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Production and characterization of camel milk yogurt using camel gelatin as a texturizing agent

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ORIGINAL ARTICLE

Abstract

The objective of this research is the enrichment of camel milk (CML) with gelatin, in order to obtain a firm-textured camel yoghurt, and to compare it with cow yoghurt. Gelatin was extracted from camel skin, characterized, and some functional properties were determined. Gelatin revealed high yield (19.36%) and high protein content (86%). One percent of gelatin was added to fermented milk. Camel's yoghurt had higher saturated fatty acids and higher levels of vitamins. The sensory evaluation of three types of yoghurt shows that camel yoghurt in the intensive system is more appreciated than cow yoghurt.

Keywords: Camel yoghurt, Cow yoghurt, Intensive system, Semi-intensive system, Physicochemical, biochemical, and microbiological Parameters

Introduction

Camel milk (CML) has been a well-known source of nutrition for people living in desert regions across various countries for centuries. Because of its health benefits, it has long been used in traditional medicine and folk remedies (Seifu, 2023). Compared to milk from ruminants, CML is richer in vitamins C and B, unsaturated fatty acids, and minerals (Al-Shamsi *et al.*, 2018). In addition, CML contains higher levels of protective proteins like immunoglobulins, lactoferrin, and lysozyme, while being lower in both lactose and cholesterol (El-Agamy, 2009; Mudgil *et al.,* 2018). However, in spite of the health benefits of CML, the commercial availability of CML products is very few (Mudgil *et al.,* 2018). The production of set-type yoghurt from CML is challenging because of its difficulty in coagulating (Galeboe *et al.*, 2018). As a result, the properties of CML yoghurt differ significantly from those of cow's milk yoghurt. Fermented CML tends to have poor consistency, and the fermentation process with starter cultures is prolonged (approximately 18 h), often resulting in a flocculent precipitate rather than solid curd (He *et al.*, 2022). These fermentation challenges are attributed to the antimicrobial proteins (such as lactoferrin, lysozyme, and immunoglobulins) present in CML, which inhibit the growth of lactic acid bacteria (Hamed et *al.,* 2024), as well as the low levels of β-casein and β-lactoglobulin (Laleye *et al.*, 2008), and a very limited amount of κ-casein in CML (Shabo *et al.*, 2005).

Various solutions have been proposed to overcome the challenges in producing set-type yoghurt from CML. One approach involves the addition of appropriate hydrocolloids or stabilizers, which can improve the texture by facilitating the formation of a protein network, thus helping to mitigate the issues typically encountered with such milks (Matumoto-Pintro *et al.,* 2011). Stabilizers are commonly used in stirred yogurt to help maintain its desired texture and prevent syneresis. Although a variety

of stabilizers are available, gelatin is often considered the most effective because of its unique gelling properties (Arab *et al.*, 2022). The gelation process of gelatin involves a reverse coil-to-helix transition, which occurs when the solution is cooled below 30°C, leading to the formation of triple helices (Gómez-Guillen *et al.*, 2011). Gelatin has been extensively used to enhance water retention, improve the gel-forming capacity of meat mince, and to modify the rheological properties of protein gels (Derkach *et al.*, 2024). Today, gelatin is widely applied in the food, cosmetic, and pharmaceutical industries. Most commercial gelatin is derived from mammals (bovine and primarily porcine). However, the use of this gelatin has become increasingly limited because of sociocultural and safety concerns (Kittiphattanabawon *et al.*, 2010; Sae-Leaw *et al.*, 2016). The use of cow gelatin, in particular, is problematic because of concerns over bovine spongiform encephalopathy (BSE) outbreaks. As a result, alternative sources are being explored. In Tunisia, slaughterhouses generate large quantities of dromedary skins, which are often discarded in landfills, contributing to environmental waste. Converting these skins into high-value products, such as collagen, could offer significant economic benefits while providing an eco-friendly alternative to bovine or porcine collagen. Yogurt is a well-known fermented dairy product created through the action of lactic acid bacteria, and its commercial demand has grown because of its consumer popularity and health benefits (Sengupta *et al.*, 2022). It is highly nutritious, particularly because of its rich content of proteins and essential minerals. From a technical perspective, protein gelation plays a key role in the preparation of yogurt, as the protein gel network is reinforced by disulfide bonds formed between denatured whey proteins and κ-casein molecules.

