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MANUFACTURE AND CHARACTERISATION OF FRESH CHEESE MADE FROM MIXED MILK OF CAMEL AND GOAT

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ABSTRACT

The aim of this research is to diversify and improve the processing of camel milk. The response surface methodology was used to optimise the coagulation parameters (pH (X_1) and temperature (X_2)) of the camel and goat milk mixture. The coagulation of the milk mixture was performed with camel rennet and was compared to the milk mixture coagulated with microbial rennet. The physicochemical composition and microstructural of optimised fresh cheese was determined and the rheological and sensory properties were studied. Results deduced to optimum points of camel rennet (CR) [X_1=6.16, X_2=37.75°C] and microbial rennet (MR) [X_1=6.31, X_2=38.84°C], which were used in adopted cheese-making process. The physicochemical characteristics of cheeses revealed a significant difference in pH, dry matter, protein and fat contents. Whereas rheological and microstructural analyses, revealed a dilatent coagulum with compact texture characterised with numerous and small pores. Sensory, camel rennet cheese (C_{CR}) was more accepted and had particular profile with creamier texture than microbial rennet cheese (C_{MR}).

Key words: Camel-goat milk, cheese, coagulation, microstructure, rheological properties, sensorial proprieties

Among the processed dairy products, cheese occupy a very important place. In addition to their undeniable nutritional values, they are appreciated for their specific sensory characteristics. The most processed milks are cow, goat and sheep milk. However, camel milk is the least used. Only a few studies have been conducted on the processing of camel milk into cheese. It is therefore not surprising that many scientists have become involved in the study of cheese making from camel milk (Fox *et al,* 2017). In addition, cheese from camel milk remains a challenge under existing conditions (Konuspayva *et al,* 2021; Baig *et al,* 2022).

Haileeyesus and Shimelis (2016) indicated that camel milk is more difficult for processing into cheese, owing to the smaller size of its caseins micelles, fat globules, and its low content of kappa caseins and consequently, limit ability for enzymatic coagulation. Addition of calcium chloride and rennet to camel milk causes a clotting reaction and the formation of a fresh light coagulum (Konuspayva *et al,* 2017; Derar and El Zubeir, 2016). Karoui and Kamal (2017) noted that limited studies are available regarding rennet-induced coagulation of camel milk. Indeed, it exhibits a rennet-induced coagulation time two to three-fold longer compared with bovine milk (Farah and Bachmann, 1987). Siboukeur *et al* (2005), Mahboub (2009) and Boudjenah-Haroun *et al* (2014) studied the properties of camel rennet with their action on camel milk. According to Leksir *et al* (2019) coagulating enzymes of animal origin have been used in Algeria on a traditional scale in the manufacture of cheese.

In Algeria, camel occupies a preponderant place in the socio-economic activity since it represents an indisputable asset in the food security of desert and arid regions (Senoussi *et al,* 2017). In arid areas, goat farming is often conducted in association with camel farming, which makes it possible to have both camel milk and goat milk. In addition, goat milk is the basis

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of excellent cheese widely valued as local product (Boumendjel *et al,* 2017).

In terms of mixed milk, camel milk is used with sheep milk for production of white soft cheese (Derar and El Zubeir, 2013; Derar and El Zubeir, 2016), with buffalo milk for the production of soft cheese (Shahein *et al,* 2014) and with cow milk for the production of Mozarella cheese (Abdallah *et al,* 2022). In addition, the exploitation of goat milk mixed with camel milk remains an untapped task.

Considering the excellent cheese-making ability of goat milk, and in order to improve the camel milk coagulation, this present work targets the optimisation of the coagulation of camel-goat mix milk using camel rennet and microbial rennet, and the characterisation of the manufactured fresh cheese with physicochemical, rheological, sensory and microstructure properties.

Materials and Methods

Milk samples

Camel milk was collected from herds of *Sahrawi* population dromedaries (*Camelus dromedarius*) living in semi-extensive breeding in natural ranges. Goat milk was collected from herds of Arbia goats. The two types of milk were from El Oued "South East of Algeria". All samples were collected cleanly and sent to laboratory with a cold chain using ice packs, then frozen at -18°C until further use. The mixed milk had an equal volume of camel milk and goat milk (50%/50%) (V/V).

Camel abomasum (Last part of Compartment 3-C3)

C3 used in this study from *Camelus dromedarius* (less than a year) was obtained from a slaughterhouse from the same region and was washed with tap water, degreased and covered in a sterile bag and frozen at -18°C.

