الجمهورية الجزائرية الدمقراطية الشعبية

People's Democratic Republic of Algeria

وزارة التعليم العالي والبحث العلمي

Ministry of Higher Education and Scientific Research

جامعة الشهيد حمه لخضر الوادي

Echahid Hamma Lakhdar EL-OUED University

كلية علوم الطبيعة والحياة

Faculty of Natural and Life Sciences

قسم البيولوجيا الخلوية والجزيئية

Department of Cellular and Molecular Biology

قسم البيولوجيا الخلوية والجزيئية

Department of Cellular and Molecular Biology

END OF STUDY THESIS

In view of obtaining the diploma of Academic Master

Major: Biological Sciences

Speciality: Applied Biochemistry

THEME

Effect of the nature of the rennet and starter cultures on the physicochemical, sensory and microstructural characteristics of a fresh cheese made from camel-goat milk mixture

Presented by:

- ✓ **BEN BOUZIANE Intissar**
- ✓ **BIA Ichrak**
- ✓ **MESSAOUDI Maria**
- ✓ **TOUANSA Djomana**

Examining Committee:

President: ZAATER Abdelmalek M.C.B ,Echahid Hamma Lakhdar El-Oued University

Examiner: LAICHE Omar Touhami M.C.A ,Echahid Hamma Lakhdar El-Oued University

Supervisor: Mme.BOURAS Biya M.A.A, Echahid Hamma Lakhdar El-Oued University

School year: 2022/2023

ACKNOWLEDGMENT

All who have contributed in one way or another to the completion of this work special thanks goes to:

Our promoter, ***Mrs. Biya Bouras*** *who contributed to the realization of this work and who framed, helped, and advised us throughout the time. We had the privilege of working with her.*

We would also like to thank:

The jury members for accepting to evaluate and examine this work and to share their recognized judicious remarks, which will only enhance the quality of this work

Mrs. Bouchrea *and* ***Mrs. Latifa****, The administrators of the laboratory where our experiment took place for their continuous help.*

Mr. Moussaoui Ahmed*: The Director of the* **SOUF LAIT** *dairy in the province of* **El Oued** *, who helped us with our experiment in terms of milk quality control.*

The officials in charge in the faculty of Natural and Life Sciences, headed by the Secretary General, **Mr. Messaoudi Abdelmalek***, for their constant help and endless support .*

2022/2023

DEDICATION

{وَآخِرُ دَعْوَاهُمْ أَنِ الْحَمْدُ لِلَّهِ رَبِّ الْعَالَمِينَ}

I thank Almighty God first and foremost, and praise be to God at the beginning and at the end, no path is completed except by effort, so praise be to God for completion and enjoyment of accomplishment.

To all those who have enlightened the minds of others with his knowledge or guided the correct response to the perplexity of his interlocutors, thus showing by his grace the humility of scholars.

To my first model, and my beacon that lights my way, to the one whose name is inseparable from my name, to the one whose head I raised proudly, my dear father ***BIA Brahim****.*

To her whose heart has seen me before her eyes, and her womb has kissed me before her hands, to her whom heaven has chosen to be under her feet, my dear mother ***MHIDA Nadia****.*

To the candles that light the way for me, my dear sisters ***Islam, Amira and Isra.***

To him with whom I strengthened my arms, and who was my shadow when I was tired ***BEN BORDI Ali.***

To those with whom I have had no blood ties... but rather the scent of friendship and the rose of love are my friends ***Zineb and Manar****.*

To my friends and to those who accompanied me during the study and the journey of success in this work ***Djomana, Intissar, and Maria.***

To all my honorable professors who did not hesitate to reach out to me, especially my professor in this work ***BOURAS Biya****.*

To all the parents and friends who accompanied the pitfalls of my career with their prayers and forgot its hardships with their love.

Finally, I dedicate this humble work to all those who will take the trouble to read it, whether to evaluate it, criticize it, or deepen their knowledge and satisfy their curiosity.

ICHRAK

2022/2023

DEDICATION

I would like to dedicate this work to:

To my father, **Abd El Malek** *may god protect him, my backbone, my biggest supporter "You have been there for me, no matter what bad choices I might have made… you lovingly repaired my broken spirit, helped me plot a new course, and set me free to fly on my own once again. There is no greater love than that. You will always be special to me, and no matter where life takes me, I'll always love you."*

My angel, to my paradise "my mother **Afaf** *whose soul taught me to believe in hard work and that so much could be done with little, who has been a source of encouragement and inspiration to me throughout my life .."*

Thank you both for giving strength to chase my dreams and made me the person I am today.

My beloved sister **Houda***, my confidence, my keeper of secrets – and my best friend "Sister is our first friend and second mother."*

My lovely sisters **Lina** *and* **Sadjida***, my bond in life, "It was nice growing up with sisters like you – someone to lean on, someone to count on… someone to tell on!"*

My little brother **Anis***, "Can't say how much I love you and how special you are to me. But I can say, my world is full of smiles, whenever you are with me."*

*My partners in this dissertation: "***Djomana, Intissar, Ichrak***" for being supportive, caring, and patient.*

My friends **Hadil** *and* **Douaa***, for whom I wish a lot of success in their life.*

All my colleges of the Master 2 Applied Biochemistry class

MARIA

2022 /2023.

DEDICATION

الحمد لله الذي تتم بنعمته الصالحات، لك الحمد حتى ترضى، ولك الحمد والشكر بعد الرضى، ولك الحمد والشكر اذا رضيت..

The story is over, and I lifted my hat farewell to the past years. I dedicate this graduation ***to my dear father****, who has a kind face and good deeds , who taught me that success only comes with patience and persistence, i dedicate this graduation to whom I prefer over myself, to whom the Lord favored her in his book, to whom she sacrificed for me and spared no effort to make me happy, which was a support for me in my career.* ***To my dear mother****.*

I dedicate this work to my dear sisters ***'Sara'*** *and* ***'Maissa'.***

To my support in life, my brothers ***'Bilel, Walid, Badis, Islam and Adem'.***

To my friends and companions on the road, ***'SOUHILA, DJOMANA, YANNA, DJIHAD, FATEMA and ACHOUAK'***

I dedicate it to my partners, as the work ***'ICHRAK' and 'MARIA'***

I dedicate it to everyone who had an impact on my access to where I am today.

And a special dedication to my brother-in-law ***'Seddik',*** *may God bless his family*

INTISSAR

2022 /2023.

DEDICATION

(وَآخِرُ دَعْوَاهُمْ أَنِ الْحَمْدُ لِلَّهِ رَبِّ الْعَالَمِينَ)

الحمدلله حمداً كثيراً طيباً مباركاً فيه ، اللهم ليس بجهدي واجتهادي وانما بتوفيقگ وفضلگ ....

ها أنا اليوم أعلن تخرُجي رسمياً أهدي نجاحي وتخرجي

إلى قدوتي الأولى إلى من أعطاني ولم يزل يعطيني بلا حدود إلى من رفعت وأرفع به رأسي عالياً

افتخاراً به الذي لم يكن يوماً رجلاً عاديا ***(والدي الغالي توانسة فتحي ..)***

لأمي التي رأتني بقلبها قبل عينيها إلى شجرتي التي لا تذبل إلى الظل الذي آوي إليه في كل حين

إليك ***(أمي الغاليه معوش صباح ..)***

إلى ***أخواتي*** **رحمة,انصاف,امنة ,اماني** النجوم التي تزين سمائي🌟🌟 ....

شكراً لكل روح عانقتني بالحب والدعوات ، لكل من كان سبباً لفرحتي

شكر خاص ***لصديقاتي*** فراشات قلبي🦋 .

شكراً لكل شخص قابلته في أيامي الدراسية .. وكـل شخص كان يدفعني دوماً إلى الأمام....

الحمدلله حتى يبلغ الحمد منتهاه ❤️

DJOMANA

2022 /2023.

Abreviations list

% : Percentage.

.**C°**: Degrees celsius.

µg : Microgramme .

ANOVA : Variance analysis.

C °: Dornic degrees.

C .A.U: Coagulant activity unit

Ca : calcuim.

CaCl2: Calcium chloride

Cl : chlorides.

CM :Camel milk .

Cm : Centimetre.

CMP : Casein macropeptide

CN: Casein .

CN-αS :Caseine αS .
CN-β :Caseine β.
CN-γ :Caseine γ.
CN-κ : Caseine κappa.

CR :Camel rennet.

DADE: Directorate of agriculture and rural develppment .

DM: Dry matter.

FAO: Food and Agriculture Organization.

FDCC :Freeze –dried camelien cheese .

FDMC : Freeze –dried microbial cheese.

G : gram .

g/l:gram/litre.

GF: fat.

GGT : gamma glutamyl transferase .

GM :Goat milk.

h : hour .

H2SO4: sulfuric acid.

Hcl: Hydrogen chloride (hydrochloric acid).

K :potassuim.

Kcal : kilocalorie

κ-CN : kappa casein

L : Litre .

LCC :liquide camelien cheese .

LDH : Lactate dehydrogenase .

LMC :liquide microbial cheese .

m : metre .

MCT :medium -chain triglycerides .

mg : Miligramme .

Mg :magnesium.

min :minute .

ml : millilitre.

mol : molarite

MR :microbein rennet .

