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Production and Characterization of Camel Milk Cheese Made Using Chicken Gizzard Inner Lining Extract as Coagulant

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Abstract: The process of camel milk's transformation into cheese is a delicate operation due to various difficulties in achieving coagulation. This study investigates the processing challenges of camel milk in the production of camel milk cheese using chicken gizzard inner lining extract (CGLE) as a coagulant. The crude extract presents an extraction yield of 55.05 ± 1.8% and a pH = 4.40 ± 0.05. The optimal coagulation conditions were pH 5 and temperature 45 °C. A fresh camel milk cheese was produced using CGLE and characterized as CME. The cheese yield of the CME was 26.88 ± 0.42%, which was higher than that obtained with chymosin (CC) at 12.66 ± 0.12%. The pH and acidity were 5.29 ± 0.09 and 56.25 ± 1.25°D. The gross composition of camel cheese (CME) was determined in comparison to (CC) fat (13.50 ± 2.82%), proteins (11.61 ± 0.19%), and dry matter (38.85 ± 1.22%). The sensory analysis demonstrated significant differences ($p < 0.05$) between the CME and CC in terms of white color, acidic taste, and consistency. Therefore, CME presents an overall acceptability in comparison to the control. The chicken gizzard inner lining extract could be used as an efficient coagulant for the production of fresh camel cheese.

Keywords: camel milk cheese; chicken gizzard inner lining; milk-clotting activity; coagulation

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1. Introduction

Camel milk is known for its distinctive composition and potential health benefits that make it a valuable resource in different cultures. This milk is known to contain a higher concentration of vitamins such as vitamin C and vitamin B3 and minerals such as sodium, potassium, phosphorus, and manganese than cow milk [1,2].

In fact, camel milk is a recent entrant in both domestic and global milk markets due to its nutritional quality and therapeutic value such as its anticancer, antioxidant, and antidiabetic effects [3–5]. This recent emergence has been accompanied by a wide range of processed products, developed using technologies originally designed for milk from other dairy animals.

Nevertheless, the lower content of k-casein, larger casein micelles, and the limited coagulation ability of camel milk have been considered to be the main factors responsible for the limitation in cheese making [6].

However, technical innovations had to be adapted to a product with specific behavior and composition. Consequently, manufacturing camel dairy products such as cheese, yogurt, or butter using the same technology as dairy products from bovine milk can result in processing difficulties and products of inferior quality [7,8].

Milk-clotting proteases, essential enzymes for various physiological and commercial purposes, are primary categorized based on their source: animal, plant, microbial, or

recombinant. These multifunctional enzymes found in a wide range of animals and plants perform diverse physiological functions, including catalysis, binding, antioxidant activity, apoptosis, complement activation, and inflammation [9].

Previous research has demonstrated that camel milk fails to form firm curd, resulting in fragile and soft cheese structure [10,11]. Compositional properties, related mainly to the low level of κ-casein and the large micelle sizes, are considered the main factors responsible for the differences in cheese coagulation between camel and bovine milk.

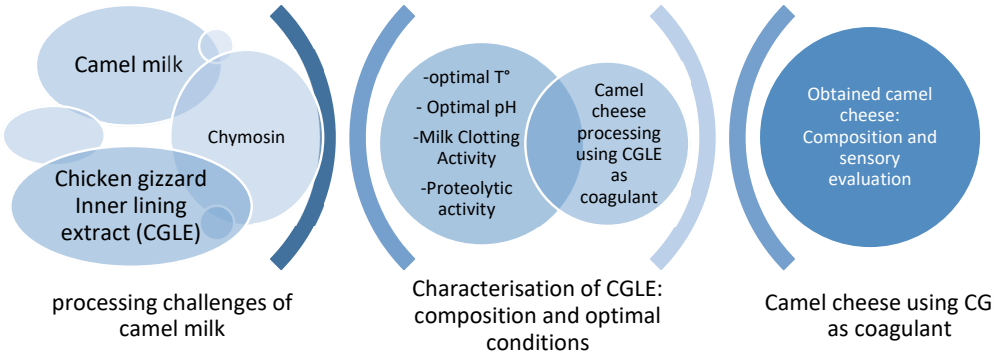
The inefficiency of calf rennet to coagulate camel milk has led to the investigation of new milk-clotting enzymes able to adequately replace calf rennet in the manufacturing of camel cheese [12].

In industrial cheesemaking, the use of gastric proteinases as rennet (from calves, kids, or lambs) and microbial milk-clotting enzymes produced by fungi and bacteria [13] is the most common.

The avian proteases from chicken and turkey are considered to be adequate sources of pepsin enzymes [14–16]. Chicken gizzard inner lining is a by-product of an animal meat product which has recently been shown to be a good source of protein and could potentially be used for human consumption [17]. GIL is enriched in bioactive and proteinaceous products that can provide a potential source of additional nutrition to consumers [18].

Moreover, chicken GIL contains high protein levels and important amino acids, such as EAAs, and its application in food processing is imperative, such as in dairy products [17].

Thus, the present study was conducted with the aim of evaluating the usefulness of the crude extract from the Kaolin layer of chicken gizzard as an alternative to rennet for clotting camel milk and making camel cheese.



