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Comparative Evaluation of the Physicochemical Properties of Fresh Cow, Goat, and Sheep Milk from Tocra Farms, Libya

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Abstract
Milk quality and nutritional value are strongly influenced by its physicochemical properties and chemical composition, which vary among animal species. This study aimed to comparatively evaluate the physicochemical characteristics and chemical composition of fresh raw cow, goat, and sheep milk collected from farms in Tocra, Libya. A total of 30 raw milk samples (10 from each animal species) were collected during the spring season. The samples were analyzed for pH, titratable acidity (expressed as lactic acid), protein content, ash content, and starch adulteration, total solids (TS). The measured values ranged from 0.13 to 0.20% for titratable acidity, 6.57 to 6.75 for pH, 2.96 to 6.20% for protein, 0.62 to 1.05% for ashe, and 11.14 to 16.90% for TS. No starch adulteration was detected in any of the samples analyzed. The results demonstrated species-dependent variations in the physicochemical properties and chemical composition of the milk samples, reflecting differences in their nutritional characteristics. These findings provide baseline information on the quality of fresh milk produced in the Tocra

region and may contribute to quality assessment and future dairy research in Libya. Further microbiological and storage studies are recommended to evaluate the shelf-life stability of these milk samples. The higher protein, ash, and titratable acidity values observed in sheep milk highlight its favorable compositional characteristics for cheese production.
Keywords: Raw milk, Physicochemical analysis, Milk quality, Titratable acidity, Protein content, Ash.

مقارنة تقييم الخصائص الفيزيوكيميائية لحليب الأبقار والماعز والأغنام الطازج من مزارع توكرة، ليبيا

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الملخص

تتأثر جودة الحليب وقيمته الغذائية بشكل كبير بخصائصه الفيزيوكيميائية وتركيبه الكيميائي، والتي تختلف بين أنواع الحيوانات. هدفت هذه الدراسة إلى تقييم الخصائص الفيزيائية–الكيميائية والتركيب الكيميائي لحليب الأبقار والماعز والأغنام الطازج الذي تم جمعه من مزارع توكرة – ليبيا. حيث تم جمع ما مجموعه 30 عينة حليب خام (10 من كل نوع من الحيوانات) خلال موسم الربيع وحللت العينات من حيث الرقم الهيدروجيني، والحموضة القابلة للعراج (المعبر عنها كحمض اللاكتيك)، ومحتوى البروتين، ومحتوى الرماد، والنشا والمواد الصلبة الكلية. القيم المقاسة تراوحت بين 0.13 إلى 0.20٪ للحموضة القابلة للمعايرة، و6.75 للحموضة الهيدروجينية، و2.96 إلى 6.20٪ للبروتين، و0.62 إلى 1.05٪ للرماد، و 11.14 إلى 16.90% للمواد الصلبة الكلية. لم يتم اكتشاف النشا في أي من العينات التي تم تحليلها. وقد أظهرت النتائج اختلافات اعتمدت على النوع عينات الحليب، مما يعكس اختلافات في خصائصها الغذائية. توفر

هذه النتائج معلومات أساسية عن جودة الحليب الطازج المنتج في منطقة توكرة وقد تسهم في تقييم الجودة وأبحاث الألبان المستقبلية في ليبيا. يوصى بإجراء دراسات ميكروبيولوجية ودراسات تخزين إضافية لتقييم استقرار عمر الحليب لهذه العينات على الصلاحية. تبرز القيم الأعلى للبروتين والرماد والحموضة القابلة للقياس في حليب الأغنام خصائصه التركيبية المواتية لإنتاج الجبن.

الكلمات المفتاحية: حليب خام، تحليل فيزيائي كيميائي، جودة الحليب، الحموضة القابلة للمعايرة، محتوى البروتين، الرماد.

Introduction

Milk is one of the most important natural foods consumed worldwide due to its high nutritional value and balanced composition. It is a complex biological fluid secreted by the mammary glands of mammals after parturition to provide essential nutrients for the growth and development of their offspring. Beyond its biological role, milk constitutes a fundamental component of the human diet and serves as a major raw material for the dairy industry. It contains a wide range of nutrients, including water, proteins, lipids, carbohydrates (*primarily lactose*), vitamins, and minerals, all of which contribute to human health, growth, and overall well-being **(Dror, & Allen; 2018 and Samuel *et al*; 2020)**.

The chemical composition and physicochemical properties of milk vary considerably depending on several factors, including animal species, breed, feeding regime, stage of lactation, environmental conditions, health status, and post-harvest handling practices. Among the different types of milk consumed worldwide, cow, goat, and sheep milk are the most important, each possessing distinct compositional characteristics that influence their nutritional value, technological properties, processing behavior, and shelf-life **(Rosati, & Aumaitre; 2004 and Kourkouta, 2021)**. These compositional differences also affect the suitability of milk for manufacturing various dairy products and contribute to differences in consumer preference and nutritional quality.

Evaluation of milk quality is primarily based on its physicochemical characteristics and chemical composition. Parameters such as pH,

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titratable acidity, protein content, ash content, and the absence of adulterants are widely recognized as important indicators of milk freshness, hygienic quality, nutritional value, and suitability for processing and consumption **(Yalew *et al*; 2024, Lim *et al;* 2023 and Lu *et al*; 2025)**. Fresh milk normally exhibits a pH ranging from approximately 6.6 to 6.8, while deviations from this range may indicate microbial activity, contamination, or improper storage conditions. Similarly, titratable acidity reflects both the natural buffering capacity of milk and the accumulation of lactic acid resulting from bacterial fermentation, making it an important quality control parameter in the dairy industry **(Lim, 2023 and Libyan National Center for Standardization and Metrology 2000)**.

