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# Effect of Fat Content on the Properties of Colombian Queso Costeño Made from Goat Milk

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**Abstract :** The processing of goat milk to obtain an autochthonous Colombian cheese, such as Queso Costeño, was an alternative to solve the problems of conservation and deterioration of this milk. Therefore, the objective of this research was to study the effect of fat content on the physicochemical, textural, microbiological and sensory properties of Queso Costeño made from goat milk, to accommodate a product similar to that commonly marketed. Nubianbreed goat milk(*Capra ibex nubiana*), was collected in the municipality of Magangué, southern of the Department of Bolívar (Colombia). Milk was standardized to 3.75 %,4.0 % and 4.25 % fat. The control samples was cow milk made from Queso Costeño. A unifactorial design with four levels was used.The increase in fat in cheeses decreased moisture and protein. The ash content, pH and acidity were not statistically different from those of the control. Goat's milk-made Queso Costeño with 3.75 %,4.0 % and 4.25 % fat were classified as soft-semifat, soft-fat and soft-extrafat, respectively. The control samples obtained the same classification as cheeses made from 3.75% fat. Hardness and chewiness decreased with increased fat content. The decreased in moisture content of Quesos Costeños made from goat milk affected their adhesiveness. Cohesiveness and springiness increased with higher fat content. Microbiological counts were at acceptable levels according to NTC 750. The acceptance of Queso Costeño with 3.75 % fat was similar to the control, and was the most preferred of the three. The results of this study could support small and medium-sized cheese producers.
**Keywords :** Queso Costeño, fat content, texture, sensory evaluation.

## 1. Introduction

In Colombia, one of the most widely produced traditional cheeses on the Caribbean coast is Queso Costeño, which is mainly characterized by being a fresh, white, always salty and soft product, although harder types are marketed that contain more sodium chloride [1], [2]. This type of fresh cheese is obtained by cutting the fresh milk with the cow rennet; it is allowed to harden, the whey is extracted, with a period of salting, and finally pressed until its characteristic rectangular shape is obtained [3].

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In the Colombian Caribbean coast, food and nutritional problems are more serious and marked in social strata 1 and 2, which confirms that the nutritional situation of the population is determined by poverty and social inequality[4].According to data from the National Nutritional Situation Survey [5], there is an average of 42.7% food insecurity in the country and it is estimated that one in three families is not guaranteed basic food. The families belonging to the departments of Bolívar and La Guajira, find their economic sustenance through goat breeding and the commercialization of their milk.

In recent years, goat milk and products derived from it have acquired great importance worldwide[6]. Its production has increased significantly in recent decades, and has contributed to improving the economy of industries in different countries and increasing the nutritional intake it offers its consumers [7].In some regions it is consumed in liquid form, although it is also processed by obtaining derivatives, mainly cheese [8].Its composition differs in certain respects from cow milk; because it has a higher percentage of fat, the contents of short-chain fatty acids such as butyric, caproic, capric and caprylic give it a different taste, and make it more digestible because they have low molecular weight, which facilitates the action of digestive enzymes and hydrolysis in a rapid and effective way [9].

All of the above features help patients with eating disorders and infant feeding disorders [10].In addition, it provides a higher percentage of protein than cow milk; and vitamins such as A, riboflavin, niacin, and minerals such as calcium, phosphorus, and magnesium [11], [12].However, in rural communities along the Colombian coast, milk has disadvantages in terms of deterioration and conservation.

On the other hand, the study of the variation of fat content in dairy derivatives is important to carry out because studies such as Tirado *et al*., [13], where the fat content of the Suero Costeño made from goat milk was varied, allowing to improve its rheological and textural properties. Therefore, goat milk derivatives could be a viable alternative to help meet food needs and minimize malnutrition problems in our region. Since there are few studies on the production of Queso Costeño made from goat milk, the main objective of this research was to evaluate the effect of the fat content on the physicochemical, textural, microbiological and sensory properties of Queso Costeño made from this raw material.