Microbial rennet (MR)

It's a commercial rennet used in this study as standard rennet. It's a fungal enzyme obtained from *Rhizomucor miehei* (Marzyme R 150MG) with a coagulating force of 1/5000.

Extraction of camel rennet (CR)

The C3 obtained was sliced ($1cm^2$), macerated in a 6% NaCl solution (1:10 w/v) containing 2% boric acid continuously for 4 days at 5°C. Then, the mixture was filtered and centrifuged at 1500 rpm for 15 minutes. The pH of the supernatant was decreased from 5.5 to 4.7 with HCl (1N) and the extracts were kept at 25°C for 24 h to activate the zymogens. The pH was then raised to 5.5 with NaOH (1N). The final rennet extract was obtained by centrifugation at the same speed (Wangoh *et al,* 1993).

Optimisation of the coagulation time of a mixture of camel and goat milk using camel rennet and microbial rennet

Experimental design

The response surface method was used for optimisation of the coagulation time of a mixed volume of camel-goat milk.

The central composite plan (CCD) with two factors (X_1 and X_2) and five levels (-α, -1, 0, +1, + α) was constructed. This plan allowed us to know the effect of pH (X_1) and temperature (X_2) on the coagulation time of milk in a mixture of camel milk and goat milk (linear, quadratic and interactive effects). The pH and temperature varied from 5 to 6.7 and from 30°C to 42°C, respectively (Table 1). The formula (1) of the second degree equation was determined from the experiments to predict the different responses as a function of the parameters studied (pH and temperature).

Table 1. Factors codes and levels of the experimental design for parameters of pH [from 5 to 6.7] and temperature (T) [from 30°C to 42°C].

	Factors (not coded)	
Levels (coded)	pH	T (°C)
Min Point (-α)	5	30
Point (-1)	5.25	31.76
Central point (0)	5.85	36
Point (+1)	6.45	40.24
Max Point (+α)	6.7	42

$$Y=b_0 + b_1 X_1+ b_2 X_2+ b_{11} X^2_1 +b_{22} X^2_2 +b_{12} X_1 X_2 \quad (1)$$

With:

Y: predicted response;

b_0, b_1, b_2, b_{11}, and b_{22}: coefficients of the equation with

b_0: constant;

b_1 and b_2: coefficients of the linear terms;

b_{11} and b_{22}: coefficients of the quadratic terms;

b_{12}: interaction coefficients;

X_1 and X_2: uncoded values of the independent variables (pH and T°).

The experiment matrix of orthogonal composite plane centered with two factors for the 13 tests is shown in table 2.

Table 2. Experimental matrix of orthogonal composite plane centered with two factors.

	Coded values		Uncoded values	
Test	A	B	pH	T
1	**0**	**0**	5.85	36
2	**1.414**	**0**	6.7	36
3	**0**	**1.414**	5.85	42
4	**0**	**-1.414**	5.85	30
5	**-1.414**	**0**	5	36
6	**0**	**0**	5.85	36
7	**0**	**0**	5.85	36
8	**-1**	**-1**	5.25	31.76
9	**0**	**0**	5.85	36
10	**1**	**1**	6.45	40.24
11	**0**	**0**	5.85	36
12	**-1**	**1**	5.25	40.24
13	**1**	**-1**	6.45	31.76

The coagulation time was obtained by adding 1mL of camel rennet and /or microbial rennet to 10 mL of mixed milk (50%/50%) (V/V). For all tests, pH adjustment was made by lactic acid solution (10%) (V/V). The coagulation time was completed when a rigid coagulum appeared in the tube (Alais, 1974).

Statistical analysis of data and graphical representation

The regression coefficients of the responses (clotting time) were determined by Minitab software (Minitab Inc., State College, PA). The value of P determined the degree of significance (α=0.05). Plots for camel and microbial rennets are shown using Statistica software (version 10, Statsoft Poland).

Camel and goat milk cheese-making process

The experimental diagram that summarises the procedure for making fresh cheese from camel milk and goat milk, coagulated with camel rennet (CR) or microbial rennet (MR) is presented in Fig 1.