Na : sodium.

NaCl: Sodium chloride.

NaHCO3: sodium carbonate

NaOH: Sodium Hydroxide.

NaOH: Sodium hydroxyl.

P :phosphore.

PGRP :peptidoglucane recognition protein .

PH: Potential hydrogen.

Q : voulem of coagulant extract .

RDI : Recommended daily intake .

RU : rennt unit.

s :second .

SEM :Scanning electrone microscopy.

SU :surface unit.

T : Temperateur.

Tc : couagulant time .

TEFD : Percentage of water content in the defatted cheese

V : volume.

WHO: World Health Organization.

β: beta.

List of Figure

List of the table

Summary

Chapter II: Cheese making

Chapter III: Characteristic of fresh cheese

Part II: Materials and Methods

Part III: Results and discussion

Abstract

The objective of this work is to study the effects of rennet and lactic ferments on the physicochemical, sensory and microstructural properties of fresh cheeses made from pasteurized mixed milk (camel milk and goat milk) with camel rennet and microbial rennet (liquid and freeze-dried). To achieve this objective, after evaluating the quality of camel milk and goat milk, the determination of some parameters of camel rennet showed a coagulant activity of (5.32±0.69) UP/mL, a coagulant force (1/52038.16) SU. We proceeded to manufacture and optimize the cheese yield according to the nature of the rennet, liquid rennet (camel and microbial) at different volumes, freeze-dried rennet (camel and microbial) at different weights. The study of the acidifying power of camel-goat milk with the mixture of mesophilic and thermophilic ferments gave the lowest final pH which is 4.26 after fermentation for 24 hours. Finally, four fresh cheese formulations are produced with camel rennet (liquid and freeze-dried) and microbial rennet (liquid and freeze-dried). The yield of LCC cheese is the highest 25.88±0.08%, while FDCC cheese is the best in terms of texture, taste and preference with 40% of tasters. Finally, and at the microstructural scale, we can conclude that the type and nature of rennet have an influence on the appearance of fresh cheeses.

Keywords: fresh cheese, camel milk, goat milk, pasteurization, camel rennet, microbial rennet, mesophilic, thermophilic.

Résumé

L'objectif de ce travail vise d'étudier des effets de la présure et les ferments lactiques sur les propriétés physicochimiques, sensorielles et microstructurales des fromages frais fabriqués à partir du lait mixte pasteurisé (lait camelin et lait chèvre) à la présure cameline et la présure microbienne (liquide et lyophilisée). Pour atteindre cet objectif, après avoir évalué la qualité du lait camelin et lait caprin, La détermination de quelques paramètres de la présure cameline a montré une activité coagulante de (5.32±0.69) UP/mL, une force coagulante (1/52038.16) SU. Nous avons procédé à la fabrication et l'optimisation du rendement fromager selon la nature de la présure, présure liquide (cameline et microbienne) à différents volumes, présure lyophilisée (cameline et microbienne) à différents poids. L'étude du pouvoir acidifiant du lait camelin-chèvre avec le mélange des ferments mésophiles et thermophiles a donné un pH final le plus bas qui est de 4.26 après fermentation de 24h. Enfin, quatre formulations de fromage frais sont produites avec présure cameline (liquide et lyophilisée) et par présure microbienne (liquide et lyophilisée). Le rendement du fromage LCC est le plus élevé 25.88±0.08%, tandis que le fromage FDCC est le meilleur en termes de texture, de goût et de préférence auprès 40% des dégustateurs. Enfin et à l'échelle microstructurale, nous pouvons conclure que le type et la nature de la présure ont une influence sur l'aspect des fromages frais.

Les mots clés : Fromage frais, lait camelin, lait chèvre, pasteurisation, présure cameline, présure microbienne, mésophiles, thermophiles.

الملخص

الهدف من هذا العمل هو دراسة تأثير المنفحة والمخمر اللبني على الخواص الفيزيائية والكيميائية والحسية والبنية المجهرية للجبن الطازج المصنوع من الحليب المختلط المبستر (حليب الإبل وحليب الماعز) مع منفحة الإبل والمنفحة الميكروبية (سائل ومجفف بالتجميد). ولتحقيق هذا الهدف وبعد تقييم جودة حليب الإبل وحليب الماعز، أظهر تحديد بعض معاملات منفحة الإبل نشاط تخثر قدره (5.32 ± 0.69) وقوة تخثر (1 / 52038.16). شرعنا في تصنيع وتحسين محصول الجبن وفقًا لطبيعة المنفحة، المنفحة السائلة (منفحة الإبل والمنفحة الميكروبية) بأحجام مختلفة، والمنفحة المجففة بالتجميد (منفحة الإبل والمنفحة الميكروبية) بأوزان مختلفة. أعطت دراسة القوة الحمضية لحليب الإبل والماعز بمزيج من الخميرة المتوسطة والمحبة للحرارة أدنى درجة حموضة نهائية بلغت 4.26 بعد التخمير لمدة 24 ساعة. أخيرًا، يتم إنتاج أربعة تركيبات من الجبن الطازج باستخدام منفحة الإبل (سائلة ومجففة بالتجميد) ومنفحة ميكروبية (سائلة ومجففة بالتجميد). محصول الجبن LCC هو الأعلى 25.88 ± 0.08٪، بينما الجبن FDCC هو الأفضل من حيث الملمس والطعم وتفضيل المتذوقين بنسبة 40٪ من المتذوقين. أخيرًا وعلى نطاق البنية المجهرية، يمكننا أن نستنتج أن نوع وطبيعة المنفحة لهما تأثير على مظهر الجبن الطازج.

الكلمات المفتاحية: الجبن الطازج، حليب الإبل، حليب الماعز، البسترة، منفحة الإبل، منفحة ميكروبية، الخميرة المتوسطة، الخميرة المحبة للحرارة.

Introduction

The dromedary (Camelus dromedarius) is an animal particularly adapted to the harsh conditions that exist in several regions of the world, particularly in the steppe and desert areas of the Algerian Sahara **(Saidi *et al*., 2021)**. This animal played a considerable role in the development of the regional economy of arid zones around the world, through its various productions and services **(Isselnane, 2014).**

Among his productions, camel milk (CM) also called white gold of the desert is more similar to human milk than any other milk and differs from other ruminant milk **(Bouras *et al*., 2022).** CM has been the main food resource for nomadic peoples since very distant times, who usually consume it raw or fermented. This milk is distinguished by a high content of vitamin C and antibacterial molecules (lysozymes, peptidoglycan recognition proteins, lactoperoxidase, lactoferrin and etc.) **(konuspayeva *et al*., 2022).** CM is considered one of the most difficult types of milk to coagulate and curdle due to its low beta-casein content and limited ability to acidify and enzymatically coagulate **(Isselnane, 2014).**

Goat milk (GM) is one of a neutraceutical health drink. GM is rich in mineral and vitamin content, it is used as the replacer for number of the supplements which are, as a source of vitamins, proteins, and antioxidant macromolecules, GM is beneficial to people, particularly infants, as a substitute for cow milk **(Lad *et al.*, 2017)**, and has specific therapeutic properties **(Park, 2017).** GM is becoming increasingly popular, not only to feed the poor and rural populations with small landholdings but also as a "super" dairy food with unique medicinal, nutritional, immunological, and biological properties **(Haenlein *et al*., 2017; Park *et al*.,2007).**

The transformation of milk into cheese is a method of preserving milk very widely used in the world at the artisanal and industrial level **(Ramet, 1991)**. In the cheese industry, there are two basic types of coagulants, one is lactic acid, and the other is enzymatic, or it can be mixed **(Boughellout, 2007).**

Cheese is one of the most complex, fascinating, and diverse foods enjoyed today. Certainly, the characteristics and activity of the specific starters and adjunct cultures selected for each variety contribute to the complexity and diversity of cheeses. In addition to the microbiological aspects, features contributing to the diversity and differentiation of cheese include the variability, among fundamental processing and aging characteristics that influence both the chemical composition of the fresh cheese and its enzymatic potential during ripening **(Almena-Aliste *et al*.,2014).**

Fresh cheeses are very appreciated by consumers due to its physical characteristics: soft, different textures—with or without mechanical eyes, whitish color, mild acid taste and mild odor **(Ribas *et al*., 2019).** The diversity and complexity of cheese varieties create difficulties with respect to classification and characterization of cheeses. Most of the classical classification systems are based exclusively on one of the following criteria: textural properties (firmness), coagulation method and cheese composition **(Almena-Aliste *et al*.,2014).**

Due to the difficulty of curdling camel milk, many researchers came up with the idea of adding another type of milk to camel milk. **Abd El-Hamid *et al*. (2017)** mixed milk (camel-cows), **Bouras *et al*. (2023**) mixed milk (camel and goat milk). To improve milk-based cheeses (camel-goat), we plan to work on the nature/type of rennet and the addition of two types of ferments (mesophilic/thermophilic)

In this present work, aims to study the effects of rennet and lactic ferments on the physicochemical, microstructural and sensory properties of soft cheeses made from mixed pasteurized milk (camel milk and goat milk) with camel rennet. and microbial rennet (liquid and freeze-dried). The following manuscript is composed of three parts:

-The first part is a bibliographical synthesis on camel milk and goat milk;

-The second part describes the material used and the methods used;

-The third part is devoted to the results and discussion. It includes the results obtained on the survey and the characterization of the raw material (camel milk and pasteurized goat milk) and the coagulants chosen, camel rennet and microbial rennet, manufacture and optimization of cheese yield, study of the acidifying power of milk and the manufacture of four soft cheese formulas of the fresh cheese type with camel rennet (liquid and freeze-dried) and by microbial rennet (liquid and freeze-dried), finally the physicochemical properties, sensory analyzes and microstructure of these cheeses.