Based on the previous suggestions, it is clear that the use of stabilizers, hydrocolloids, and the supplementation of CML with other types of milk can enhance the texture and quality of CML yoghurt. Consequently, the aim of the present study was to optimize the production of set-type yoghurt by incorporating camel gelatin as a texturing agent.

Material and Methods

Sample

The milk used in this study was obtained from Maghrebi camels (*Camelus dromedarius*) belonging to the experimental herd of the Arid Land Institute (IRA) in Medenine, Tunisia. The camels were raised under two different breeding systems: a semi-intensive system at the Laboratory of Livestock and Wildlife, and an intensive system at the Chenchou station. Cow milk was collected from a herd of dairy cows raised on a farm located in the same region of southern Tunisia (Medenine). Both milk types were transported in isothermal containers to the laboratory, where they were analyzed and processed promptly upon arrival.

The methodology described for extracting gelatin from camel skin aligns with established practices in gelatin production. The process involves several key steps:

1. **Collection and Preparation:**
   - Obtaining fresh camel skin from a slaughterhouse ensures the material is suitable for the extraction of gelatin.
   - Washing the skin with cool tap water removes surface impurities.
   - Cutting the skin into small pieces enhances uniform processing.
   - Storing the skin at −20°C preserves it until further use, with a storage duration of less than 2 months.
2. **Alkaline Pretreatment:**
   - Soaking the skin in a 0.5 M NaOH solution at a 1:5 (w/v) ratio for 3 days helps remove noncollagenous proteins.
   - Changing the solution daily ensures effective removal of unwanted proteins.
   - Washing the alkaline-treated skin with tap water until a neutral pH is achieved eliminates residual alkali.
3. **Acid Treatment:**
   - Soaking the skin in a 0.1 M citric acid solution at a 1:5 (w/v) ratio for 1 h further purifies the skin.
   - Washing the samples with tap water until neutral pH ensures the removal of acid residues.

This process is consistent with methods reported in the literature. For instance, a study by Bessalah *et al.* (2023) utilized similar alkaline and acid treatments to extract gelatin from camel skin, resulting in a gelatin yield of 29.1% under optimized conditions.

It's important to note that variations in pretreatment conditions, such as NaOH concentration, soaking time, and temperature, can influence the yield and quality of the extracted gelatin. Therefore, optimizing these parameters is crucial for efficient gelatin extraction.

Extraction of gelatin

The swollen skin was mixed with distilled water at 1:5 (w/v) at different temperatures (50, 60, and 70°C) for various times (3, 6, 9, and 12 h). The mixtures were then filtered using filter paper to remove insoluble materials.

The supernatant was freeze-dried and subjected to analyses (Bessalah *et al.,* 2023).

Determination of yield

The yield of gelatin was calculated based on the wet weight of fresh skin as follows:

$$\text{Yield } (\%) = \frac{\text{weight of dry gelatin (g)}}{\text{weight of initial skin (g)}} \times 100$$

Viscosity

The relative viscosity of the prepared solution of gelatin was contrasted with that obtained at 4°C. Viscosity was measured using a Brookfield coaxial cylinder viscometer and expressed in centipoise (cP).

Protein content (PC) analysis

PC of camel skin gelatin (CSG) was determined by the Kjeldahl method (AOAC, 1999) with slight modifications. In short, approximately 2 g of CSG was accurately measured. The results were expressed using a nitrogen conversion component factor of 5.55 for gelatin (AOAC, 1984).

Determination of functional properties

Emulsifying properties

Emulsion activity index (EAI) and emulsion stability index (ESI) of gelatin samples were determined, following the conditions adopted previously (Pearce and Kinsella 1978). Soybean oil (2 mL) and gelatin solution (1, 2, and 3%, 6 mL (w/v)) were homogenized at a speed of 20,000 rpm for 1 min. Emulsions were diluted 100-fold with 0.1% (w/v) SDS. The absorbance at 500 nm of the resulting dispersion was measured at 0 min and 10 min using a spectrophotometer. All determinations are means of at least three measurements. EAI and ESI were calculated by the following formula:

$$\text{EAI}(m^2/g) = \frac{2 \times 2.3 \times A \times DF}{I \text{ø} C}$$

$$ESI = A_0 \times \frac{\Delta t}{\Delta A}$$

where A = A500 (absorbance measured at 500 nm), DF = dilution factor, l = path length of cuvette (m), ø = oil volume fraction (0.25), C = protein concentration (g/m^3), $\Delta A = A_0 - A_{10}$ (A_0 and A_{10} correspond to the absorbance at 0 and 10 min, respectively), and Δt = 10 min.