2. Materials and Methods

Reagents and chemicals

All reagents were of analytical quality and used as purchased. Sodium hydroxide (NaOH, 98% purity, MW: 40 g/mol) was obtained from Loba Chemie, Bombay, India. Hydrochloric acid (HCl, 99% purity, MW: 36.46 g/mol) was obtained from SRL Chemicals, India. Sulfuric acid (H_2SO_4, 95% purity, MW: 98.08 g/mol), sodium carbonate (Na_2CO_3, 96% purity), and sodium chloride (Nacl, 98% purity) were purchased from Oxford Lab Fine Chem LLP, Maharashtra, India, and BSA (99%, from Sigma-Aldrich).

Camel chymosin FAR-M was obtained from CHYMAX® M. 1000 International Milk-Clotting Units (IMCUs)/mL, Chr. Hansen A/S, Hørsholm, Denmark.

Raw material

Raw chicken gizzard inner layers were extracted from the digestive system of chicken and then carried in an icebox immediately to the lab. Fresh samples were washed several times in distilled water, cut, dried, crushed, and conditioned in sealed plastic bags and, finally, stored at −20 °C until they were used.

Fresh camel milk was collected from female camels (Camelus dromedarius) belonging to the Arid Land Institute (IRA Medenine, Tunisia). Milk samples were brought to the laboratory in an isothermal container and were analyzed and processed upon arrival.

Preparation of extracts

The chicken gizzard inner lining extract (CGLE) was prepared according to the method described by BOHAK 1970 [19]; briefly, after drying and grinding the kaolin layers, 50 g of the obtained powder was macerated in 150 mL of ($NaCl/NaCO_3$) solution for 3 h with stirring at 40 °C. The mixture was filtered, and the filtrate was then centrifuged at 3200× *g* at 4 °C for 20 min and filtered again. After filtration, the enzymatic extract was activated by a decrease in and adjustment of pH (from 6 to 2).

Characterization of CGLE

Protein content

The total protein concentration was determined by the Bradford method [20], using bovine serum albumin (BSA) (10–80 $mg.mL^{-1}$) as standard for protein quantification. Absorbance was measured using a spectrophotometer (Thermo Fisher Scientific, GEN10S UV-Vis, Santa Clara, CA, USA) at 595 nm.

Dry matter content

The dry matter (g/L) content was determined after drying 1 mL of CGLE at 105 °C (oven, Binder, ED 115, Tuttlingen, Germany) for 24 h [21]:

$$DM = (M1 - M0)/V) \times 1000$$

where DM: dry matter, M0: mass in g of empty crucible, M1: mass in g of crucible with residue after drying and cooling, and V: volume in mL of sample

Extraction yield

Extraction yield (%) was determined as the ratio of the weight CCE to the weight of CCE and the residual products after extraction. Extraction yield (%) was calculated by the mathematical relationship described by Tressler and Joslyn (1961) [22]:

$$Extraction\ yield\ (\%) = Weight\ of\ CGLE\ (g)/weight\ of\ CGLE\ (g) + weight\ of\ residual$$

Optimal temperature, pH, and $CaCl_2$ determination

The effect of pH on the milk-clotting activity (MCA) of CGLE was tested at 30 °C in the pH range of 5.0–8.0 at an interval of 0.5. The pH solution was adjusted with either 0.1 N HCl or 0.1 N NaOH. The pH was measured with a pH meter (Phoenix, EC-45 pH, Mannheim, Germany), which was previously calibrated using buffer solutions at pH 4 and pH 7.

The effect of temperature on the MCA of the proteases was determined following the standard assay procedure in the temperature range of 30–60 °C at intervals of 10 °C [23].

The optimal calcium chloride ($CaCl_2$) concentration was determined by varying the $CaCl_2$ ion concentration of the Berridge substrate (BS) (12 g of skimmed milk powder in 100 mL of a 0.01 M $CaCl_2$ solution [24]) from 0.01 M to 0.09 M with a range of 0.01 M at 30 °C and pH 6.6. The flocculation time was recorded for each concentration.

Milk-Clotting Activity (MCA)

The MCA was measured according to the Berridge method [24], modified by Collin et al. [23]: 1 mL of CGLE was added to 10 mL of the substrate (Berridge substrate (BS)

and CM) and the clotting time was recorded at 35 °C. The MCA was calculated using the following equation [25]:

$$MCA\ (\mathrm{U/mL}) = 2400\ \mathrm{S}/\ \mathrm{tE}$$

where t: clotting time (sec), S: volume of milk (mL), and E: volume of enzymatic solution (mL).

Specific milk-clotting Activity (SA)

The SA was defined by the ratio of MCA to protein content:

$$SA(\mathrm{U/mg}) = MCA(\mathrm{U/mL})/Protein\ content(\mathrm{mg/mL})$$

Proteolytic activity (PA)

The PA of the CGLE was determined using BS and CM as substrates [26]. Briefly, 1 mL of substrate solution was mixed with 1 mL of CGLE, and the mixture was incubated at 35 °C for 60 min. The reaction was stopped by the addition of trichloroacetic acid (TCA) (12%) (w/v), and then the absorbance was measured at 280 nm. One unit of the PA was defined as the amount of protein (mg) required to increase the absorbance by one unit.