Part I

Bibliographic

Chapter I

Camel and goat milk

Milk is generally characterized by nutritional and therapeutic properties that were and are still under study. In this field, we will discuss the study of the vital and functional properties and the chemical composition (protein, fat, vitamins, minerals, etc.) for both camel milk (CM) and goat milk (GM). We will also study the places and nature of living and their distribution. At the level of Algeria in general and El Oued in particular.

I. Camel milk

I.1 Characteristics of camel milk

Recently, camel milk has been considered as a health-promoting icon due to its medicinal and nutritional benefits **(Bakry *et al*., 2021).**

Camel milk is white opaque, with a slightly salty taste with pH ranges from 6.2 to 6.5 **(El-Hatmi *et al*., 2015)**. Its fat content is very low **(Ereifej *et al*., 2011)**. Furthermore, the fat globuls average size is smaller compared to cow, and goat milk fat globules **(Khalesi *et al*., 2017)**. Because camel milk is highly digestible **(Meena *et al*., 2014).**

Camel milk is superior to cow milk and quite close to human milk in terms of its nutritional value. It contains high concentrations of many bioactive compounds that are essential for human health **(Ho Thao *et al*., 2022),** is rich in vitamins including, B1, B2 and C **(Ereifej *et al*., 2011)**. Vitamin C is higher which makes it an important part of diet in arid areas where green foods have limited accessibility **(Zhao *et al*., 2015; Kamal *et al*., 2017).**

I.2 Camel livestock in the wilaya of El Oued

The number of camel in the region of El-Oued experienced strong growth during the period between 2009 and 2018 (Table 01).

The camel herd of the wilaya of El-Oued is essentially made up of the population "Sahrawi" (90%) which remains highly esteemed in the Souf region. The "Berberi" population represents 13% only. The "Sahrawi" population adapts very well to environmental conditions and reproduces without too much of difficulties **(Titaouine *et al*., 2006).**

Table n°01: Evolution of the workforce camel in the wilaya of El Oued **(DADR, 2022).**

Camels		
Year	**Number of camels**	**Total**
2009	15500	27000
2010	19500	30000
2011	20000	31000
2012	21000	34000
2013	22000	37000
2014	23000	38000
2015	24000	40000
2016	25000	42000
2017	27000	45000
2018	34000	55000
2022	33700	54000

I.3 Composition of camel milk

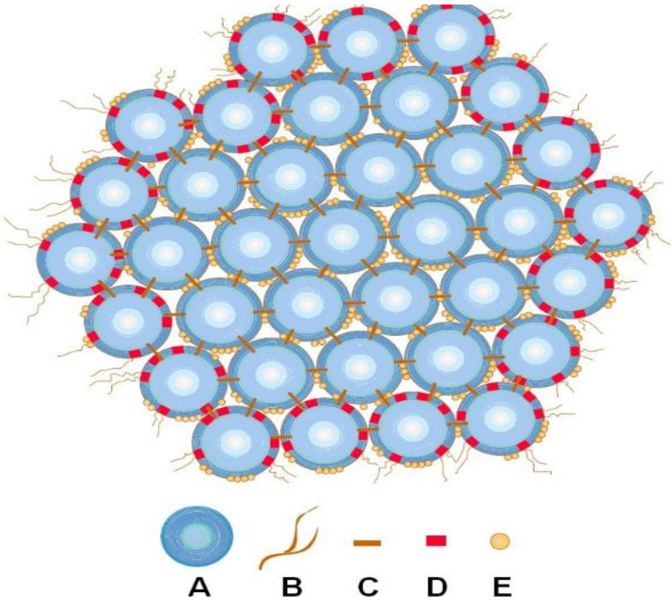
I.3.1 Protein

Camel milk contains two main fractions of proteins: casein and whey protein. The total amount of proteins varies from 2.15 to 4.90 %, resp 3.1% in average **(konuspayeva *et al*.,2009).** The content of proteins in camel milk is influenced by the breed and season, there is a strain that produces milk with higher protein content compared with other breeds. The protein content is lowest in august 2.48% and highest in december and january 2.9% **(Haddadin *et al*., 2008)**.

I.3.2 Casein

Casein (CN) is the main camel milk protein and its share in the milk of camels is 1.63-2.76 %, which represents about 52-87 % of total protein.

There are 4 main casein fractions casein: αs1-casein 22%, αs2-casein 9.5%, β-casein 65%, and κ-casein 35%. their proportion is diverse and polymorphism of these proteins was demonstrated in most of the animal species **(Jilo *et al*., 2016; Brezovečki *et al*., 2015) (Figure 01).**



A casein micelle**; A:** a submicelle**; B:** protruding chain; **C:** Calcium phosphate**; D:** κ-casein**; E:** phosphate groups

Figure 01: Representation of the casein micelle **(Boudjenah,2012)**

I.3.3 Whey

Whey protein is the second biggest fraction of protein of camel milk which covers 20 to 25 percent of camel milk protein. The milk of dromedary camel has a whey protein in range of 0.63 and 0.80 percent **(Khaskheli *et al*., 2005)** β -lactoglobulin is found in trace, while α-lactalbumin comprises the major camel milk portion. In the milk of cow, α-lactalbumin constitute only 25 percent, while β-lactoglobulin made 50 percent of the total whey protein that make it the major whey protein of cow milk **(laleye *et al*., 2008)**. Whey protein of camel milk consists of some other main components such as peptidoglycan, recognition protein, immunoglobulins, lactoferrin and serum albumin. **(Jilo *et al*., 2016)**

I.3.4 Fats

Fat is the major substance defining milk energetic value and makes a major contribution to the nutritional properties of milk, as well as to its technological suitability, milk fat globules have an average diameter of less than 0.1 µm to approximately 18 µm **(El-Zeini, 2006)** and consist of a triglyceride core surrounded by a natural biological membrane. The milk fat globules membrane contains the typical components of any biological membrane such as cholesterol, enzymes, glycoproteins, and glycolipids **(Fauquant *et al*., 2007; Mansson, 2008)** claims that lipids build 30% of the membrane and can be further broken down into the following groups: phospholipids (25%), cerebrosides (3%), and cholesterol (2%). The remaining 70% of the membrane consists of proteins. **(D'Urso *et al*., 2008).**

I.3.5. Lactose

Lactose is main carbohydrate in camel milk **(Farah, 1993)**. The lactose content of camel milk ranges between 2.40 and 5.80% **(Sakandar *et al*.,2018)**. It remains almost unchanged over a season **(Haddadin *et al*., 2008)** and under hydrated or dehydrated conditions though it is only found to change slightly for camel milk of some camel breeds in different part of the world. The variation would be because camel usually graze on wide variation in arid plants and salty bushes available in desert **(Singh *et al*.,2017).** Camel generally like to take halophilic plants like Salosa, Acacia and Artiplex to fulfill their physiological necessities of salts **(Abas *et al*., 2013).**

I.3.6 Minerals

Camel milk is an excellent source and is rich in minerals, including micro and macro minerals.

I.3.6.1 Macrominerals

Major minerals in CM are calcium, phosphorus, magnesium, sodium, potassium, and chlorides. These minerals are generally electrically charged, and it is possible to distinguish the cations **(Konuspayeva, 2020)**.

- The values of total calcium in CM are comprised between 0.3 and 2.57 g/L **(Faye *et al*., 2018)** and the dehydration status can influence milk calcium concentration **(Konuspayeva *et al*., 2022)** .
- The total quantity of phosphorus in CM is lower than calcium. Literature data give a range of 0.34 to 1.00g/L **(Faye *et al*., 2018),** phosphorus is in higher concentration in dromedary milk (0.91±0.19 g/L) with significant seasonal variation, values in summer being significantly lower than in spring and winter.
- Magnesium concentrations in CM varied between 45 and 200 mg/L**.** **(Konuspayeva *et al*., 2022)**

- Potassium content in CM is generally high, the values being comprised between 520 and 1800 mg/L **(Faye *et al*., 2018).**
- There are few data regarding chloride in CM. Reported values range around 2,000–2,800 mg/L.
- After dehydration , chloride content in milk increased by almost 100% as well as potassium while sodium increased by 80% **(Konuspayeva *et al*., 2022).**