Milk proteins, particularly caseins and whey proteins, represent one of the most valuable nutritional and technological components of milk. They provide essential amino acids required for growth, tissue repair, and numerous physiological functions, while also playing a crucial role in the manufacture of dairy products such as cheese and yogurt **(Gaucheron; 2020, Lucey; 2002 and Pyne 1932).**

Likewise, ash content provides an estimate of the total mineral content of milk, which is important for evaluating its nutritional quality. In addition, routine screening for adulterants, including starch, remains an essential aspect of milk quality assessment, especially in regions where fresh, unpasteurized milk is widely marketed. The detection of such adulterants is important for ensuring product authenticity, maintaining consumer confidence, and complying with food quality standards **(Marshall; 2017)**.

Several studies have demonstrated that the physicochemical properties and chemical composition of milk differ among animal species and geographical regions because of variations in genetics, feeding systems, environmental conditions, and management practices. **Park *et al.* 2007** conducted a review comparing the physicochemical properties of goat, sheep, and cow milk. They found that sheep milk has higher concentrations of total solids and nutrients than both goat and cow milk. The study highlighted that variations in fat, protein, minerals, and casein micelle characteristics among these species influence technological properties such as coagulation behavior and cheese yield. In another study, Park

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reviewed the rheological characteristics of goat and sheep milk, noting that viscosity is influenced by factors such as fat and protein concentrations, temperature, pH, and milk age. Average viscosities were about 2.12 cP for goat milk and 2.48 cP for sheep milk, compared to approximately 1.70 cP for cow milk. The higher viscosities in sheep and goat milk correlate with differences in composition and structural characteristics, indicating that rheological properties are valuable for comparing milk from various animal species **(Park; 2007)**.

Li *et al*., 2022 investigated seasonal variations in the composition and physicochemical characteristics of sheep and goat milk in New Zealand, assessing factors like macronutrients, minerals, and viscosity. They found notable differences attributed to animal species and seasons, with sheep milk showing more pronounced seasonal variations. Specifically, late production season sheep milk exhibited greater increases in casein micelle size and viscosity after heat treatment, highlighting the influence of species and environmental factors on milk properties.

Several investigations in Libya have evaluated the physicochemical and nutritional quality of milk and dairy products. A study by **Elbagermi *et al*., 2020** analyzed pasteurized and long-life cow milk in Misurata, assessing parameters like moisture, ash, non-fat solids, total solids, protein, fat, lactic acid, pH, and total sugar in 11 samples. Results showed protein levels between 2.43 to 3.50%, fat from 0.25 to 3.50%, total acidity from 0.13 to 0.18%, and total sugars from 2.96 to 4.39%, generally conforming to Libyan standards **(Elbagermi *et al*., 2020)**. In another study, **Elbagermi *et al*., 2020** evaluated essential and heavy metals in pasteurized and long-life cow milk from supermarkets in Misurata, analyzing samples for various elements using microwave plasma atomic emission spectrometry. Potassium was the most abundant essential element, while zinc was the highest among heavy metals. Cobalt and cadmium were below detection limits in all samples. The study highlights the importance of assessing mineral composition in commercially available milk alongside traditional physicochemical properties.

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Elsherif *et al*., 2017 investigated major and minor elements in dairy products from local companies in Misurata, analyzing 15 samples. Zinc had the highest concentration among minor elements, while potassium was more abundant than sodium among major elements. Significant differences in heavy-metal concentrations were noted among dairy products, with fresh milk generally exhibiting lower concentrations than buttermilk, yoghurt, and yoghurt drinks.

Despite the available studies on milk quality in Libya, a clear research gap remains regarding the comparative characterization of fresh raw milk from different animal species under local production conditions. Most previous investigations have focused on commercially processed cow milk or specific dairy products, with limited attention given to fresh milk obtained directly from farms. Moreover, comparative data on the physicochemical properties and chemical composition of cow, goat, and sheep milk produced within the same geographical region are scarce. In particular, information on milk produced in the Tocra area is limited, making it difficult to establish representative baseline values for locally produced raw milk. Addressing this gap is important for evaluating species-related differences in milk quality and nutritional composition and for assessing the potential suitability of different milk types for dairy processing applications.

Accordingly, the present study aimed to compare the physicochemical properties and chemical composition of fresh raw cow, goat, and sheep milk collected from farms in the Tocra region of Libya. The parameters investigated included pH, titratable acidity, protein content, ash content, and starch adulteration. The findings of this study are expected to provide baseline information on the quality characteristics of locally produced milk and contribute to future research and quality control programs for the Libyan dairy sector.

2. Materials and methods

2.1. Sample collection

This study focused on the three most commonly consumed types of fresh milk in the Tocra region, Libya, namely cow, goat, and sheep milk. The selection of these milk types was guided by a preliminary survey conducted among 22 local farmers to identify the types of

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milk commonly produced and consumed in the region. Based on the survey findings, cow, goat, and sheep milk were selected for comparative evaluation. A total of 30 fresh raw milk samples were collected from different farms in the Tocra area during the spring season, comprising 10 samples each of cow, goat, and sheep milk. Immediately after collection, the samples were labelled according to animal species as cow (C), goat (G), and sheep (S), and each sample was assigned a unique identification code (C1–C10, G1–G10, and S1–S10). The samples were transported to the laboratory under refrigerated conditions and stored at 6 ± 1°C until analysis.

2.2 Reagents and Chemicals

All reagents used in this study were of analytical grade. Sodium hydroxide (0.1 N) and phenolphthalein indicator were purchased from BDH Ltd. (Poole, UK) and Riedel-de Haën AG (Germany), respectively, and used without further purification. Deionized water (18.2 MΩ·cm) was obtained from a Milli-Q water purification system (Millipore, Bedford, MA, USA) and was used throughout the study. Before use, all glassware and polyethylene containers were soaked in 10% (v/v) nitric acid (HNO_3) for at least 24 h, rinsed thoroughly three times with deionized water, and air-dried. Reagent blanks containing only the analytical reagents were prepared and analyzed together with the samples to verify the absence of contamination.

