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Compositional features, microbial quality, and sensory evaluation of milk and cheese obtained from Oases autochthonous Arbi goat

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Abstract: The purpose of this study was to assess the compositional features and microbiological quality of the milk produced by the autochthonous oasis goat in order to evaluate its suitability for cheesemaking. To attain this, two fresh cheeses with and without basil flavor were prepared and evaluated. One hundred milk samples were collected from multiparous lactating Arbi goats reared in the continental oasis region of Tunisia and processed into unflavored and basil-flavored cheese according to a traditional recipe. Milk samples were subjected to physical, chemical, and microbial analyses. The basic composition, mineral content, and bacterial profile of the cheeses were determined. In addition, the cheeses were subjected to organoleptic evaluation. The physical parameters of the analyzed milk were 6.54, 15.64, and 1030.89 for pH, acidity, and density, respectively. For the chemical properties of the milk, the results showed a respectable level of nutritional quality with a noteworthy content of dry matter, fat, protein, casein, and minerals, especially potassium, calcium, and phosphorous. With an average yield of 25%, the assessment of both cheeses illustrated good hygienic quality for all microflora examined, except total coliforms; a very noticeable organoleptic quality, as judged by all jury members; and satisfactory nutritional quality, with a significant protein and lipid level and a richness of mineral elements, particularly high levels of calcium and phosphorus. Basil-flavored cheese had the best aroma and taste, making it highly desirable to consumers. With the exception of coliforms and *E. coli*, the products bacteriological quality was acceptable and met legal requirements. The total absence of dangerous *Salmonella* and *sulfite-reducing Clostridium* strictly met the legal standards. The findings revealed the substantial chemical and nutritional value of milk and cheese made from local goats. However, additional studies are required to improve the microbial quality of the studied products.

Keywords: Goat cheese, milk, nutritional value, organoleptic evaluation, autochthonous breed, oasis.

Introduction

Animal production is the second most important sector in the economies of oasis regions, after phoeniciculture. Domestic animal genetic resources in the region are primarily composed of camel species and small ruminant breeds (Khaldi et al., 2020). The goat herd, which numbers 315,150 heads and is primarily composed of local population (Khaldi et al., 2022), has always been the largest animal species. Despite its importance in oasis regions, the goat breeding sector remains unorganized and even marginalized, leading to the creation of an extensive goat breeding system based on resources from rangelands bordering oases and deserts, as well as oasis byproducts (wasted dates, quack grass, fodder crops, etc.) (Khaldi et al., 2022).

Improving the productivity and profitability of the goat sector is of considerable importance, even as a priority, for the region. Livestock breeding in the oases of southern Tunisia represents the possibility of diversifying production and securing farmers' income. In continental oases, the breeding of small ruminants, particularly goats, seems to support diversified oasis agriculture, which remains a complex production system that can only survive with complete control over the association between agriculture and breeding. One interesting avenue is to valorize Oasis goat milk production. Goat milk has a more pronounced and distinct flavor than cow milk, making it especially popular for cheesemaking. Due to these particularities, goat milk can be used in specific human food applications, most notably in producing cheeses, yogurts, and other dairy products (Muehlhoff et al., 2013). Goat milk and its derivatives are extremely popular among consumers because of their distinct taste and aroma, as well as their nutritional and dietary benefits. Goat cheeses and other products are perceived as organic, natural, and rich in bioactive ingredients (Fatihov & Haertdinov, 2017). Goat's milk is a source of nutrients as well as macro and micronutrients. It is considered to be superior to milk from other species due to its numerous health benefits and lower risk of allergies. It may be an alternative for people with food allergies because it contains less αs1 casein, which is known to be associated with approximately 60% of allergic reactions linked to milk consumption. It contains bioactive components that support human metabolism and function (Fatihov & Haertdinov, 2017; Kawęcka & Pasternak, 2022). Furthermore, goat milk and cheese are widely recognized as excellent alternatives to cow milk products because they can satisfy a wide range of nutritional needs (Innosa et al., 2020). In addition, goat's milk is generally better tolerated; it is known for easier digestion (smaller fat globules), high calcium and phosphorus content, vitamin richness, and optimal bone mineralization. Among ruminants, goat milk is the most similar to human milk, making it ideal for children (Getaneh et al., 2016).

The region's goat populations are distinctive for their great resistance to pathogens, ability to adapt to harsh conditions (Ayeb et al., 2016), and their great diversity and heterogeneity (Khaldi et al., 2022), which is triggered by uncontrolled mixing between different breeds or populations as a consequence of continual introduction of broodstock or female units breeds imported for meat (Boer, Damasquine, Hijazi) and milk (Alpine, Sannen, Murciana, Maltese) aptitude (Khaldi et al., 2022). Animals are managed in a pastoral and semi-intensive oasis system to produce meat and milk. The main purpose of its milk production is direct consumption (Vacca et al., 2009), but it is also processed only into traditional and local dairy products with very short shelf-life, such as fresh cheeses, fermented milk (Rayeb and Leben), D'hen, and butter (Khaldi et al., 2022).

Information regarding the properties of milk and its derivatives from mammalian species other than dairy cattle and the dairy Sicilo-Sarde sheep breed is scarce in Tunisia. However, in western oasis areas, information on the composition and microbial quality of local goat milk is extremely limited and totally absent for cheese and other dairy products. Only a few physical (pH, density, and acidity) and chemical (total solids, fat, proteins, lactose, and ash) characteristics are mentioned in the scant literature on local goat milk (Ayeb et al., 2016). There are limited research reports on the amount of casein, mineral concentrations, bacterial counts, or the prevalence of pathogenic germs (Khaldi et al., 2022). Moreover, such literature data on biochemical composition, microbial quality, and sensory attributes of cheese prepared from Tunisian local genetic resources milk are completely missing. According to Roy et al. (2020), goat's milk can be valorized to produce decent specialized dairy products with national (local cultural) and international relevance. These products include fermented milk, probiotic dairy drinks, yogurt, cheese, butter, ice cream, infant formulas, and milk tablets. To achieve this goal, knowledge of the composition, quality, and cheese-making potential of milk is required to develop efficient management plans for the improvement of this underutilized local goat. These plans will strengthen human nutrition, support agricultural development, generate income for the oases' residents, and preserve local genetic resources in the oases.

Accordingly, the current study aimed to evaluate the physical properties, chemical characteristics, mineral concentrations, and bacteriological quality of milk produced by the autochthonous oasis goat in order to determine its suitability for cheese production. To accomplish this, fresh cheeses with and without basil flavor were prepared from the studied goat milk, and their composition parameters, hygienic properties, and sensory attributes were assessed.

