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Dietary Factors and Production Season Effect on the Properties of Goat Cheese

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Abstract: Artisan goat cheeses (AGCs) from four different producers in Coahuila, Mexico, along with a pasteurized goat cheese (C), were subjected to a comprehensive analysis covering production, chemical, microbiological aspects, and texture. The study aimed to discern the impact of feeding practices, seasonality, and manufacturing technology on their properties. Aspects such as the manufacturing production, chemical composition, microbiological load, and texture characteristics were analyzed. The results highlighted a higher protein content in the cheeses from grazing goats (14.51%), while the highest fat (14.25%) and ash (3.27%) contents were found in the cheeses made during spring from stabled goats. Correlations were noted between the protein content and hardness, as well as the acidity and adhesiveness. Most of the analyzed cheeses showed microbiological levels higher than those allowed by national regulations, with counts ranging from 1 to 7.5 Log cfu g^{-1} for total coliforms, 2.39 to 7.52 Log cfu g^{-1} for molds and yeasts, as well as 2.16 to 6.53 Log cfu g^{-1} for *Staphylococcus*. The findings of this study offer a comprehensive insight of the effects of feeding practices, seasonality, and manufacturing technology on AGC properties, potentially guiding improvements in both production processes and product quality.

Keywords: goat milk; stabled goats; grazing goats; artisan cheese

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1. Introduction

In Latin America, goats are primarily raised under local conditions for milk and meat, with their products mostly marketed informally. Especially in arid regions, goat milk is a crucial protein source, yet government policies often overlook dairy goats, focusing instead on cattle [1]. Additionally, goat milk's significant role in artisanal cheese production is well-documented, noted for enhancing organoleptic and textural properties through factors like microbiota, seasonality, production techniques, and diet [2,3].

The feeding system significantly impacts goat milk quality. Free-grazed goats produce milk with better fatty acid profiles and a higher protein content, particularly easily digestible casein. This unique composition makes their milk more digestible and less allergenic. Additionally, free-grazed goat milk contains higher levels of essential minerals and conjugated linoleic acid (CLA), offering potential health benefits [4,5]. Research by Mele et al. [6] found that altering forage-to-concentrate ratios in the diet of stabled goats affects the milk composition. Increasing the concentrate led to higher milk fat and protein contents [4]. Sanz Sampelayo et al. [7] reported that certain feed supplements, like sunflower oil, can enhance the fatty acid profile, particularly the CLA concentration [5].

The seasonal fluctuations in goat milk composition significantly influence the quality and attributes of the resulting cheese. Ramos et al. [8] demonstrated that cheese made from spring milk exhibited a higher moisture content and a more desirable fatty acid profile when compared to cheese made from autumn milk. Moreover, findings from Sanz Sampelayo et al. [9] indicated that the sensory characteristics of cheese, including flavor and texture, are likewise impacted by the season of milk production. The microbiological quality of cheeses is also affected, as the occurrence of specific pathogenic microorganisms in goat milk and cheese exhibits seasonal variations. For instance, Montel et al. [10] observed a heightened presence of *L. monocytogenes* in goat cheese during summer, likely attributed to increased environmental contamination and elevated temperatures. Similarly, Quigley et al. [11] noted an elevated prevalence of Salmonella spp. in goat milk during spring and summer. Furthermore, Renes et al. [12] documented a greater prevalence of spoilage bacteria, such as Pseudomonas spp., and an increased risk of contamination with pathogenic microorganisms like *E. coli* O157 and *S. aureus* in cheese derived from summer milk.

Controlling milk microbiota during the cheesemaking process is crucial for ensuring the safety of the final product [13]. This is particularly important because cheeses made from raw milk pose health risks due to the potential presence of pathogenic microorganisms such as *S. aureus*, *L. monocytogenes*, *E. coli*, *Salmonella*, and other harmful bacteria [14]. European Union regulations [15] permit the use of raw milk for cheesemaking only if the cheese undergoes a minimum aging period of 60 days, although compliance with this regulation is primarily advisory.

On the other hand, the Mexican artisan cheese industry faces regulatory challenges, particularly in demonstrating the safety of cheeses made from raw milk and in implementing effective quality systems [16]. Given that Mexican standards currently exclude artisanal cheeses, including those made from goat milk, this study aims to assess how production seasons, feeding practices, and artisanal procedures affect the chemical composition, texture, and microbiological characteristics of artisan goat cheese from Coahuila, Mexico (AGC). This research is vital, given the absence of scientific and technological information that defines the authenticity and which ensures the safety of these products. This study will also explore how handling and facility cleanliness impact the microbiota of the milk, a critical factor for cheese quality and safety.

2. Materials and Methods

2.1. Research Design

This study was conducted by analyzing cheeses from four AGC producers in the southeastern region of Coahuila, Mexico. Two of the producers maintain their goats under a free-range feeding regimen, where the goats graze in open fields during the day, and their diet consists of native vegetation from the semi-desert region such as mesquite (*Prosopis laevigata*), huisache (*Vachellia farnesiana*), and blue grama, as well as agricultural residues. At night, the goats are sheltered in pens. The other two producers keep their goats under a stabled regimen, meaning that they are kept in a facility throughout their lives, and their diet is controlled based on the animal's weight, consisting of corn grains, soybean meal, alfalfa, and minerals. The four producers participating in this study maintain an average of 100 animals each. The peak milk production seasons for the goats are winter and spring, which correspond to the kidding seasons. Therefore, these two seasons were considered for the study. Additionally, a commercial goat cheese purchased from a formal establishment was analyzed for comparison with the artisanal cheeses.

2.2. Production Process of Cheeses

The general steps to make AGC are summarized in Figure 1. Small variations may occur between producers. The process began with the manual milking step (6:30 to 7:00 a.m.), carried out in small enclosures where the goats were gathered. The milk was collected in plastic containers and transported to the cheese manufacturing facility (the milk was

generally collected in the pens located only a few meters from the cheese production facility and processed as soon as possible, because the producers have no way to preserve the milk), where the milk was filtered using a muslin cloth to remove macro-impurities such as hair and debris primarily from the environment. Immediately after, the coagulation process was performed by two different methods, depending on the producer. Grazing goat cheese producers employed abomasum (approximately 5 mL/10 L of milk) extracted from baby goatlings, which was fermented for 21 days in milk whey, serving as a coagulant. Stabled goat cheese producers utilized synthetic rennet (Cuamex brand), prepared following the supplier's instructions, by adding 1.5 mL of the rennet previously diluted in 10 mL of water per 10 L of warm milk (32 to 35 °C). The average coagulation time was 30 to 40 min at room temperature. After the coagulation period, the curd was cut into approximately 5 cm squares using an aluminum knife or a similar instrument. Manual agitation was applied to gradually release the whey, which was then discarded. The curd was salted at a concentration of 1% (*w*/*w*) or according to the producers' preference. During this stage, salt was thoroughly mixed into the curd through manual kneading. Subsequently, the curd was shaped into cheeses using round aluminum or plastic molds ranging from 250 to 400 g. After approximately 10 min, the cheeses ware de-molded and stored under refrigeration temperature.