2.3 Determination of pH

The pH of the milk samples was determined according to the AOAC method [19] using a digital pH meter (pHs-2F, Harris, England). Prior to measurement, the instrument was calibrated using standard buffer solutions of pH 4.0, 7.0, and 10.0. Approximately 50 mL of each milk sample was transferred into a clean beaker, and the pH was recorded after the reading had stabilized.

2.4 Determination of Titratable Acidity

Titratable acidity (TA) was determined according to AOAC Official Method 947.05 **(AOAC International; 2023)**. A known volume of milk was titrated with 0.1 N sodium hydroxide using phenolphthalein as the indicator until a persistent pale pink endpoint was obtained. The titratable acidity was expressed as percentage lactic acid and calculated using Equation (1).

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$$\% \text{ titrable acidity} = \frac{S \times N \times 90 \times 100}{V \times 1000} \quad (1)$$

where V is the volume (mL) of 0.1 N NaOH consumed, N is the normality of NaOH, and S is the volume (mL) of milk analyzed. The molecular weight of lactic acid was taken as 90 g mol^{-1}.

2.5 Detection of Starch Adulteration

Starch adulteration was determined qualitatively using the iodine test. Briefly, 5 mL of each milk sample was boiled and allowed to cool to room temperature. Subsequently, 1 mL of 1% iodine solution was added and mixed thoroughly. The appearance of a blue coloration indicated the presence of starch, whereas the absence of color change indicated that no starch adulteration had occurred.

2.6 Determination of Protein Content

Protein content was determined using the formol titration (Pyne's) method **(Marshall; 2017)**. In this method, formaldehyde reacts with amino groups in milk proteins, and the liberated hydrogen ions are titrated with standardized sodium hydroxide solution. The protein content was calculated using Equation (2).

$$\% \text{ total protion} = (V - V_b) \times 1.7 \quad (2)$$

where V is the volume (mL) of 0.1 N NaOH used for the sample, V_b is the volume (mL) consumed for the reagent blank, and 1.7 is the conversion factor.

2.7 Determination of Ash Content

Ash content was determined according to the standard gravimetric method **(Marshall; 2017)**. A known quantity of milk was first dried and subsequently incinerated in a muffle furnace at 600°C until a constant weight was obtained. The ash content was calculated using Equation (3).

$$\% \, ash = \frac{C}{A} \times 100 \quad (3)$$

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where A is the initial weight of the milk sample and C is the weight of the ash residue.

2.8 Determination of Total Solids (TS)

Total solids (TS) were determined gravimetrically according to previously reported methods (Javaid et al; 2009 and Bradley; 2017). Approximately 5 g of each milk sample (A) was heated at 70°C for 1 h, followed by drying at 120°C for 6 h until constant weight. The dried residue (B) was weighed, and the TS percentage was calculated using Equation (4).

$$\% TS = \frac{\mathrm{B}}{\mathrm{A}} \times 100 \qquad (4)$$

where A is the initial sample weight and B is the weight of the dried residue.

2.9. Statistical analysis

All measurements were performed on ten independent samples for each milk type ($n = 10$), and the results are presented as mean ± standard deviation (SD). Statistical differences among cow, goat, and sheep milk samples were evaluated using one-way analysis of variance (ANOVA), followed by Tukey's honestly significant difference (HSD) post hoc test. Statistical analyses were performed using IBM SPSS Statistics version 21 (IBM Corp., Armonk, NY, USA), and differences were considered statistically significant at $P < 0.05$.

3. Result and Discussion

3.1 Physicochemical Properties of Fresh Cow, Goat, and Sheep Milk

The physicochemical characteristics of fresh cow, goat, and sheep milk are summarized in Table 1, while the individual analytical results for each sample are presented in Table 2. Significant differences ($P < 0.05$) were observed among the three milk types for all measured parameters, indicating that animal species had a marked influence on milk composition and quality.

TABLE (1): Mean (± SD) values of the physicochemical properties and chemical composition of fresh cow, goat, and sheep milk samples (n=10).

Parameter	Cow	Goat	Sheep	p-value
Titratable acidity (%)	0.145 ± 0.013	0.166 ± 0.010	0.192 ± 0.006	<0.001
pH	6.693 ± 0.035	6.643 ± 0.038	6.641 ± 0.037	0.005
Protein (%)	3.310 ± 0.193	3.715 ± 0.205	5.651 ± 0.381	<0.001
Ash (%)	0.694 ± 0.035	0.717 ± 0.039	0.952 ± 0.065	<0.001
TS %	11.243 ± 0.092	11.343 ± 0.080	14.570 ± 1.333	<0.001

Values are presented as mean ± SD (n = 10). The p-values indicate the overall statistical significance among the three milk species as determined by one-way ANOVA. A p-value < 0.05 was considered statistically significant

As shown in (Table 1), titratable acidity differed significantly among the milk samples ($P < 0.001$), with cow milk exhibiting the lowest mean value (0.145 ± 0.013%), whereas goat and sheep milk showed higher acidity (0.166 ± 0.010%). Conversely, cow milk had the highest mean pH (6.693 ± 0.035), followed by goat (6.643 ± 0.038) and sheep milk (6.641 ± 0.037), although the differences were relatively small but statistically significant ($P = 0.0049$). These results demonstrate the expected inverse relationship between pH and titratable acidity.
Protein content varied markedly among the three milk types ($P < 0.001$). Sheep milk contained the highest protein concentration (5.651 ± 0.381%), followed by goat milk (3.715 ± 0.205%) and cow milk (3.310 ± 0.193%). A similar trend was observed for ash content, with sheep milk exhibiting the highest mineral content (0.952 ± 0.065%), whereas cow and goat milk contained significantly lower ash concentrations. Likewise, total solids (TS) were significantly higher in sheep milk (14.570 ± 1.333%) than in cow (11.243 ± 0.092%) and goat milk (11.343 ± 0.080%) ($P < 0.001$), reflecting its higher concentration of solids, particularly proteins and minerals.
The observed interspecies differences are primarily attributed to variations in milk composition, including protein, mineral, and buffering constituents, in addition to genetic background, breed, feeding regime, stage of lactation, and environmental conditions.