Cheese making process

After pasteurization (63 °C for 30 min), camel milk was inoculated with 5% (v/v) of the prepared extract of CGLE at 45 °C. The incubation continued until the firm curd was obtained, and then the curds were placed in cheesecloth to drain for 3 h and for 6 h. The obtained cheese (CME) was stored at 4 °C until analysis. The control cheese (CC) was made using camel chymosin powder (FAR-M, 1 g/50 L, Chr. Hann A/S, Hørsholm, Denmark).

Characterization of obtained cheese

Cheese yield

The cheese yield was calculated immediately after draining using the following formula [27].

$$Cheese\ yield\ (\%) = ((weight\ of\ cheese)/weight\ of milk) \times 100$$

Physicochemical composition

The obtained cheese samples were analyzed using the standard methods of AFNOR (1993): for total solids (after drying at 105 °C (oven, Binder, ED 115, Tuttlingen, Germany)), ash (measured by incineration in a muffle furnace at 560 °C for 6 h), pH (pH meter, Phoenix, EC-45 pH, Mannheim, Germany), and titratable acidity.

First, a slurry was prepared by blending 10 g of grated cheese with 10 mL of distilled water, and then the pH was measured.

The fat and protein contents were measured following the Soxhlet and Bradford methods, respectively.

The moisture content (Hm) was calculated after the determination of the dry matter content according to the following formula:

$$Hm(\%) = 100 - DMC$$

where Hm: humidity and DMC: dry matter content

Mineral content

The minerals' quantification, including Na, K, Mg, Ca, and Fe, was determined according to ISO/IDF (2007) [28] by flame AAS (Atomic Absorption Spectroscopy).

Microbiological test

The microbiological analysis of cheese samples (CC and SC) was carried out by serial dilutions of 1 g of cheese in sterile saline solution (9 g/L NaCl) at a dilution ratio of 1:10.

The total viable bacteria and total yeasts and mold counts were determined using the pour plate technique. Plate Count Agar (PCA) (Biokar Diagnostics, Beauvais, France) was used to determine the total viable bacterial count. MRS Agar (Biokar Diagnostics, Beauvais, France) was used for the lactic acid bacteria viable count. Bacteria counts were enumerated after 48 h of incubation at 37 °C. The colonies were counted using a colony counter, and plates containing between 30 and 300 colonies were selected. The result was expressed as colony-forming unit per g (CFU/g).

Sensory Analysis

The sensory evaluation of the CME and CC samples was achieved by 25 trained panelists (panelists were formed for every descriptive vocabulary of the basic sensory modalities, that is, appearance and texture, odor, and taste). Cheese samples were assessed for their white color, odor intensity, creamy taste, consistency, bitter taste, and overall acceptability using a six-point scale, ranging from 0 (low intensity) to 5 (high intensity) (ISO 13299, 2016) [29].

Statistical Analysis

All experiments were performed in triplicate. Differences were considered significant at $p < 0.05$. Results were analyzed for statistical significance with an ANOVA and Duncan's test and expressed as mean ± standard deviation (SD). The statistical analysis of the data was performed with an SPSS program (SPSS 11) and graphPad Prism 7.0 (GraphPad Prism software Inc., La Jolla, CA, USA).

3. Results and Discussion

3.1. Characterization of CGLE

Table 1 shows that the CGLE is acidic; this pH value could be because GIL is part of the stomach tissue, which is normally in continual contact with stomach acid [17]. The protein content (8.64 ± 0.5 mg/mL) was similar to that found in a study on crude extract from turkey proventriculus (9.2 mg/mL) [16]. However, the dry matter content of CGLE was higher than that of rennet (1.23 mg/mL) and the fruit extract of Withania somnifera (2.47 mg/mL), as mentioned in other studies [30,31].

Table 1. Characterization of CGLE.

	CGLE Composition
pH	4.40 ± 0.05
Extraction yield (%)	55.05 ± 1.8
Dry matter (mg/mL)	35.1 ± 2.11
Proteins (mg/mL)	8.64 ± 0.5

CGLE: chicken gizzard inner layer extract.

3.2. Optimum Conditions of the CGLE Clotting Activity

3.2.1. Optimal Temperature

Figure 1 illustrates the change in the CGLE milk-clotting activity with temperature; the MCA increased from 30 to 45 °C and then decreased, with the highest MCA observed at 45 °C. Optimum temperatures for calf rennet and turkey proventriculus were found to be 40 °C and 55 °C, respectively [16,30].

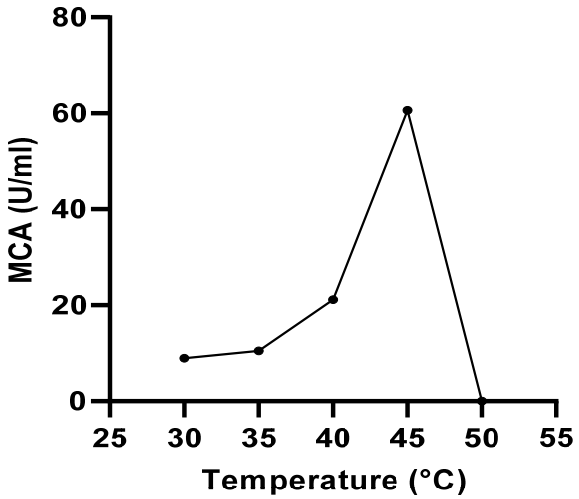


Figure 1. Effect of temperature on the CGLE milk-clotting activity (MCA).