I.3.6.2 Microminerals

- Copper content in CM ranges from 30 to 800 g/100 mL **(Faye *et al*.,2018)** but more extreme values are mentioned in the literature. For example, in Morocco 1,130 + 490 g/100 ml **(konuspayeva,2022)** while very low values were found in Kazakhstan 5-7 pg/100 mL **(Discono *et al*., 2008).** There are few data regarding the effect of copper supplementation on the CM mineral status: On camel receiving trace element supplementation, **(Dell'Orto *et al*., 2000)**, did not observe significant change in the milk copper content between supplemented 37 g/100 mL and no supplemented camels 40 µg/100 mL **(konuspayeva et al., 2022).**
- Zinc content in milk is highly variable according to au- thors 30-1,200 µg/100 mL. Thus, the reference values are not clear, and probably the results reported in the literature are depending on the analytical procedures and potential contamination, dust being rich in zinc. In camel milk samples from different regions of Kazakhstan, a mean of 470 pg/100 mL was found, with significant regional variation, and wide range between camel farms from 150 to 7,400 µg/100 mL. Zinc content changed also according to lactation stage with a significant trend to de- crease throughout the lactation (from 440 to 390 µg/100 mL). And according to the farming systems, the milk collected in ex- tensive system being richer (580 ± 52) than in intensive farms (42021 µg/100 mL). However, there were no clear seasonal patterns **(konuspayva *et al*., 2022)**.
- Iron is one of the most important trace elements for the young mammals as their requirements are high before weaning, and milk of the mother is the only source of iron. Like for other elements, data regarding iron content in camel milk are highly variable between references with contradictory observations regarding the comparison with milk from other species. For example, in the old reference

of **(Sawaya *et al.*, 1984),** even lower value was reported: 0.26 mg/100 mL. **(konuspayeva *et al*., 2022)**

- Manganese is less commonly determined in camel milk, probably because it is not a convenient indicator of its intake. Moreover, data from the literature are not very coherent, varying from around 5-6 µg/100 mL **(Haddadin *et al*., 2008)** to 780 pg/100 mL. Camel colostrum contained more manganese 10.7 ± 1.6 than mature milk 8.3 ± 1.6 µg/100 mL **(Konuspayeva *et al*., 2022)**

I.3.7 Vitamins

Numerous vitamins such as D, E, A, C and vitamins of B group are found in dromedary camel milk **(Haddadin *et al*., 2008).** Camel milk rich in vitamin C is the mean value of vitamin C concentration present in camel milk is 34.16 mgL-1 **(Singh *et al*.,2017).** The low pH due to higher concentration of vitamin C, stabilizes the milk and therefore it can be kept for relatively longer periods without cream layer formation. The availability of relatively higher amount of vitamin C in camel milk is of significant relevance from the nutritional point of view as it exerts powerful anti-oxidant activity **(Mal *et al*., 2007).** According to **USDA (2009),** milk (250 mL) of dromedary camel nourish a normal adult by means of 10.5 percent of ascorbic acid (C), 5.25 percent of vitamin A, 8.25 percent of riboflavin (B2), 15.5 percent of cobalaminand pyridoxine and thiamin of the Recommended Daily Intake (RDI) **(Jilo *et al*.,2016)**

I.3.8 Milk enzymes, protective protein and hormones

The enzyme activity of gamma glutamyl transferase (GGT), lactate dehydrogenase (LDH), lactoperoxidase and catalase in camel milk were 241 ± 13.55 IU/L, 140 ± 15.08 IU/L, 2.2 ± 0.30 unit/ml and 0.128±0.025 mol/ min/gm of protein, respectively **(Raghvendar *et al*.,2001)**. Camel milk contains a number of protective proteins, mainly enzymes that exert antibacterial and immunological properties, lysozyme, lactoferrin, lactoperoxidase and peptidoglycan recognition protein (PGRP) **(Singh *et al*.,2017).** Lysozyme activity of camel milk ranged from 0.03 to 0.65 mg/dl **(Mal *et al.*, 2012).** According to different researches, camel milk contains 228 and 500 l g 100 mL-1 of lysozyme **(Duhaiman, 1988).** The variations in the observed values were mainly due to the effect of lactation period **(Kappeler *et al*, 1998).**

Immunoproteins IgG, IgA, IgM, C3 and C4 in milk were determined to study antibacterial factors. The values of these proteins in camel milk are 2799 ± 71.2, 210 ± 21.0,84 ± 15.9, 3.3 ± 0.25 and 0.5 ± 0.14 mg/dl, respectively **(Raghvendar *et al*.,2006).**

The values of prolactin, insulin, TSH, progesterone and cortisol ranged from 8 to 11 ng/ml, 45 to 128 uU/ml, 0.12 to 0.15 uIU/ml, 0.35 to 0.1.40 ng/ml and 25 to 34 ng/ml, respectively **(Singh *et al*.,2017).**

I.4 Nutritive and therapeutic value

It has been reported that camel milk provides various nutritional components such as vitamins, minerals and essential amino acids. In the past decades, many studies have shown that camel milk contains a variety of water-soluble and fat-soluble vitamins, such as vitamins A, C, D, E and B group, with a total vitamin content of about 3.7 g/liter.

Camel milk is distinguished by its high content of B3 vitamins (niacin) as well as vitamin C, whose content is five times higher than that of cow milk (24-52 mg/L), which constitutes an important nutritional contribution for people living in desert areas where fruits are not available and vegetables **(Lajnaf *et al*., 2020)**.

The low level of fat and cholesterol in camel milk makes it healthier than the milk of other ruminants. Numerous studies have revealed the medicinal effects of camel milk when ingested. Many diseases such as diabetes, autism, constipation and tuberculosis can be treated with camel milk. In addition, the latter has the ability to prevent and treat milk allergy (especially cow milk) as well as many immune diseases and digestion problems **(Hassani *et al*., 2022).**

II Goat Milk

II.1. Characteristics of goat milk

The goat milk is a with an opaque white color and a sweet taste, with potential benefits for infants. It is considered one of the most complete foods for human consumption, due to the characteristics of its components such as protein. Goat milk is small and easily digested by Pepsin, which makes it easy for humans to quickly absorb high-quality protein **(Sun *et al.,* 2023)**. The chemical composition of milk may vary according to individuel characteristics such as race, food composition, time of lactation, management, climate, and the region where the animals are found **(Adela Bidot Fernández, 2019).**

II.2 Goat livestock in the Algerian

The distribution of goat herds across the national territory depends on the nature of the region, the farming method, and the importance given to goats **(Hafid, 2006).** Shows that most of the goat population is in the steppe and Saharan zones (Oasis), then in the mountainous zones, on the other hand the number is low at the level of the coast.

According to the statistics of the Directorate of Agricultural Services **(DADR,2022)** of El Oued, of the last years which are represented **(Table n° 02)** There is a decrease in the number of goat due to the lack of traditional breeding.

Table n°02: Evolution of the workforce goat in the wilaya of El Oued **(DADR, 2022)**

Goats		
Year	**Number of Goats**	**Total**
2009	289000	430000
2010	292000	470000
2011	306000	484000
2012	320000	496000
2013	342000	526000
2014	346000	532000
2015	348000	540000
2016	349000	542000
2017	288000	498000
2018	287000	496000
2022	200200	339700

II.3. Composition of goat milk

The factors genetic, environmental, physiological, and handling variables are generally considered factors that influence goat milk composition **(Helmut *et al.*, 2012)**. There is a considerable variation in content between animals within the same breed **(Amigo *et al.*, 2011)**. Nevertheless, goat milk generally consists of a good amount of significant macronutrients, including fat (4%), water (87%), carbohydrates (4.5%), protein (3.5%), and Ash (1%) **(Haenlein *et al.*, 2001)**.

II. 3. 1.Protein

The most significant macronutrient in any goat species of milk is protein, which serves as a suitable benchmark for evaluating and analyzing the quality of nutrition in dairy products **(García *et al*., 2014; Zhu *et al.*, 2018)**. The amount of protein in milk varies depending on the breed, species, lactation time, udder health, nutrition, and environmental conditions **(Park *et al*., 2007; Kondyli *et al.*, 2012)**. All casein (αS1-, β-, αS2-, and k-CN) account for 80% of milk protein, whereas whey protein (serum albumin, α-lactalbumin, β-lactoglobulin, immunoglobulins, proteose peptones, and lactoferrin) accounts for 20% **(Trujillo *et al*.,2000).**

II.3.2. Caseins

Goat milk has these casein constituents (αS1, αS2, β, κ and γ casein). Shares several similarities with it **(Roudj *et al*., 2005)**. Caseins are devoid of sulfur amino acids, therefore not structured by disulfide bridges. On the other hand, they are rich in proline residues (particularly β-casein), residues known for their stereo chemical rigidity, thus explaining the absence of organized structure for these proteins.

These caseins have polar side chains (phosphoryl, glutamyl and aspartyl residues) on the N-terminal side and apolar side chains on the C-terminal side (αS and β casein), reversed representation for κ casein **(Lorient et Cayot, 2000) (Figure 02).**

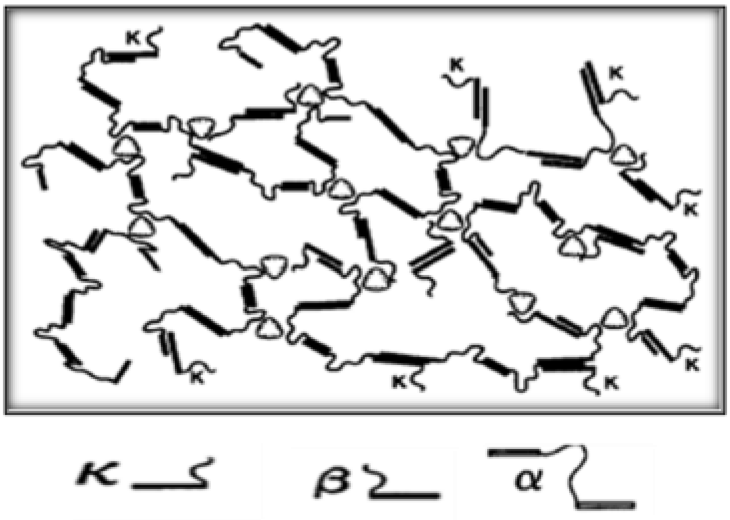


Figure 02: Schematic representation of the structure of the casein micelle according to the model of **(Horne, 1998)**.