## 2. Materials and Methods

### 2.1 Collection of milk samples

Goat milk was obtained from the Nubian goat breed (*Capra ibex nubiana*), a type of ruminant "double-purpose", as it is a good producer of milk and meat, as well as supporting warm and temperate climates [14].The milk for the production of the Queso Costeño was collected in the municipality of Magangué, southern department of Bolívar. The other ingredients were purchased at the local market in the city of Cartagena de Indias. It was packaged in pre-sterilised plastic containers and kept cool at 4 °C until analysis.

### 2.2 Production process of the goat milk-made Queso Costeño

Goat milk was pasteurized in an Alfa Laval® brand pasteurizer (Alpha-Laval Inc, Fort Lee, NJ, USA) at 65°C for 30 min. For the standardization of milk, a skimmer brand Motor Sich (STSM 80-100®, Kiev, Ukraine) was used.The milk was kept at 35 - 40 °C according to the equipment manual. The milk was skimmed to fat content of 3.75%,4.0% and 4.25 % to make the cheese from goat milk.Two grams of calcium chloride per 10 L of pasteurised goat milk were added to improve curd firmness [15]. Then, one mL of Marschall® brand liquid rennet was poured into the milk for every 10 L of pasteurized milk.The curd was cut with a knife, the curds were drawn in semigrand grains (2 cm). After 20 min to drain all the whey, then remove each curd. Four percent of NaCl was added to each cheese. The moulding was carried out in square moulds with holes of 500 g capacity, then the cheeses were left pressed (40 lbs of weight) for a time of one hr and 30 min.The control samples of Queso Costeño, i. e., cheese samples made from cow's milk, were purchased at the local market in the municipality of Magangué.

### 2.3 Physicochemical properties

Goat milk was determined for fat (AOAC 989.05), protein using the Kjeldahl method (AOAC 991.20), acidity (AOAC 947.05), pH (AOAC 981.12), total solids (ISO 6731:1989), density (AOAC 925.22) and ash

(AOAC 930.30).The moisture, fat, protein, acidity, pH and moisture content were also determined for Queso Costeño samples. In order to classify the cheeses obtained in accordance with the Colombian Technical Standard (NTC) 750 of 2000, the percentage of Moisture without Fat Matter (%MWFM) and Fat in Dry Extract (%FDE) were determined.

### 2.4 Texture profile analysis

The texture profile of Queso Costeño samples was determined using a TA-XT2i Texture Analyzer (Stable Micro Systems, Godalming, England)coupled with software Texture Expert Exceed version 2.64.The measurement consisted of two successive axial compressions with 75 % of the sample height using a 500 N load cell and a speed of 3 mm $s^{-1}$.The cheese samples had dimensions of 2 cm × 2 cm × 2 cm × 2 cm maintained at a temperature of 10 °C ± 0.1 °C. It was noted that the cubic sample should be taken from the central part of the cheese as the texture may vary from one end to the other.The resting time between compressions was 3 s. The parameters evaluated were hardness (kg m $s^{-2}$), springiness (mm), cohesiveness (dimensionless), adhesiveness (N × m) and chewiness (kg).

### 2.5 Microbiological evaluation

In order to determine its microbiological quality in goat's milk, it was determined the reduction time of methylene blue(NTC 6103)[16], total coliform count (NTC 4458) [17], mesophilic aerobes (NTC 4519) [18] and somatic cell count (AOAC 975.16).Total coliform, moulds and yeasts, *Staphylococcus aureus* coagulase positive (IDF 145) [19], *Salmonella* spp. (IDF 93B) [20]and *Listeria monocytogenes* (NTC 4666) [21]were counted in Queso Costeño samples.

### 2.6 Sensory evaluation

The sensory test was conducted with 50Queso Costeño consuming panelists between ages of 18 and 25 years old in a suitable room. The members of the group were asked to indicate how much they liked or disliked the Queso Costeño made from goat milk, using a 5-point hedonic scalesince 1 “I dislike it very much” to 5 “I like it extremely”. The samples were delivered to the panelists on trays with a white surface containing each treatment in individual, transparent coded containers. The sample temperature was 4 °C ± 0.1.The test was carried out in afree-odour and illuminated space at a temperature of 25 °C and a relative humidity of 62 %. Together with the samples, they were given a glass of water to rinse the mouth after each tasting and an evaluation format in which they evaluated the acceptance of each characteristic according to the scale in the format reported by Ramírez-Navas *et al*.,[22].The overall acceptability of the products, taste, aroma, appearance and colour characteristics were recorded. Data were collected on a spreadsheet and transformed into numerical scores for analysis[23].