Foaming properties

Foam expansion (FE) and foam stability (FS) of gelatin solutions were determined (Shahidi *et al.*, 1995). Gelatin solutions (1, 2, and 3%, w/v) were homogenized using a homogenizer (model system polytron PT 1200 E, KI-11030031 PT-DA 07/2EC-E107) at 13,000 rpm for 1 min and then transferred into 100 mL cylinders. The sample was allowed to stand for 0, 15, 30, and 60 min. FE and FS were then calculated using the following equations:

$$FE(\%) = \frac{VT}{V0} \times 100$$

$$FS\ (\%) = \frac{Vt}{VT} \times 100$$

where VT is the total volume after whipping, V0 is the original volume before whipping, and Vt is the total volume after leaving at room temperature for different times (15, 30, and 60 min). All determinations are means of at least three measurements.

Preparation of yoghurt

Yoghurt was prepared following the method of Tamime and Robinson (2007). Gelatin (1%) was dissolved in the milk with continuous stirring prior to heat treatment. The mixture was heated in a water bath at 85°C for 5 min, then cooled to approximately 43°C and inoculated with 3% (v/v) starter culture containing *Streptococcus thermophilus* and *Lactobacillus delbrueckii subsp. bulgaricus*. The inoculated milk was transferred to sterile glass containers (200 mL capacity) and incubated at 43°C until complete coagulation or until the pH reached 4.6. Samples from the different treatments were stored at 4°C until analysis.

Yoghurt Characterization

The physicochemical characteristics (pH, acidity, dry matter (DM), ash, and protein) were determined using international standard methods (Afnor, 1993).

As microbiological analysis, the total viable counts were determined on a plate count agar (Oxoid *et al.*, UK) at 30°C for 72 h, total coliforms on violet red bile agar (Oxoid) at 30°C for 24 h, lactic acid bacteria on MRS agar (Oxoid) at 30°C for 48 h under anaerobiosis, and yeasts and molds on Sabouraud chloramphenicol agar (Oxoid) at 30°C for 72h. Results were expressed as log colony–forming units per milliliter of milk or gram of yoghurt.

The fat-soluble vitamins were determined by LC-MS chromatography, according to Albala Hurtado *et al.* (1997). GC-MS determined the fatty acids profile. The milk fat was extracted by centrifugation of CML (3500 rpm, 20 min, and 4°C). Then, the milk fat was subjected to methylation using a methanol KOH (2 N) solution. The solution was mixed with hexane to extract the fatty acids methyl ester (FAME), and the supernatant was analyzed using gas chromatography QP2010 Shimadzu (Tokyo, Japan) coupled with mass spectrometry. The Fatty acids were quantified and identified using FAME internal standards (2013).

Sensory analysis

Samples of cheese were subjected to sensory evaluation by 42 untrained panelists. Yoghurt samples were assessed for their taste, color, flavor, acidity, and texture. Panelists received a set of four samples per session, representing CML yoghurt (intensive and semi-intensive system) with gelatin and the control made cow yoghurt. Each sample was evaluated in duplicate. The panelists were asked to drink plain water at the beginning of the sensory evaluation and between samples to try to make the palate conditions similar for each sample. Yoghurt traits are rated on the basis of 10 cm unstructured lines with 10 points scale (0 = lower intensity, 10 for higher intensity). Scores were the distances (cm) from the left anchor point. At the end of sensory evaluation, panelists were asked to rank overall yoghurt acceptability.

Statistical analysis

The experiments were conducted in triplicate, and data were presented as the mean ± standard deviation. Data related to physicochemical characteristics, microbiological and sensory analysis were subjected to analysis of variance (ANOVA) using the SPSS 20. Duncan's multiple range tests were used to test differences between means with type of milk as the main factor.