The freshness of milk was ensured by measuring the pH of camel milk and goat milk. Then, a mixture of milk was made (50%/50%) (V/V) and filtered. Then $CaCl_2$ (0.01%-0.015%) was added and the milk mixture was allowed to stabilise for 30 minutes. The mixed milk was heated to the optimal temperature for coagulation. Afterwards, salting (5g/L) was carried out and followed by adjustment of the optimal pH with lactic acid. At these optimal parameters (temperature and pH), and based on the coagulant strength of each rennet, the camel rennet (CR) was added at a concentration of 0.24ml/l and that of the microbial rennet (MR) at 0.2 ml/l. After coagulation, which took a maximum 45 minutes, the cheese was drained spontaneously and then molded. The cheese made with camel rennet (C_{CR}) and with microbial rennet (C_{MR}) were placed in clean food trays and kept in a refrigerator at 4°C.

Analysis of the crude composition and yield of the cheese

The physicochemical composition (protein, dry matter, fat and ash) and pH were determined from cheese stored at 4°C for a maximum of 24h. The methodological standards for analysis were followed as described by Bradley *et al* (1993). The pH of the cheese was measured by a digital pH meter (inolab, Germany). Total nitrogen was determined by the Kjeldahl method. Dry matter was calculated by drying 2g of fresh cheese at 103°C±2°C for 3h (dry oven, Memmert, Spain), fat was measured by the Van Gulik method (FUNKE GERBER centrifuge, Germany) and ash was determined by total incineration (muffle oven, Memmert, Spain).

Cheese yield is the percentage of total cheese weight (kg) in relation to the initial milk weight (kg) (Mahaut *et al,* 2000).

Cheese yield (%) = (cheese weight/milk weight) × 100.

Rheological analysis (flow test)

The flow test of cheese produced with camel rennet (C_{CR}) and/or with microbial rennet (C_{MR}) was measured by a rheoviscosimeter HAAKE 550 (HAAKE MessTechnik Gmbh Co, Karlsruhe, Germany). The cheese samples were placed on a parallel plate geometry. The plate diameter was 50 mm (Haake, PK 5, 0.5 grads), and the gaps between plates were 4.5 mm. The viscosity of cheese samples was measured for 180s with an initial shear rate of 1.2 s^{-1} and 200 s^{-1} as the final shear rate. Rheological data were analysed with HAAKE Rheo Win software version 2.09. The temperature was maintained at 20°C by a thermostat bath. The number of measuring points were 100. Each test was performed in triplicate. The rheological analysis method was cited by Boughellout (2007) and Djeghim *et al* (2021).

The apparent viscosity was determined using the low power law model (Ostwald de Waele):

$\eta_{ap} = K.\gamma^{n-1}$

where

ηap: apparent viscosity (Pa.s);

γ: shear rate (s^{-1});

n: flow behaviour index;

K: consistency index ($Pa.s^n$) represents the stress required to obtain a shear rate of $1s^{-1}$.

Microstructural analysis by environmental scanning electron microscopy (ESEM)

The purpose of this analysis was to visualise the microstructure of the enzymatic gel based on the mixture of camel and goat milk by observation under an environmental scanning electron microscope (ESEM – FEI QUANTA 250) operating under a large file detector (LFD) and a low vacuum with an accelerating voltage of 10.00 KV.

First, a small piece of each fresh cheese, newly clotted, was finely cut (0.5 cm in length, 0.5 cm in width) and air-dried for 4 to 5 hours. Then, drying in an atmosphere saturated with glutaraldehyde overnight (12h). Then, each piece of cheese was fixed by a series of ethyl alcohol from 10° to 100° for 5 minutes by solution. Thereafter, the pieces of cheese were dried in open air for a few hours before proceeding to observation (Attia *et al,* 1991).

Sensorial profile analysis

The objective of this analysis was to give the sensory profile of the cheese and check its quality. It involved giving a subject of cheese sample and the sensory characteristics were assessed through visual observations and tastings. The characterisation relates to the appearance and texture; smell and taste with aroma. It was made with 20 'student and teacher' tasters. Cheese samples were cut into small squares at about 10g and placed in a closed box for one hour at room temperature before testing. The taster answers the questions on the evaluation grid and assesses the sensory characteristics (Berodier *et al,* 2003).

The comparison between means of crude composition, rheological analysis and the sensory profile values of the studied cheese was done.

Results and Discussion

Effect of pH and temperature on clotting time of mixed milk of camel and goat with camel and microbial rennet

The optimisation gave us the optimum points of pH and temperature for obtaining a suitable coagulation time of mixed milk camel and goat. Table 3 shows the performance of camel and microbial rennets to coagulation of mixture of camel and goat milk.