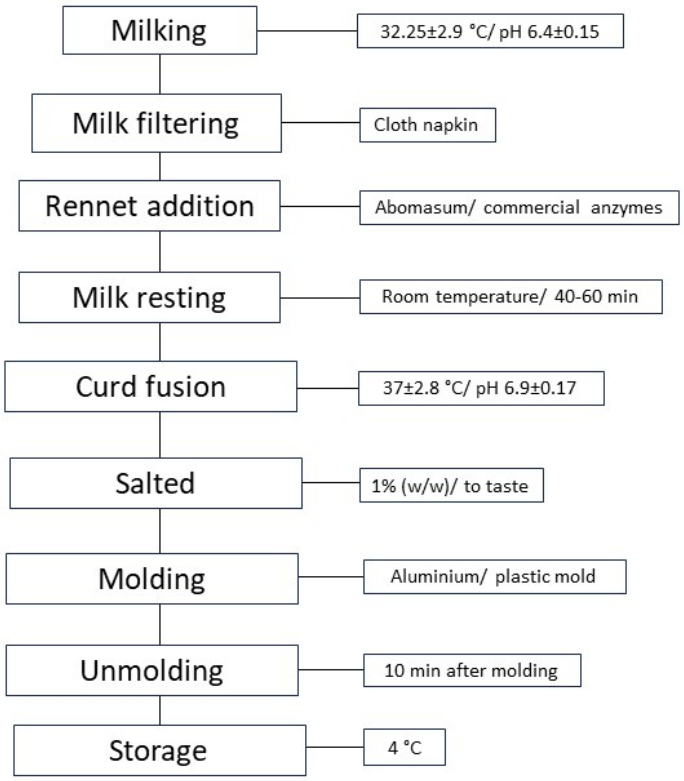

Figure 1. Production process of AGC from the southeast region of Coahuila, México.

The production of commercial cheese was carried out following the same steps used for the AGC, in this case using milk pasteurized at 67 °C for 15 min.

2.3. Sampling

Cheeses were identified as G1W (cheese from grazing goats, producer 1, made in winter), G2W (cheese from grazing goats, producer 2, made in winter), S1W (cheese from stabled goats, producer 1, made in winter), S2W (cheese from stabled goats, producer 2, made in winter), G1S (cheese from grazing goats, producer 1, made in spring), G2S (cheese from grazing goats, producer 2, made in spring), S1S (cheese from stabled goats, producer 1, made in spring), S2S (cheese from stabled goats, producer 1, made in spring), and C

(commercial pasteurized goat cheese), resulting in a total of 9 cheeses sampled in triplicate over a period of less than a week between each collection. The cheeses were round and weighed approximately 300 g. The samples were kept and transported aseptically and stored at 4 °C. The cheeses were analyzed within the first 24 h.

2.4. Chemical Composition

The analyses were performed according to the Association of Analytical Communities [17]. The protein content was determined by the micro-Kjeldahl method (991.20), the ash content was determined through the gravimetric method (945.46), the fat content was determined through the Babcock method (989.04), the moisture content was determined by the oven-drying method (990.19), the pH was measured with a potentiometer (Hanna 211R), and the acidity was determined by the titration method (920.124). Mineral determination was carried out by X-ray fluorescence in a spectrometer (Epsilon 1 X-ray); then, the cheeses were lyophilized and ground, loaded into a sample holder coupled with a nylon plastic film (E. I. Du Pont de Nemours and Co., Wilmington, DE, USA), and irradiated at 1.5 mA using a 15 W high-stability side lamp at 50 KV. The Omnian software (version 2.2, Madrid, Spain) was used to process the data considering the ratio of ash to organic matter in the samples [18].

2.5. Texture Profile Analysis (TPA)

The TPA was carried out according to a modification of the methodology mentioned by Tomar et al. [19] using a Texture analyzer (Brookfield CT3 45000, Berwyn, PA, USA). All of the cheeses were cut into 2 cm^3 cubes and, in this case, a 50 mm cylindrical probe was used. The probe test speed was 10 mm/s. The samples were compressed to about 40% of their height with a 5 s space between the two compressions. The hardness (N), adhesiveness (mJ), cohesiveness, elasticity, chewiness (N), and gumminess (N) were calculated according to the TexturePro CT V1.9 software.

2.6. Microbiological Analysis

Microbiological tests were evaluated by the count plate method following the indications of the Bacteriological Analytical Manual (FDA) [20] for the quantification of the total coliforms (VRBA medium, 37 °C for 48 h), molds and yeasts (PDA medium, 25 °C, acidified at pH of 3.5 with tartaric acid for 5 days), as well as for *Staphylococcus aureus* (Baird–Parker agar supplemented with egg yolk tellurite at 37 °C for 48 h). LAB quantification was performed following the methodology mentioned by Cuevas et al. [21] in MRS agar incubating at 35–37 °C for 48 h.

2.7. Statistical Analysis

Statistical treatment of the data was performed under a completely randomized block design with three replications. Results were analyzed by an analysis of variance (ANOVA), and the treatment means were compared using Tukey's multiple-range test (p = 0.05) when necessary. In addition, planned orthogonal contrasts were performed to analyze the different factors, as follows: Contrast 1, "Seasonality": cheeses produced in winter versus cheeses produced in spring (G1W, G2W, S1W, and S2W versus G1S, G2S, S1S, and S2S); Contrast 2, "Feeding regimen": cheeses from grazing goats versus cheeses from stabled goats (G1W, G2W, G1S, and G2S versus S1W, S2W, S1S, and S2S); Contrast 3, "Manufacturing technology": commercial pasteurized goat cheese versus AGCs (C versus G1W, G2W, S1W, S2W, G1S, G2S, S1S, and S2S). The previous analyses were performed using Infostat software (version 10.0.22631, Madrid, Spain). Additionally, principal component analysis (PCA) and cluster analysis were performed using Infogen software (version 2011, Madrid, Spain).

3. Results and Discussion

3.1. Chemical Composition

Table 1 shows the chemical composition. The goat cheeses (AGCs and the control cheese "C") exhibited moisture contents exceeding 50% (*w*/*w*), classifying them as soft cheeses according to the categorization proposed by Lenoir et al. [22]. These cheeses were characterized by rennet action, being slow draining (with only cutting), and uncooked and unpressed. According to the Mexican regulation (NOM-223-SCFI/SAGARPA-2018) [23], the tested cheeses are classified as fresh cheeses, which are characterized by their high moisture and pH contents, being unripened, lacking a thin rind, and ready for consumption immediately after production. All of these characteristics result in a short shelf-life for these cheeses due to the presence of microorganisms in the raw milk [24].

The protein variable did not show significant differences between the cheeses produced in winter and those produced in spring (Seasonality, Contrast 1) (Table 2). However, significant differences were observed for the protein variable. In Contrast 2, cheeses derived from grazing goats exhibited a higher average protein percentage compared to those derived from stabled goats, with 14.51% and 13.35%, respectively. Similarly, in Contrast 3, the AGCs presented a higher protein content than the C cheese, with 13.93% and 10.81%, respectively. Referring to the Mexican regulation (NOM -223-SCFI/SAGARPA-2018) [23], which stipulates that cheeses marketed in Mexico should have a maximum moisture content of 80% and a minimum protein content of 10% (*w*/*w*), it could be explained that the milk used for the production of the C cheese, unlike the milk used in the artisan cheeses, may be standardized to meet the minimum percentage (10.81% *w*/*w*) established by the regulation. In a study conducted by Tadjine et al. [25] analyzing raw and pasteurized goat milk and cheeses, it was observed that the protein and fat contents were higher in pasteurized goat milk, while the ash content was higher in pasteurized cheeses. This suggests that pasteurization may increase the nutrient levels, likely attributable to the improved moisture retention within the cheese, a phenomenon observed in pasteurized milk that results in the enhanced retrieval of whey proteins and soluble solids [26]. However, in contrast to our findings, the AGCs showed a higher protein, fat (except for G2W, S1S, and S2S), and ash content. The average fat content was higher in the cheeses produced during the spring season, as well as in those derived from stabled goats, and the same pattern was observed for the ash content and the pH variable. Kucevic et al. [27] found that goat milk from traditional farming (full-time grazing) showed a higher fat content. Goats in this farming system were fed with corn stubble, soybean, turnips, alfalfa, and hay grass, and received a concentrate (approximately 20%) composed of soybean, corn, barley, and meal. Similarly, the feed for the stabled goats in the present study consisted of corn grains, soybean meal, alfalfa, and minerals. It can be explained that the feeding practices mentioned above contribute to higher levels of fat and minerals in the milk, and consequently in the cheeses.