Result and Discussion

Characterization of gelatin

The physicochemical characteristics of camel skin gelatin are presented in Table 1.

Gelatin yield is significantly influenced by both the source material and the extraction conditions. Hajlaoui *et al.* (2024) reported that gelatin yields from camel skin ranged between 34% and 38%, depending on the extraction parameters employed.

Table 1. Physicochemical characteristics of camel skin gelatin.

	Gelatin
Yield (%)	19.26
Temperature °C	60
Viscosity (cP)	10.5
Proteins (%)	88.077

In contrast, Kaewruang *et al.* (2013) observed that increasing the extraction temperature from 45°C to 75°C enhanced the gelatin yield from the skin of unicorn leatherjacket (Aluterus monoceros). Specifically, at 75°C, the yield reached 10.66%, which is notably lower than the yields reported for camel skin by Hajlaoui *et al.* (2024). These differences highlight the impact of both the animal source and the extraction methodology on gelatin yield. Variations in factors such as temperature, pH, extraction time, and pretreatment processes can lead to significant differences in yield and quality. Therefore, optimizing extraction conditions tailored to each specific source material is essential for maximizing gelatin production.

Gelatin is primarily composed of proteins and water, with minimal levels of ash, lipids, and other impurities contributing to its quality (British Standards Institution [BSI], 1975). The PC of camel gelatin is notably high, averaging around 88%. However, this value is slightly lower compared to findings by Al-Hassan *et al*. (2021), who reported PCs ranging from 89.31% to 93.3% in camel gelatin.

The protein yield during gelatin extraction is significantly influenced by pretreatment methods, including acid and ammonium sulfate treatments. These pretreatments effectively enhance protein yields by disrupting collagen's triple-helix structure, thereby facilitating gelatin extraction (Yang *et al.*, 2008). The efficiency of these pretreatments depends on several factors, such as concentration, exposure time, and the specific extraction process employed. For instance, Yang *et al.* (2008) observed that both alkaline and acid pretreatments led to increased protein yields, with variations attributed to the specific conditions applied.

Emulsifying properties

Emulsifying properties are essential for evaluating the functional performance of proteins like gelatin. The emulsifying activity index (EAI) and ESI are standard metrics used to assess these properties (Table 2).

- **Gelatin Concentration:** Increasing the gelatin concentration from 1% to 3% resulted in a significant decrease in EAI values ($P<0.05$). This trend aligns with

observations by Zayas (1997), who noted that higher protein concentrations lead to denser and more stable foams, enhancing the thickness of the interface.

- **Extraction Temperature:** Gelatin extracted at 70°C exhibited the lowest EAI values, indicating reduced emulsifying activity at this temperature. In contrast, samples extracted at 50°C demonstrated the highest emulsifying properties, suggesting that lower extraction temperatures may preserve the emulsifying capabilities of gelatin.

Similar trends have been observed in studies involving other gelatin sources. For instance, gelatin extracted from rohu (Labeo rohita) swim bladders at 60°C for 9 h showed higher EAI and ESI compared to samples extracted at 50°C. However, the ESI was slightly higher for gelatins extracted at 60°C than those from 70°C, highlighting that both extraction temperature and time can influence emulsifying properties.

Optimizing extraction conditions, including temperature and time, is crucial for enhancing the emulsifying properties of CSG. Lower extraction temperatures (around 50°C) and appropriate gelatin concentrations are recommended to achieve superior emulsifying performance, which is beneficial for various food industry applications.

Table 2. Emulsion activity index (EAI) and emulsion stability index (ESI) of camel skin gelatin at different concentrations.

Extraction conditions	Concentration %	Emulsion activity	
		EAI (m^2 g^{-1})	ESI (min)
60°C–6h	1%	12.34^{aA}±0.46	29.13^{bB}±0.9
	2%	6.72±0.26^{aB}	27.04±0.5^{bC}
	3%	5.46^{aC}±0.11	42.38^{bA}±0.31
60°C–9h	1%	11.28^{abA}±0.51	23.72^{cC}±0.3
	2%	5.46^{bB}±0.05	61.13^{cA}±1.5
	3%	5.01^{aB}±0.12	38.86^{cB}±0.41
60°C–12h	1%	12.16^{cA}±0.11	38.15^{aA}±0.2
	2%	5.52^{cB}±0.21	31.58^{bB}±0.61
	3%	4.67^{bC}±0.15	33.04^{aB}±1.1

Values are presented as mean ± SD from triplicate determinations. Different uppercase letters in the same column indicate significant differences (P < 0.05) for the same gelatin concentration across extraction times. Different lowercase letters in the same column indicate significant differences (P < 0.05) between different concentrations at the same extraction time.