Results showed that camel rennet coagulated the milk mixture at a minimum time of 15±0.00s at pH:5.85/T:36°C pair and a maximum time of 180±0.00s at pH:5.25/T:31.76°C pair. According to Bouras *et al* (2022), the camel milk coagulation with camel rennet gives a minimum and maximum time of 60±0.01s and 248±0.04s, respectively. In addition, Hailu *et al* (2016) reported that time gelation of camel milk with camel chymosin is mainly affected with temperature and enzyme concentration. Whereas, microbial rennet takes a minimum time of 7.24±0.00s, and a maximum time of 106±0.03s for pH:6.45/T:40.24°C and for pH:5/T:36°C pairs in mixed milk of camel and goat.

Table 3. Clotting time responses of mixed milk camel and goat with CR and MR.

Test	Coded values		CR	MR
1	0	0	43±0.00	12.31 ± 0.01
2	1,414	0	59 ± 0.00	13.85 ± 0.00
3	0	1,414	50 ± 0.03	20.36 ± 0.02
4	0	-1,414	97 ± 0.04	9.69 ± 0.00
5	-1,414	0	120 ± 0.04	106 ± 0.03
6	0	0	19 ± 0.01	9.39 ± 0.01
7	0	0	15 ± 0.00	10.5 ± 0.01
8	-1	-1	180 ± 0.00	14.14 ± 0.02
9	0	0	57 ± 0.02	7.78 ± 0.00
10	1	1	42 ± 0.02	7.24 ± 0.00
11	0	0	49 ± 0.01	8.79 ± 0.02
12	-1	1	159 ± 0.00	8.29 ± 0.02
13	1	-1	105 ± 0.00	18.5 ± 0.04

CR : Camel Rennet, **MR** : Microbial Rennet.

For camel rennet, plot in fig 2 showed that the pH had a significant effect (linear and quadratic) on the coagulation of milk mixture (b1=0.012, b11=0.014) with a significant effect (quadratic) on temperature (b22=0.038). Based on surface plot analysis and relationship between response and variables, a milk mixture clotting time is optimal assuming these pairs of pH and temperature: [X_1=6.16, X_2=37.75°C]. Concerning microbial rennet, the coagulation of milk mixture is sensitive to the variation of pH (linear and quadratic effects: b1=0.000, b11=0.000) with the interaction of pH and temperature (interactive effect) (b_{12}=0.000). Based on surface plot analysis and relationship between response and variables, a milk mixture clotting time is optimal assuming these pairs of pH and temperature: [X_1=6.31, X_2=38.84°C].

Results showed that the addition of goat milk to camel milk considerably increases the performance of camel milk to coagulate with camel rennet. Subsequently, the reducing of coagulation time increases the cheese-making ability of camel milk. So, the optimum pH and temperature pairs are subsequently used in fresh cheese processing using camel rennet or microbial rennet.

Crude composition and yield of fresh cheeses

Table 4 is the summary of the main physicochemical properties of C_{CR} and C_{MR} fresh cheese.

Table 4. Physicochemical properties of C_{CR} cheese and C_{MR} cheese (mean ± standard deviation for 100g).

Parameters	C_{CR}	C_{MR}	P-value
pH	6.48±0.01	6.28±0.01	**
Dry matter (%)	26.7±2.1	45.2 ±0.9	**
Proteins (%)	11.1±1.5	23±0.7	**
Fat (%)	9.7±0.4	18.7±1.25	**
Ash (%)	6.81±0.5	9.29±1.09	NS
Yield (%)	17±1.8	18.3±0.4	NS

C_{CR}: Camel Rennet Cheese, C_{MR}: Microbial Rennet Cheese. Presented values are the means of three replicate trials. NS: Non-Significant, **P <0.01 (Student's t-test).

For pH, it appears to be a significant difference between cheese coagulated with camel rennet and cheese coagulated with microbial rennet (P<0.05). In addition, both types of cheese were characterised by the absence of acidity. These results are explained by the fact that C_{CR} and C_{MR} cheese are initially acidified only by the addition of lactic acid in order to achieve the optimum pH of coagulation.

For the main components, the dry matter of C_{CR} and C_{MR} were significantly different (P<0.05). C_{CR} cheese produced by camel rennet had a dry matter content of 26.7±2.1% compared with C_{MR} cheese, which has a dry matter content of 45.2±0.9%. According to Hailu *et al* (2014), several factors were considered into the cheese, variation in dry matter, such as the nature of the ingredients added during the cheese making, the dry matter content of the raw material and the addition of salt.