II.3.3 Fats

Fat content of goat milk across breeds ranges from 2.45 to 7.76%. Average diameters of fat globules for goat, are reported as 3.49 µm, goat milk fat contains 97-99% free lipids (of which about 97% is triglycerides) and 1-3% bound lipids (about 47% neutral and 53% polar lipids). Goat milk fat has significantly higher levels of short- and medium-chain-length fatty acids (MCT) than cow and human milks. **(Park, 2010)**.

II.3.4 Lactose

Goat milk main carbohydrate is lactose, it is made in the mammary gland from glucose and galactose. Oligosaccharides, glycopeptides, glycoproteins, and nucleotides are small amounts of carbohydrates found in goat milk, goat milk has a higher concentration of lactose derived oligosaccharides. In comparison to human milk, goat milk has a higher proportion of oligosaccharides, and the oligosaccharide structures found in goat milk are the most similar to those found in human milk, this is especially important for baby feeding **(Soumya *et al*., 2021).**

II.3.5 Minerals

The mineral content in goat's milk is higher than in human milk, and represent a small part of the milk constituents, ranging from 3 to 8 g/l. **(Park ,2006)** goat milk is an excellent source of calcium and phosphorus **(Prosser, 2021)** but is not a good source of other minerals such as iron, cobalt and magnesium **(Park, 2006)**.

- Goat milk contains about 134 mg Ca and 121 mg Potasuim /100 g, while human milk has only one-fourth to one-sixth of these two major minerals. The concentrations of macro-minerals may not fluctuate much, but they vary depending on the breed, diet, individual animal, stage of lactation, and status of udder health **(Kumar *et al*., 2012).**
- Overall, goat milk is an excellent source of Ca, P, K, Mg and Cl but is not a good source of other minerals such as iron, cobalt, S and Na. **(Prosser, 2021 ; Park et Chukwu, 1988 ; Chandan *et al*., 1992).**

II.3.6 Vitamins

Goat milk is an excellent source of vitamins. Similar to human milk, it contains vitamin A, which is important for innate and adaptive immune responses as well as good antibody formation. It is rich in vitamin B as well but due to the conversion of β-carotene into retinol, goat lacks βcarotene in its milk **(Park *et al*., 2007; Raynal *et al*., 2008)**. This is the reason goat milk is whiter than cow milk. Goat milk has an excessive amount of vitamin B, I.E, thiamine, riboflavin, and pantothenate which are very important for infants, and hence it can solely be dependent upon goat milk for infancy and these minerals and vitamins can fully gratify the children obligation **(Saikia *et al*.,2022).**

II.3.7 Enzymes

Milk contains various enzymes, including alkaline phosphatase, lysozyme, lactoperoxidase, catalase, lipase. The last three play a bacterial growth inhibitory function. In general, it can be said that these enzymes are scarce, but the reactions and transformations they produce are of such importance that they can condition the composition and properties of milk. They are very sensitive to variations in pH and temperature, so that an elevation of the temperature causes them to be quickly inactivated and thus allow the quality and handling of the product to be assessed **(Adela bidot fernández, 2019)**

II.4 Nutrition and therapeutic value

Goat milk is similar to breast milk because it contains vitamins, minerals, enzymes, proteins, lactose and fatty acids that are easily absorbed by the body **(Bhatia *et al*.,2021).** Medium-chain triglycerides (MCTs) found in goat milk have been identified as unique fats with health benefits. The most important effect of goat milk proteins is its therapeutic effect on cow milk allergy, which is the most common type of food allergy that causes many deaths in infants. Lactose is the main carbohydrate of all types of milk, and its content in goat milk is lower from others. In contrast, goats milk, which is rich in oligosaccharides, is important in its protective function of the intestinal flora against pathogens and in the development of the brain and nervous system in addition to the high amounts of certain minerals, the bioavailability of minerals in goat milk is higher than the minerals in cow milk. The higher vitamin A content may be the most significant difference between other vitamins in goat milk compared to cow milk, considering that millions of children die every year due to vitamin a deficiency, goat milk is a very important source **(Turkmen, 2017).**

Chapter II

Cheese making

Usually the manufacture of cheese comprises three stages: The formation of a casein gel, which is the coagulation of the milk; the partial dehydration of the gel, it is the draining which leads to a curd and the next stage is salting. These steps concern fresh cheeses, the rest of the cheeses also undergo a ripening stage.

I. Stages of cheese making

These stages are: milk preparation, coagulation, drainage and salting

I.1 Milk Preparation

The first step in cheese making depends on processing the milk, which in turn consists of different stages:

- Receiving milk as a raw material.
- Cleansing milk and separating potential solid particles such as impurities.
- Pasteurization is sufficient heating to eliminate all germs with confirmed pathogens. The most common pasteurization temperature is 60 to 75 °C and sometimes 80 °C for 15 to 20 minutes **(Low *et al.*,2010).**
- Then a starter culture is added to acidify the milk. This acts on the milk sugar (lactose), turning it into lactic acid, effectively souring it **(Powell *et al*., 2011)**

I.2 Coagulation

The coagulation of milk results from the association of more or less modified casein micelles. It is generally the transformation of liquid milk into gel, called coagulum or curd, which, after a certain number of transformations, will become cheese **(El-Bendary *et al*., 2007; Shieh *et al*., 2009; Ahmed *et al*., 2010).**

The coagulation process is caused by the action of a coagulant, added at a well-defined rate to the manufacturing milk, under controlled temperature and pH conditions **(Boudjenah, 2012)**.

In cheese making technology there are three types of coagulation: enzymatic coagulation, acid and mixed coagulation.

I.2.1 Enzymatic coagulation

Enzymatic coagulation is ensured by a large number of proteolytic enzymes, of animal, microbial or vegetable origin, having the property of coagulating milk. We must also take into account their great additional non-specific proteolytic activity which allows them to hydrolyze α and β caseins with the release of peptides **(Mietton, 1995).**

I.2.1.1 Main sources of milk clotting enzymes

There are three sources: Animal, microbial et vegetable.

I.2.1.1.1 Enzymes of animal origin

The rennet is a mixture of chymosin and pepsin.

a) Chymosin

Chymosin is a protease found in rennet that can precipitate milk proteins and promote the formation of curds during cheese making **(zhao *et al.*, 2020).** The enzyme works on milk κ-CN and is separating these particles. This process causes an adjustment of micelle surface charge, increases their hydrophobicity, and encourages their conglomeration **(Koc *el al.*, 2008).** Furthermore, the natural substrate of chymosin is separated at the peptide connection between amino corrosive deposits as phenylalanine (105) and methionine (106). The chymosin induces the hydrolysis of κ-CN, which causes destabilization and aggregation of casein micelles **(Nilsson *el al.*,2020).** In the process of making cheese from milk, when the cheese is aged, the hydrolysis of caseins prompts changes. Proteolysis is frequently considered to be the main biochemical pathway affecting the surface and flavor development **(Soltani *et al.*,2019).**

b) Pepsin

Pepsin is an acid protease present in the gastric juice of all mammals and birds. One of its remarkable characteristics is its great activity in this acidic environment; it is active even at pH 1 where several enzymes and proteins undergo rapid denaturation **(Isselnane, 2014).** Pepsin is relatively stable at pH values between 5 and 5.5. Its enzymatic activity is higher between pH 1 and 4 with a maximum around 1.8 and varies according to the nature of the substrate. It is a thermosensitive enzyme in solution after 55°C. It is denatured at temperatures of 70°C **(Talantikite, 2015).**

I.2.1.1.2 Enzymes of microbial origin

Microbial coagulants all the well-known microbial coagulants used for cheese making are of fungal origin. Most of the bacterial proteases described as milk-clotting enzymes have been found to be unsuitable, mainly because they have too high a proteolytic activity of the fungal coagulants **(Low et al.,2010)**.

I.2.1.1.3 Enzymes of vegetable origin

The coagulation of milk can come from practices that are found all over the world, by the use, not of lactic acid or animal enzymes, but of plant extracts **(Froc, 2001**). There are, in various countries, plants likely to provide enzymes having the property of coagulating milk, in general, these various vegetable preparations have given rather disappointing results in cheese making because they most often have a very proteolytic activity. High and produce bitter cheeses **(Lo Piero *et al*., 2002).**

In Algeria, the use of thistle flowers, artichoke extract, pumpkin seeds, or fig tree sap are known practices for the production of traditional Jben **(Amroune, 2019).**

I.2.1.2 Enzymatic Coagulation Steps

During enzymatic coagulation, casein is hydrolyzed. It results in the coagulation of the milk without modifying the pH **(Brulé *et al*., 1997)**, there are three phases.