The pH of the C cheese was inversely proportional to the lactic acid bacteria (LAB) content, as indicated in Tables 1 and 2. This is because the C cheese is produced by adding starter cultures under controlled conditions. On the other hand, this effect is not observed in the AGCs, as the pH value depends on factors such as the quantity and diversity of the initial LAB, the initial lactose content, and the fermentation conditions, which vary for each artisan cheese under study [28,29].

Table 1. Chemical and mineral composition, TPA and microbiological analysis of AGCs produced during two seasons of the year and a pasteurized goat cheese.

	Cheese								
	G1W	**G2W**	**S1W**	**S2W**	**G1S**	**G2S**	**S1S**	**S2S**	**C**
Physicochemical parameters									
Moisture (%)	53.15 ± 1.2 d ^{e}	50.92 ± 1.6 ^{f}	54.90 ± 0.6 $^{c\,d}$	54.02 ± 1.0 ^{d}	51.71 ± 0. 5 $^{e\,f}$	56.92 ± 0.3 $^{b\,c}$	64.35 ± 0.8 ^{a}	57.05 ± 0.2 ^{b}	62.87 ± 0.4 ^{a}
Protein (%)	18.25 ± 0.7 ^{a}	11.81 ± 0.3 $^{e\,f}$	12.05 ± 0.7 $^{d\,e\,f}$	12.75 ± 0.4 $^{c\,d\,e}$	14.38 ± 0.2 $^{b\,c}$	13.61 ± 0.8 $^{c\,d}$	12.71 ± 0.6 $^{c\,d\,e}$	15.90 ± 0.5 ^{b}	10.81 ± 0.5 ^{f}
Fat (%)	10 ± 0 ^{e}	14 ± 0 ^{c}	15 ± 0 ^{b}	15 ± 0 ^{b}	15 ± 0 ^{b}	16 ± 0 ^{a}	13 ± 0 ^{d}	13 ± 0 ^{d}	14 ± 0 ^{c}
Ash (%)	2.80 ± 0.10 ^{b}	2.71 ± 0.15 ^{b}	2.05 ± 0.03 ^{c}	2.53 ± 0.03 $^{b\,c}$	2.08 ± 0.1 ^{c}	3.46 ± 0.4 ^{a}	3.53 ± 0.3 ^{a}	4.01 ± 0.2 ^{a}	1.35 ± 0 ^{d}
Acidity (%)	0.69 ± 0.1 ^{c}	0.99 ± 0.1 ^{b}	0.21 ± 0.05 ^{d}	0.18 ± 0 ^{d}	0.27 ± 0 ^{d}	0.21 ± 0.1 ^{d}	0.15 ± 0.1 ^{d}	0.18 ± 0.1 ^{d}	1.71 ± 0.1 ^{a}
pH	5.77 ± 0.9 ^{e}	5.63 ± 0.5 ^{e}	6.17 ± 0.6 ^{d}	6.33 ± 0.2 ^{c}	6.33 ± 0.1 ^{c}	6.7 ± 0.1 $^{a\,b}$	6.8 ± 0.1 ^{a}	6.23 ± 0.1 ^{c}	4.1 ± 0.1 ^{f}
Ca (%)	1.49 ± 0.2 $^{b\,c\,d}$	1.42 ± 0.07 $^{c\,d}$	1.25 ± 0.02 $^{d\,e}$	1.54 ± 0.02 $^{b\,c\,d}$	0.94 ± 0 ^{e}	1.88 ± 0.2 ^{b}	1.67 ± 0.1 $^{b\,c}$	2.36 ± 0.1 ^{a}	0.23 ± 0 ^{f}
P (%)	0.40 ± 0.01 ^{b}	0.27 ± 0.02 $^{b\,c}$	0.23 ± 0 e	0.30 ± 0 ^{d}	0.27 ± 0 $^{d\,e}$	0.37 ± 0 $^{a\,b}$	0.33 ± 0 ^{a}	0.48 ± 0 ^{a}	0.11 ± 0 ^{f}
K (%)	0.20 ± 0.02 $^{d\,e}$	0.28 ± 0.02 $^{b\,c}$	0.23 ± 0 $^{c\,d}$	0.26 ± 0 $^{c\,d}$	0.14 ± 0 ^{e}	0.34 ± 0 $^{a\,b}$	0.38 ± 0 ^{a}	0.36 ± 0 ^{a}	0.27 ± 0 ^{c}
S (%)	0.17 ± 0.01^{a}	0.12 ± 0.01 ^{c}	0.11 ± 0 $^{c\,d}$	0.12 ± 0 ^{c}	0.11 ± 0 $^{c\,d}$	0.15 ± 0 $^{a\,b}$	0.13 ± 0 $^{b\,c}$	0.16 ± 0 $^{a\,b}$	0.08 ± 0 ^{d}
Cl (%)	0.12 ± 0.01 ^{d}	0.6 ± 0.04 ^{b}	0.21 ± 0 $^{c\,d}$	0.29 ± 0 ^{c}	0.09 ± 0 ^{d}	0.69 ± 0.1 ^{b}	1.0 ± 0.1 ^{a}	0.63 ± 0 ^{b}	0.57 ± 0 ^{b}
Texture parameters									
Hardness (N)	8.25 ± 0.05 ^{b}	4.27 ± 0.8 $^{c\,d}$	3.58 ± 0.55 $^{c\,d}$	6.49 ± 0.16 $^{b\,c}$	14.35 ± 1.38 ^{a}	14.08 ± 2.34 ^{a}	13.01 ± 1.3 ^{a}	3.28 ± 0.14 ^{d}	4.13 ± 0.99 $^{c\,d}$
Adhesiveness (mj)	0.19 ± 0.17 ^{a}	0.5 ± 0.23 ^{a}	0.44 ± 0.6 ^{a}	0.16 ± 0.04 ^{a}	0.06 ± 0.09 ^{a}	0.27 ± 0.31 ^{a}	0.08 ± 0.08 ^{a}	0.12 ± 0.04 ^{a}	0.35 ± 0.20 ^{a}
Elasticity	0.93 ± 0.01 ^{a}	0.88 ± 0.06 ^{a}	0.93 ± 0.02 ^{a}	0.92 ± 0.02 ^{a}	0.95 ± 0 ^{a}	0.91 ± 0.04 ^{a}	0.95 ± 0.01 ^{a}	0.93 ± 0.01 ^{a}	0.56 ± 0.08 ^{b}
Cohesiveness	0.80 ± 0.04 ^{a}	0.71 ± 0.12 ^{a}	0.68 ± 0.17 ^{a}	0.74 ± 0.02 ^{a}	0.75 ± 0.02 ^{a}	0.72 ± 0.07 ^{a}	0.81 ± 0.02 ^{a}	0.86 ± 0.03 ^{a}	0.36 ± 0.04 ^{b}
Chewiness (N)	6.24 ± 0.30 ^{b}	2.88 ± 0.87 ^{c}	2.56 ± 0.07 $^{c\,d}$	4.93 ± 0.35 ^{b}	10.18 ± 1.01 ^{a}	9.12 ± 1.18 ^{a}	9.92 ± 0.85 ^{a}	2.64 ± 0.03 $^{c\,d}$	0.80 ± 0.01 ^{d}
Gumminess (N)	6.55 ± 0.36 $^{a\,b\,c}$	2.97 ± 0.84 $^{c\,d}$	2.77 ± 0.07 $^{c\,d}$	5.01 ± 0.18 b $^{c\,d}$	10.72 ± 1.06 ^{a}	9.97 ± 1.03 ^{a}	10.48 ± 0.87 ^{a}	7.83 ± 4.1 $^{a\,b}$	1.45 ± 0.21 ^{d}
Microbiological Counts (Log cfu g^{-1})									
Total coliforms	7.5 ± 0.05 ^{a}	5.40 ± 0.03 ^{c}	1 ± 0 ^{h}	1.5 ± 0.20 ^{g}	4.50 ± 0.03 ^{e}	4.50 ± 0.2 ^{e}	5.96 ± 0.02 ^{b}	4.89 ± 0.04 ^{d}	3.76 ± 0.06 ^{f}
Mold and yeast	7.52 ± 0.05 ^{a}	7.42 ± 0.05 ^{a}	2.39 ± 0.03 ^{g}	4.85 ± 0.01 ^{d}	5.59 ± 0.02 ^{b}	3.74 ± 0.26 ^{f}	5.25 ± 0.02 ^{c}	4.98 ± 0.07 $^{c\,d}$	4.12 ± 0.12 ^{e}
Staphylococcus	6.53 ± 0.06 ^{e}	5.73 ± 0.11 $^{a\,b}$	2.16 ± 0.16 ^{e}	4.72 ± 0.02 $^{b\,c\,d}$	5.39 ± 0.05 $^{a\,b\,c}$	5.50 ± 0.04 $^{a\,b\,c}$	3.62 ± 1.62 $^{d\,e}$	4.98 ± 0.07 $^{b\,c\,d}$	4.09 ± 0.09 $^{c\,d}$
LAB	4.67 ± 0 ^{e}	6.07 ± 0.04 ^{c}	1.77 ± 0.0 ^{g}	4.06 ± 0.06 ^{f}	6.24 ± 0.10 $^{b\,c}$	6.31 ± 0.03 ^{b}	6.34 ± 0.05 ^{b}	5.05 ± 0.10 ^{d}	6.82 ± 0.07 ^{a}