For proteins content, there was a significant difference between the two cheese types (P <0.05) and these values for C_{CR} and C_{MR} cheese were 11.1±1.5% and 23±0.7%, respectively. Concerning lipids, the fat content of C_{MR} cheese was 18.7±1.25% and higher than that of C_{CR} cheese 9.7±0.4%.

Cheese yield showed no significant difference between C_{CR} and C_{MR}. It was therefore construed that the enzymatic extract of camel rennet can be a strong competitor of microbial rennet in terms of cheese yield in camel-goat cheese. There appeared a clear impact of the type of enzyme on the composition of the fresh cheese.

Shahein *et al* (2014) produced fresh cheese from camel milk and buffalo milk. These cheese were characterised by a dry matter of 13.58% to 15.15%, proteins of 3.62% to 3.9%, fats of 3.6% to 5.3%, ash of 0.81% to 0.84% and a cheese yield of 14.7% to 20.1%.

Fresh cheese were also made from camel milk only using different proteolytic enzymes. Saima *et al* (2003) reported 97.04% total solids not fat and 78.38% total proteins using commercial rennet and skimmed camel milk. El Zubeir and Jabreel (2008) reported 7.5% dry matter, 4.2% protein, 1.9% fat and 0.2% ash using Camifloc as a coagulant. Bekele *et al* (2018) reported a dry matter content of 34.76±0.26 % to 43.44±2.8%, a protein content of 11.12±0.02% to 17.49±1.73%, a lipid content of 17.99±0.45% to 20.91±0.82% and a yield of 9.5±0.34% to 13.44±0.09% using camel chymosin. The latter was also valorised in the study of Mbye *et al* (2020), who reported a yield of 12.3±1.2%.

The fresh cheese coagulated with recombinant camel chymosin had pH 5.27±0.05%, proteins content 15.62±0.71%, fat content 20.21±0.67%, ash content 2.47±0.53% and a cheese yield 8.75±1.68% (Al-Zoreky and Almathen, 2021).

Rheological analysis (flow test)

Rheological parameters of C_{CR} fresh cheese made with camel rennet and C_{MR} fresh cheese made with microbial rennet are represented in table 5.

Table 5. Rheological parameters of C_{CR} cheese and C_{MR} cheese.

Parameters	K (Pa.sn)	n	χ2	R
C_{CR}	2174±226.9*	-1.4±0.48 ^{NS}	5.58±3.79	0.82±0.03
C_{MR}	5694±850*	-0.92±0.27 ^{NS}	1.48±0.50	0.77±0.14

C_{CR}: Camel Rennet Cheese, C_{MR}: Microbial Rennet Cheese. Presented values are the means of three replicate trials. K: consistency coefficient; n: flow behaviour index; r: statistical correlation coefficient; χ2: Chi-square, NS: Non-Significant, **P* <0.05 (Student's *t*-test).

According to Ostwald model, the statistical analysis showed low values of chi-square (χ2) and high values of regression coefficient (r) for both C_{CR} and C_{MR} cheese formulations. The consistency index (K) is an indicator of the viscous nature of the system (Koocheki *et al,* 2009).The C_{CR} cheese produced with camel rennet had a coefficient of consistency K value, which was 2174±226.9 (Pa.sn); whereas C_{MR} cheese produced with microbial rennet had 5694±850 (Pa.sn). Statistical analysis revealed a significant difference between the two values of K (P <0.05).

The flow index (n) may vary from n=1 (leading to the Newtonian law) to n<1 or n>1 to describe shear thinning or shear-thickening flow behaviour (Steffe, 1996; Fischer *et al,* 2009).

The C_{CR} cheese n value was greater than 1 indicating a dilatent coagulum (shear thickening) and this value of C_{MR} cheese was less than 1 indicating a pseudoplastic coagulum (shear-thinning).

The behaviour of the shear thinning coagulum has been molecularly interpreted as the molecules or structural units of the substance gradually align in the direction of flow as the shear rate increases. In the case of the shear thickening coagulum, this behaviour was less frequent than the thinning coagulum. It was molecularly interpreted by a redistribution of the solvent (lubricant) at the level of the particles, after swelling of the liquid phase (Couarraze and Grossiord, 1991).