I.2.1.2.1 Primary phase

Primary phase Rennet attacks the component that stabilizes the casein micelle κ-casein at the Phe105-Met106 bond **(Mahaut *et al*., 2000; Vignola, 2002; Anema *et al*., 2005)**. There is then a cleavage of the peptide chain into two unequal segments: the primary segment -105 is the paracasein-κ and the segment 106-169, the caseinomacropeptide (CMP). κ-paracasein linked to α and β-caseins remains integrated in the hydrophobic micelle and the CMP containing all the carbohydrates is released and passes into the whey. CMP is the part of κ-casein which is strongly negatively charged and responsible for steric and electrostatic repulsions. Chymosin removes this stabilizing hair from the micelle **(Cayot and Lorient, 1998).**

I.2.1.2.2 Secondary phase

It is a stage of agglomeration of a mechanism that is still poorly understood. During this phase, the destabilized micelles can come together and form hydrophobic bonds by the intervention of calcium ions which unite with the negatively charged part of the micelles, thus reducing the electrostatic repulsion forces to which they are subjected, which promotes their aggregation **(Holt, 1997; Mietton *et al*., 2004)**. This phase is observable by the formation of the gel. The start of this phase requires that at least 85 to 90% of the κ-casein is hydrolyzed. The CMP is detached from the κ-casein and the micelle loses its hydrophilic character. There is a decrease in its degree of hydration and its surface potential. Hydrophobic and electrostatic bonds are then established between the modified micelles and will lead to the formation of the gel **(Dalgleish, 1992; Mahaut *et al*., 2000) (Figure 03)**

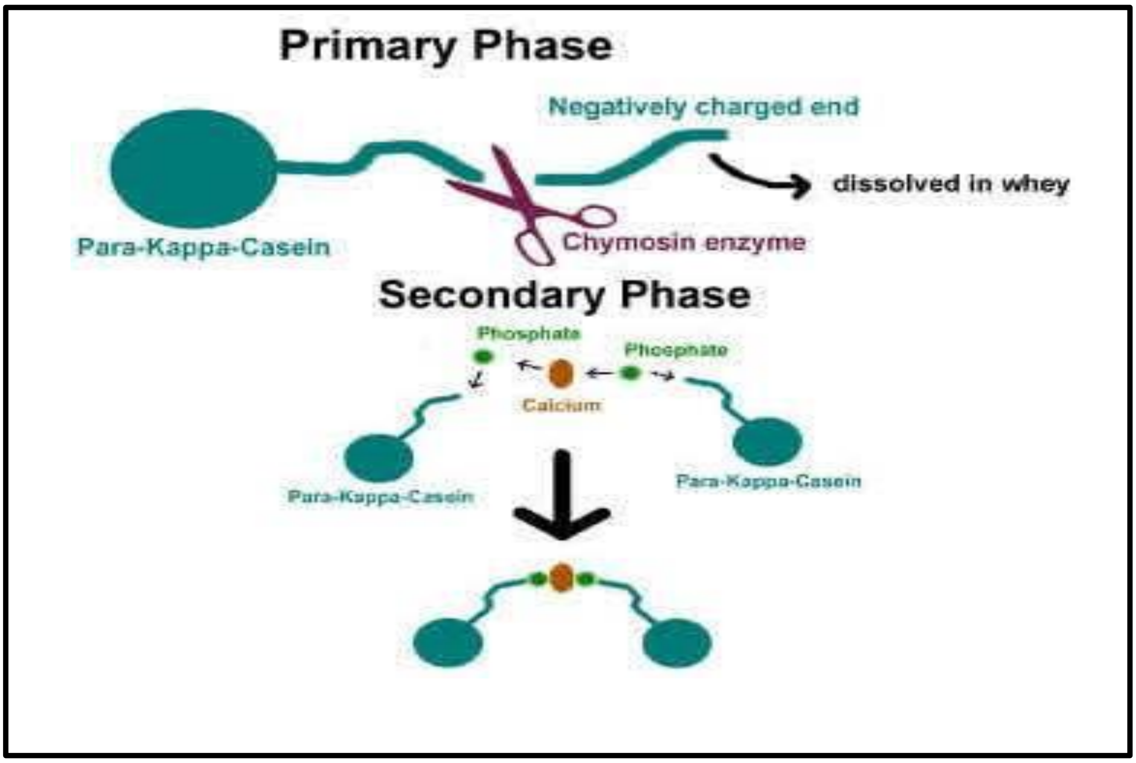


Figure 03: Enzymatic coagulation steps **(Buffa *et al*., 2001)**

I.2.1.2.3 Tertiary phase

The aggregated micelles undergo profound reorganizations by the establishment of phosphocalcic bonds and perhaps disulphide bridges between the paracaseins. These mechanisms occurring during phases (2 and 3) are quite complex and still poorly understood **(Mahaut *et al*., 2000)**.

I.2.2 Acid coagulation

It consists in precipitating the caseins at their pHi=4.6 by biological acidification using lactic ferments which ferment the lactose into lactic acid, or by chemical acidification by means of injection of CO_2, addition of glucono-δ-lactone or whey added protein at acidic pH. The gel obtained by acidification has good permeability but great friability. The absence of network structuring results in practically zero elasticity

and plasticity and low resistance to mechanical treatment **(Vignola, 2002; Jeantet *et al*., 2008).**

I.2.3 Mixed Coagulation

Mixed coagulation is carried out according to two phenomena: acidification which consists in precipitating isoelectric caseins by acidification using lactic ferments which transform lactose into lactic acid and the addition of the enzyme coagulant, this coagulation requires temperatures varying from 28 to 32°C **(Remache *et al*., 2020)**. In practice, this method is used for the production of fresh cheese for example soft cheeses **(Mahaut *et al*., 2003)**

I.3 Draining

Drainage is a dynamic phenomenon characterized by partial dehydration (elimination of whey) and hardening of the gel. This leads to obtaining a curd corresponding to the cheese formed and with a more or less high dry matter content **(Brulé *et al*., 1997)**. This phenomenon depends on direct factors (these are mechanical and thermal treatments), indirect factors (these are enzymatic coagulation and/or acidification) and factors linked to the raw material (richness in caseins, soluble protein and fat) **(Ramet, 1985).**

The gel obtained by the enzymatic route (impermeable gel with mechanical drainage) has rheological properties opposite to those of the gel obtained by the acid route (very friable gel with spontaneous drainage) **(Veisseyre ,1975).**

I.4 Salting

Salting is an essential operation in most cheeses which consists of enriching the cheese with sodium chloride. By acting on water activity, salting preserves the cheese, improves the aroma and accelerates the drying mechanism **(Bendimerad,2013).**

Adding salt, it slows down or stops the acidification of the curd**,** it prevents excessive demineralization of the dough and completes drainage by osmotic effect**,** it also controls the proliferation of pathogenic or harmful bacteria and selects useful microorganisms for ripening **(Vigneux, 2017).**

The salt content of cheeses varies according to the type of cheese on average it is 0.5-2 g/100 g in most cheeses. The methods of salting are by dry salting and mass salting **(Alais et Linden, 1997)**.

II. Factors influencing cheese making

Many factors are likely to modify the coagulation of milk and the physical characteristics of coagulums. These factors are mainly related to pH, temperature, enzyme concentration, calcium content and type of milk.

II.1 Effect of pH

The influence of pH on coagulation time and curd firming speed is very strong **(Ilboudo et al., 2012).**

The optimal pH of hydrolysis pH is between 5.6 to 6.7, the coagulation rate is increased. This results from an increase in the rate of hydrolysis and consequently an increase in the rate of firming of the gel. Firmness is significantly greater from pH 6.6 to pH 6.0 due to greater availability of ionized calcium. Below pH 6.0, casein demineralizes and disintegration of the micellar structure is accentuated until it becomes complete at pH 5.2 **(Boughellout, 2007).**

II.2 Effect of temperature

The principal effect of set temperature is on the secondary phase of enzymatic coagulation, which does not occur at temperatures below around 18°C. Above this temperature, the coagulation time decreases to a broad minimum at 40-45°C and then increases again, as the enzyme becomes denatured. In cheese making, rennet coagulation normally occurs at around 31°C. This is necessary to optimize the growth of starter bacteria which will not survive the temperature more than 40°C. In addition, the structure of the coagulum is improved at the lower temperature, which is therefore used even for cheeses made using thermophilic cultures **(Kanawjia *et al.*,2016)**

II.3 Effect of The enzyme concentration

Like any enzymatic reaction, the enzyme concentration has a great influence on the rennet coagulation process. This coagulation is the result of an enzymatic hydrolysis reaction followed by a protein aggregation reaction. Clotting time decreases with increasing enzyme concentration. Some authors have also observed an increase in gel firmness associated with an increase in rennet concentration **(Ilboudo *et al*., 2012)**

II.4 Effect of calcium ions ($CaCl_2$)

Calcium salts play an important role in rennet coagulation and in the structure of gels. The addition of calcium reduces clotting time by neutralizing the negative charges of casein residues, which increases the aggregation of casein micelles **(Lucey and Fox, 1993).**

II.5 Ability of milk to coagulate

Mainly, fresh cheeses worldwide are made from cow milk. On the other hand, several works have accentuated the manufacture of cheeses made from goat milk. **(Skeie ,2014)**

The coagulation ability of goat milk is strongly dependent on the αs1-casein content. If the content of this protein in the milk is higher, it is associated with a higher total protein content, a lower pH, a shorter coagulation time and a higher curd firmness. **(Karachiviev., 2018)**.