Materials and methods

Animals and sample collection

The milk obtained from the local Oasis goat, named Arbi, as well as the cheese made from it constituted the material for the study. Goats were reared under a semi-intensive feeding system where herds grazed on natural pasture in the oases' vicinity during the daytime (6-7h/day). Upon confinement, the animals were given 400–500 gd^{-1} supplementation based on barley (DM: 91%; CP: 12.7%; NDF: 26.3%; Ash: 3.9%; Net energy content: 1817.01Kcal. Kg^{-1}DM), wheat bran (DM: 86.92%; CP: 14.9%; NDF: 37.7%; Ash: 4.1%; Net energy content: 1624.97 Kcal. Kg^{-1}DM) throughout the year, and waste dates (DM: 88.56%; CP: 3.11%; NDF: 17.81%; Ash: 2.69%; Net energy content: 1931.42 Kcal. Kg^{-1}DM) during the period from October to June. In the evening, animals received alfalfa (*Medicago sativa*) (DM: 28.66%; CP: 19.22%; NDF: 45.3%; Ash: 14.20%; Net energy content: 1320 Kcal. Kg^{-1}DM). Feedstuffs were distributed to the animals regardless of their physiological stage. Goats were kept with their kids during the day and in the evening, except on days when milk samples were taken.

A sample of one hundred animals, two to three goats per farm, was selected from private flocks raised in the continental oases region of southern western Tunisia. 500 ml of fresh milk from each animal was collected by manual milking from complete milking in the morning from multiparous and healthy animals in their second month of lactation from Oasis goat herds in the governorate of Tozeur. Milk was collected in sterile tubes and kept in an ice container during sampling and transportation to the laboratory for processing and various analyses. The study material included 40 fresh cheeses, both unflavored and basil-flavored. Using the mixture of collected milk, 20 samples of each type of cheese were prepared for the current study. The cheese was produced following traditional cheese-making practices using pasteurized goat milk. After receiving the milk (T = 4°C, pH = 6.5), each milk sample was filtered and pasteurized at 72°C for 30 seconds before cooling to 35-38°C. Using commercial lactic ferment, the milk was inoculated (3 drops/liter) according to the manufacturer's instructions. The curd formed was cut, dried, and placed in molds; the molded cheeses were rubbed with salt. The same technological process was used for the flavored cheese, with the addition of 5 g of basil per five liters of milk during the draining stage.

Ethical approval

This study was reviewed and approved by the specialized experimentation unit of the Oasis Agriculture Regional Research Center. The owners granted permission for their animals to participate in the research. The animals were treated in accordance with good biological sampling practices and the national ethical guidelines for animal care and use for scientific purposes recommended by the National School of Veterinary Medicine of Sidi Thabet (ENMV) and the General Direction of the Veterinary Service (DGSV) (Number: CEEA-ENMV 36/21).

Physical and chemical analyses of the milk and cheese samples

The physical characteristics of the milk (pH, acidity, and density) were measured on the same sampling day. The pH was determined at 20°C with a Consort C933 pH meter. Titratable acidity was determined using the titrimetric method recommended by AOAC (2000) for milk and AOAC (2006) for cheese. The density of the raw milk was obtained using a Gerber thermolacto-density meter, and measurements were taken at 20°C. Lactose and ash levels in the milk samples were determined using official AOAC international analytical methods (AOAC, 2005; AOAC, 2012). According to the standard methods of the International Milk Federation (IDF), fat (IDF, 2009), dry matter (IDF, 2010), and total protein (IDF, 2014) contents were determined. The Kjeldahl method (IDF, 2004) was used for determining the casein content by subtracting total nitrogen from non-casein nitrogen.

Using standard methods, the cheese samples were analyzed for dry matter (ISO/IDF, 2004), protein (IDF, 2014), casein (IDF, 2014), fat (IDF, 2009), lactose, and ash (AFNOR, 1993).

Mineral analysis

The calcium, sodium, potassium, and phosphorus contents of the milk and cheese samples were analyzed. Calcium was measured according to IDF (2007) using an atomic absorption spectrophotometer (Analytikjena: Nova 400). The determination of sodium and potassium was carried out by Jenway flame emission spectroscopy according to AOAC (1984). A colorimetric method involving the phosphovanado molybdate complex (GB, 2010) was applied to quantify the phosphorus present in the milk and cheese samples.

Microbiological analysis

The milk and cheese samples were submitted for microbial enumeration of total mesophilic aerobic bacteria (TMAB), total coliform count (TCC), fecal coliform count

(FCC), lactic acid bacteria (LAB), *Clostridium sulfite-reducing* (CSR), yeasts and molds (Y/M), fecal streptococci (F. Strep), *Staphylococcus aureus* (*S. aureus*), *Escherichia coli* (*E. coli*), and *Salmonella*. After properly mixing the raw milk samples, 1 mL was collected and diluted with 9 mL of peptone water for bacterial analysis. Ten grams of cheese were homogenized in 90 mL of sterile physiological water to obtain a stock solution. Other decimal dilutions were prepared using this dilution (ISO, 2001a) and spread on a suitable support. According to the standards of the International Organization for Standardization (ISO), the counts of flora TMAB (ISO, 2013), TCC and FCC (ISO, 2006), LAB (ISO, 1998), CSR (ISO, 2003a), yeasts and mold (ISO, 2004), *S. aureus* (ISO, 2003b), *E. coli* (ISO, 2001b), and *Salmonella* (ISO, 2009) were performed on duplicate samples. The results are averaged, and the number of microorganisms is expressed in colony-forming units per milliliter (CFU/mL) for milk and per gram (CFU/g) for cheese.

Sensory evaluation of the cheeses

Based on the official method NF V 09-015 (AFNOR, 1995) and that used by Barłowska et al. (2018), the sensory analysis of three types of cheese was conducted using the hedonic scoring test, which entails asking tasters to fill out a survey sheet for commercial fresh cow cheese (A), fresh goat cheese (B), and goat cheese flavored with basil (C). The samples are presented one at a time in a precise tasting order. Each sample was placed on a plate, and a number was assigned. The test consists of rating the overall appreciation on a scale of 1 (extremely dislike) to 9 (extremely like) as well as the sensory attributes of taste, smell, and texture. The sensory panel consisted of sixty people of both sexes aged 23 to 50 who tasted commercial, flavored, and unflavored cheeses. To eliminate any aftertaste between samples, mineral water and unsalted crackers were provided.