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Overall, these findings demonstrate that sheep milk possesses a more concentrated composition than cow and goat milk, whereas cow milk is characterized by lower acidity and lower concentrations of total solids. The individual values presented in Table 2 further confirm the consistency of these compositional differences among the analyzed samples.

TABLE 2: Total acidity, % titratable acidity, pH, % Protein, % Ash, and % TS in various types of fresh milk samples.

Code of Sample	Type of Milk	Titratable acidity (%)	pH	Protein%	Ash%	TS%
C1	Cow	0.13	6.73	3.42	0.68	11.16
C2		0.16	6.65	2.97	0.62	11.14
C3		0.14	6.70	3.30	0.70	11.26
C4		0.13	6.75	3.35	0.69	11.20
C5		0.13	6.72	3.47	0.72	11.32
C6		0.15	6.67	3.42	0.71	11.30
C7		0.14	6.69	3.40	0.72	11.33
C8		0.16	6.64	2.96	0.68	11.18
C9		0.16	6.68	3.50	0.75	11.40
C10		0.15	6.70	3.31	0.67	11.14
G11	Goat	0.15	6.70	3.55	0.66	11.20
G12		0.16	6.65	3.63	0.73	11.35
G13		0.16	6.67	3.76	0.69	11.31
G14		0.17	6.63	3.80	0.74	11.39
G15		0.17	6.65	4.10	0.70	11.28
G16		0.17	6.69	3.49	0.77	11.42
G17		0.18	6.63	3.65	0.67	11.18
G18		0.18	6.62	3.59	0.71	11.31
G19		0.16	6.57	4.02	0.78	11.47
G20		0.16	6.62	3.56	0.72	11.36
S21	Sheep	0.18	6.65	5.16	0.87	13.21
S22		0.19	6.60	6.02	0.85	13.18
S23		0.19	6.58	5.83	0.96	14.20
S24		0.20	6.62	5.50	0.94	14.00
S25		0.20	6.61	6.20	0.99	15.10
S26		0.20	6.66	5.60	1.05	16.90
S27		0.19	6.69	5.10	0.97	14.05
S28		0.19	6.65	5.30	0.89	13.96

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Code of Sample	Type of Milk	Titratable acidity (%)	pH	Protein%	Ash%	TS%
S29		0.19	6.68	6.00	0.98	14.23
S30		0.19	6.67	5.80	1.02	16.87

3.2 Titratable Acidity of Fresh Cow, Goat, and Sheep Milk

Titratable acidity is an important quality parameter used to evaluate milk freshness, compositional characteristics, and suitability for dairy processing. Unlike pH, which represents the concentration of free hydrogen ions, titratable acidity reflects the total amount of acid-reactive components present in milk, including lactic acid, casein, phosphate salts, dissolved carbon dioxide, and other weak acid systems **(Kourkouta; 2021 and Gashu et al; 2010)**. Therefore, variations in titratable acidity among different milk types are influenced not only by microbial acid production but also by the intrinsic buffering capacity of milk.

The titratable acidity values of the analyzed milk samples are presented in Table 1 and Table 2. Significant differences were observed among the three milk types ($P < 0.001$), with the highest acidity recorded in sheep milk (0.192 ± 0.006%) then goat milk (0.166 ± 0.010%) followed by cow milk (0.145 ± 0.013%). The individual sample values ranged from 0.13–0.16% for cow milk, 0.15–0.18% for goat milk, and 0.18–0.20% for sheep milk, showing the following general trend: sheep milk > goat milk > cow milk.

The higher titratable acidity observed in sheep milk can be attributed to its higher concentrations of proteins, particularly casein, minerals, and total solids, which contribute to the buffering capacity of milk and increase the amount of alkali required during titration. Similar trends have been reported in previous studies, where sheep milk generally exhibited higher titratable acidity than cow milk, while goat milk showed intermediate or relatively elevated values depending on breed, feeding conditions, and lactation stage.

Although increased titratable acidity is often associated with microbial fermentation and lactic acid production, the higher values observed in sheep and goat milk do not necessarily indicate deterioration or poor quality. Instead, they may reflect differences in the natural composition of small ruminant milk, particularly the

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higher protein and mineral content. The relationship between titratable acidity and milk quality should therefore be interpreted together with pH values and other compositional parameters.
According to the permissible limits reported by the Libyan National Centre for Standardization and Metrology (LNCSM) [8], the observed acidity values showed variation among the analyzed samples. However, species-related differences should be considered when evaluating milk quality because natural compositional variations can influence acidity measurements. The variation of titrable acidity among raw milk samples is presented in (Figure 1).