Coefficient of consistency K and flow index depend on the temperature and the formulation (Cheremisinoff, 1990; Djeghim *et al,* 2021). Negative values of flow index n can be justified by molecular degradation of the sample, viscosity dispersion or presence of slippage in the fluid (Padmanabhan *et al,* 1991; Drozdek and Faller, 2002; Djeghim *et al,* 2021).

In rheological characterisation of cheese it is generally classified as a viscoelastic material because its stress–strain ratio exhibits both solid and liquid behaviour. In addition, cheese rheology depends on its internal environment, such as its pH and temperature (Giha *et al,* 2021).

Attia *et al* (2001) recorded a plastic gel behaviour for fermented camel milk; where as Ayyash *et al* (2022) reported a pseudoplastic gel for a heat treated and fermented camel milk.

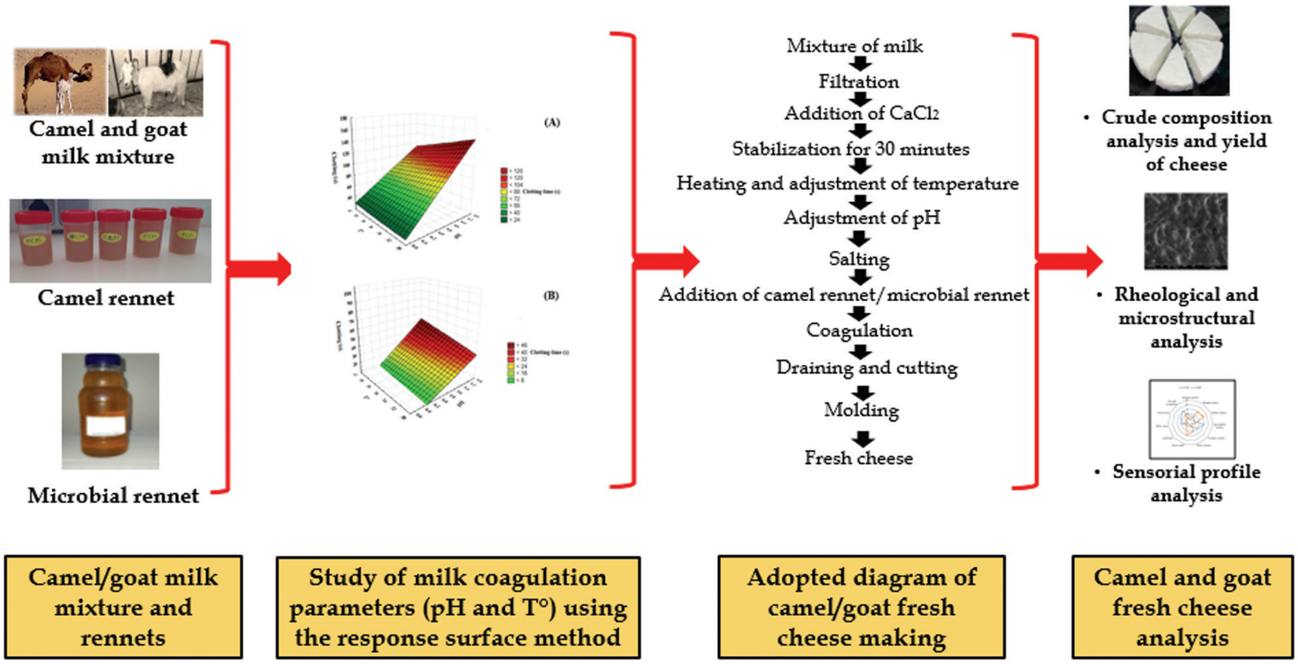


Fig 1. Experimental diagram of cheese.