Statistical analysis

The results of the physico-chemical analysis, mineral content, and bacterial loads of milk and cheeses were expressed as mean and standard deviation. Prior to statistical analysis, bacterial numbers were $\log_{10}$ transformed to normalize distributions. To compare unflavored and basil-flavored cheese, the statistical analysis was performed by comparing the averages of various parameters between the cheese types under consideration. To determine significant differences between means of physical, chemical, mineral, and bacteriological parameters, a one-way ANOVA was performed using the SAS (2004) software's general linear model (GLM) procedure. To differentiate the type of cheese based on taste, aroma, texture, and general qualification, ANOVA was also used in sensory analysis. The two groups' least-squares means were compared using the Tukey test at significance levels of $P < 0.05$.

Results and Discussion

Physicochemical, mineral, and bacteriological characteristics of the milk

The physicochemical and microbiological characteristics of the collected goat milk are summarized in Table 1. The physical properties of local goat milk were as follows: pH 6.54, acidity 15.64, and density 1030.89. The 3 physical parameters are within the standards of Tunisian legislation setting the minimum threshold for acceptance of raw milk (N.T. 14-141-2004). These values largely align with the ranges reported by various authors for Tunisian populations (Ayeb et al., 2016; Khaldi et al., 2022) and other international populations (Park et al., 2007; Kondily et al., 2012). However, the physical characteristics in this study differ from those found in other studies (Tadjine et al., 2020). The pH and acidity of milk are key indicators of both animal welfare and milk cleanliness. Healthy animals typically produce milk with pH values between 6.5 and 6.8 (Park et al., 2007), while lower pH levels in fresh milk may be generated by bacterial activity. Conversely, a higher pH may suggest mastitis or udder infection (Carloni et al., 2016). Elevated acidity levels reflect the presence of microorganisms and the development of lactic flora, which are influenced by temperature and storage conditions (Özdemir & Kahyaolu, 2020). In addition to pH, milk acidity provides insights into the total solids content and freshness of the milk, making it essential for assessing quality and ensuring proper processing (Burke et al., 2018).

The average dry matter content (Table 1) of local Oasis goat milk founded (149.3 g/L) exceeds those observed in the indigenous Greek breed (Kondily et al., 2012), the Saanen breed (Raynal-Ljutovac et al., 2008), and the local breed from Tenerife (Puerto et al., 2004). However, some breeds reported in the literature exhibited higher dry matter contents than those founded in this study (Mestawet et al., 2012; Mahieddine et al., 2017). Similar results were noted for the Greek landrace (Raynal-Ljutovac et al., 2008), as well as the Moroccan (Kouniba et al., 2007) and Tunisian (Ayeb et al., 2016) local goats.

The protein content of milk, which serves as a critical nitrogen source, is a fundamental determinant of cheese yield. According to Le Jaouen (2004), variations in milk composition account for approximately 75% of the differences observed in cheese yield. The average protein content in this study was 37.65 g/L, which far exceeds the Tunisian standards (N.T. 14-141-2004) for this component (28 g/L).The result came in full agreement with those reported for the Moroccan Draa (Ibnelbachyr et al., 2015), Tunisian breeds (Ayeb et al., 2016), and Greek native breeds (Kondily et al., 2012). Conversely, our findings surpassed those for Saanen (Catunda et al., 2016), Alpine (Mahieddine et al., 2017), and Maltese (Currò et al., 2019) breeds, yet were lower than the protein content founded in Arsi-Bale (Mestawet et al., 2012). This variation in protein content further emphasizes the influence of breed on protein concentration.

In terms of casein, our results were consistent with those from local populations (Khaldi et al., 2022) and the Damascus breed (Raynal-Ljutovac et al., 2008), but lower than those obtained in various Turkish breeds (Barłowska et al., 2020). The casein levels identified indicate a favorable profile for cheesemaking, yet higher values founded in Alpine, Draa (Kouniba et al., 2007), Arsi-Bale, and Somali breeds (Mestawet et al., 2012) breeds suggest these breeds might be more advantageous for specific dairy applications.

Similar to the protein levels, the fat content (39 g/L) also complies with the national legislation (N.T. 14-141-2004) regarding composition thresholds (30 g/l). The average fat content was comparable to others of North African breeds (Ibnelbachyr et al., 2015) but lower than that of local Tunisian breeds (Ayeb et al., 2016) and various Spanish (Ferro et al., 2017) and Greek (Kondily et al., 2012) goat breeds. This fat content is significant for flavor and texture in cheese (Chilliard et al., 2003), and optimizing feeding strategies could potentially enhance this attribute in the Oasis breed.

Lactose concentration averaged 41.28 g/L, similar to levels observed in Baladi and Saanen breeds (Catunda et al., 2016; Tabet et al., 2016). While some studies reported diverse lactose levels (Mestawet et al., 2012; Ayeb et al., 2016; Raynal-Ljutovac et al., 2008; Kondily et al., 2012), the consistency within our results suggests adequate lactose for lactic acid fermentation during dairy processing, which is crucial for producing high-quality fermented products (St-Gelais et al., 2000).

Lastly, the ash content of 8.33 g/L closely resembles findings for Damascus goats (Raynal-Ljutovac et al., 2008) and the Arbi population (Khaldi et al., 2022). Lower (Catunda et al., 2016; Tabet et al., 2016) and higher (Mohsin et al., 2019) ash levels have been documented for various goat breeds. Ash content is an essential component that reflects the mineral composition of milk, which is crucial for both nutritional quality and milk processing (Currò et al., 2019).

Overall, the chemical composition of goat milk is influenced by a complex interplay of genetic, environmental, and management factors (Park et al., 2017). As demonstrated in numerous studies, breed plays a critical role in determining the composition of milk and its derived products (Ferro et al., 2017). Additionally, factors such as season, lactation rank, and litter size can significantly affect the biochemical quality of milk (Chentouf et al., 2006). Understanding these variations is essential for optimizing milk production and processing strategies, particularly in regions where specific goat breeds are predominant.