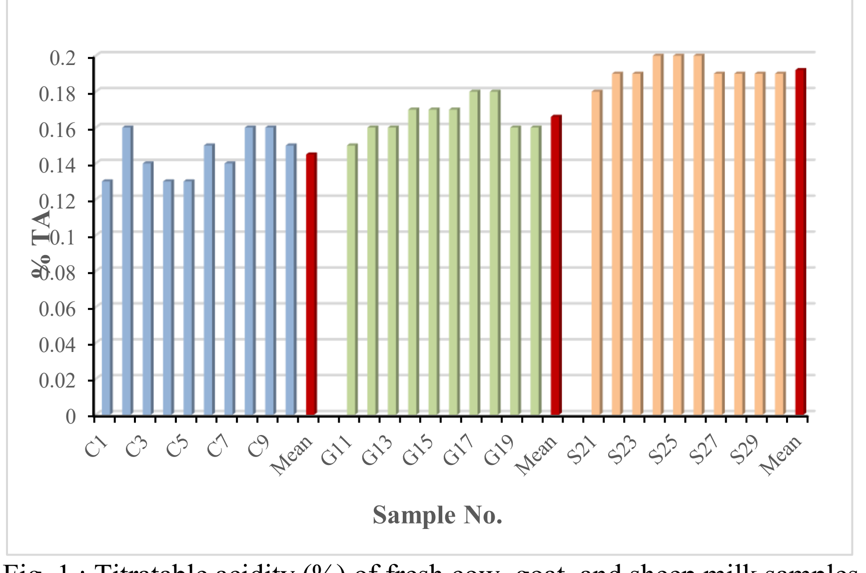

Fig. 1.: Titratable acidity (%) of fresh cow, goat, and sheep milk samples

3.3 pH Characteristics of Fresh Cow, Goat, and Sheep Milk

The pH values of the analyzed milk samples are presented in **(Table 1 and Table 2)**, while the comparison among different milk types is illustrated in Figure 2. Significant differences were observed among cow, goat, and sheep milk samples (P = 0.0049). The pH values ranged from 6.64 to 6.75 for cow milk, 6.57 to 6.70 for goat milk, and 6.58 to 6.69 for sheep milk, indicating that all samples were within the typical range reported for fresh milk.

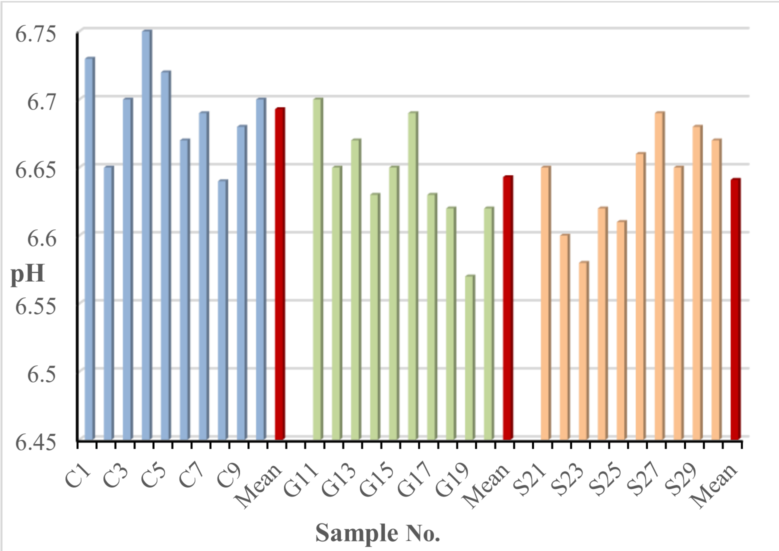

Fig. 2.: pH values of fresh cow, goat, and sheep milk samples collected from Tocra, Libya.

The mean pH values followed the order: cow milk (6.693 ± 0.035) > goat milk (6.643 ± 0.038) ≈ sheep milk (6.641 ± 0.037). Although milk acidity and pH generally show an inverse relationship, these parameters describe different aspects of milk acidity. Titratable acidity reflects the total concentration of acid-reactive components, including weak acids, proteins, and mineral salts, whereas pH represents the activity of free hydrogen ions in the aqueous phase. Therefore, differences in protein content, mineral composition, and buffering systems may result in variations in titratable acidity without causing proportional changes in pH.

The slightly lower pH values observed in goat and sheep milk compared with cow milk may be associated with differences in their protein and mineral composition, particularly the casein fraction and calcium–phosphate equilibrium system. Casein and phosphate salts contribute significantly to the buffering capacity of milk by resisting changes in hydrogen ion concentration. Consequently, milk composition plays an important role in controlling pH stability.

All analyzed samples were within the pH range specified for fresh milk according to the Libyan National Centre for Standardization and Metrology (LNCSM) standard (pH 6.4–6.8) **(Libyan National**

Center for Standardization and Metrology; 2020). However, pH alone should not be considered a definitive indicator of milk freshness, as microbial activity, storage conditions, temperature, and handling practices may also influence milk acidity. Therefore, pH evaluation should ideally be combined with other quality parameters, including titratable acidity and microbiological analysis.

3.4 Qualitative Detection of Starch as a Milk Adulterant

The presence of starch adulteration in fresh milk samples was evaluated using the iodine test. No color change was observed after the addition of iodine solution to any of the analyzed samples, with the iodine color remaining yellow–brown. This result indicates the absence of detectable starch in all cow, goat, and sheep milk samples collected from the Tocra region. The absence of starch suggests that none of the analyzed samples had been adulterated with starch-based additives. Starch detection represents an important quality control measure because starch is sometimes added fraudulently to milk to increase apparent solids content and mask dilution. However, the iodine test is specific for starch detection and does not exclude the presence of other possible adulterants.

3.5 Protein Content of Fresh Cow, Goat, and Sheep Milk

Milk proteins represent one of the most important nutritional and functional components of milk. They provide essential amino acids required for human growth and tissue maintenance and contribute significantly to the technological properties of dairy products. Milk proteins consist mainly of caseins and whey proteins, which influence nutritional quality, coagulation behavior, and suitability for the production of fermented dairy products and cheese. In the present study, protein content was determined using the formol titration method, which is a simple and widely applied approach for estimating total milk protein due to its rapidity and acceptable accuracy **(Gashu et al; 2010 and International Dairy Federation (IDF); 1986)**.