The values represent the averages ± standard deviation (n = 3). Different letters for the same parameter indicate significant differences ($p \leq 0.05$) among cheeses. Where: cheese from grazing goats, producer 1, made in winter (G1W); cheese from grazing goats, producer 2, made in winter (G2W); cheese from stabled goats, producer 1, made in winter (S1W); cheese from stabled goats, producer 2, made in winter (SCW); cheese from grazing goats, producer 1, made in spring (G1S); cheese from grazing goats, producer 2, made in spring (G2S); cheese from stabled goats, producer 1, made in spring (S1S); cheese from stabled goats, producer 2, made in spring (S2S) and commercial pasteurized goat cheese (C).

Table 2. Planned orthogonal contrasts of the chemical composition, TPA, and microbiological analysis of the AGCs produced during two seasons of the year and a pasteurized goat cheese.

	Cheese Population		
	Seasonality Contrast 1	**Feeding Regiment Contrast 2**	**Manufacturing Technology Contrast 3**
	G1W, G2W, S1W, and S2W vs. G1S, G2S, S1S, and S2S	**G1W, G2W, G1S, and G2S vs. S1W, S2W, S1S, and S2S**	**C vs. G1W, G2W, S1W, S2W, G1S, G2S, S1S, and S2S**
Physicochemical parameters			
Moisture (%)	53.25 vs. 57.51 **	53.18 vs. 57.58 **	62.87 vs. 55.38 **
Protein (%)	ns	14.51 vs. 13.35 **	10.81 vs. 13.93 **
Fat (%)	13.5 vs. 14.25 **	13.75 vs. 14 **	14 vs. 13.88 **
Ash (%)	2.52 vs. 3.27 **	2.76 vs. 3.03 **	1.35 vs. 2.9 **
Acidity (%)	0.52 vs. 0.20 **	0.54 vs. 0.18 **	1.71 vs. 0.36 **
pH	5.98 vs. 6.52 **	6.11 vs. 6.38 **	4.1 vs. 6.25 **
Ca (%)	1.42 vs. 1.71 **	1.43 vs. 1.70 **	0.23 vs. 1.57 **
P (%)	0.30 vs. 0.36 **	ns	0.11 vs. 0.33 **
K (%)	0.24 vs. 0.30 **	0.24 vs. 0.31 **	ns
S (%)	ns	0.14 vs.0.13 *	0.08 vs. 0.14 **
Cl (%)	0.31 vs. 0.60 **	0.38 vs. 0.53 **	0.57 vs. 0.45 **
Texture parameters			
Hardness (N)	5.65 vs. 11.18 **	10.24 vs. 6.59 **	4.13 vs. 8.41 **
Adhesiveness (mj)	ns	ns	ns
Elasticity	ns	ns	0.56 vs. 0.93 **
Cohesiveness	0.73 vs. 0.79 *	ns	0.36 vs. 0.76 **
Chewiness (N)	4.15 vs. 7.97 **	7.11 vs. 5.01 **	0.80 vs. 6.06 **
Gumminess (N)	4.33 vs. 9.75 **	ns	1.45 vs. 7.04 **
Microbiological counts			
Total coliforms (Log cfu g^{-1})	3.69 vs. 4.96 **	5.32 vs. 3.34 **	3.76 vs. 4.33 **
Molds and yeast (Log cfu g^{-1})	5.55 vs. 4.89 **	6.07 vs. 4.37 **	4.12 vs. 5.22 **
Staphylococcus (Log cfu g^{-1})	ns	5.79 vs. 3.87 **	4.09 vs. 4.83 *
LAB (Log cfu g^{-1})	4.14 vs. 5.99 **	5.82 vs. 4.30 **	6.82 vs. 5.06 **

Means are significantly different at $p \leq 0.05$ and $p \leq 0.01$ when followed by * or ** in the same row, respectively; ns: not significant. Cheeses are as follows: cheese from grazing goats, producer 1, made in winter (G1W); cheese from grazing goats, producer 2, made in winter (G2W); cheese from stabled goats, producer 1, made in winter (S1W); cheese from stabled goats, producer 2, made in winter (SCW); cheese from grazing goats, producer 1, made in spring (G1S); cheese from grazing goats, producer 2, made in spring (G2S); cheese from stabled goats, producer 1, made in spring (S1S); cheese from stabled goats, producer 2, made in spring (S2S); commercial pasteurized goat cheese (C).

The mineral composition (Table 1) shows the predominant elements found in the cheeses under study, consistent with the naturally high presence of these elements in goat milk, as reported by Park [30]. These findings are in line with the results reported by Ledesma et al. [31], demonstrating that calcium (Ca) and phosphorus (P) are the minerals associated with fresh cheeses from the Palermo region, Italy. Herman et al. [32] analyzed goat cheeses from the humid region of Yucatán, México, located in the southern part of the country. The goats were fed with a diet primarily consisting of bejuco (*Cissu verticillata*), king grass (*Saccharum sinense*), orange bagasse (*Citrus sinensis*), alfalfa (*Medicago sativa*), corn stubble (*Zea mays*), and acorns (*Quercus ilex*). These authors found calcium (Ca) and potassium (K) to be the major minerals, with concentrations of 0.69% and 0.11%, respectively. In contrast, the present study yielded average concentrations of 1.57% and 0.27% for these same elements in the AGCs. It is important to note that the livestock in this study were fed with a diet consisting of alfalfa, corn, soybean meal, and commercial supplement, while the

grazing livestock primarily consumed plants from the semi-desert region, such as sweet acacia (*Acacia* spp.), mesquite (*Prosopis laevigata*), creosote bus (*Larrea tridentata*), and alkali sacaton grass (*Sporobolus airoides*) [33,34]. These plants grow in calcareous soils, resulting in a higher mineral concentration. Our findings align with those of other researchers, such as Armienta [35], who reported concentrations of Ca, P, and Mg at 1.03, 0.09, and 0.09%, respectively, in these types of plants. This correlation supports the notion that variations in the mineral content are influenced by factors including the types of feed and soil characteristics, feeding practices, production season, and manufacturing technology.