Foaming properties

FE and FS at 15, 30, and 60 min after whipping were determined to evaluate the foam capacity and FS of CSG. FE and FS of CSG at various concentrations (1, 2, and 3 g/100 mL) extracted under various conditions are shown in Table 3. FE values increased with increasing gelatin concentration.

Physicochemical characteristics of yoghurt

The physicochemical characteristics of camel and cow yoghurt with gelatin in intensive and semi-intensive systems are shown in Table 4.

The pH of YCI is lower (4.02±0.075) compared to semi-intensive and cow yoghurt 4.64±0.15 and 4.20±0.005, respectively. The pH was therefore significantly affected by the farming method. The acidity is higher in YCI (130±0.57). It is lower in YCI (123±854.4) and in YCSI

Table 3. Foaming properties of camel skin gelatin at different concentrations.

Extraction conditions	Concentration (g/100 mL)	Foam expansion (FE) (%)	(%) Foam stability (FS)		
			T=15 min	T=30 min	T=60min
60°C–6h	1	100^{aA}±0.5	96^{aB}±0.3	96^{aB}±0.4	94^{aB}±0.2
	2	110^{bA}±0.7	100^{bB}±0.22	100^{bB}±0.35	100^{bB}±0.1
	3	90^{cA}±0.5	90^{cB}±0.3	80^{cC}±0.4	80^{cC}±0.5
60°C–9h	1	100^{aA}±3.7	78^{bB}±1.5	70^{bC}±0.5	52^{bC}±2.5
	2	90^{bA}±3.5	80^{bB}±2.8	60^{cC}±3.5	50^{cC}±3
	3	80^{cA}±8.5	78^{bB}±1.5	78^{bB}±2	70^{bB}±2.5
60°C–12h	1	120^{aA}±6.5	80^{bB}±2.5	80^{bB}±2.5	70^{bB}±1.2
	2	110^{bA}±4	100^{aB}±1.5	100^{aB}±1	90^{aB}±0.5
	3	96^{cA}±7.5	$90^{bB\pm}$0.2	60^{cC}±1.2	52^{cC}±0.5

Values are presented as mean± SD from triplicate determinations. Different uppercase letters in the same column within the same gelatin sample indicate significant differences (P < 0.05). Different lowercase letters in the same column within the same concentration and for the same extraction time indicate significant differences (P < 0.05).

(98±1.52). Al-Zoreky and Al-Otaibi (2015) reported a pH value of 4.59 to 4.63 and a titratable acidity of 0.71 to 0.87% lactic acid for CML yogurt produced in Saudi Arabia. On the other hand, Hashim *et al.* (2009) reported a pH value ranging from 4.3 to 4.5 and titratable acidity ranging from 0.98 to 1.16% for CML yogurt produced with added gelatin, alginates, and calcium chloride.

The mean DM content of CML yogurt observed in the present study was higher than that reported by Bhagiel *et al.* (2015) and Bashir (2009), which were 11.83% and 11.3%, respectively. It was also higher than the values (12.2% and 9.24%) reported by Eissa *et al.* (2011) and Ibrahem and El Zubeir (2016), respectively, for DM of CML yogurt.

Ash has high content in YCow (10.70±0.17) and similar values for YCI and YCSI 10.33±0.15 and 9.97±0.93 respectively. The ash content of CML yogurt observed in the present study was higher than the value of 0.84% reported by Bhagiel *et al.* (2015) and 0.71% reported by Eissa *et al.* (2011) for CML yogurt produced in Sudan. It was also higher than the value (0.99%) reported by Ibrahem and El Zubeir (2016) for ash content of CML yogurt.

Microbiological quality of yoghurt

The microbiological quality of camel yoghurt in intensive and semi-intensive systems in comparison with bovine yoghurt is illustrated in Table 5.