### 2.7 Experimental design

For the production of the cheese, a completely random unifactorial design was used; under controlled conditions of temperature and humidity; with four (4) levels: Queso Costeño made from goat milk with 3.75 % (F1), 4.0 % (F2), 4.25 % (F3) fat and control (F4), Queso costeñomade from cow's milk) for a total of 4 experimental treatments. The response variables were: physicochemical (moisture, fat, acidity, protein, pH, ashes), microbiological (total coliforms, *Staphylococcus aureus*-coagulase positive, moulds and yeasts, *Salmonella* spp., *Listeria monocytogenes*), textural (hardness, adhesiveness, cohesiveness, springiness, chewiness) and sensory properties (taste, flavor, color, overall acceptability).The analyses were performed with three replicas of each treatment, in a total of 12 experimental units. Results were recorded by treatment with arithmetic mean and respective standard deviation.

### 2.8 Data analysis

The data processing obtained in the mentioned analyses was carried out using the statistical software STATGRAPHICS (Statgraphics Centurion Version 16.1.15, Chicago, EE.UU) [24], in which it was determined that there were statistically significant differences in each of the parameters to be evaluated by means of a Variance Analysis (ANOVA) and multiple comparisons with Tukey's HSD Test with a 95% confidence level and 5% significance ($p \leq 0.05$).Also, a correlation was made with the r-Pearson test, between each of the parameters of the instrumental texture and those found in the physicochemical tests, in order to analyze the

relationships between the levels of the variable of interest and to find the best final characteristics of the product depending on the fat content. The correlation was considered significant at the 0.05 level and highly significant at the 0.01 (bilateral) level, similar to Alvarez *et al*. [25]and Paula and Conti-Silva [26].

## 3. Results and Discussions

### 3.1 Physicochemical properties

The results obtained of physicochemical analysis from raw goat milk (Table 1) were similar to studies reported[27]–[29]. Similarly, in other researches such as the one reported by Chacón [30] where it was studied the nutritional aspects of goat milk and its variations in the agro-industrial process, fat matter values of 4.14%, 3.56 % protein, acidity of 0.16 % to 0.19 % lactic acid, pH values ranging 6.3 – 6.7, 12.97 % total solids, 4.45 % carbohydrates, 0.82 % ash and density in a range of 1.030 – 1.034 g $mL^{-1}$ were found, which are consistent with those obtained in the present research.

**Table 1. Results physicochemical properties of raw goat milk samples**

| **Parameters** | **Amount** |
|---|---|
| Fat matter (%) | 4.12 ± 0.18 |
| Protein (%) | 3.50 ± 0.30 |
| pH | 6.35 ± 0.1 |
| Acidity (% Acid Lactic) | 0.17 ± 0.01 |
| Total solids (%) | 12.20 ± 0.70 |
| Density (g $mL^{-1}$) | 1.03145 |
| Ash (%) | 0.82 ± 0.20 |

Ocampo *et al*.,[31] studied the composition of milk from ruminants such as goats, recording fat matter values of 4.44 ± 0.30 %, protein of 3.01 ± 0.29 %, total solids of 12.59 ± 0.10 %, lactose of 4.20 ± 0.01 %.Variations in physicochemical parameters are due to various factors such as the diet of the goat, its breed, lactation period, season, health status, and production systems, among others [32].

Similarly, these characteristics were evaluated in Queso Costeño samples made from goat milk and the control sample (cow milk) (Table 2).There were statistically significant differences in moisture content ($p < 0.05$), which decreased as the percentage of fat in milk increased. The moisture percentage was in a range of 50.30 to 56.01% considered as soft cheeses similar to that reported by Duran *et al*.,[33].The behavior of moisture and fat content was similar to those reported by Rudán *et al*., [34] cited by Schenkel et al. [35], where they evaluated the effect of different fat percentages on the physicochemical properties and yield of Mozarella cheese.