3.2.2. Optimal pH

The pH dependence of CGLE's milk-clotting activity is illustrated in Figure 2, showing maximum activity at pH 5. An increase in pH led to a gradual decrease in milk-clotting activity.

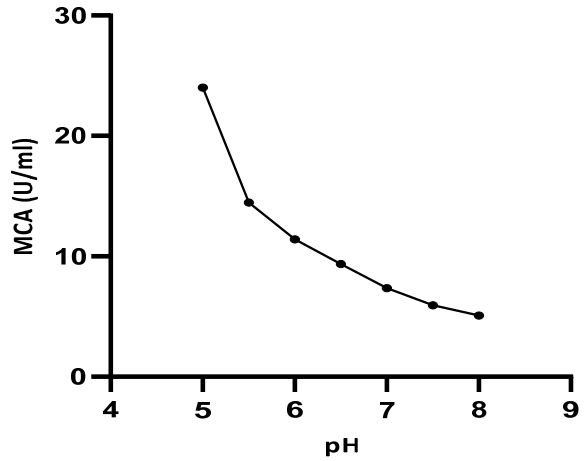


Figure 2. Effect of pH on the CGLE milk-clotting activity.

Similar findings were reported by Nouani et al. (2009) [28], confirming that extracts from chicken proventriculus and rennet are most active at pH 5. Additionally, Mekhaneg et al. (2018) [16] demonstrated maximal clotting activity for turkey proventriculus at pH 5.4. Bouazizi et al. (2022) [32] also found that an optimal pH of 4 is required to coagulate camel milk using Urtica dioica enzymatic extract.

3.2.3. Optimal $CaCl_2$ Concentration

The variations of CGLE milk clotting activity depending to the concentration of Cacl2 are presented in Figure 3. Supplementing milk with calcium chloride is a common practice in cheese making that has been found to impact the milk-clotting activity of enzymes. It is suggested that the main effect of $CaCl_2$ occurs during the second stage of the clotting process, where Ca^{2+} binds with paracasein, leading to the formation of solid clots [33].

The clotting ability of camel milk is notably affected by $CaCl_2$, as the addition of calcium ions from calcium chloride significantly improves camel milk coagulation, influencing both coagulation time and firmness, resulting in an increased cheese yield [34,35].

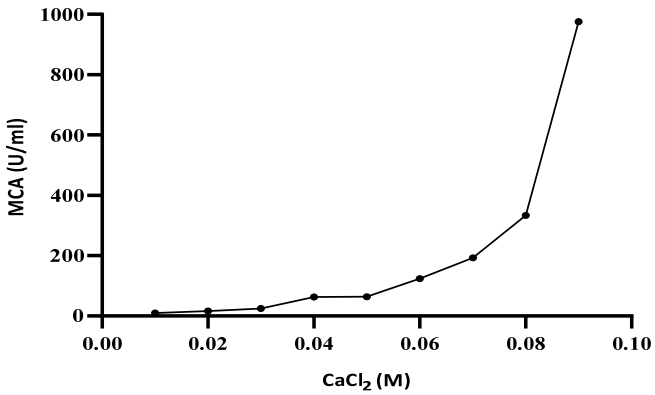


Figure 3. Effect of the $CaCl_2$ concentration on the CGLE milk-clotting activity.

3.3. Milk-Clotting Activity (MCA)

As shown in Table 2, the clotting activity of CGLE was significantly higher, and its proteolytic activity was significantly lower on camel milk compared to the Berridge substrate. Pure chymosin and porcine pepsin exhibited MCAs of 10.9 RU/mL and 22.1 RU/mL, respectively, on camel milk [36]. Additionally, Fguiri et al. (2021) [37] suggested plant extracts like kiwi (Actinidia arguta), pineapple (Ananas comosus), and ginger rhizome (Zingiber officinale Roscoe) as potential coagulants for camel milk. According to Roseiro et al. (2003) [38], clotting activity is linked to the enzyme's ability to cleave the peptide bond Phe (105)-Met (106) of k-casein crucial for cheese making.

Table 2. CGLE milk-clotting activity, specific activity, and proteolytic activity.

Type of Milk	MCA (U/mL)	SA (U/mg)	PA (U/mL)
BS	130 $^{\text{ainthis}}$ ±1.22	15.04 ^{a} ± 0.22	0.979 ^{a} ± 0.16
CM	140.75 ^{b} ±1.02	16.20 ^{b} ± 0.12	0.233 ^{b} ± 0.08

BS: Berridge substrate; CM: camel milk. Different lowercase letters indicate significant variation ($p < 0.05$).

The CGLE presented a significantly higher SA on CM than that on the Berridge substrate. The SA of CGLE on camel milk surpassed that of turkey (Meleagris gallopavo) proventriculus (1.2 ± 0.1 U/mg) and *Tenebrio molitor* larva extract (4.03 U/mg) [16,39].