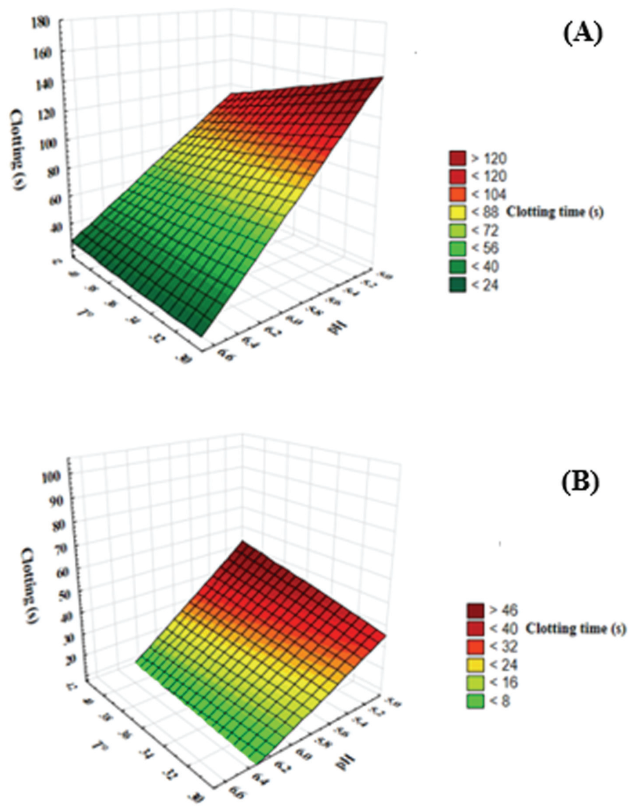
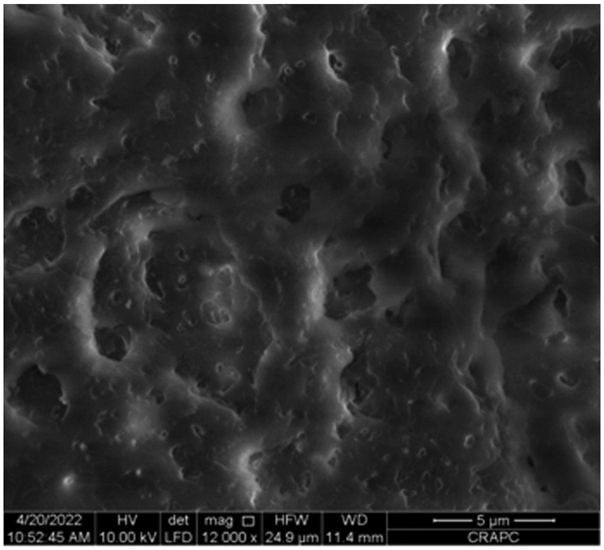
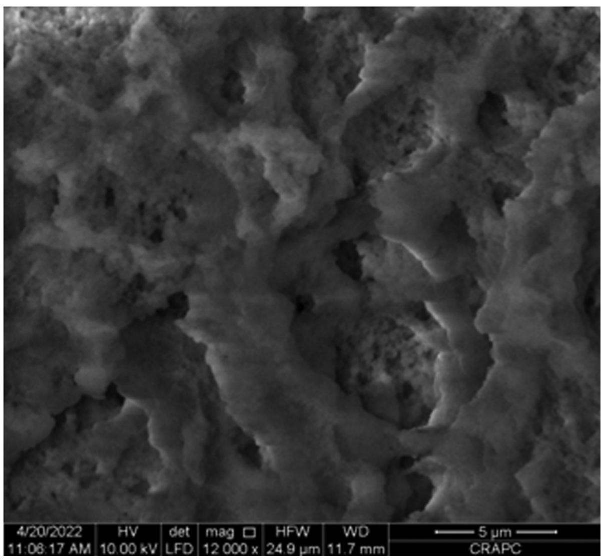


Fig 2. Surface response plot of camel-goat milk mixture with CR (A) and MR (B).



(A)



(B)

Fig 3. Microstructure of C_{CR} cheese (A) and C_{MR} cheese (B).

The difference in the coagulum behaviour of C_{CR} cheese and C_{MR} cheese could be due to specific affinity of each rennet towards the caseins of camel milk, and by the effect of the addition of goat milk.

Microstructure

The ESEM images of cheese produced with camel rennet and commercial rennet are shown in Fig 3.

Results of coagulated C_{CR} cheese and C_{MR} cheese microstructure showed that the type of coagulant had an effect on the casein network formation. It appears that the network of C_{CR} and C_{MR} cheese are continuous. In addition, the pores of C_{CR} cheese are more numerous and smaller compared to C_{MR} cheese. The protein network brins of C_{MR} cheese are thicker than C_{CR} cheese. The presence of evident spaces in cheese is related to the specificity of the coagulant (Fox *et al,* 2000). The ESEM image showed that the protein network of C_{CR} cheese is more compact than that of C_{MR} cheese.

Boudjenah-Haroun (2012) found that the microstructure of cheese made from camel milk and produced with coagulant enzyme extracts isolated from C3 (abomasum) was a compact and uniform structure.

The presence of the small pores may be justified by the reduction in protein activity of the camel chymosin, which was leading to a more compact network, in comparison with the proteolytic activity of the microbial rennet of *Rhizomucor miehei* (Soltani *et al,* 2016).