According to the manufacturing technology, the highest concentration of Ca was observed in the AGCs in Contrast 3 (Table 2), produced during the spring season from livestock from the stables. This is a result of the mineral supplementation given to the livestock that the S1 and S2 cheeses are derived from. On the other hand, Ca was affected by various technological processes. A storage temperature below 10 °C can damage calcium caseinate [36], while prolonged exposure to severe heating above 90 °C can reduce the concentration of soluble calcium by up to 20% [37]. These factors may likely explain why cheese "C" exhibits the lowest calcium content. Phosphorus (P), potassium (K), and sulfur (S) did not exhibit significant differences between Contrasts 2, 3, and 1, respectively. However, variations in the chloride (Cl) content among the cheeses are likely attributed to the salting process of the curds.

3.2. TPA Analysis

The Texture Profile Analysis (TPA) of the nine cheeses under study (Table 1) did not show a significant difference for the adhesiveness variable, which represents the work required to overcome the attractive force between the surface of a food and the surface of other materials with which the food comes into contact [38]. McMahon et al. [39] mentioned that low-fat cheeses with a Ca content of 0.6% exhibited a low adhesiveness; conversely, cheeses with higher moisture contents and lower levels of this mineral showed increased adhesiveness. These findings contrast with the results obtained in the present study. The lowest hardness index was observed in the cheeses with the lowest protein content, while the fat content did not appear to have an influence on this variable (Table 1). In contrast, Álvarez et al. [40], after analyzing the texture of Canarian goat cheeses, found a positive correlation between the hardness and fat contents. Protein interactions have a similar impact on cheese hardness as fat does, with a high protein content being an indicator of hardness in cheeses [41]. On the other hand, the AGCs exhibited the highest hardness compared to cheese C (Contrast 3), especially when they were produced during the spring season (Contrast 1) and when sourced from stabled goats (Contrast 2). This finding aligns with Contrasts 2 and 3 for the protein variable (Table 2) and confirms a positive relationship between both variables for this type of cheese.

Like hardness, the same behavior was observed for chewiness, which is strongly related to the previous variable, as it is defined as the mechanical work before swallowing the cheese. Therefore, greater hardness corresponds to greater chewiness. This trend is according to the results obtained by Álvarez et al. [41]. Elasticity and cohesiveness were found to be statistically different between the AGCs and the C cheese. Additionally, gumminess showed no statistical difference between the cheeses sourced from grazing cattle and those sourced from stabled cattle. However, significant differences were observed in the rest of the contrasts, as shown in Table 2.

Cheese acidity directly impacts the pH. When the pH is higher than the isoelectric point (4.4–5.7), caseins acquire a negative charge, resulting in repulsion between the protein aggregates. This leads to an increased water absorption capacity in the cheese, resulting in a less compact texture and increased elasticity [42]. As the elasticity of the cheeses increases, so does the cohesiveness, as the resistance to the deformation of the food increases due to the flexibility bonds [43]. Moreover, free Ca promotes the binding of casein in the protein network of the curd [41], which may explain why the AGCs, which have a higher content of this mineral, also exhibit higher elasticity and cohesiveness compared to cheese C, which

had a lower amount of Ca. In this study, gumminess showed a relatively similar behavior to the chewiness, which agrees with the finding reported by Diezhandino et al. [44] after analyzing the texture of Spanish blue cheese.

By integrating the results of both the physicochemical composition and TPA, Figure 2 displays the principal component analysis, revealing correlations among the variables studied for this type of cheese. In the biplot, CP1 accounts for 49.5% of the variance, while CP2 explains 17.7% of the variance, together totaling 67.2% of the total variance of the cheeses under study. CP1 is positively influenced by S1S, S2S, and G2S, characterized by higher ash and gumminess contents. G1W and G1S were characterized by higher protein and elasticity contents, as well as a lower fat content, and negatively affected by G2W, S1W, and C, characterized by high acidity and adhesiveness. On the other hand, cheese S2W was the most balanced cheese under study according to the studied variables. In CP2, the S1S, S2S, G2S, and C cheeses aligned positively, while the S1W, S2W, G1S, and G1W cheeses aligned negatively. For this component, cheese G2W exhibited a balance in the studied variables. The biplot also shows that the acidity and adhesiveness variables were close, as were the pH, gumminess, P, and hardness and chewiness variables. A relative closeness was observed between protein and elasticity, fat and moisture, and ash, calcium, and P, as well as between Cl and K. On the other hand, the fat and protein variables were positioned at opposite points, as well as between the pH and acidity.

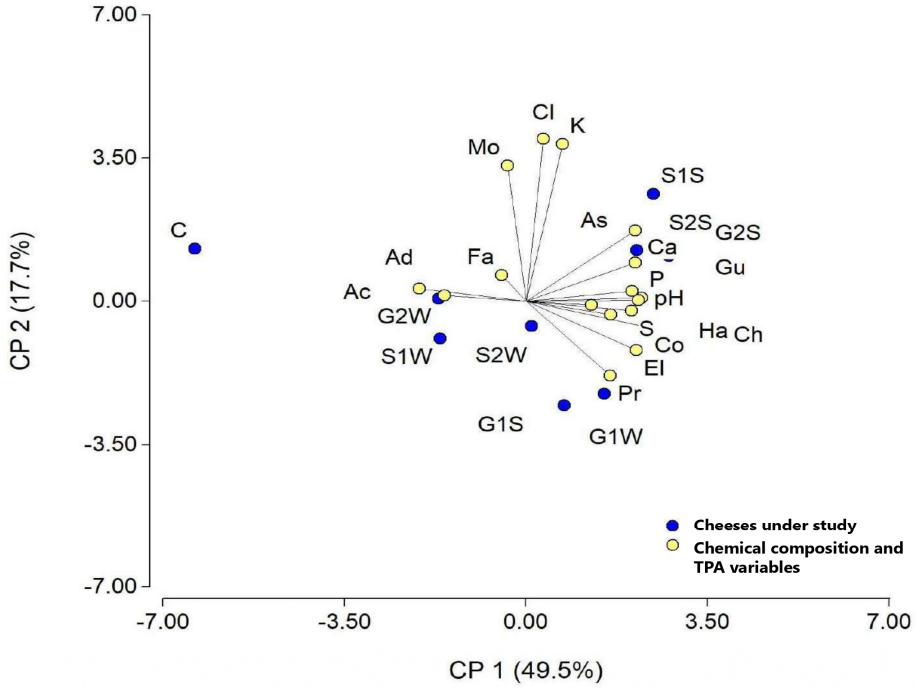

Figure 2. Principal component analysis of the chemical composition and TPA of the AGCs and a commercial pasteurized goat cheese. Mo: moisture, Pr: protein, Fa: fat, As: ash, Ac: acidity, pH: pH, Ca: calcium, P: phosphorus, K: potassium, S: sulfur, Cl: chorine, Ha: hardness, Ad: adhesiveness, El: elasticity, Co: cohesiveness, Ch: chewiness, Gu: gumminess; G1W: cheese from grazing goats, producer 1, made in winter; G2W: cheese from grazing goats, producer 2, made in winter; S1W: cheese from stabled goats, producer 1, made in winter; S2W: cheese from stabled goats, producer 2, made in winter; G1S: cheese from grazing goats, producer 1, made in spring; G2S: cheese from grazing goats, producer 2, made in spring; S1S: cheese from stabled goats, producer 1, made in spring; S2S: cheese from stabled goats, producer 2, made in spring; C: commercial pasteurized goat cheese.