3.4. Characterization of Obtained Camel Cheese

3.4.1. Physicochemical Composition

The physicochemical composition of camel cheese coagulated with CGLE (CME), and the control cheese (CC) is illustrated in Table 3.

The cheese yield from camel milk clotting with CGLE (26.38 ± 0.42%) was significantly higher than that from camel chymosin (18.12 ± 1.4%). The CME yield exceeded that reported by konuspayeva at al. (2017) (9.31 ± 0.64% and 8.22 ± 0.90%) [40] when using recombinant camel chymosin to produce dry and brine-salted soft camel cheese. Recent studies on camel cheese have explored the use of different coagulants as alternatives to rennet. These studies have shown varying cheese yields depending on the type of coagulant used: 12.3% using chymosin, 13.6% using citric acid, and 13.2 using acetic acid [10] and 20.7% using kiwi juice, 11.5% with ginger extract, and 19.74% using pineapple juice as coagulants [37].

The CME exhibited higher acidity than the CC, possibly due to the acidic pH of CGLE (pH = 4.4). Additionally, Chien-Hsiang et al. (2018) [17] mentioned that the gizzard inner lining was acidic (pH = 3.4). The dry matter and ash and protein contents of the CME were higher than those of the CC. Similar results were obtained by Chien-Hsiang et al.

(2018) [17] when analyzing the composition of the gizzard inner lining. According to the study by López (2012) [39], the selection of coagulant has a significant impact on the dry matter content of cheeses. Furthermore, the protein content of the obtained camel cheese (CME) was similar to that reported by Omrani et al. (2024) [40] when characterizing camel cheese coagulated with green carob extract (11.91 ± 0.29%). However, the protein contents of the obtained camel cheese were lower than that reported by [35] when making camel cheese coagulated with pineapple (28.42 ± 0.13 g/L) or kiwi (31.25 ± 0.47 g/L) juices.

Table 3. Physicochemical composition of camel cheese made using CGLE as coagulant.

	CME	CC
pH	5.29 ± 0.09 ^{a}	5.33 ± 0.14 ^{a}
Acidity (°D)	56.25 ± 1.25 ^{a}	55 ± 1.74 ^{a}
Cheese yield (%)	26.38 ±0.42 ^{a}	18.12 ± 1.4 ^{b}
Dry matter (%)	38.85 ± 1.22 ^{a}	30.11 ± 1.45 ^{b}
Ash (%)	3.93 ± 0.17 ^{a}	1.77 ± 0.44 ^{b}
Fat (%)	13.50 ± 2.82 ^{a}	14.18 ± 0.4 ^{a}
Protein (%)	11.61 ± 0.19 ^{a}	7.93 ± 1.28 ^{b}
Mineral composition (mg/100 g)		
Na	38.43 ± 1.36 ^{a}	39.83 ± 0.4 ^{a}
K	105.46 ± 2.06 ^{a}	101.16 ± 1.46 ^{a}
Ca	407.50 ± 3.78 ^{a}	400.5 ± 3.18 ^{b}
Mg	6.5 ± 0.80 ^{a}	6.33 ± 0.76 ^{a}

Different lowercase letters indicate significant variation ($p < 0.05$). CC: control cheese; CME: camel cheese prepared with CGLE as coagulant.

3.4.2. Microbiological Analysis

The microbial counts of the cheese samples are shown in Table 4. The total viable bacteria count was lower in SC compared to the CC, possibly due to the potential antimicrobial properties of CGLE similar to other animal by-products [41,42]. Previous studies [43,44] have shown that the addition of carob green pods extract and sea buckthorn (*Hippophae rhamnoides*) extract as a colorant, respectively, inhibited the growth of microorganisms and improved the microbial quality of fresh cheese. However, there was no significant difference ($p > 0.05$) in the number of lactic acid bacteria between the cheese samples.

Table 4. Microbial counts of cheese samples (cfu/g).

	CME	CC
Total viable bacteria (cfu/g)	5.5×10^{3} ^{a}	2.7×10^{5} ^{b}
Lactic acid bacteria (cfu/g)	2.6×10^{7} ^{a}	2.52×10^{7} ^{a}

CME: camel cheese coagulated by CGLE; CC: control cheese. Different lowercase letters indicate significant variation ($p < 0.05$)

3.4.3. Sensory Analysis

The sensory scores for different attributes of the two types of cheeses prepared using CGLE as coagulants are presented in Figure 4.

The sensory scores of the two types of cheese are presented in Figure 4. The panelists identified significant differences ($p < 0.05$) between the CME and CC in terms of white color, acidic taste, and consistency. The use of CGLE as a coagulant increased the consistency and creamy taste of the CME compared to the cheese obtained using chymosin as a coagulant.

The white color and the odor intensity did not show any significant differences between the two compared camel cheeses. Therefore, Omrani et al. (2024) [42] showed that the use of green carob extract as a coagulant reduces the whiteness of camel cheese.