**Table 2.Results of physicochemical properties of goat's milk-made Queso Costeño and Control sample**

| **Parameters** | **Goat's milk-made Queso Costeño** | | | **Cow's milk-made Queso Costeño** | **ANOVA** | |
|---|---|---|---|---|---|---|
| | F1 | F2 | F3 | Control | F | P-value |
| **Moisture (%)** | 56.01 ± 1.04c | 53.03 ± 1.57b | 50.30 ± 1.95a | 54.39 ± 0.76bc | 8.82 | 0.0064<0.05 |
| **Fat matter (%)** | 21.91 ± 1.94a | 27.30 ± 1.75b | 33.49 ± 0.46c | 20.90 ± 1.42a | 46.02 | 0.0001<0.05 |
| **Protein (%)** | 24.96 ± 1.67d | 23.56 ± 0.49bc | 21.73 ± 0.87b | 20.36 ± 1.00a | 10.19 | 0.0042<0.05 |
| **Acidity (%)** | 0.22 ± 0.02ab | 0.23 ± 0.01b | 0.20 ± 0.01ab | 0.22 ± 0.01a | 2.70 | 0.1159>0.05 |
| **pH** | 6.34 ± 0.03a | 6.30 ± 0.10a | 6.36 ± 0.011a | 6.33 ± 0.016a | 0.81 | 0.5212>0.05 |
| **Ash (%)** | 7.43± 0.37a | 7.56 ± 0.20a | 7.62 ± 0.27a | 7.61 ± 0.20a | 0.50 | 0.6954>0.05 |
| **Yield Cheese** | 12.50b | 13.89c | 15.01d | 11.03a | 52.02 | 0.000<0.05 |

**F1** = Milk with 3.75% fat; **F2** = Milk with 4.0% fat; **F3** = Milk with 4.25% fat. **Note:** The different letters within the same row indicate the existence of statistically significant difference ($p \leq 0.05$).

The protein content of the Queso Costeño samples varied significantly ($p < 0.05$), decreasing from 24.96% to 20.36% according to the increase in fat percentage in milk. This behaviour is due to the fact that milk fat and moisture act as fillers in the casein matrix of Queso Costeño.This behavior was similar to the research reported by Sánchez-Macías *et al*.,[36]. Van Hekken et al. [37] found the same behavior in their study on the reduction of fat content in proteolysis and rheological properties of Cheddar cheese made from goat milk, in which they stated that moisture and protein content increase when the fat percentage is low.

The acidity percentages of the samples were in the range of 0.20 - 0.23% lactic acid with no significant statistical difference between them. Duran *et al*.,[33] stated that if the acidity values are between 0.19 - 0.28 % lactic acid, they indicate that the cheeses have been properly processed. As regards pH and ash content of the samples, no statistically significant differences were found with values between 6.30 - 6.36 and 7.56 - 7.62 %, respectively.

In contrast, Van Hekken *et al*.,[37] found in their study that the pH of Cheddar cheese samples with different fat contents varied. However, this statistically significant variation was shown to be a reflection of biochemical and microbiological activity in cheeses with reduced fat content, by inhibiting enzyme reactions and decreasing the lactate-protein reaction that ultimately affects pH.

The cheese yield was affected by the fat content, the more fat in the milk the more milk yield obtained cheeses. Romeih *et al*.,[38] stated that the supply of fat to milk provides an unavoidable increase in its yield, as this constituent and the casein content determine cheese production as such.In addition, in order to classify the goat milk-madeQueso Costeño and control cheese obtained in accordance with NTC 750 of 2000, the MWFM % and FDE % (Table 3) were determined.There were statistically significant differences in the MWFM % ($p < 0.05$) and FDE % ($p < 0.05$) that increased with the fat percentage. In accordance with the NTC 750 of 2000, cheeses made from 3.75 % fat goat milk were classified as soft and semi-fat cheeses, and also for the control sample.