The analysis of mineral composition in the goat milk samples revealed concentrations of calcium, phosphorus, sodium, and potassium at 1.47 g/L, 1.24 g/L, 0.34 g/L, and 1.56 g/L, respectively. Among these, potassium emerged as the predominant mineral, surpassing the levels of calcium and phosphorus. This finding aligns with previous studies, including those by Currò et al. (2019), who documented similar trends in various local Italian goat breeds and the cosmopolitan Saanen breed. Furthermore, Stergiadis et al. (2019) corroborated these results in their analysis of British goats, reinforcing the notion of potassium as a preeminent mineral in goat milk. Supporting this observation, Raynal-Ljutovac et al. (2008) and Mohsin et al. (2019) also indicated that potassium consistently ranks higher than other minerals across multiple goat breeds. Comparative studies revealed variability in mineral concentrations among different breeds. For instance, Helmut & Fiechter (2012) observed similar potassium and sodium levels in six Austrian goat breeds; however, their calcium and phosphorus concentrations were notably lower than those detected in our study. In contrast, Mohsin et al. (2019) noted that both Saanen and Shami breeds exhibited comparable calcium levels but demonstrated higher sodium and potassium concentrations than our samples. This discrepancy suggests that breed characteristics significantly influence mineral profiles. Additionally, Metsawet et al. (2012) reported varying mineral profiles in four Ethiopian goat breeds, with their samples displaying elevated levels of calcium and potassium while sodium and phosphorus concentrations were comparable to our findings.

The variations in mineral concentrations observed in our study compared to existing literature can be attributed to several factors. Firstly, breed differences play a significant role, as genetic variations can influence mineral metabolism and composition in milk. Secondly, the health of the udder, as discussed by Stocco et al. (2019), can affect the mineral content, with healthy animals typically producing milk with enhanced nutritional profiles. Thirdly, dietary factors are crucial; as noted by Haenlein & Anke (2011), the mineral content of goat feed directly impacts the composition of milk. Finally, as Khan et al. (2006) point out, the stage of lactation may lead to fluctuations in mineral concentrations, with variances observed throughout the lactation cycle.

In summary, our findings contribute to the growing body of literature on local goat milk mineral composition, emphasizing the need for further research to elucidate the specific factors that influence these variations. Understanding these dynamics can enhance the nutritional profiling of goat milk and support better management practices in goat husbandry.

Table 1 - The physicochemical characteristics (mean ± standard deviation) of raw goat milk from the local Arbi population in the Jérid region.

Traits	Milk
pH	6.54±0.07
Acidity (°D)	15.64±2.20
Density(kg/m^3)	1030.89±2.7
Dry matter (g/L)	149.3±21.75
Protein (g/L)	37.65±5.15
Casein (g/L)	28.64±4.31
Fat (g/L)	39±5.24
Lactose (g/L)	41.28±6.21
Ash (g/L)	8.33±1.50
Calcium (g/L)	1.47±0.20
Phosphorus (g/L)	1.24±0.18
Sodium (g/L)	0.34±0.08
Potassium (g/L)	1.56±0.25

The microbiological analysis of goat milk samples, as detailed in Table 2, revealed that certain microbial flora was of satisfactory quality, while others deviated from the required legislation. The loads of total aerobic mesophilic flora (TMAB) and total coliform flora were 5.01 $\log_{10}$ CFU/mL and 3.33 $\log_{10}$ CFU/mL, respectively. According to Tunisian standards (N.T. 14-141-2004), the acceptable limit for TMAB in raw milk is 5.69 $\log_{10}$ CFU/mL, which our study meets comfortably. However, the total coliform levels observed slightly exceed the Tunisian regulatory threshold of 3 $\log_{10}$ CFU/mL. This discrepancy may stem from suboptimal hygiene practices during milking and sample collection, emphasizing the need for improved handling procedures to ensure milk safety. The founded TMAB and coliforms results are consistent with findings from some studies conducted in Tunisia (Khaldi et al., 2022), France (Morgan et al., 2003), Brazil (Rios et al., 2018), and Ethiopia (Ahmed et al., 2022), which reported similar microbial loads in goat milk. However, research by Kondily et al. (2012) and Tabet et al. (2016) indicated higher levels of both TMAB and total coliforms in raw goat milk, while Da Silva et al. (2013) reported lower concentrations.

The presence of *E. coli* at 0.29 $\log_{10}$ CFU/mL in the examined samples is noteworthy and supports the notion of environmental and potential fecal contamination. This level matches with earlier investigations by Khaldi et al. (2022) and Da Silva et al. (2013). Monitoring these indicators is crucial, as they are significant for assessing the hygienic quality of food products. Coliforms signify environmental contamination, while *E. coli* presence suggests a higher risk of pathogenic microorganisms, as noted by Gottardi et al. (2008).

Staphylococcus aureus was detected at a rate of 0.44 $\log_{10}$ CFU/mL, making it lower than the Tunisian legislative limit. The *S. aureus* concentration is a measure of both the sanitary quality of milk and the health of the animals raised. The occurrence of

Staphylococci is often attributed to inadequate hygiene practices and improper milking procedures (Khaldi et al., 2022), as well as from mastitis in the animals (Rola et al., 2015). Given that the animals in this study were healthy and hygienically treated, the detection of Staphylococci may reflect the presence of subclinical mastitis (Alebie et al., 2021), a common condition that can lead to significant economic losses in the dairy sector (Rola et al., 2015).

The *lactic acid bacteria* (LAB) counts were notably present, averaging around 3.19 log_{10} CFU/mL, thereby fulfilling the limits of standard N.T. 14-141-2004. In comparison to the literature, local Greek goats (Kondily et al., 2012) and Brazilian goats (Da Silva et al., 2013) exhibited higher LAB levels. Khaldi et al. (2022) corroborated these findings within the same oasis region. LAB plays a pivotal in dairy products, contributing to fermentation and providing numerous health benefits, including antifungal properties, bacteriocin production, among others (Delavenne et al., 2012).

The contamination of raw goat milk in Tunisia by yeasts and molds at 3.72 log_{10} CFU/mL revealed a noncompliance of milk collected with the usual values of 3 log_{10} CFU/mL, as required by raw milk standards. Overall, these results were consistent with those of Kondily et al. (2012) in Greece, as well as similar levels reported in Tunisian oases (Khaldi et al., 2022). These findings indicate that, while yeast and mold presence is not uncommon, their levels remain manageable.

Importantly, none of the samples tested positive for *Salmonella* or *Clostridium sulfite-reducing* bacteria, mirroring results from studies on Baladi goats (Tabet et al., 2016) and Saanen goats (Cavicchioli et al., 2015). This absence of pathogenic bacteria is reassuring and serves as a positive indicator of overall milk safety.