The protein contents of the analyzed milk samples are presented in **(Table 1 and Table 2)**, while the comparison among different milk species is illustrated in Figure 3. Significant differences were observed among the three milk types ($P < 0.001$). Sheep milk

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exhibited the highest protein content (5.651 ± 0.381%), followed by goat milk (3.715 ± 0.205%) and cow milk (3.310 ± 0.193%). The individual sample values ranged from 2.96–3.50% in cow milk, 3.49–4.10% in goat milk, and 5.10–6.20% in sheep milk.

The higher protein concentration observed in sheep milk reflects its naturally richer composition compared with cow and goat milk. Similar trends have been reported in previous studies, where sheep milk generally contains greater amounts of casein and total protein, making it particularly suitable for cheese production. Goat milk also showed higher protein content than cow milk, although the difference was less pronounced.

The differences in protein concentration among milk species may be related to genetic factors, breed characteristics, feeding conditions, stage of lactation, and environmental influences. The higher protein content of sheep milk was also consistent with the elevated ash and total dissolved solids values observed in the present study, indicating a more concentrated milk composition. According to the reference values reported for milk quality standards **(Konte; 1999)**, variations in protein content among species should be interpreted considering the natural compositional differences between cow, goat, and sheep milk.

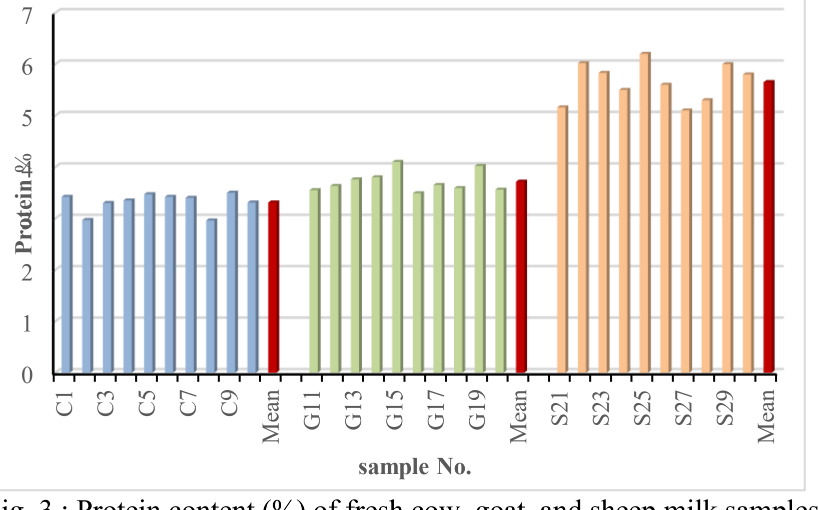

Fig. 3.: Protein content (%) of fresh cow, goat, and sheep milk samples collected from Tocra, Libya.

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3.6 Ash Content of Fresh Cow, Goat, and Sheep Milk

Ash content represents the total inorganic mineral fraction remaining after complete incineration of milk samples and provides an indication of the mineral composition of milk. These minerals, including calcium, phosphorus, magnesium, potassium, and sodium, contribute to the nutritional value of milk and influence important technological properties such as buffering capacity, coagulation behavior, and dairy product quality.

The ash content values of the analyzed milk samples are presented in **(Table 1 and Table 2)**, while the comparison among milk types is shown in Figure 4. Significant differences were observed among cow, goat, and sheep milk samples ($P < 0.001$). Sheep milk exhibited the highest ash content (0.952 ± 0.065%), followed by goat milk (0.717 ± 0.039%) and cow milk (0.694 ± 0.035%). The individual sample values ranged from 0.62–0.75% in cow milk, 0.66–0.78% in goat milk, and 0.85–1.05% in sheep milk.

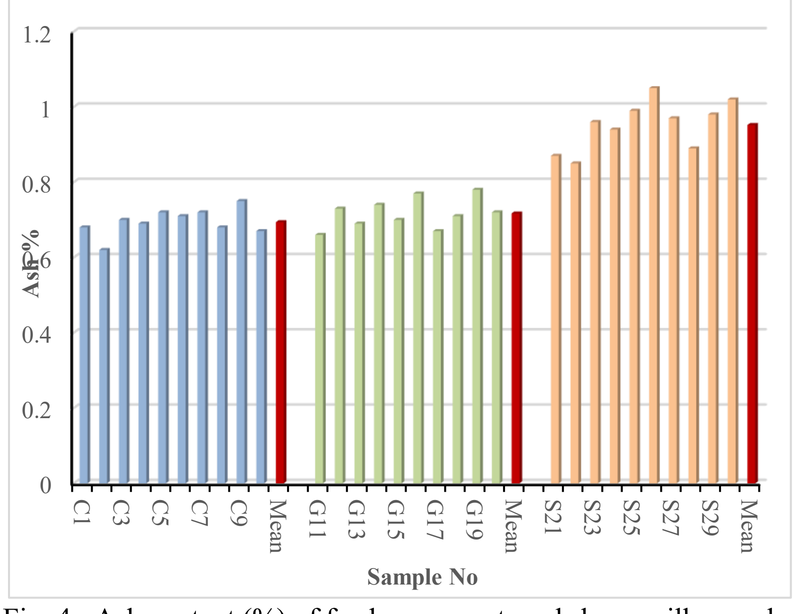

Fig. 4.: Ash content (%) of fresh cow, goat, and sheep milk samples collected from Tocra, Libya.

The higher mineral content observed in sheep milk is consistent with its greater protein concentration and total solids content recorded in

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this study. The increased levels of minerals and proteins contribute to the stronger buffering capacity of sheep milk, which may partly explain the higher titratable acidity observed compared with cow milk. Similar differences among milk species have been reported previously and are generally attributed to genetic factors, breed characteristics, feeding conditions, and lactation stage.