The processing of camel milk into cheese is difficult or even impossible **(Diskon, 1951; Gast *et al*., 1969; Yagel, 1982; Wilson, 1984; Siboukeur *et al*.,2005)**. Because of its properties that make it difficult to coagulate, especially with the use of classic rennet. The main explanation is the low concentration of casein (only 3% versus 13% in cow's milk). Therefore, most of the research for the last 80 years has focused on improving the curdling of camel milk**. (Konuspayeva *et al*., 2019)**

Recently, authors have reported studies that are carried out on the manufacture of fresh cheese from mixed milk, citing cow-goat **(Tajine *et al*., 2019),** camel-cow **(Abd Elhamid *et al*., 2017)**, camel-ewe **(Saadi *et al*., 2019)** and cow-ewe **(kuroda *et al*.,2020)**. The first work that considers the manufacture of camel-goat fresh cheese is cited by **(Bouras *et al*., 2023)**

Chapter III

Characteristic of fresh cheese

In this chapter we will focus on the most important characteristics of fresh cheese in terms of its components of protein and minerals, including calcium, phosphours, and vitamins, and dividing it into two principles according to (TEFD) (fat content) in addition to nutritional value, microstructure and sensory appearance.

III.1 Definition of Cheese

Cheese according to the standard **Codex stan 283 (1978)**, is the ripened or unripened product, of soft or semi-hard, hard or extra-hard consistency which may be coated and in which the whey protein/casein ratio does not exceed that of milk, and which is obtained:

(a) by complete or partial coagulation of proteins from milk, skimmed milk, partly skimmed milk, cream, whey cream or buttermilk, singly or in combination, by the action of rennet or other suitable coagulating agents and by partial draining of the whey resulting from this coagulation, while respecting the principle according to which the manufacture of cheese leads to the concentration of milk proteins (particularly casein), the protein content of the cheese being therefore significantly higher than the protein content of the mixture of the above raw materials which was used to manufacture the cheese and/or

(b) by the use of manufacturing techniques involving the coagulation of milk proteins and/or products derived from milk, so as to obtain a finished product having physical, chemical and organoleptic characteristics similar to those of the product defined in paragraph (a).

III.2 Composition of fresh cheese

Cheese is a rich source of nutrients, the most important of which are proteins, fats, vitamins and minerals

III.2.1 Proteins

The value of protein in soft cheese made from cow milk and camel milk ranged respectively 13.4% to 15.24% **(Neamat *et al*., 2014),** the amount of protein varies according to the type of cheese, type of milk and other factors.

III.2.2 Fats

Fat is essential in cheese and it is varies based on the milk content and the cheese-making process. Between 20% and 35%, it contributes to the flavor and texture of the cheese **(Richard *et al*.,2011).**

The types of fat found in cheese are triglycerides, saturated fatty acids, and unsaturated fatty acids, including monounsaturated and polyunsaturated fatty acids **(Sanz *et al*.,2007).**

III.2.3 Minerals

The concentration of minerals in cheese varies according to the type of cheese, the manufacturing process, the coagulation method, and the amount of salt added in the cheese. There are many minerals, the most important of which are calcium, phosphorus, and some other minerals**.**

III.2.3.1 Calcium

Cheeses are excellent sources of calcium, however, the calcium level varies according to the water content and the method of manufacture. The calcium in cheese is well assimilated by the human body due to the respective proportions of calcium provided by the cheese maker and the concomitant presence of proteins that promote intestinal absorption **(Richard, 2012)**.

III.2.3.2 Phosphorus

Cheese also act as good source of phosphorus which exist in various forms such as soluble phosphate exists in the serum phase and bound phosphate exist in the paracasein part of cheese curd. The bound phosphate also in two forms one as bound organic phosphate and another is bound inorganic phosphate **(Richard,2012).**

III.2.4 Vitamins

The main vitamins present in the cheese are the fat-soluble vitamins (A, D and E) retained by the curd, which contains 90% of the milk fat. As to the water-soluble vitamin content, it varies significantly from one cheese to another depending on microbial synthesis that occurs in cheese during ripening **(FOX, 2017)**. Some bacterial strains as lactobacillus sp. And bifidobacterium sp. involved in dairy products fermentation can provide an additional source of B vitamins (thiamin, riboflavin, cobalamin, folate and biotin) during dairy fermentation **(Levit, 2016; Van Wyk, 2011;**

Laino, 2013). Also the dairy propionic acid bacteria, especially P. freudenreichii ssp. shermanii, the main component of ripening flora in Swisstype cheeses, are used for the production of vitamin B12 and there is an increasing interest in their potential use as probiotics **(Gardner, 2005; Vorobjeva, 2008; Rabah, 2017).**

III.3 Classification of cheese

The classification of cheese according to Codex Alimentarius **Codex stan 283 (1978)** standards is based on TEFD (Percentage of water content in the defatted cheese), fat content.

III.3.1 According to TEFD

Where the product is not designated by a variety name but by the sole designation “cheese”, the designation may be accompanied by the appropriate descriptive formulas shown in the following table 03:

Table 03: Classification according to TEFD

DENOMINATION ACCORDING TO THE CHARACTERISTICS OF FIRMNESS AND REFINING		
According to firmness: Formula 1		**According to the main degree of ripening: Formula 2**
TEFD %	**Denomination**	
< 51	Extra-hard dough	Refined
49–56	hard dough	Refined to molds
54–69	Firm/semi-hard cheese	Unripened/fresh
> 67	Soft dough	In brine

TEFD = Percentage of water content in the defatted cheese, i.e:

$$\frac{Weight\ of\ water\ in\ cheese}{Total\ cheese\ weight - \ fat\ in\ cheese} \times 100$$

III.3.2 According to milk fat content

Depending on the fat content, we can classify cheeses into

- **Extra fat or double cream** (if the fat content is equal to or more than 60%)
- **Full fat or whole milk or cream** (if the fat content is greater than or equal to 45% and less than 60%)
- **Semi-fat or semi-skimmed** (if the fat content is greater than or equal to 25% and less than 45%)
- **Partially skimmed** (if the fat content is greater than or equal to 10% and less than 25%)
- **Lean or skimmed** (if the fat content is less than 10%).

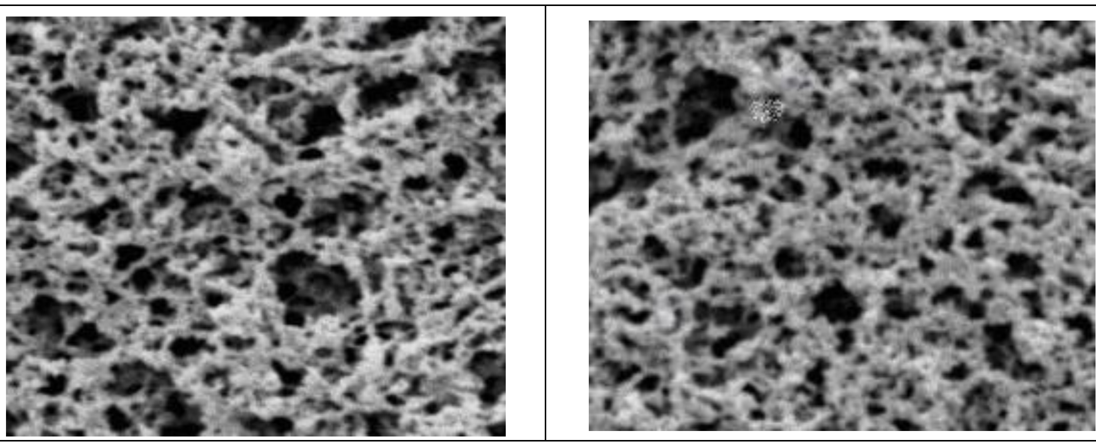
III.4 Nutritional values of cheeses

The caloric content of the different cheeses varies from 100 Kcal for 100 g of fresh cheese to 350 Kcal, most of the calories come from lipids, proteins and carbohydrates **(Sellah ,2021).**