In conclusion, the microbiological loads detected in the raw goat milk from the studied population were acceptable and compliant with Tunisian legislation (NT 14.141, 2004) in terms of TMAB, LAB, *S. aureus*, CSR, and *Salmonella*, but not in TCC, *E.coli*, and Y/M. In fact, numerous factors, including breed (Kondily et al., 2012), milking practices, animal health, lactation stage (Da Silva et al., 2013), seasonal variations (Salmeron et al., 2002), and environmental conditions (Khaldi et al., 2022), have been documented to influence milk quality. These findings emphasize the importance of rigorous hygiene practices during milking and handling to maintain milk safety and quality, ultimately supporting the health of both consumers and livestock. However, continued efforts and further research should explore the impact of specific management practices on microbial load to further enhance the safety and quality of goat milk.

Table 2 -Microbiological test results (log_{10} UFC/mL) of milk

Microbiol flora	Raw milk
TMAB	5.01±0.44
TCC	3.33±0.38
LAB	3.19±0.33
CSR	0
Y/M	3.72±0.10
S. aureus	0.44±0.56
E. coli	0.33±1.12
Salmonella	0

TMAB: Total mesophilic aerobic bacteria; TCC: Total coliforms count; LAB: Lactic acid bacteria; CSR: Sulphite-reducing clostridium; Y/M: Yeast and mold; S. aureus: Staphylococcus aureus; E. coli: Escherichia coli.

Physicochemical, mineral, and bacteriological properties of the produced cheeses

Cheese yield is a critical metric in the cheese industry, reflecting the effective utilization of milk constituents during the cheese-making process. As highlighted by Stocco et al. (2018), cheese yield, defined as the mass of cheese produced relative to the volume of processed milk, serves not only as a measure of manufacturing efficiency but also as an essential economic indicator for producers striving for profitability.

In this study, the cheese yield derived from 1 liter of goat's milk was 125 grams, equating to a yield of 25%. This finding is consistent with the results of Soryal et al. (2005) for Egyptian Nubian goats and De la Cruz (2007) for Mexican Alpine goats, both showing yields of 27%. Similarly, Kouniba et al. (2007) reported a yield of 23.8% for the Moroccan Drâa breed. Notably, our yield surpasses that reported by Sanz Sampelayo (1998), who noted yields ranging from 20.1% to 26.2% for Grenadines' goats, and is significantly higher than the lower end of the spectrum for Domiati cheese (12-18%) (Soryal et al., 2004), as well as the 17.3% noted for Alpine goats in Morocco (Kouniba et al., 2007). Comparatively, Guerzoni et al. (1999) recorded yields of approximately 20.3% using pasteurized goat milk, while Mahieddine et al. (2017) indicated a 31% greater yield in improved Alpine goats in Algeria, underscoring the influence of breed and milk composition on yield outcomes.

The variance in cheese yield observed in our study compared to other literature can largely be attributed to differences in the chemical composition of the milk used. Colin et al. (1992) highlighted that higher protein levels in milk significantly enhance cheese yield. Numerous studies have established a strong correlation between key milk components, such as fat, protein, and total solids, and cheese yield, leading to the development of several predictive equations (Zeng et al., 2007). Fox (2002) stated that the chemical composition of milk, particularly the levels of casein, milk fat, calcium, and pH, profoundly influences various aspects of cheese production, including rennet coagulation, gel firmness, syneresis, and ultimately, the cheese yield, particularly for fresh cheeses. Furthermore, Gilles and Lawrence (1985) reinforced that casein concentration is a decisive factor in determining cheese yield. Kouniba et al. (2007) quantified the impact of casein levels, noting that an increase of 5.6% to 15.7% in casein content could enhance cheese yield by 6.5 g/kg to 27.3 g, respectively. This relationship suggests that each additional gram of casein contributes approximately 1.16 g to cheese yield. Significantly, milk protein levels can account for up to 76% of the variability in cheese yield (Kouniba et al., 2007), while the combined effects of protein and fat content may explain 77% of the yield variation (Colin et al., 1992). Barillet et al. (1996) further identified several key criteria, comprising the level of useful dry matter, the combined butter and protein content, and the total butter to total protein (TB/TP) ratio, as reliable indicators for predicting cheese yield and the fat content of matured cheeses. The microbiological quality of the milk used also affects cheese yield. According to Park et al. (2017), milk with high somatic cell counts coagulate slowly and drain poorly, leading to low cheese yield due to greater protein and fat losses in the whey.

The observed yield of 25% is competitive within the context of existing literature and highlights the importance of optimizing milk composition and processing practices to enhance cheese production outcomes. Future studies should focus on the interplay between genetic selection, nutritional management, and processing techniques affecting cheese yield to optimize production strategies.

Table 3 - Physical, chemical, and mineral composition (mean ± standard deviation) of cheeses

Traits	Unflavored cheese	Flavored cheese
pH	5.20±0.03[a]	5.50±0.07[a]
Acidity(°D)	47.30±5.78[a]	46.87±6.33[a]
Dry matter (%)	47.40±1.20[a]	49.10±1.56[a]
Moisture (%)	52.6±2.33[a]	50.90±1.99[a]
Protein (%)	33.29±1.29[a]	33.98±1.75[a]
Casein (%)	25.40±3.10[a]	26.10±3.27[a]
Fat (%)	35.40±2.50[a]	35.80±2.01[a]
Lactose (%)	4.51±0.91[a]	4.98±1.01[a]
Ash (%)	6.40±0.48[a]	6.33±0.40[a]
Calcium (g/kg)	5.58±0.62[a]	5.44±0.55[a]
Phosphorous (g/kg)	4.96±0.52[a]	4.90±0.50[a]
Sodium (g/kg)	0.56±0.20[a]	0.61±0.15[a]
Potassium (g/kg)	1.67±0.34[a]	1.66±0.33[a]

[a,b,c] *values with different superscripts within the same column are significantly different.* $P < 0.05$*

The physicochemical properties and mineral composition of the two types of fresh local goat cheese (Table 3), alongside their microbiological quality (Table 4), showed no significant differences (P>0.05). The inclusion of basil did not alter (P>0.05) the physical characteristics, chemical properties, mineral concentrations, or microorganism loads. According to bibliographic sources, adding basil to cheese had a significant impact on its quality and basic composition, while other studies demonstrate the opposite effect. Regarding physical characteristics, a similar behavior of the absence of the effect of added basil has previously been observed for pH (Hosseini-Parvar et al., 2015; Abbas et al., 2018). Contrary to this, the work of Ribas et al. (2016) clearly highlighted the effect of basil on these two physical parameters by reducing the pH and increasing the acidity of cheese, most likely due to the presence of polyphenols and organic acids (oxalic, quinic, malic, etc.) (Carocho et al., 2016). Basil's phenolic compounds could have degraded to monomeric acids with varying acid concentrations (pKa) through cleavage or oxidative hydrolysis, lowering the pH of the cheese (Wegrzyn et al., 2008). Pavelkova et al. (2016) advanced both the significant and insignificant impact of basil on titrable acidity, according to the basil doses.