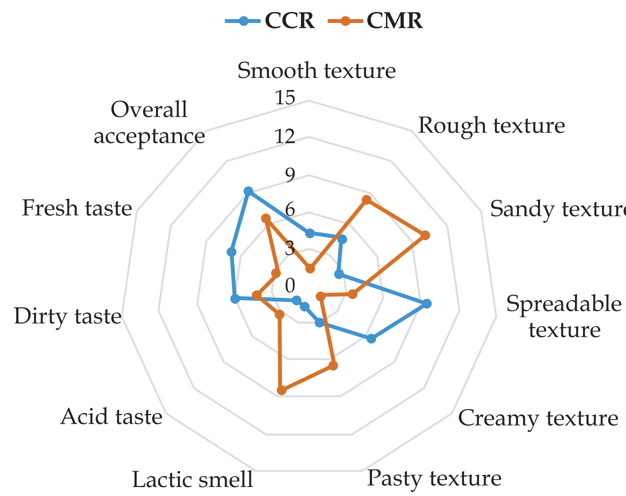


Fig 4. Sensory profile of C_{CR} cheese and C_{MR} cheese.

Sensorial profile analysis

The sensory profile of C_{CR} and C_{MR} fresh cheese are shown in Fig 4. All cheese sensory characteristics were evaluated from 0 to 15 scale.

For the texture, C_{CR} cheese is weakly smooth, rough and pasty with a score of 4.25±1.64, 4.6±0.72 and 2.85±0.99, respectively. In addition, it is characterised by a moderately spreadable texture of 9.2±2.66. Whereas, C_{MR} cheese is weakly smooth, spreadable and creamy with a score of 1.6±0.34, 3.35±0.79 and 1±0.58, respectively. On the other hand, it had a moderately rough texture with 8.3±2.72 and pasty with 6.35±1.76.

For taste and aroma, C_{CR} and C_{MR} cheese are characterised by a weakly acidic taste, which is consistent with the 2 pH cheeses results. In addition, both types of cheese have an average salinity of 6.1±1.19 for C_{CR} cheese and 4.3±1.88 for C_{MR} cheese.

There is a significant difference ($P<0.05$) between C_{CR} and C_{MR} cheese in terms of texture, smell and taste. For the texture, the C_{CR} cheese was less sandy and creamier than the C_{MR} cheese. For smell, C_{CR} cheese had less lactic smell. For taste, C_{CR} cheese was more fresh than C_{MR} cheese.

On the scale of general acceptance, C_{CR} cheese more accepted by tasters compared to C_{MR} cheese with a score of 9.1±2.53 and 6.55±3.39, respectively.

In the literature, fresh cheese made from camel milk only was characterised by a slightly acidic taste, a moderately smooth texture, slightly rough with a salty taste and an acceptance of fresh cheese as reported by El Zubeir and Jabreel (2008). The appreciation of a certain roughness in the texture of fresh cheese made from camel milk was still observed in the study by Ramet (2001) which was justified by the reduction in the fat content of camel milk. At this level, our results are compatible with that of the fat composition of C_{CR} and C_{MR} cheese even with the addition of goat milk. In addition, Mbye *et al* (2020) reported a weakly hard and moderately spreadable and crumbly texture.

For salinity, it was appreciated in C_{CR} and C_{MR} fresh cheese. This assessment was compatible with the considerable ash content for both types of cheese. Besides, the salinity of fresh cheeses was further justified by the high content of camel milk in the region of El Oued in the study by Bouras *et al* (2022).

According to Mehaia (1993), the acceptability score of fresh cheese made from camel milk was between 4.10 and 7.80. In another study by Benkerroum *et al* (2011) found the acceptability score to be 2.90 and 4.70. In this study, we can say that the addition of goat milk to camel milk increased the acceptability score of C_{CR} and C_{MR} cheese.

Conclusion

The coagulation of camel milk is a key step in cheese making process. In this study, the type of rennet used had a significant effect on the overall quality of the cheese. The coagulation of camel milk was improved when mixed with goat milk, regardless of the type of enzymes used (camel or microbial rennet). The fresh cheese produced had very interesting physicochemical and textural characteristics. Microscopic analysis showed that the coagulum obtained was quite firm and on the other hand it presented specific sensory characteristics. These results seem therefore encouraging to exploit the camel rennet in the manufacture of other cheeses, mainly ripened.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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