel, T. C., Bolini, H. M. A., Freitas, M. Q., & Cruz, A. G. (2017). Repid consumer-based sensory characterization of requeijão cremoso, a spreadable processed cheese: performance of new statistical approaches to evaluate check-all-that-apply data. *Journal of Dairy Science*, 100(8), 6100-6110. http://dx.doi.org/10.3168/jds.2016-12516. PMid:28571992.

Universidade Estadual de Campinas – UNICAMP. (2012). *Tabela Brasileira de Composição de Alimentos - TACO* (4. ed.). Campinas: UNICAMP/NEPA. Retrieved from http://www.unicamp.br/nepa/taco/contar/taco_4_edicao_ampliada_e_revisada.pdf?arquivo=taco_4_versao_ampliada_e_revisada.pdf

Wen, Z. (2012). *New uses for crude glycerin from biodiesel production*. Retrieved from http://www.extension.org/pages/29264/new-uses-for-crude-glycerin-from-biodiesel-production