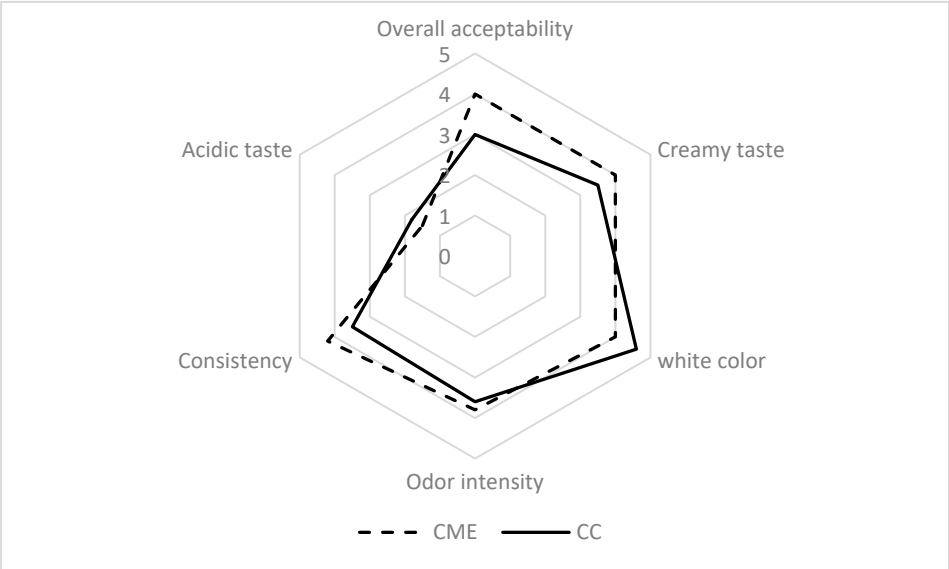


Figure 4. Sensory attributes assessed in the sensory profile of camel milk cheeses. CC: control cheese; CME: camel cheese coagulated with CGLE.

Since CGLE did not affect the viability of the lactic starter cultures, the two types of cheese (CC and CME) presented close scores for the majority of descriptors, essentially the odor intensity and the acidic taste. In fact, [45] demonstrated that the lactic cultures produced the most key flavor components during the fermentation of yogurt. In addition, the control presented less consistency acceptability than the CME. In terms of overall acceptability, the panelists gave the highest score to the CME (4 ± 0.09) compared with the CC.

4. Conclusions

The results of this study suggest that camel milk cheese can be produced with a substantial yield by using chicken gizzard layer extract (CGLE) as a substitute for rennet. The optimal conditions for the CGLE activity include a coagulation temperature of 45 °C and an acidic pH. This optimization resulted in a significant increase in cheese yield from 18.12% to 26.38%. Therefore, CGLE can be a suitable coagulant for cheese making as an alternative to rennet. Camel milk cheese made with CGLE showed higher levels of dry matter, ash, and proteins compared to cheese made with chymosin. The panelists preferred camel cheese made with CGLE. These findings suggest that chicken gizzard inner lining extract could be used as an efficient coagulant for the production of camel cheese and can be considered a useful alternative to rennet and camel chymosin to make camel cheese and facilitate the commercialization of this dairy product. Further research is recommended to determine the suitable form for preserving CGLE activity and investigate the rheological properties and biological activities of camel milk cheese made with CGLE.

Author Contributions: Conceptualization, A.S. and T.K.; methodology, A.S., A.R., A.O. and M.D.; software, A.S. and I.F.; validation, A.S. and T.K. writing—original draft preparation, A.S. and I.F.; writing—review and editing, A.S., A.O. and T.K., project administration, A.S. All authors have read and agreed to the published version of the manuscript.

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Data Availability Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

CGLE	chicken gizzard inner lining extract
CME	camel cheese coagulated with CGLE
CC	Control cheese
BS	Berridge Substrate
MCA	Milk clotting Activity
CM	Camel milk