**Table 3. Moisture without Fat Matter (%) and Fat in Dry Extract (%) in goat's milk-made Queso Costeño and control sample**

| **Parameter** | **Goat's milk-made Queso Costeño** | | | **Cow's milk-made Queso Costeño** | **ANOVA** | |
|---|---|---|---|---|---|---|
| | **F1** | **F2** | **F3** | **Control** | **F** | **p-valor** |
| % MWFM | 70.8 ± 0.45b | 73.16 ± 1.06c | 76.0 ± 0.45d | 68.53 ± 0.47a | 68.86 | 0.001<0.05 |
| % FDE | 45.73 ± 0.06b | 58.21 ± 0.10c | 66.30 ± 0.4d | 43.05 ± 0.05a | 7998.5 | 0.003<0.05 |
| Classification | Soft - Semifat | Soft -fat | Soft - Extrafat | Soft - Semifat | -- | -- |

**F1** = Milk with 3.75% fat; **F2** = Milk with 4.0% fat; **F3** = Milk with 4.25% fat. **Note:** The different letters within the same row indicate the existence of statistically significant difference ($p \leq 0.05$).

The goat's milk-made Quesos Costeños to 4.0 % and 4.25 % were also in the group of soft cheeses with the difference of being fat and extra-fat, respectively.Guzmán *et al*.,[39] carried out a comparative analysis of texture profiles of goat and cow's milk cheeses, also classifying cheeses (15,30 and 50 % fat) according to the NTC 750. They obtained semi-fat-semi-hard cheeses, fat-semi-hard cheeses and extra-fat-semi-hard cheeses.

### 3.2 Texture profile analysis

Table 4 shows the data obtained from the TPA carried out on Queso Costeño samples made from goat milk with different fat percentages and control sample. The instrumental texture properties are a set of measurable parameters that provide the characteristics of a foodstuff such as hardness (N), fracturability (N), cohesiveness (dimensional), springiness (mm) and chewiness (kg), which help to establish ideal conditions in a given production volume, in order to maintain the same textural quality in all of them[40], [41].Texture specifically in cheeses helps determine the identity of a product [42].

**Table 4. Texture Profile Analysis (TPA) results for goat's milk-made Queso Costeñoand control sample**

| **Parameter** | **Goat's milk-made Queso Costeño** | | | **Cow's milk-made Queso Costeño** | **ANOVA** | |
|---|---|---|---|---|---|---|
| | **F1** | **F2** | **F3** | **Control** | **F** | **P-value** |
| Hardness (N) | 37.60 ± 1.12c | 33.43 ± 1.10b | 28.23 ± 1.0a | 38.30 ± 0.75c | 63.36 | 0.0010<0.05 |
| Adhesiveness (N × m) | -0.65 ± 0.02d | -0.43 ± 0.01b | -0.34 ± 0.04a | -0.47 ± 0.10c | 65.33 | 0.0023<0.05 |
| Cohesiveness | 0.42 ± 0.01b | 0.51 ± 0.02c | 0.55 ± 0.09d | 0.30 ± 0.03a | 134.38 | 0.0035<0.05 |
| Springiness (mm) | 6.46 ± 0.07b | 7.12 ± 0.02c | 7.89 ± 0.08d | 5.20 ± 0.01a | 1103.07 | 0.0041<0.05 |
| Chewiness (kg) | 55.21 ± 0.611d | 49.63 ± 0.56b | 46.96 ± 0.55a | 51.9 ± 0.75c | 93.46 | 0.0076<0.05 |

**F1** = Milk with 3.75% fat; **F2** = Milk with 4.0% fat; **F3** = Milk with 4.25% fat. **Note:** The different letters within the same row indicate the existence of statistically significant difference ($p \leq 0.05$).