The cluster analysis that showed the highest cophenetic correlation coefficient (0.970) with the Positive Matching Cluster Distance is shown in Figure 3. It can be observed that the AGCs produced in the winter season are more diverse in terms of the studied variables compared to those produced in spring. Using a separation threshold of 70%, six distinct

groups can be identified. The cheeses with the highest similarity are S1S and G2S, which are approximately 50% apart. These cheeses are statistically similar in the physicochemical variables of protein, ash, acidity, pH, Ca, P, K, and S. Regarding texture, they are statistically similar in all of the studied variables. This similarity can be explained by the fact that, in spring, the nutrient content of the native pastures that feed the grazed goats has a different composition, being higher in protein at the beginning of summer, as reported by Reyes-Estrada et al. [45], while the diet of the stabled goats remains constant throughout the year. Joining them at 60% is cheese S2S. Further along, at 70% of the distance, cheese G1W is grouped, followed by G1S at 78% and S2W at 86%. Finally, cheese S1W joins this group at an approximate distance of 92%. Cheeses G2W and C show the greatest differences with the variables under study, as they are joined at the furthest distance. Walstra et al. [41] indicated that, rather than the original composition of the cheeses, aspects such as the technology applied during cheese production, the presence of lactic acid bacteria either in the milk or in the starter cultures, as well as the ripening conditions have a greater impact on the cheese texture.

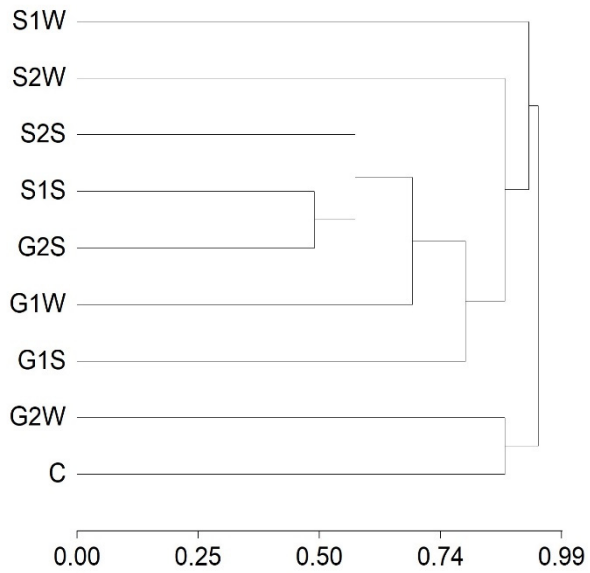

Figure 3. Dendrogram of the Euclidian distance of the chemical composition and TPA of the AGCs and a commercial pasteurized goat cheese. G1W: cheese from grazing goats, producer 1, made in winter; G2W: cheese from grazing goats, producer 2, made in winter; S1W: cheese from stabled goats, producer 1, made in winter; S2W: cheese from stabled goats, producer 2, made in winter; G1S: cheese from grazing goats, producer 1, made in spring; G2S: cheese from grazing goats, producer 2, made in spring; S1S: cheese from stabled goats, producer 1, made in spring; S2S: cheese from stabled goats, producer 2, made in spring; C: commercial pasteurized goat cheese.

3.3. Microbiological Analysis

The counts of different microbial groups are shown in Table 1. It is worth noting that the Mexican regulation (NOM-243-SSA1-2010) [46] establishes a maximum allowable limit of 2, 2.69, and 3 Log cfu g^{-1} for total coliforms, molds and yeasts, and *Staphylococcus*, respectively. However, no limit is set for LAB (lactic acid bacteria) due to their beneficial nature. In this regard, cheese S1W complies with the specifications established for this type of cheese, while the rest of the analyzed cheeses exceed the permitted specifications for the analyzed microbial groups. Hacène et al. [47] reported slightly higher values for LAB (8.37 log cfu g^{-1}) and lower values for total coliform bacteria (2.48 log cfu g^{-1}) and molds and yeasts (4.4 log cfu g^{-1}) in Bouhezza cheese made with raw goat's milk compared to the results obtained in this study. Bouhezza cheese is prepared using raw goat's milk that was previously acidified for 24–36 h, which implies a higher development of LAB prior to its production.

On the other hand, Gursoy et al. [48] reported a range from 7.1 to 8.5 log cfu g^{-1} for lactobacilli and between 1.0 and 4.8 log cfu g^{-1} for molds and yeasts present in Söğle cheese, which is a type of traditional Tulum cheese made with goat's skin bag. This cheese undergoes a different production process that includes the maturation of the curd for a period of 3 months, which promotes the development of acidity by LAB. Acidity (1.4–2.6%) controls the growth of microorganisms such as molds and yeasts. The above information suggests that a maturation period for Coahuila AGC would improve its microbiological quality if allowed. Additionally, it can be inferred from the above that the amount of different microbial groups is dependent on the technological characteristics under which the cheese is produced.

Table 2 shows the different contrasts established for the microbiological study of the tested cheeses, where it can be observed that, except for the counts of *Staphylococcus*, the rest of the microbial groups showed higher levels in the AGCs produced during the spring season, most likely due to environmental conditions, since the cheesemaking region registers an average temperature of 30 °C during the spring season [49], and this factor encourages the proliferation of microorganisms. On the other hand, being an artisan cheese manipulated directly by cheesemakers during the salting, molding, and unmolding processes, it is highly likely that contamination by *Staphylococcus* occurs. This pathogen is mainly transmitted by food handlers and contact with surfaces [50], which is why it is present in the cheeses regardless of the season of production. These findings agree with those results mentioned by Rozos et al. [51], who analyzed goat milk from two types of farming systems (group A: stabled, fed with concentrates and hay, and milked in milking parlors; group B: grazing throughout the day with manual milking). Samples from group B exhibited counts of this microorganism for four out of the six months sampled, compared to group A, which only showed the presence in two of the sampled months. Similarly, Wanniatie et al. [52] analyzed the bacterial groups present in organic goat milk (from grazing goats) and milk obtained from conventional farms (without specifying the production conditions), and found higher counts in the organic milk compared to the conventional milk for *S. aureus*, Enterobacteriaceae, and coliforms. Although the livestock from which the cheeses in this study were derived were all manually milked, grazing livestock have greater contact between the udder and various surfaces, which could explain the higher microbial counts. This, along with the handling and manufacturing practices of the cheeses, may contribute to the observed differences.

Additionally, the AGCs showed higher levels of microbial groups compared to the C cheese, except for the LAB group. This is because the C cheese is made with pasteurized milk and the addition of starter cultures (the species is not specified), ensuring a high presence of this microbial group. However, despite the high presence of LAB in the C cheese, which generates a higher acidity, and the pasteurization process that guarantees a reduction in the pathogenic bacteria in most cases, this cheese still presents microbial levels outside of the legal limits, thus making it equally unsafe for consumption as with the AGCs. This could be explained by the possible re-contamination after the manufacturing process, possibly during the packaging, where it is handled by humans again. Villegas et al. [16] state that pasteurization without proper post-processing aseptic precautions does not exclude food contamination, as a complementary technological package is required to ensure the safety of the cheese. The same authors also indicated that cheeses made with pasteurized milk, in the event of possible re-contamination, provide a more conducive environment for the proliferation of coliforms and pathogens compared to raw milk of good sanitary quality and its cheeses, where microbial consortia, mainly LAB, tend to inhibit pathogenic microbiota.

4. Conclusions

This study reveals how factors such as goat feeding, the production season, and the manufacturing process significantly affect the nutritional quality of artisanal goat cheeses (AGCs), surpassing commercial pasteurized cheeses (C) in protein, fat, and mineral contents.

This research demonstrates that these nutritional differences have a direct impact on the physical characteristics of the cheese, such as the hardness, adhesiveness, and cohesiveness, which are, respectively, related to the protein content, acidity, and pH.