In terms of chemical composition, Ribas et al. (2019) concluded that the addition of basil to the cheese manufactured with organic buffalo milk did not affect the amount of protein (236.7–253.4 g/kg), fat (422.1–485.0 g/kg), or mineral matter (44.2–44.3 g/kg). Similarly to our findings, these authors reported a slight decrease in moisture in basil-based cheeses due to increased syneresis during the manufacturing process. This increased syneresis was manifested in the form of increased cheese yield. Comparing "Serra da Estrela" cheeses, Carocho et al. (2016) observed that considering the basil effect, moisture and proteins did not undergo significant changes, oppositely to fat, ash, and energy values. Likewise, adding basil has greatly raised calcium, potassium, and sodium levels. Depending on the dose of basil added, Pavelkova et al. (2016) reported a significant or non-significant impact on the protein and fat content of the studied cheeses. Based on El-Bialy et al. (2016), the resultant soft cheese treatments supplemented with different levels of basil revealed no significant difference in fat and lactose content among all studied treatments. Increasing the amount of basil added resulted in a slight increase in total solids content and a decreased tendency for protein.

The addition of grounded plants had no significant influence on the microbiota studied ($p > 0.05$) compared to unflavored cheese. The same effect on total mesophilic bacteria, lactic acid bacteria, enterococci, and mold/yeast has been founded in the Dalmatian (Zdolec et al., 2024) and Egyptian (Hamad et al., 2020) cow cheese added or not with dried basil. In a related vein, El-Bialy et al. (2016) did not detect any difference between buffalo's fresh cheeses and those fortified with basil leaves with regard tototal bacterial and mold/yeast counts. The current results illustrated a decreasing tendency, though not statistically significant, of TMAB and *S. aureus* with the addition of basil. Previous TMAB studies have reported on this phenomenon (Hamad et al., 2020). Further, Zdolec et al. (2024) and Carocho et al. (2016) reported that *Staphylococcus aureus* is extremely sensitive to basil plant extract.

The average pH values for the unflavored and flavored cheeses were similar at 5.2 and 5.5, respectively, aligning with the observations of Boutoial et al. (2013) and Tabet et al. (2016), while Messias et al. (2021) mentioned even higher pH levels. Our results are higher than those declared by Kouniba et al. (2007), Noutfia et al. (2014), Mahieddine et al. (2017), and Tadjine et al. (2020) for similar products in Morocco and Algeria. The relatively low pH observed can be attributed to the lactic acid fermentation process predominant during coagulation, coupled with an extended acidification phase during whey drainage (Kouniba et al., 2007). The average titratable acidities of the unflavored and flavored cheeses were 47.3 and 46.87, respectively, corroborating the results of Tadjine et al. (2020) and Moraes et al. (2018). However, previous studies have reported both higher (Kouniba et al., 2007; Noutfia et al., 2011; Noutfia et al., 2014) and lower (Peres et al., 2016) titratable acidity values. The increase in titratable acidity compared to raw milk emphasizes the effectiveness of lactic acid fermentation during cheese production (El Marnissi et al., 2013).

The dry matter content of the cheeses was measured at 47.4% for the unflavored variety and 49.1% for the flavored variant. These figures fall within the expected range for fresh goat cheeses, which spans from 40% to 65% (Jaubert, 1997). Furthermore, the dry matter content of the Oasis goat cheeses exceeds that of fresh cheeses from Egypt (Soryal et al., 2005), Morocco (Kouniba et al., 2007; Noutfia et al., 2014), and Lebanon (Tabet et al., 2016), while being comparable to those announced in Algeria (Mahieddine et al., 2017) and Poland (Barłowska et al., 2018). Given its high dry matter content, Oasis goat cheese can be classified as semidry, aligning with the 40% to 60% range identified by Noutfia et al. (2014).

In terms of major constituents, the unflavored cheese contained 33.29% protein and 35.4% fat, whereas the flavored variant had slightly higher values of 33.98% protein and 35.8% fat. These results are superior to those recorded by Soryal et al. (2005), Ntoufia et al. (2014), Tabet et al. (2016), and Barłowska et al. (2018). The protein levels reported here align closely with those from Mahieddine et al. (2017), though the fat content was found to be greater. In contrast, Ereifej (2005) noted lower protein and higher fat levels in fresh cheeses made from Jordanian goat milk. The casein content of the two types of cheese was determined to be 25.4% and 26.1%, respectively. Increased concentrations of protein and casein in milk are associated with enhanced cheese yields and improved texture quality (Barłowska et al., 2018). The casein concentration directly impacts cheese quality, influencing coagulation and gel formation rates, both of which improve with higher casein levels (Mbye et al., 2022). According to Barłowska et al. (2011), the technological suitability of milk for cheese production is largely determined by its protein content, particularly casein.

Lactose levels in both cheese types have been detected as 4.51% and 4.98%, contrasting sharply with findings from other studies suggesting lactose is either absent (Tabet et al., 2016) or present in trace amounts (Noutfia et al., 2014). However, Hosseini-Parvar et al. (2015) obtained analogous lactose amounts, whereas Raynal-Ljutovac et al. (2008) found lower values. No significant variations have been observed ($P>0.05$) for the ash content of the two cheese types (6.4% and 6.33%). The current results are consistent with those from Lteif et al. (2009) on Halloumi-type cheeses and outperform those of Noutfia et al. (2014), Barłowska et al. (2018), and Kawęcka & Pasternak (2022) for fresh goat cheeses.

The chemical composition of cheese is influenced by several factors, including the genetic potential of the animals (species and breed), the dairy production environment, and processing technologies (Fekadu et al., 2005; Vacca et al., 2018), lactation stage, and dietary factors (Park et al., 2017). Additionally, the inherent chemical and microbiological properties of the raw milk significantly affect cheese yield and quality (Park et al., 2017; Boutoial et al., 2013). Importantly, the type of rennet used can also alter the total protein, fat, ash content, and volatile fatty acid profile of the cheese due to the varying activities and specificities of proteolytic and lipolytic enzymes (Taboada et al., 2015). Understanding these interactions is crucial for optimizing cheese production and enhancing product quality.