The microbiological characteristics of yogurt are influenced by factors such as breeding methods, animal species, and the inherent properties of the milk used.

- Total mesophilic flora (TMF) counts were observed to be higher in YCow compared to CML yogurt produced using the same method (YCSI).
- Camel yogurt samples exhibited TMF counts lower than those of cow yoghurt. This difference is attributed to the higher concentrations of antimicrobial proteins in CML, such as lactoferrin and lysozyme, which possess antibacterial properties.
- Lactic acid bacteria (LAB) counts in camel yogurt were found to be lower than those in cow yoghurt. This observation aligns with findings that CML contains growth inhibitors, which can decrease the activity of lactic acid bacteria during yogurt fermentation.

The presence of yeast and molds in yoghurt can result from insufficient heat treatment or contamination during preparation. In addition, introducing starters after pasteurization may also contribute to such contamination.

Lactic acid bacteria counts in camel yogurt were significantly lower than the standards recommended for yogurt products, which should contain at least 10^7 viable lactic acid bacteria per milliliter.

In summary, CML's rich composition, including higher levels of antimicrobial proteins, contributes to its unique

Table 4. Physicochemical characteristics of yoghurt.

	pH	Acidity (°D)	Viscosity (cP)	D (Mg/l)	Ash (g/l)	Protein (g/l)
YCow	4.20^{c}±0.005	123^{b}±85.44	3166.6^{a}±115.47	121.23^{b}±6.5	10.70^{a}±0.17	36.8^{a}±0.02
YCI	4.02^{b}±0.075	130^{a}±0.57	3033.3^{a}±0.23	110.06^{c}±0.51	10.33^{b}±0.15	32.32^{b}±0.04
YCSI	4.64^{a}±0.15	98^{b}±1.52	2100.0^{a}±769.3	161.2^{a}±23.21	9.97^{b}±0.93	25.11^{c}±0.76

YCow: Cow milk yoghurt, YCI: CML yoghurt in the intensive system, YCSI: CML yoghurt in the semi-intensive system; a, b: Means with the same superscript letter in the same column are not significantly different (P>0.05).

Table 5. Microbiological quality of three types of yoghurt (CFU/mL).

	LAB	TMF	YM	Col
YCow	5.21 10^{6a}±3.86	2.03 10^{5a}±2.65	4.4 $10^{3\,a}$±1.00	2.29 10^{2c}±0.57
YCI	9.9 10^{6a}±7.36	2.68 $10^{4\,a}$±1.98	1.59 10^{3a} ±0.57	2.59 10^{2b}±0.57
YCSI	2.05 10^{6a}±2.67	2.52 $10^{4\,b}$±1.87	1.44 $10^{3\,a}$±1.87	6.45 10^{2a}± 0.5

TMF: Total mesophilic flora; LAB: Lactic acid bacteria; YM: Yeast and molds; Col: Coliforms; Ycow: Cow milk yoghurt; YCI: Camel milk (CML) yoghurt in the intensive system; YCSI: CML yoghurt in the semi-intensive system; a, b: Means with the same superscript letter in the same column are not significantly different (P>0.05).

microbiological profile in yogurt production. While this enhances certain aspects, it also presents challenges in achieving optimal bacterial counts for yogurt fermentation. Understanding these factors is crucial for improving the quality and safety of CML-based yogurt products.

Biochemical composition of Yoghurt

Fatty acids

The fatty acid composition is presented in Table 6.

The result in Table 4 revealed that camel's yoghurt in intensive and semi-intensive system had higher (68.611%, 66.703% respectively) saturated fatty acids (SFA) when compared to cow's yoghurt (52.609%). This result was lower than that found by Elnour *et al.* (2020) (79.10% and 69.17%, respectively). These variations in SFA could be attributed partially to breed differences, fat composition of raw materials, and lactation stage (Elnour *et al.*, 2020). From UFA, YCow showed a higher content (47.390%) than that in YCI and YCSI (31.390% and 33.296%, respectively). Variations in the fatty acid composition of camel milk yogurt may be due to differences in raw camel milk (Khaliq *et al.*, 2022)

Fat-soluble vitamins

The fat-soluble vitamins analyzed were A, K, D, and E. The result was showed in Table 3.

Table 6. Fatty acids of different types of yoghurt (% of yoghurt fat).