Seven of the analyzed AGCs and cheese C do not comply with the current national sanitary regulations, except for the S1W cheese. These results indicate an urgent need to improve the hygiene practices on farms and during the manufacturing process for all of the producers who participated in this study to ensure the safety of the AGCs. Furthermore, the results suggest that optimizing the manufacturing process could assist artisanal producers in meeting the regulations without sacrificing the distinctive qualities of their products. By addressing these challenges, AGC producers can enhance the quality and safety of their products, thereby benefiting consumers.

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References

1. Skapetas, B.; Bampidis, V. Goat production in the world: Present situation and trends. *Livest. Res. Rural. Dev.* **2016**, *28*, 200.
2. Pozzolan, M.; Stocco, G.; Dettori, M.; Bittante, G.; Vacca, G. Effect of goat milk composition on cheesemaking traits and daily cheese production. *J. Dairy Sci.* **2019**, *102*, 3947–3955.
3. Rangel OS, C.; Campos ML, G.; Charles RA, V.; Chávez GM, L.; Palomo, L.L.; Contreras EJ, C.; Solanilla DJ, F.; Flores GA, C.; Rodríguez, H.R. Biological control of pathogens in artisanal cheeses. *Int. Dairy J.* **2023**, *140*, 105612. [CrossRef]
4. Abd El-Salam, M.H.; El-Shibiny, S. Conjugated Linoleic Acid in Milk from Grazing and Non-Grazing Dairy Goats. *J. Food Sci.* **2019**, *84*, S1448–S1456.
5. Caroprese, M.; Marzano, A.; Marino, R.; Gliatta, G.; Muscio, A.; Sevi, A. Effects of Grazing and Indoor Feeding on Milk Quality and Immune Function in Dairy Goats. *J. Dairy Res.* **2018**, *85*, 147–155.
6. Mele, M.; Buccioni, A.; Petacchi, F.; Antongiovanni, M. Effect of forage-to-concentrate ratio on milk composition and fatty acid profile in stall-fed goats. *J. Dairy Sci.* **2022**, *105*, 5123–5134.
7. Sanz Sampelayo, M.R.; Chilliard, Y.; Schmidely, P.; Boza, J. Influence of type of diet on the fat constituents of goat and sheep milk. *Small Rumin. Res.* **2021**, *40*, 45–70. [CrossRef]
8. Ramos, P.A.; Barreira, J.C.; Fernandes, Â.; Pereira, J.A.; Ferreira, I.C.; Sarmento, B. Influence of season on the characteristics of cheese from goat milk. *J. Dairy Sci.* **2023**, *106*, 2510–2521.
9. Sanz Sampelayo, M.R.; Chilliard, Y.; Schmidely, P.; Boza, J. Seasonal variations in the sensory properties of goat cheese. *J. Food Sci.* **2021**, *86*, S1448–S1456.
10. Montel, M.C.; Buchin, S.; Mallet, A.; Delbes-Paus, C.; Vuitton, D.A.; Desmasures, N.; Berthier, F. Seasonal variations in the prevalence of Listeria monocytogenes in goat cheese. *Int. J. Food Microbiol.* **2022**, *279*, 77–87.
11. Quigley, L.; O'Sullivan, O.; Beresford, T.P.; Ross, R.P.; Fitzgerald, G.F.; Cotter, P.D. Seasonal variations in the prevalence of Salmonella spp. in goat milk. *J. Dairy Sci.* **2023**, *106*, 2510–2521.
12. Renes, E.; González, L.; Fresno, J.M.; Tornadijo, M.E.; Prieto, B. Seasonal changes in the microbial composition of artisanal cheeses. *Food Microbiol.* **2023**, *74*, 103–112.
13. Legg, A.K.; Carr, A.J.; Bennett, R.J.; Johnston, K.A. Cheese: Chemistry, physics and microbiology. In *Book General Aspects of Cheese Technology*, 4th ed.; McSweeney, L.H., Fox, P.F., Cotter, P.D., Everett, D.W., Eds.; Academic Press: San Diego, DA, USA, 2017; Volume 1, p. 643e675.
14. Yoon, Y.; Lee, S.; Choi, K.H. Microbial benefits and risks of raw milk cheese. *Food Control* **2016**, *63*, 201–215. [CrossRef]

15. EC. Regulation (EC) No. 853/2004 of the European Parliament and of the Council Laying Down Specific Hygiene Rules for the Hygiene of Foodstuffs. UNEP Law and Environment Assistance Platform (n.d.). 2004. Available online: https://leap.unep.org/countries/eu/national-legislation/regulation-ec-no8532004-european-parliament-and-council-laying (accessed on 11 September 2022).
16. Villegas de Gante, A.; Santos, M.A.; Cervantes, E.F. *Los Quesos Mexicanos Tradicionales*, 1st. ed.; Juan, P., Ed.; Universidad Autonoma de Chapingo: El Cooperativo, Mexico, 2016; ISBN 978-607-711-364-5.
17. AOAC. *Official Methods of Analysis*, 15th ed.; Kenneth, H., Ed.; Association of official Analytical Chemists, Inc: Arlington, VA, USA, 1990; Volume 1, pp. 69–80, ISBN 0-935584-42-0.
18. Garcia OJ, D.; Flores GA, C.; Espinoza, V.J.; Ascacio VJ, A.; Nery FS, D.; Rodríguez, H.R. Morphological, physicochemical, techno-functional, phytochemical, and antioxidant evaluation of polyembryonic and non-polyembryonic maize sprouts. *Biocatal. Agric. Biotechnol.* **2023**, *47*, 102583.
19. Tomar, O.; Akarca, G.; Gök, V.; Çağlar, M.Y. The effects of packaging materials on the fatty acid composition, organic acid content, and texture profiles of Tulum cheese. *J. Food Sci.* **2020**, *85*, 3134–3140. [CrossRef] [PubMed]
20. Food and Drug Administration (US). Bacteriological Analytical Manual (BAM). Laboratory Methods. Available from: Bacteriological Analytical Manual (BAM) FDA. Available online: https://www.fda.gov/food/laboratory-methods-food/bacteriological-analytical-manual-bam (accessed on 11 September 2021).
21. Cuevas GP, F.; Heredia, C.P.Y.; Méndez RJ, I.; Hernández, M.A.; Reyes, D.R.; Vallejo, C.B.; González, C.A.F. Artisanal Sonoran cheese (Cocido cheese): An exploration of its production process, chemical composition and microbiological quality. *J. Sci. Food Agric.* **2017**, *97*, 4459–4466. [CrossRef] [PubMed]
22. Lenoir, J.; Lambert, G.; Schmidt, J.L.; Tourneur, C. La maîtrise du bioréacteur fromage. *Biofutur* **1985**, *41*, 23–50.
23. Norma Oficial Mexicana NOM-223-SCFI/SAGARPA-2018, Queso-Denominacion, Especificaciones, Información Comercial y Métodos de Prueba. Available online: https://www.dof.gob.mx/normasOficiales/6973/seeco11_C/seeco11_C.html (accessed on 9 September 2021).
24. Saxer, S.; Miescher, S.S.; Lacroix, C. Characterization of the microflora of industrial Mexican cheeses produced without added chemical preservatives. *LWT* **2013**, *53*, 314–320. [CrossRef]
25. Tadjine, D.; Boudalia, S.; Bousbia, A.; Khelifa, R.; Mebirouk, B.L.; Tadjine, A.; Chemmam, M. Pasteurization effects on yield and physicochemical parameters of cheese in cow and goat milk. *Food Sci. Technol.* **2020**, *40*, 580–587. [CrossRef]
26. Lucey, J.; Kelly, J. Cheese yield. *Int. J. Dairy Technol* **1994**, *47*, 1–14. [CrossRef]
27. Kucevic, D.; Pihler, I.; Plaversusic, M.; Vukovic, T. The composition of goat milk in different types of farmings. *Biotechnol. Anim. Husb.* **2016**, *32*, 403–412. [CrossRef]
28. Plessas, S.; Bosnea, L.; Psarianos, C.; Koutinas, A.A.; Marchant, R.; Banat, I.M. Lactic acid production by mixed cultures of *Kluyveromyces marxianus*, *Lactobacillus delbrueckii* ssp. bulgaricus and *Lactobacillus helveticus*. *Bioresour. Technol.* **2008**, *99*, 5951–5955. [CrossRef] [PubMed]
29. Rossetti, L.; Fornasari, M.E.; Gatti, M.; Lazzi, C.; Neviani, E.; Giraffa, G. Grana Padano cheese whey starters: Microbial composition and strain distribution. *Int. J. Food Microbiol.* **2008**, *127*, 168–171. [CrossRef] [PubMed]
30. Park, Y.W. Goat Milk—Chemistry and Nutrition. In *Handbook of Milk of Non-Bovine Mammals*; John Wiley & Sons, Ltd.: Hoboken, NJ, USA, 2017; pp. 42–83.
31. Ledesma, L.; Fresno, M.; Álvarez, S.; Darias, J.; Rodríguez, E.; Díaz, C. Cambios de la composición mineral de quesos de cabra en función de la dieta y el cuajo usado. *Arch. Zootec.* **2007**, *56*, 719–723.
32. Herman, L.E.; Bolóivar, M.D.; Toledo, L.V.M.; Cuevas GL, F.; Lope NM, C.; Barron ZJ, A.; Díaz, R.P.; Ramírez, R.E. Minerals multi-element analysis and its relationship with geographical origin of artisanal Mexican goat cheeses. *Food Sci. Technol. Int.* **2019**, *39*, 517–525. [CrossRef]
33. Suárez, C.C.G. Un Queso con Historia. Bordeando el Monte 58. Secretaria del Medio Ambiente. Available online: https://sma.gob.mx/wp-content/uploads/2021/09/Bordeando_58.pdf (accessed on 7 January 2023).
34. Maldonado JJ, A.; Granados RL, D.; Hernández, M.O.; Pastor LF, J.; Isidro RL, M.; Salinas, G.H.; Torres, H.G. Uso de un alimento integral como complemento a cabras locales en pastoreo: Respuesta en producción y composición química de la leche. *Nova Sci.* **2017**, *9*, 55–75.
35. Armienta, T.; Gilberto, T. Perfil Mineral del Suelo, Forraje y Tejidos del Ganado en Agostaderos del Estado de Nuevo León. Doctoral Dissertation, Universidad Autónoma de Nuevo León, San Nicolás de los Garza, Mexico, 1995. Available online: http://eprints.uanl.mx/id/eprint/5657 (accessed on 22 March 2022).
36. Chacón, V.A. Aspectos nutricionales de la leche de cabra (*Capra hircus*) y sus variaciones en el proceso agroindustrial. *Agron. Mesoam.* **2005**, *16*, 239–252. [CrossRef]
37. Raynal, K.; Remuf, F. The Effect of heating on physicochemical and renneting properties of milk, a comparison between caprine, ovine and bovine milk. *Int. Dairy J.* **1998**, *8*, 695–706. [CrossRef]
38. Pavia, M.; Trujillo, A.J.; Guamis, B.; Ferragut, V. Evolución de la composición y textura de un queso de oveja en la maduración. *Alimentaria* **1999**, *306*, 43–47.
39. McMahon, D.J.; Paulson, B.; Oberg, C.J. Influence of Calcium, pH, and Moisture on Protein Matrix Structure and Functionality in Direct-Acidified Nonfat Mozzarella Cheese. *J. Dairy Sci.* **2005**, *88*, 3754–3763. [CrossRef] [PubMed]