As expected, the cheeses exhibited significantly higher average concentrations of all investigated mineral elements compared to the milk used in their production. This enhancement is attributable to the cheese-making process, which concentrates nutrients while reducing moisture content (Osorio et al., 2015). Specifically, unflavored cheese contained 5.58 g/kg of calcium, while flavored cheese had a slightly lower concentration of 5.44 g/kg. Corresponding calcium levels have been documented in fresh goat cheeses by Raynal-Ljutovac et al. (2008), Lteif et al. (2009), and Kawęcka et al. (2020). However, Kawęcka & Pasternak (2022) identified an even higher calcium concentration of 7.17 g/kg in milk cheeses derived from the local Polish Carpathian goat. Similarly, Garcia et al. (2006) found significantly elevated calcium concentrations of 9.8 and 10.2 g/kg in fresh and semidry cheeses made from Majorera, Palmera, and Tinerfeña goats, respectively. Conversely, lower calcium levels were observed in local and Alpine goats raised in Morocco (Kouniba et al., 2007) and in Alpine and Saanen goats from France (Lucas et al., 2008), suggesting that geographic and breed-related factors play a critical role in the nutritional profile of cheese.

Phosphorus concentrations were identified to be 4.96 g/kg for unflavored cheese and 4.90 g/kg for flavored cheese. The phosphorus levels in Oasis goat cheese are lower than those found in Brazilian goat cheese (Messias et al., 2021) but higher than the values reported by Elijah et al. (2020). Similar phosphorus levels were noted by Raynal-Ljutovac et al. (2008). Inversely, Lucas et al. (2008) recorded lower phosphorus concentrations of approximately 2.19 g/kg in French Rocamadour cheese. In line with findings from Garcia et al. (2006), Lucas et al. (2008), and Kawęcka et al. (2020), the potassium concentrations were 1.67 g/kg for unflavored cheese and 1.66 g/kg for flavored cheese. The potassium levels in goat cheese are higher than those reported by Messias et al. (2021), but lower than those found by Raynal-Ljutovac et al. (2008) and Kawęcka & Pasternak (2022), indicating variability in potassium content. At 0.56 g/kg for flavored cheese and 0.61 g/kg for unflavored cheese, the sodium levels were comparatively low. This is in contrast to several studies that indicate higher sodium concentrations in other goat cheeses. (Raynal-Ljutovac et al., 2008; Messias et al., 2021). Garcia et al. (2006), however, found that the sodium content of Tenerife-produced fresh and semidry cheeses was comparable. Notably, Elijah et al. (2020) discovered that Nigerian goat cheese had lower sodium content.

Fresh cheese, like any fermented product, is characterized by a high abundance of microorganisms, particularly mesophilic flora, which play a crucial role in fermentation (Chentouf et al., 2015). The microbiological analysis of basil-flavored and unflavored local goat cheeses provides significant insights into their quality and safety. The total aerobic mesophilic flora count in unflavored and flavored goat cheeses averaged 4.20 and 4.13 $\log_{10}$ CFU/g, respectively, meeting Tunisian standards of 5 × 105 CFU/g (5.7 $\log_{10}$ CFU/g). These values are relatively close to those of raw milk used for cheese production and are lower than the counts reported by Boutoial et al. (2013) and Tabet et al. (2016) for similar cheeses. The enumeration of a natural product's total mesophilic flora reflects its overall microbiological quality and allows for the tracking of its evolution, providing an indication of the product's freshness or decomposition (Guiraud, 2003).

For unflavored cheese, the total coliform concentration was 3.09 ± 1.45 $\log_{10}$ CFU/g, while for basil-flavored cheese; it was 3.12 ± 1.33 $\log_{10}$ CFU/g. The acceptable limit for coliforms is typically 1×10^2 CFU/g (2 $\log_{10}$ CFU/g) in Tunisian standard. The cheeses slightly exceeded this limit, suggesting a need for improved hygiene during production. These findings are less than the high levels (7 $\log_{10}$ CFU/g) noted by El Galiou et al. (2015) in Moroccan goat cheeses, but they are similar to those published by Chentouf et al. (2015) for fresh farm goat cheeses from Northern Morocco and by Tadjine et al. (2020) for fresh goat and cow cheeses in Algeria. The presence of coliforms, often indicative of hygienic issues, highlights the need for stringent quality control measures during cheese production, particularly concerning the cleanliness of both raw materials and equipment (Larpent, 1997).

Lactic acid bacteria (LAB) loads were consistent across both cheese types and fell within the ranges documented for fresh goat cheeses (Hamou et al., 2020). Previous studies indicated higher LAB levels in goat cheeses from various regions, ranging from 6.8 to 9.7 $\log_{10}$ CFU/g (El Galiou et al., 2015; Kalhotka et al., 2019). LAB plays a crucial role in developing flavor and texture during fermentation, while their metabolic byproducts contribute to the preservation of cheese by lowering pH and inhibiting spoilage organisms (Leskir, 2018).

Referring to the yeasts and molds present in the two experimental cheeses, the bacteriological loads were 2.54±0.3 and 2.50±0.29 $\log_{10}$ CFU/g for the unflavored and flavored cheeses, respectively. These findings are in agreement with those of Boutoial et al. (2013), who reported values around 2.17–2.23 $\log_{10}$ CFU/g in goat cheeses with or without rosemary. Similar counts were observed by Tadjine et al. (2020) in pasteurized fresh goat's milk cheese and by Hamou et al. (2020) in fresh cheeses from Algerian Arbia goats. ElGaml et al. (2017) reported lower contamination levels (1.11–1.20 $\log_{10}$ CFU/g) in Halloumi-type cheeses. These microorganisms are common in cheeses and can influence flavor development, but high levels may indicate spoilage or poor hygiene (Boutoil et al., 2013).

Staphylococci aureus germs are considered major pathogenic bacteria (Dodd & Booth, 2000), causing mammary infections and accompanied by an increase in permeability between the blood compartment and the milk, resulting in changes in the composition of milk and cheese (Rainard & Poutrel, 1993). Enumeration of these germs in the cheeses revealed charges of 0.26±0.35 and 0.19±0.23 log_{10} CFU/g. Several studies have reported the absence of *S. aureus* in goat cheese (ElGaml et al., 2017; Hamou et al., 2020), cow cheese (Mennane et al., 2007), and sheep cheese (Cosentino & Palmas, 1997). However, higher levels have been found by Boutoial et al. (2013). Furthermore, *E. coli* was detected at low levels (0.23 ± 0.33 and 0.25 ± 0.13 log_{10} CFU/g), which, although higher than levels reported in some other studies (Boutoial et al., 2013; Messiah et al., 2021), still pose minimal risk relative to the findings from Kalhotka et al. (2019). Additionally, the complete absence of *sulfite-reducing Clostridium* and *Salmonella* is consistent with findings in cheeses made from several goat breeds, reinforcing the microbiological safety of the cheeses (Boutoial et al., 2013; Tabet et al., 2016; Peres et al., 2016). National Standards limits required for *S. aureus* (<2 log_{10} CFU/g), *E. coli* (<2 log_{10} CFU/g), *CSR* (absence), and *Salmonella* (absence) were fully filled.