References

1. Karaman, A.F.; Akgül, F.Y.; Serdal, O.; Hale, S.C.; Alvarez, V. Gross composition of raw camel's milk produced in Turkey. *Food Sci. Technol. Camp.* **2022**, *42*, 59820. [CrossRef]
2. Sboui, A.; Khorchani, T.; Djegham, M.; Belhadj, O. Comparaison de la composition physicochimique du lait camelin et bovin du Sud tunisien; variation du pH et de l'acidité à différentes températures. *Afr. Sci. Rev. Int. Sci. Technol.* **2009**, *5*, 293–304. [CrossRef]
3. Krishnankutty, R.; Iskandarani, A.; Therachiyil, L.; Uddin, S.; Azizi, F.; Kulinski, M.; Bhat, A.A.; Mohammad, R.A. Anticancer Activity of Camel Milk via Induction of Autophagic Death in Human Colorectal and Breast Cancer Cells. *Asian Pac. J. Cancer Prev.* **2018**, *19*, 3501–3509. [CrossRef]
4. Hamouda, M.; Sboui, A.; Salhi, I.; Hammadi, M.; Souchard, J.P.; Bouajila, J.; Khorchani, T. Effect of heat treatment on the antioxidant activities of camel milk alpha, beta and total caseins. *Cell. Mol. Biol.* **2022**, *68*, 199. [CrossRef]
5. Sboui, A.; Atig, C.; Khabir, A.; Hammadi, M.; Khorchani, T. Camel milk used as an adjuvant therapy to treat type 2 diabetic patients: Effects on blood glucose, HbA1c, cholesterol, and TG levels. *J. Chem.* **2022**, *2022*, 5860162. [CrossRef]
6. Konuspayeva, G.; Faye, B. Recent advances in camel milk processing. *Animals* **2021**, *11*, 1045. [CrossRef]
7. Mbye, M.; Ayyash, M.; Abu-Jdayil, B.; Kamal-Eldin, A. The Texture of Camel Milk Cheese: Effects of Milk Composition, Coagulants, Conditions. *Front. Nutr.* **2022**, *9*, 868320. [CrossRef]
8. Birhanu, B. Innovative Approach of Cheese Making from Camel Milk: A Review. In *Dairy Processing-From Basics to Advances*; Intechopen: Rijeka, Croatia, 2022; p. 16. [CrossRef]
9. Chinmayee, C.; Martin, A.; Kumar, B.G.; Singh, S.A. A new thermostable rhizopuspepsin: Purification and biochemical characterisation. *Process Biochem.* **2022**, *112*, 26. [CrossRef]
10. Mbye, M.; Sobti, B.; Al Nuami, M.K.; AlShamsi, Y.; Al Khateri, L.; Al Saedi, R. Physicochemical properties, sensory quality, and coagulation behavior of camel versus bovine milk soft unripened cheeses. *NFS J.* **2020**, *20*, 36. [CrossRef]
11. Siddig, S.M.; Sulieman, A.M.E.; Salih, Z.A.; Abdelmuhsin, A.A. Quality characteristicsof white cheese (Jibnabeida) producedusing camel milk and mixture of camelmilk and cow milk. *Int. J. Food Sci. Nutr. Eng.* **2016**, *6*, 54.
12. Milica, M.; Grozdanovic, L.B.; Marija, G.J. Kiwifruit (*Actinidia deliciosa*) extract shows potential as a low-cost and efficient milk-clotting agent. *Int. Dairy J.* **2013**, *32*, 52.
13. Di Rosa, D.R.; Accetta, F.; Nicosia, F.D.; Litrenta, F.; Pino, A.; Lopreiato, V.; Caggia, C.; Randazzo, C.C. Microbiological, chemical, and artificial sensory assessment of Sicilian cheeses made using different milk-clotting enzymes. *Food Biosci.* **2024**, *59*, 103917. [CrossRef]
14. Temiz, H.; Aykut, U.; Okumus, E. The partial purification and properties of pepsin obtained from Turkey proventriculus. *Biotechnol. Bioprocess. Eng.* **2007**, *12*, 450–456. [CrossRef]
15. Temiz, H.; Emin, O.; Umut, A.; Muhammet, D.; Fehmi, Y. Partial purification of pepsin from turkey proventriculus. *World J. Microb. Biotech.* **2008**, *24*, 1855. [CrossRef]