40. Álvarez, S.; Rodríguez, V.; Ruiz, M.E.; Fresno, M. Correlaciones de textura y color instrumental con la composición química de quesos de cabra canarios. *Arch. Zootec.* **2007**, *56*, 663–666.
41. Walstra, P.; Geurts, T.J.; Noomen, A.; Jellema, A.; Van Boekel MA, J.S. *Dairy Technology: Principles of Milk: Properties and Processes*, 1st ed.; Marcel Dekker: New York, NY, USA, 1999; Chapter 1.
42. Adda, J.; Gripon, J.C.; Vassal, L. The chemistry of flavour and texture generation in cheese. *Food Chem.* **1982**, *9*, 115–129. [CrossRef]
43. Guzmán, L.E.; Tejada, C.; de la Ossa, Y.J.; Rivera, C.A. Análisis comparativo de perfiles de textura de quesos frescos de leche de cabra y vaca. *Biotecnol. Sect. Agropecu. Agroind* **2015**, *13*, 139–147. [CrossRef]
44. Diezhandino, I.; Fernández, D.; Sacristán, N.; Combarros-Fuertes, P.; Prieto, B.; Fresno, J.M. Rheological, textural, colour and sensory characteristics of a Spanish blue cheese (Valdeón cheese). *LWT* **2015**, *65*, 1118–1125. [CrossRef]
45. Reyes-Estrada, O.; Murillo-Ortiz, M.; Herrera-Torres, E.; Gurrola-Reyes, J.N.; Carrete-Carreón, F.O. Cambios estacionales en consumo, composición química y degradabilidad ruminal de la dieta seleccionada por novillos en pastoreo. *Ecosistemas Recur. Agropecu.* **2015**, *1*, 97–106.
46. Norma Oficial Mexicana NOM-243-SSA1-2010, Productos y Servicios. Leche, Fórmula Láctea, Producto Lácteo Combinado y derivados lácteos. Disposiciones y Especificaciones Sanitarias. Métodos de Prueba. Available online: https://dof.gob.mx/normasOficiales/4156/salud2a/salud2a.htm (accessed on 11 September 2023).
47. Hacène, M.; Lamia, A.; Mohammed, N.Z.; Ali, A.H. Proteolysis, microbiology, volatiles and sensory evaluation of Algerian traditional cheese Bouhezza made using goat's raw milk. *Int. J. Food Prop* **2017**, *20*, S3246–S3265.
48. Gursoy, O.; Küçükçetin, A.; Gökçe, Ö.; Ergin, F.; Kocatürk, K. Physicochemistry, microbiology, fatty acids composition and volatile profile of traditional Söğle tulum (goat's skin bag) cheese. *An. Acad. Bras. Ciências* **2018**, *90*, 3661–3674. [CrossRef] [PubMed]
49. National Institute of Statistics and Geography (INEGI) (2023) Coahuila de Zaragoza. Clima. Coahuila de Zaragoza. Available online: https://cuentame.inegi.org.mx/monografias/informacion/coah/territorio/clima.aspx?tema=me&e=05 (accessed on 8 September 2023).
50. Normanno, G.; Corrente, M.; La Salandra, G.; Dambrosio, A.; Quaglia, N.C.; Parisi, A.; Greco, G.; Bellacicco, A.L.; Virgilio, S.; Celano, G.V. Methicillin-resistant Staphylococcus aureus (MRSA) in foods of animal origin product in Italy. *Int. J. Food Microbiol.* **2007**, *117*, 219–222. [CrossRef] [PubMed]
51. Rozos, G.; Skoufos, I.; Fotou, K.; Alexopoulos, A.; Tsinas, A.; Bezirtzoglou, E.; Tzora, A.; Voidarou, C. Safety Issues Regarding the Detection of Antibiotics Residues, Microbial Indicators and Somatic Cell Counts in Ewes' and Goats' Milk Reared in Two Different Farming Systems. *Appl. Sci.* **2022**, *12*, 1009. [CrossRef]
52. Wanniatie, V.; Sudarwanto, M.B.; Purnawarman, T.; Jayanegara, A. Comparison of Microbiological Quality between Organic and Conventional Goat Milk: A Study Case in Bogor, Indonesia. *Adv. Anim. Vet. Sci.* **2019**, *7*, 593–598. [CrossRef]