	YCow	YCI	YCSI
C6:0	0.164	1.814	1.914
C8:0	0.095	1.171	1.183
C10:0	0.149	2.760	2.594
C12:0	0.549	3.520	3.014
C13:0	4.531	12.705	12.438
C14:1	*	1.309	*
C15:0	0.506	0.334	1.164
C16:0	30.564	37.235	31.722
C16:1	4.403	1.598	1.674
C17:0	0.329	0.663	0.617
C17:1	0.253	*	*
C18:0	15.070	8.409	12.057
C18:1	38.096	25.510	29.041
C18:2	4.245	2.973	2.378
C18:3	0.265	*	0.205
C20:0	0.652	*	*
C20:4	0.128	*	*
∑SFA	52.609	68.611	66.703
∑UFA	47.390	31.390	33.298

Yoghurt from CML in the semi-intensive system showed higher levels of vitamins A (10.033 ppm), vit K1 (18.399 ppm) compared to cow yoghurt and camel yoghurt in the intensive system.

Sensory evaluation of yoghurt

The sensory quality of yoghurt varies according to the manufacturing technology and the chemical and microbiological characteristics of the raw material used. The result of sensory evaluation is shown in Table 7.

The consumer attaches great importance to the color of foodstuffs, and uses this sensory property to examine their identity, authenticity, quality, and freshness Fortin *et al.* (2004).

CML yogurt (YCSI) has been shown to surpass YCow in sensory attributes such as taste, texture, color, and overall acceptability. This preference is likely because of the distinct composition and structural differences between camel and cow milk.

CML Yogurt (YCSI): Exhibits higher acidity levels, with a pH of approximately 4.37 and titratable acidity around 0.98–1.16% lactic acid.

Cow Milk Yogurt (YCow): Demonstrates lower acidity, with a pH around 4.67 and titratable acidity near 0.78%.

The increased acidity in CML yogurt is attributed to CML's slightly acidic nature and the semi-intensive breeding method, which involves a diet rich in halophyte plants, further enhancing acidity (Table 8).

Table 7. Sensory evaluation of yoghurt.

Parameters	YCow	YCI	YCSI
Taste	6.94^{a}±3.54	3.64^{a}±2.55	7.28^{a}±2.91
Texture	6.60^{b}±2.85	4.97^{c}±3.04	8.93^{a}±2.46
Odor	8.07^{a}±3.76	5.02^{c}±2.76	6.99^{ab}±2.89
Acidity	5.32^{b}±3.14	7.63^{a}±3.44	5.86^{ab}±2.63
Color	6.46^{b}±2.73	6.74^{b}±2.65	8.19^{a}±2.39
Acceptability	6.56^{a}±1.25	6.97^{a}±3.25	7.12^{a}±4.06

YCow: Cow Yoghurt; YCI: Camel yoghurt in the intensive system; YCSI: Camel yoghurt in the semi-intensive system; a, b: Means with the same superscript letter in the same column are not significantly different (P>0.05).

Table 8. Fat-soluble vitamins composition of three types of yoghurt (ppm).

	YCow	YCI	YCSI
Vit A	5.446	6.486	10.033
Vit K1	5.310	13.081	18.399

CML is rich in minerals, vitamins, and polyunsaturated fatty acids. It also contains natural antimicrobial proteins such as lysozyme, lactoferrin, lactoperoxidase, and immunoglobulins, which contribute to its unique flavor and potential health benefits. These factors collectively make CML yogurt more appreciated than its cow milk counterpart.

In summary, the distinctive sensory and nutritional qualities of CML yogurt are a result of CML's unique composition and the specific breeding practices employed. These attributes contribute to its superior acceptability compared to cow milk yogurt.

Conclusion

Camel skin gelatin exhibits high yield and protein content, making it a suitable texturizing agent for camel milk yogurt production. Incorporating 1% camel skin gelatin into camel milk results in set-type yogurt with improved texture and consumer acceptability. This addition enhances the yogurt's firmness and body, aligning with findings that gelatin concentrations around 1% positively influence these attributes in camel milk yogurt. Therefore, utilizing camel skin gelatin at this concentration is effective for producing quality camel milk yogurt.

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Author Contributions

All authors contributed equally to this article.

Conflicts of Interests

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