The higher ash content of sheep milk may provide technological advantages in dairy processing, particularly in cheese production, because mineral components influence casein micelle stability, coagulation properties, and final product characteristics.

3.7 Total Solids (TS) of Fresh Cow, Goat, and Sheep Milk

Total solids (TS) represent the fraction of milk remaining after removal of water and include soluble components such as lactose, minerals, and other non-water constituents. The TS values of the analyzed milk samples are presented in **(Table 1 and Table 2)**, while the comparison among different milk types is illustrated in (Figure 5).

Significant differences were observed among cow, goat, and sheep milk samples ($P < 0.001$). Sheep milk showed the highest TS content (14.570 ± 1.333%), with individual values ranging from 13.18 to 16.90%, followed by goat milk (11.343 ± 0.080%), with values ranging from 11.18 to 11.47%. Cow milk exhibited the lowest TDS values (11.243 ± 0.092%), ranging from 11.14 to 11.40%.

The TS values showed a marked difference in both mean values and variability among the three milk types. Cow and goat milk exhibited relatively low and consistent TS values of 11.243 ± 0.092% and 11.343 ± 0.080%, respectively, whereas sheep milk recorded a considerably higher mean TS value of 14.570 ± 1.333%. The relatively large standard deviation observed for sheep milk indicates greater variability among the individual sheep milk samples compared with cow and goat milk. This variation may reflect natural differences in the concentrations of dissolved milk constituents, including lactose, soluble proteins, and mineral salts, which can be influenced by factors such as animal-to-animal variation, feeding conditions, stage of lactation, hydration status, and farm management practices.

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The higher TS content observed in sheep milk is consistent with its greater concentrations of protein and mineral components, as demonstrated by the higher protein and ash values obtained in this study. The increased concentration of milk solids contributes to the higher nutritional density of sheep milk and may influence its technological properties, particularly during cheese and fermented dairy product manufacturing. Similar differences among milk species have been attributed to variations in genetic characteristics, feeding systems, and lactation conditions.

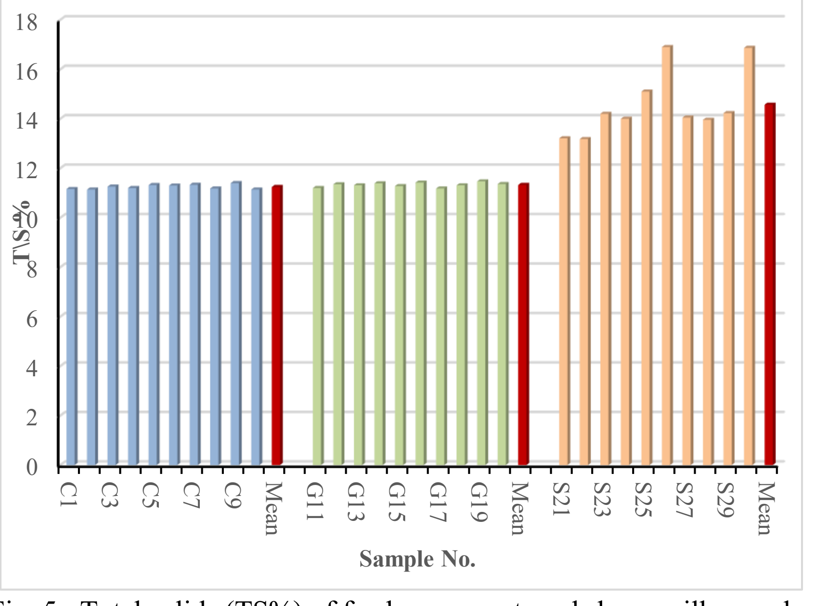

Fig. 5.: Total solids (TS%) of fresh cow, goat, and sheep milk samples collected from Tocra, Libya.

3.8 Limitations of the Study

Several limitations should be considered when interpreting the findings of the present study. First, milk samples were collected during a single season (spring) and from one geographical area (Tocra, Libya); therefore, seasonal and regional variations in milk composition could not be evaluated. Second, the analysis focused on selected physicochemical and chemical parameters, and other important components, particularly fat, lactose, and solids-not-fat

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(SNF), were not determined. Third, microbiological analyses were not performed; consequently, the microbiological quality and safety of the raw milk samples examined were not assessed. These limitations should be considered in future studies by including samples collected across different seasons and geographical areas, together with a broader compositional analysis and microbiological evaluation.

4. Conclusion

This study evaluated the physicochemical characteristics and compositional quality of fresh cow, goat, and sheep milk collected from farms in the Tocra region, Libya. Significant differences were observed among the three milk types, demonstrating the influence of animal species on milk composition and quality characteristics.

The results showed that sheep milk exhibited the highest values of protein, ash, and total solids, accompanied by higher titratable acidity, whereas cow milk generally showed the lowest values for most compositional parameters. Goat milk presented intermediate characteristics between cow and sheep milk. These variations are mainly associated with differences in genetic factors, physiological characteristics, feeding conditions, and environmental influences among animal species.

All analyzed milk samples showed pH values within the expected range for fresh milk, and no starch adulteration was detected in any sample, indicating acceptable quality at the time of collection. The higher concentration of protein and mineral components in sheep milk suggests its greater nutritional density and potential advantages for dairy processing, particularly cheese production.