The fat content in milk significantly modified all the textural properties in Queso Costeño samples. Statistically significant differences there were found ($p < 0.05$) in hardness, which decreased as fat content increased.This phenomenon was related to the moisture content of the samples, since those with high percentages showed a greater firmness than those with low percentages. Guzmán *et al*.,[39] explained that the moisture content allows the cheese curd to harden structurally, bearing in mind that proteins should be further apart. On the other hand, the control sample obtained a greater hardness value of 38.30 ± 0.75 N than samples F2 and F3, without finding a statistical difference with F1.This is due to the way fat globules were formed in goat's and cow's milk, being in the first small and the second larger ones, making their coagulation time shorter due to the thickness of the micelles and a firmer curd [39].

In other research such as that reported by Clark *et al.*[43] cited by Johansson *et al.*[44] stressed the importance of $\alpha_{s1}$ casein in the cheese coagulation process and stated that the Nubian goat breed is good for cheese production, but this will depend on a high content of total solids immersed in milk [7].Adhesiveness varied significantly between the Queso Costeño samples, which was found in an interval between -0.65 N × m and -0.34 N × m. Negative values that tended to zero, meant less adhesiveness between the samples. This parameter was influenced by the moisture content of the samples; the higher the moisture content, the greater the surface tension between the compression cell and the sample as such. The behavior was similar to that reported by Guzmán *et al*., [39].Cohesiveness also varied, increasing with fat content between the interval (0.30 - 0.55). This is because the fat content made the cheese more deformable.

This behavior was similar to that reported by Guzmán *et al*. [39].In contrast, Sánchez-Macías et al. [45] and Van Hekken et al. [37] in their studies obtained lower cohesiveness values when there was a reduction in fat content in cheeses. The springiness in the Queso Costeño samples was increased with fat content, in an interval of (5.20 - 7.89).Springiness confirmed the deformation capacity of goat cheese samples without matrix rupture. Regarding chewiness, the samples as the fat content increased required less strength to chew as the surface became softer and softer. The values of this parameter decreased from 55.21 kg to 49.63 kg. On the other hand, the correlations obtained between physicochemical and textural parameters from Queso Costeño samples with control cheese are shown (Table 5).

**Table 5.Correlations between physicochemical and textural parameters**

| | **Moisture** | **Fat** | **Protein** | **Acidity** | **Ash** | **pH** | **MWFM** | **FDE** | **Hardness** | **Adhesiveness** | **Cohesiveness** | **Springiness** | **Chewiness** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Moisture** | | -0.74* | 0.34 | -0.22 | -0.06 | -0.23 | -0.67* | -0.80* | 0.82* | -0.86* | -0.62* | -0.61* | 0.83 |
| **Fat** | -0.74* | | -0.01 | 0.28 | 0.25 | 0.17 | 0.94* | 0.96* | -0.92* | 0.69* | 0.85* | 0.90* | -0.82* |
| **Protein** | 0.34 | -0.01 | | 0.51 | -0.13 | -0.27 | 0.13 | -0.01 | 0.17 | -0.58 | 0.28 | 0.28 | 0.46 |
| **Acidity** | -0.22 | 0.28 | 0.51 | | -0.34 | -0.62* | 0.54 | 0.44 | -0.34 | 0.03 | 0.62 | 0.56 | -0.18 |
| **Ash** | -0.06 | 0.25 | -0.13 | -0.34 | | -0.06 | 0.13 | 0.18 | -0.13 | 0.35 | -0.02 | 0.06 | -0.31 |
| **pH** | -0.23 | 0.17 | -0.27 | -0.62* | -0.06 | | -0.02 | 0.03 | -0.16 | 0.09 | -0.04 | 0.01 | -0.01 |
| **MWFM** | -0.67* | 0.94* | 0.13 | 0.54 | 0.13 | -0.02 | | 0.95* | -0.91* | 0.57* | 0.92* | 0.96* | -0.74* |
| **FDE** | -0.80* | 0.96* | -0.01 | 0.44 | 0.18 | 0.03 | 0.95* | | -0.96* | 0.72* | 0.91* | 0.93* | -0.86 |
| **Hardness** | 0.82* | -0.92* | 0.17 | -0.34 | -0.13 | -0.16 | -0.91* | -0.96* | | -0.73* | -0.86* | -0.88* | 0.86* |
| **Adhesiveness** | -0.86* | 0.69* | -0.58* | 0.03 | 0.35 | 0.09 | 0.57* | 0.72* | -0.73* | | 0.42 | 0.43 | -0.94 |
| **Cohesiveness** | -0.62 | 0.85 | 0.28 | 0.62 | -0.02 | -0.04 | 0.92 | 0.9155 | -0.86* | 0.42 | | 0.97 | -0.62* |
| **Springiness** | -0.61* | 0.90* | 0.28 | 0.56 | 0.06 | 0.01 | 0.96* | 0.93* | -0.88* | 0.43 | 0.97 | | -0.63* |
| **Chewiness** | 0.83* | -0.82* | 0.46 | -0.18 | -0.31 | -0.01 | -0.74* | -0.86* | 0.86* | -0.94* | -0.62* | -0.63* | |