16. Mekhaneg, B.; Girardet, J.M.; Humbert, G.; Saulnier, F.; Poirson, C.; Bellal, M.M. Physico-chemical characterization of a milk-clotting fraction extracted from turkey (*Meleagris gallopavo*) proventriculus. *Innov. Food Sci. Emerg. Technol.* **2018**, *48*, 178. [CrossRef]
17. Ni, C.H.; Lee, C.S.; Chuan, F.Y.; Enomoto, H.; Takeda, S.; Lin, L.C.; Sakata, R. Investigation of the Chemical Cmposition and Functional Proteins of Chicken Gizzard Inner Lining. *Food Sci. Technol. Res.* **2018**, *24*, 893–901. [CrossRef]
18. Jayathilakan, K.; Sultana, K.; Radhakrishna, K.; Bawa, A.S. Utilization of byproducts and waste materials from meat, poultry and fish processing industries: A review. *J. Food Sci. Technol.* **2012**, *49*, 93. [CrossRef]
19. Bohak, Z. Methods in enzymology. In *Proteolytic Enzymes*; Perlmann, G.E., Lorand, L., Eds.; Academic Press Inc.: New York, NY, USA, 1970; Volume 19, p. 358.
20. Bradford, M.M. A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein-dye binding. *Anal. Biochem.* **1976**, *7*, 54. [CrossRef]
21. AFNOR. Controle de la Qualité des Produits Alimentaires: Lait et Produits Laitiers. In *Analyses Physicochimiques*, 4th ed.; AFNOR: Paris, France, 1993; Volume 581.
22. Tressler, D.K.; Joslyn, M.A. *Fruit and Vegetable Juice Processing Technology*; AVI Publishing Company Inc.: Westport, CT, USA, 1961; p. 457.
23. Collin, J.C.; Grappin, R.; Legraet, Y. Etude de la méthode de mesure selon Berridge du temps de coagulation du lait additionné d'une solution enzymatique. *Rev. Laitière Française* **1977**, *355*, 389–439.
24. Berridge, N.J. Some Observation on the Determination of the Activity of Rennet. *Analyst* **1952**, *77*, 62. [CrossRef]
25. Upasana, A.C.; Tripathi, A.C.Y. Assessment of milk clotting activities of plant latex. *AJHS* **2013**, *8*, 456–460.
26. Bergere, J.L.; Lenoir, J. Les accidents de fromagerie et les défauts des fromages. In *Le Fromage*; Eck, A., Gillis, J.C., Eds.; Technique et Documentation Lavoisier: Paris, France, 1997; p. 541.
27. Al-Zoreky, N.S.; Almathen, F.S. Using recombinant camel chymosin to make white soft cheese from camel milk. *Food Chem.* **2021**, *337*, 127994. [CrossRef] [PubMed]
28. Nouani, A.; Hamrani, L.; Bellal, M.M. Purification et caracterisation de protease coagulant le lait extraite a partir du proventricule de poulet (gallus gallus). In Proceedings of the 9ème Journées de la Recherche Avicole, Tours, France, 29–30 March 2011.
29. *ISO 8070:2007*; Milk and Milk Products—Determination of Sodium, Potassium, Calcium and Magne Sium Contents—Method by Flame AAS. International Organization for Standardization (ISO): Geneva, Switzerland, 2007.
30. *ISO 13299:2016*; Sensory Analysis-Methodology-General Guidance for Establishing a Sensory Profile. International Organization for Standardization (ISO): Geneva, Switzerland, 2016.
31. Kazemipour, N.; Salehi, I.M.; Valizadeh, J.; Sepehrimanesh, M. Clotting characteristics of milk by Withania coagulans: Proteo-mic and biochemical study. *Int. J. Food Prop.* **2017**, *20*, 1290–1301. [CrossRef]
32. Bouazizi, A.; Felfoul, I.; Attia, H.; Karoui, R. Monitoring of dromedary milk clotting process by Urtica dioica extract using fluorescence, near infrared and rheology measurements. *Food Control* **2022**, *141*, 192. [CrossRef]
33. Chazarra, S.; Sidrach, L.; López-Molina, D.; Rodríguez-López, J.N. Characterization of the milk-clotting properties of extracts from artichoke (*Cynara scolymus* L.) flowers. *Int. Dairy J.* **2007**, *17*, 1400. [CrossRef]
34. El Zubeir, I.E.; Jabreel, S.O. Fresh cheese from camel milk coagulated with Camifloc. *Int. J. Dairy Technol.* **2008**, *61*, 95. [CrossRef]
35. Konuspayeva, G.; Camier, B.; Gaucheron, F.; Faye, B. Some parame-ters to process camel milk into cheese. *EJFA* **2014**, *26*, 358. [CrossRef]
36. Wangoh, J.; Farah, Z.; Puhan, Z. Extraction of camel rennet and its comparison with calf rennet extract. *Milchwissenschaft* **1993**, *48*, 325.
37. Fguiri, I.; Atigui, M.; Sboui, A.; Marzougui, C.; Dbara, M.; Hammadi, M.; Khorchani, T. Camel Milk-Clotting Using Plant Extracts as a Substitute to Commercial Rennet. *J. Chem.* **2021**, *2021*, 6680246. [CrossRef]
38. Roseiro, L.B.; Barbosa, M.; Jennifer, M.A.; Wilbey, R.A. Cheesemaking with vegetable coagulants—The use of *Cynara* L. for the production of ovine milk cheeses. *Int. J. Dairy Technol.* **2003**, *56*, 85. [CrossRef]
39. Mengxiao, Y.; Aiqian, Y.; Yang, Z.; David, W.; Gilbert, E.P.; Singh, H. Kinetics of pepsin-induced hydrolysis and the coagulation of milk proteins. *J. Dairy Sci.* **2022**, *105*, 1003.
40. Konuspayeva, G.; Camier, B.; Aleilawi, N.; Al-Shumeimyri, M.; Al-Hammad, K.; Algruin, K.; Alshammari, F.; Beaucher, E.; Faye, B. Manufacture of dry- and brine-salted soft camel cheeses for the camel dairy industry. *Int. J. Dairy Technol.* **2017**, *70*, 101. [CrossRef]
41. Chernukha, I.M.; Fedulova, L.V.; Kotenkova, E.A.; Takeda, S.; Sakata, R. Hypolipidemic and anti-inflammatory effects of aorta and heart tissues of cattle and pigs in the atherosclerosis rat model. *Anim. Sci. J.* **2018**, *89*, 784–793. [CrossRef] [PubMed]
42. Toldrá, F.; Mora, L.; Reig, M. New insights into meat by product utilization. *Meat Sci.* **2016**, *120*, 54–59. [CrossRef] [PubMed]
43. Omrani, A.; Sboui, A.; Hannachi, H.; Hamouda, M.; Dbara, M.; Hammadi, M.; Khorchani, T.; Maqsood, S. Optimisation of soft camel cheese production coagulated with green carob extract using response surface methodology: Yield, physicochemical, microbial, sensorial, and rheological properties. *Int. J. Dairy Technol.* **2024**, *77*, 1160. [CrossRef]

44. Ghendov-Mos, A.A.; Sturza, R.O.; Lung, I.; Popescu, L.; Popovici, V.; Patras, A. Effect of lipophilic sea buckthorn extract on cream cheese properties. *J. Food Sci. Technol.* **2020**, *57*, 628–637. [CrossRef]
45. Chen, C.; Zhao, S.; Hao, G.; Yu, H.; Tian, H.; Zhao, G. Role of lactic acid bacteria on the yogurt flavour: A review. *Int. J. Food Prop.* **2017**, *20*, 316–330. [CrossRef]

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