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4. Reference

AOAC International. (2023). AOAC Official Method 947.05: Acidity of milk—Titrimetric method. In G. W. Latimer Jr. (Ed.), Official Methods of Analysis of AOAC INTERNATIONAL (22nd ed.).AOAC INTERNATIONAL. https://doi.org/10.1093/9780197610145.003.3040

Bradley, R. L. (2017). Moisture and total solids analysis. In S. S. Nielsen (Ed.), Food analysis laboratory manual (pp. 88–91). Springer. Dror, D. K., & Allen, L. H. (2018). Overview of nutrients in human milk. Advances in Nutrition, 9(3), 278S–294S. https://doi.org/10.1093/advances/nmy022

Elbagermi, M. A., Bin Haleem, A. A., & Elsherif, K. M. (2020). Evaluation of essential and heavy metal levels in pasteurized and long-life cow milk. International Journal of Advanced Chemistry,8(1), 6–14. https://doi.org/10.14419/ijac.v8i1.30154

Elbagermi, M. A., Bin Haleem, A. A., & Elsherif, K. M. (2020). Physicochemical properties and nutritional values of pasteurized milk and long-life milk: A comparative study. Journal of Analytical Sciences and Applied Biotechnology, 2(1), 38–45. https://doi.org/10.48402/IMIST.PRSM/jasab-v2i1.19403

Elsherif, K. M., Abu Khater, R. A., & Hegaig, F. A. (2017). Determination of major and minor elements in dairy products produced in Misurata city–Libya. Maghrebian Journal of Pure and Applied Science, 3(2), 9–17.

Gashu, D., Reta, N., & Dessie, G. (2010). Determination of the levels of essential and toxic metal constituents in cow's whole milk from selected sub-cities in Addis Ababa, Ethiopia (Master's thesis, Addis Ababa University, Ethiopia). Unpublished. Gaucheron, F. (2020). Milk proteins: An overview. In Milk proteins: From expression to food (3rd ed., pp. 21–98). Elsevier. https://doi.org/10.1016/B978-0-12-815251-5.00002-5

International Dairy Federation. (1986). Proceedings of the IDF seminar on production and utilization of ewe's and goat's milk. International Dairy Federation Bulletin No. 202. Javaid, S., Gadahi, J., Khaskeli, M., Bhutto, M., Kumbher, S., &

Panhwar, A. (2009). Physical and chemical quality of market milk sold at Tandojam, Pakistan. Pakistan Veterinary Journal, 29(1), 27–31.

Konte, M. (1999). Le lait et les produits laitiers. Développement de systèmes de productions intensives en Afrique de l'ouest (pp. 2–25). Université de Nouakchott, Faculté des Sciences et Technologies des Aliments. Kourkouta, L., Frantzana, A., Koukourikos, K., Iliadis, C., Ioanna, P., Tsaloglidou, A., & Papathanasiou, V. (2021). Milk nutritional composition and its role in human health. Journal of Pharmacy and Pharmacology, 9(1), 10–15. https://doi.org/10.17265/2328-2150/2021.01.002

Libyan National Center for Standardization and Metrology, Ministry of Commerce. (2000). Libyan standard concerning milk (No. 363, pp. 1–5). Libyan Standard Legislation for Industrial and Non-Industrial Food. Li, S., Delger, M., Dave, A., Singh, H., & Ye, A. (2022). Seasonal variations in the composition and physicochemical characteristics of sheep and goat milks. Foods, 11(12), 1737. https://doi.org/10.3390/foods11121737

Lim, S. H., Chin, N. L., Sulaiman, A., Tay, C. H., & Wong, T. H. (2023). Microbiological, physicochemical and nutritional properties of fresh cow milk treated with industrial high-pressure processing (HPP) during storage. Foods, 12(3), 592. https://doi.org/10.3390/foods12030592

Lu, H., Dang, C., Liu, R., Zhang, S., Xue, Y., Feng, L., Zhang, Y., Wu, Y., & Wang, S. (2025). The effects of sampling sites, collection time, and refrigerated storage duration on microbiota of raw milk from a Chinese dairy farm: An exploratory study. Journal of Food Protection, 88(1), 1–12. https://doi.org/10.4315/JFP-24-193

Lucey, J. A. (2002). Formation and physical properties of milk protein gels. Journal of Dairy Science, 85(2), 281–294. https://doi.org/10.3168/jds.S0022-0302(02)74078-2

Marshall, M. R. (2017). Ash analysis. In S. S. Nielsen (Ed.), Food analysis laboratory manual (pp. 108–109). Springer. Park, Y. W. (2007). Rheological characteristics of goat and sheep milk.

Small Ruminant Research, 68(1–2), 73–87. https://doi.org/10.1016/j.smallrumres.2006.09.015

Park, Y. W., Juárez, M., Ramos, M., & Haenlein, G. F. W. (2007). Physico-chemical characteristics of goat and sheep milk. Small Ruminant Research, 68(1–2), 88–113. https://doi.org/10.1016/j.smallrumres.2006.09.013

Pyne, G. T. (1932). The determination of milk proteins by formaldehyde titration. Biochemical Journal, 26(3), 1006–1014. https://doi.org/10.1042/bj0261006

Rosati, A., & Aumaitre, A. (2004). Organic dairy farming in Europe.
Livestock Production Science, 90(1), 41–51. https://doi.org/10.1016/j.livprodsci.2004.07.005

Samuel, T. M., Zhou, Q., Giuffrida, F., Munblit, D., Verhasselt, V.,
& Thakkar, S. K. (2020). Nutritional and non-nutritional composition of human milk is modulated by maternal, infant, and methodological factors. Frontiers in Nutrition, 7, 576133. https://doi.org/10.3389/fnut.2020.576133

Yalew, K., Pang, X., Huang, S., Zhang, S., Yang, X., Xie, N., Wang,
Y., Lv, J., & Li, X. (2024). Recent development in detection and control of psychrotrophic bacteria in dairy production, ensuring milk quality. Foods, 13(18), 2908. https://doi.org/10.3390/foods13182908