*Statistically significant ($p < 0.05$).

This data corroborated the strong influence of fat content and moisture on the textural properties of goat's milk-made Queso Costeño samples on their textural properties.In contrast, Alvarez *et al*.,[25] also correlated texture parameters with the composition of Canary Island goat cheeses, and found a positive correlation between fat content, hardness and chewiness, and negative for cohesiveness and elasticity.The moisture content was negatively correlated with protein content and all textural parameters except cohesiveness and elasticity. All these variations will also be influenced by the method of production and the type of cheese to be produced.

### 3.3 Microbiological analysis

#### 3.3.1 Microbiological evaluation to goat milk

Data obtained from physicochemical analyses of raw goat's milk were found to be within acceptable levels for NTC 399 (Table 6). 100.000 CFU $mL^{-1}$ of mesophilic aerobics were quantified, the maximum limit being 700.000 CFU $mL^{-1}$, milk was categorized as good quality, which indicated that there was a great deal of supervision in pumping milk from the udder, without contaminating it from foreign bodies on the surface of the udder, from tools or implements used [46].

With respect to reductase testing, the results are similar to those reported by Ludeña *et al*. [47], as milk resisted decolourization for approximately 4 h, showing little contamination by microbial load [48].Coliform values below the maximum ranges of the regulations were obtained, which shows that the handlers did not contaminate faecal origin.

**Table 6. Results of microbiological evaluation of goat's milk**

| **Microbiological analysis** | **Goat milk** |
|---|---|
| Mesophilic Aerobes (UFC $mL^{-1}$) | 100.000 |
| Methylene blue reduction time (h) | 4 |
| Total Coliforms(UFC $mL^{-1}$) | 35 |
| Somatic Cells(cel $mL^{-1}$) | 430.000 |

In addition, 410.000 cells $mL^{-1}$ were determined in milk, indicating a low concentration of leukocytes and epithelial cells, as well as a lower level of subclinical infection in the goat mammary gland [49]. Chen *et al*.,[50] studied the effect of somatic goat's milk somatic cell count on yield, sensory quality and profile of semi-soft cheeses, found that changes in physicochemical properties occurred when the milk was outside the somatic cell range of 214.000 and 1.450.000 cells $mL^{-1}$.On the other hand, the amount of somatic cells did not affect performance, except in the textural properties when the concentration was high.

#### 3.3.2 Microbiological evaluation to Queso Costeño samples

The microbiological results of the Queso Costeño samples (Table 7) confirmed the treatment applied to it in terms of the specific thermal and hygienic conditions required, i. e. good manufacturing practices. The total coliform count, moulds and yeasts showed lower values, discarding it as a vector of contamination, that is to say, at the time of its elaboration a good sanitary quality was obtained [51].