In conclusion, while the microbiological quality of both basil-flavored and unflavored goat cheeses largely meets safety standards, efforts to improve hygienic practices and reduce coliform counts will enhance overall product safety and quality, aligning more closely with both national and international benchmarks.

Table 4 - Microbiological test results of studied cheeses (log_{10} UFC/g).

Microbiol flora	Unflavored cheese	Flavored cheese
TMAB	4.06±0.64^{a}	3.98±0.80^{a}
TCC	3.09±1.45^{a}	3.12±1.33^{a}
LAB	4.15±0.20^{a}	4.25±0.30^{a}
CSR	0	0
Y/M	2.54±0.3^{a}	2.50±0.29^{a}
S. aureus	0.26±0.35^{a}	0.19±0.23^{a}
E. coli	0.23±0.33^{a}	0.25±0.13^{a}
Salmonella	0	0

TMAB: Total mesophilic aerobic bacteria; TCC: Total coliforms count; LAB: Lactic acid bacteria; CSR: Sulphite-reducing clostridium; Y/M: Yeast and mold; S. aureus: Staphylococcus aureus; E. coli: Escherichia coli.

^{a,b,c} *values with different superscripts within the same column are significantly different.* * $P < 0.05$

Organoleptic and sensory evaluations of the experimental cheeses

The organoleptic and sensory evaluations of fresh basil-flavored goat cheese, unflavored local goat cheese, and fresh commercial cow cheese were conducted to assess the acceptability and sensory attributes of these dairy products. Using a nine-point hedonic scale, the sensory analysis (Table 5) revealed that all three types of cheese elicited positive responses from the panelists, as indicated by hedonic scores exceeding 5 for each descriptor—taste, aroma, texture, and overall quality. This outcome points to a general acceptance of both flavored and unflavored local goat cheeses among the evaluators. Goat cheese with a basil flavor received the highest score, followed by goat cheese without flavor and commercial cow cheese (P<0.05), with the texture parameter being the exception where all cheeses had similar results (P>0.05). Compared with other varieties, flavored cheese is highly valued due to its superior taste, aroma, and overall quality. Indeed, Abbas et al. (2018) stated that basil highly enhanced the flavor of the cheese and gave a good acceptability as well as a softer body and texture. In the study of Ribas et al. (2019), the cheeses with basil were well accepted by consumers (notes above 6.64), with a preference for cheeses containing 2.5 and 5.0 g dried basil/kg cheese. This finding aligns with Noutfia et al. (2021), who noted that the sensory attributes of goat cheese are significantly enhanced through aromatization, improving both perception and overall enjoyment. The preference for flavored cheeses is well-documented, with literature highlighting that goat milk contains a higher concentration of unique fatty acids, such as capric, caprylic, and caproic acids, compared to cow, buffalo, and sheep milk (Kosikowski & Mistry, 1999). These fatty acids contribute not only to the flavor but also to the creamy, earthy profiles associated with aged goat cheese. Thus, the pronounced aromatic and taste attributes observed in our basil-flavored variant may stem from both the intrinsic qualities of goat milk and the additive nature of basil.

A variety of factors influence cheese's sensory qualities, including animal genetics, the dairy production environment, and the processing technologies used (Fekadu et al., 2005), in addition to the chemical and microbiological characteristics of the raw material (Coulon et al., 2004).

Table 5- Mean sensory attributes of the cheeses under investigation.

Cheese Type	Taste	Aroma	Texture	GQ
Commercial cow cheese	6,6^{c}	6,6^{b}	6,6^{a}	6,85^{c}
Unflavored cheese	7 ^{b}	6,65^{ab}	6,9^{a}	7,1^{b}
Flavored cheese	7,35^{a}	6,8^{a}	7,15^{a}	7,65^{a}

*^{a,b,c} values with different superscripts within the same column are significantly different.*P < 0.05. GQ: General qualification.*

Conclusion

The present study attempted to investigate the composition and quality of the raw milk produced by the autochthonous Arbi goat and to explore its suitability for cheesemaking, in a global vision of valuation of underutilized local animal genetic resources. Overall, the analyses performed on the goat milk from the oasis and the cheeses generated from it illustrate the good quality of these products.The raw milk reached results revealed good physicochemical characteristics and an appreciable mineral profile compared to standards encountered in scientific literature. The microbiological loads detected in the raw goat milk from the studied population were acceptable and compliant with Tunisian legislation (NT 14.141, 2004) in terms of TMAB, LAB, *S. aureus*, Y/M, CSR, and *Salmonella*, but not in TCC and *E. coli*, which enables possible transmission of pathogenic microorganisms through this food product and represents a major public health risk to consumers. Consequently, further improvement of the bacteriological quality is needed. The production of goat cheese was successfully completed in a second section, with a cheese yield of approximately 25%. This is confirmed by the manufacturing inspection results.

The evaluation of the quality of unflavored and flavored goat cheese revealed very noticeable organoleptic quality, as judged by all the members of the jury, and satisfactory nutritional quality with a richness of mineral elements, particularly high levels of phosphorus and calcium, as well as significant protein and lipid levels. Nevertheless, the microbial quality of the two cheese variants indicated compliance with national standards for all investigated microflora, except for the total coliform loads, which intend that more efforts are required to reduce their counts and enhance overall product safety and quality, aligning more closely with legislative limits.

It could be concluded that there is a relatively high potential for high-quality milk for possible processing valuation in these neglected local genetic resources given proper management and improvement. Given the social and economic significance of goats in the oasis ecosystem, as well as their desire to increase their income through diversification of production, this study's data provide Oasis people with valuable insights to promote the processing of goat milk into fresh cheese, flavored or not, using simple technology. Nevertheless, more thorough research on the fatty acid and volatile compound profiles could provide a better understanding of the particularities of cheeses. Further, the effect of different doses of basil and other local aromatic plants from the oasis on cheese-making must be studied and elucidated.

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Conflicts of interest

The authors declare that they have no competing interests.

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