**Table 7. Microbiological analyses carried out on goat's milk-made Queso Costeño samples and control**

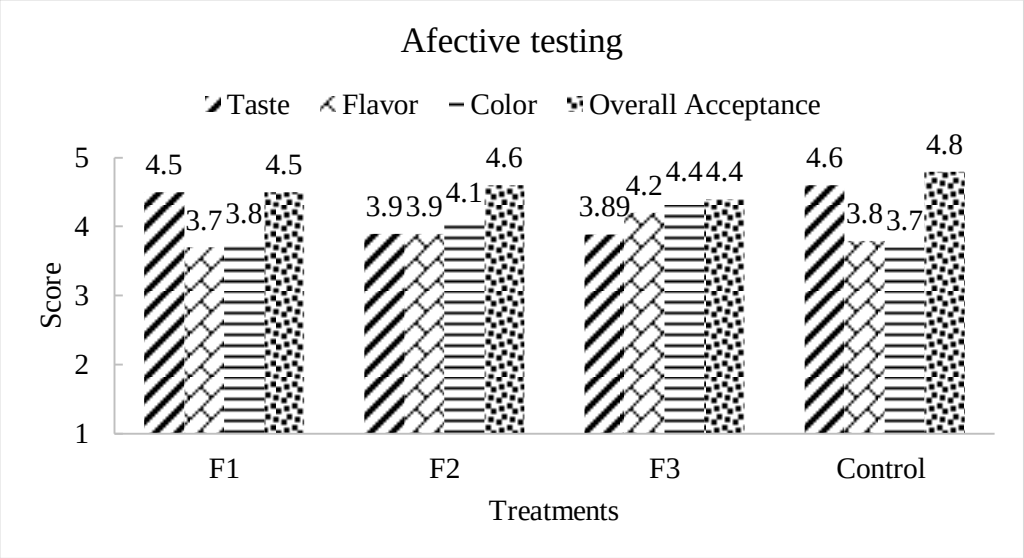
| **Cheese** | **Total Coliforms (UFC $g^{-1}$)** | **Molds and Yeast (UFC $g^{-1}$)** | ***Staphylococcus* coagulase (+) (UFC $g^{-1}$)** | ***Salmonella*/25gr** | ***Listeria monocytogenes*/25g** |
|---|---|---|---|---|---|
| 3.75% | 20 | <10 | <100 | Negative | Negative |
| 4.0% | 25 | <10 | <100 | Negative | Negative |
| 4.25% | 23 | <10 | <100 | Negative | Negative |
| Control | 22 | <10 | <100 | Negative | Negative |

On the other hand, the positive - coagulase count gave as results Colony Forming Units lower than 100 per gram, therefore cheeses cannot be considered as a risk of food poisoning by *Staphylococcus aureus* being

relatively lower counts, besides ruling out the existence of caprine mastitis, this microorganism being the main pathogen that causes it [49].No strains of *Salmonella* were detected in the cheese samples evaluated, which correlates with the data reported by El-Galiou *et al*.,[52]. Furthermore, no strains of *Listeria monocytogenes* were detected. Araya *et al.*,[53] staed that there are several reasons for the absence of this micro-organism. Firstly, its number is low in dairy products, secondly because it is inhibited by the production of acid by lactic bacteria and also the fact that bacteria have seasonal variation and in summer it is common to isolate less than one bacteria per mL.

### 3.3.3 Sensory evaluation

There were statistically significant differences ($p < 0.05$) in terms of taste, color, flavor and overall acceptability (Figure 1). The control sample showed no statistically significant difference with the F1 samples, positioning it as the preferred sample of goat milk-made Queso Costeño.




Sanchez-Macías *et al.*[36] stated that the fat content positively modifies sensory properties and consumer acceptance. They studied the effect of storage and different fat contents in fresh goat cheese, finding a low intensity of odour as the fat content decreased in cheese, similar to that observed in this study.High values were found in the taste of the cheeses, obtaining a lower limit of 3.89 and a maximum of 4.6. The Queso Costeño is salty, therefore salt tends to contribute to the taste directly[2], [40].

## 4. Conclusions

The fat content significantly influenced physicochemical parameters such as moisture content, protein and cheese yield. Goat's milk-made Queso Costeño of 3.75 % milk fat, obtained similar characteristics to traditional cow's milk-made Queso Costeño, according to the classification according to NTC 750 and sensory attributes. The increase in fat in the goat milk-made Queso Costeño samples made them less adhesive because of their low moisture. However, it increased its cohesiveness, springiness and deformability. The moisture was related to the hardness of the cheeses, as it allowed the structural hardening of the curd by supporting the binding between proteins.

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