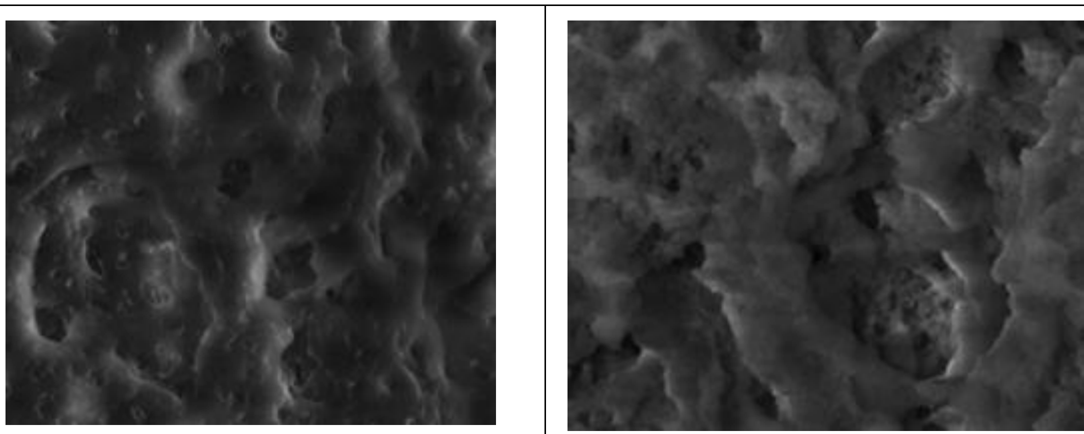
The interest of cheeses has many points in common with that of milk. However, their manufacture is accompanied by changes in composition and nutritional value. In addition to being a source of various nutrients such as vitamins and excellent quality proteins, cheeses, especially those with a firm and hard paste, contain a large amount of calcium **(Amoiot *et al*., 2002)**

III.5 Microstructure of cheese

The structural properties of cheese greatly influence its chemical, mechanical and nutritional properties. Scanning electron microscopy (SEM) image processing is a powerful tool for knowing and estimating the microscopic properties of cheese **(Mistry et al., 1993; El-Bakry, 2014; Mehta,2018),** and this is what prompted many researchers to implement this technique among them **(Figure 03) (Boudjenah ,2012 ; Bouras *et al*., 2023)**



A



B

Figure 04: Examples of the microstructure of fresh cheeses**. A**: fresh camel cheese and cow cheese **(Boudjenah,2012)** and **B**: Camel-goat fresh cheese (camel rennet/microbial rennet**) (Bouras *et al*.,2023).**

II.6 Sensory profile

The objective of sensory analysis is to determine different sensory attributes in terms of texture, taste and smell. In this sense, several authors have reported the sensory characterization of fresh cheese made from camel milk **(Boudjenah, 2012)** or goat's milk **(Noutifia *et al*., 2019)**. On the other hand, in terms of mixed milk **(Bouras *et al*., 2023)** reported the sensory profile of a fresh cheese made from high-grade camel milk.

Part II

Material and methods

The objective of this work is on the one hand to valorize the camel rennet in the manufacture of fresh cheese based on camel-goat milk mixture, and on the other hand to characterize the cheeses produced (physico-chemical, microstructure and sensory profile) in comparison with commercial (microbial) rennet.

This study is divided into four parts:

First part: Study of the raw material

1. Physico-chemical characterization of camel milk, goat milk and cow milk (as reference)

2. Extraction of camel rennet.

3. Characterization of camel enzymatic extract.

Second part: Manufacture and optimization of cheese yield (effect of the nature of the rennet)

1. Liquid rennet (at different volumes)

- Liquid camel extract stored at -18°C

- Liquid microbial rennet stored at -18°C

2. Freeze-dried rennet (at different weights)

-Freeze-dried camel extract.

-Freeze-dried microbial rennet.

Third part: Study of the acidifying power of milk (blend of mesophilic and thermophilic acid lactic bacteria)

1- Study of the acidifying power on milk alone
2- Study of the acidifying power on the camel-goat milk mixture

Fourth part: Manufacture and characterization of fresh cheeses

1-Manufacture of fresh cheeses

- Camel fresh cheese of camel-goat milk mixture

-Microbial fresh cheese of camel-goat milk mixture

2-Characterization of fresh cheeses

-Raw and mineral composition

-Microstructure

-Sensory profile

The different sections are shown schematically in figure 05.

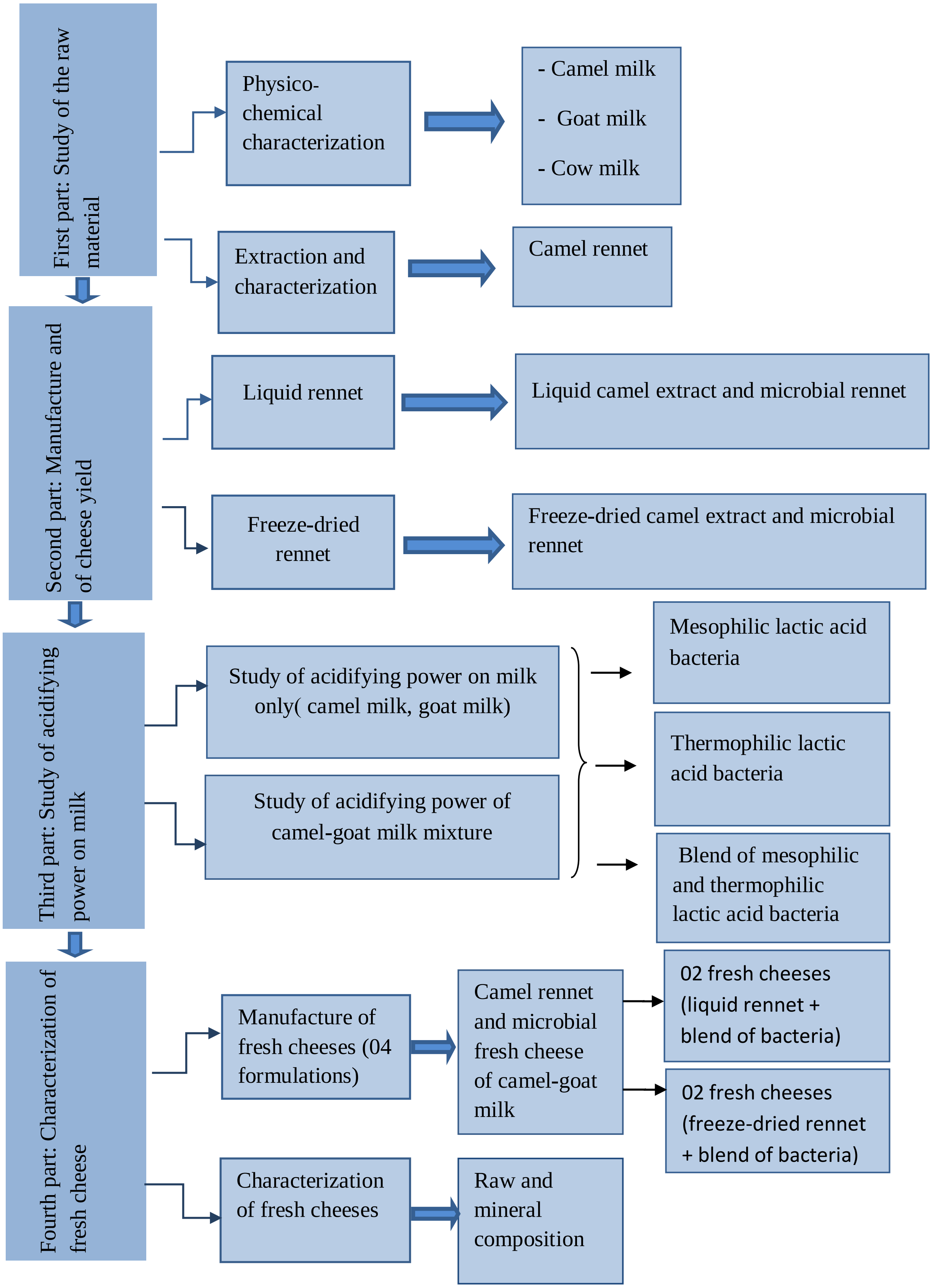


Figure 05: Experimental diagram of the study

I Material

I.1 Biological material

I.1.1 Camel milk

Camel milk was collected from the *Sahraoui* population in extensive breeding from different regions of El-Oeud (Al-Rabah, Hamraia, Hassi Messaoud) under suitable conditions.

I.1.2 Goat milk

Goat milk was collected from the *Arbia* race in extensive breeding from different regions of El-Oued (Al-Rabah, Souihla, Bayadha and Tiksebt) under suitable conditions.

I.1.3 Cow milk

Cow milk was collected from the extensive farms of breeders from different regions (Al-Bayadha and Al-Rabah) under appropriate hygienic conditions, and we used this milk as a reference.

I.1.4 BERRIDGE substrate

Skimmed milk (0% fat) powder (Supplied by Dairy Souf Milk), it is used as standard substrate in order to measure the flocculation time and the coagulating force according to the BERRIDGE substrate which is chosen for its good cheese-making capacity (Appendix N° 1). This substrate is composed of 12g of skimmed milk powder dissolved in 100ml of distilled water with 0.147g (0.01M) of $CaCl_2$ pH 6.4 with gentle stirring for 20 min. Next, the milk is kept for 24 hours at 4°C.

I.1.5 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.

I.1.6 Microbial rennet (commercial rennet)

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.

I.1.7 Lactic acid bacteria

- **Mesophilic bacteria**

  The ferment used for the manufacture of cheeses in an aromatic mesophilic ferment type LD, the culture produces aroma and CO_2 of *lactococcus lactis subsp. cremoris*, *leuconostoc* , *lactococcus lactis subsp,lactococcus lactis subsp. biavar diacetylactis*.

- **Thermophilic bacteria**

  The thermophilic ferment consists of two genera : *lactobacillus thermophilus and sterptoccocus bulgaricus.*

I.2 Machines

- Milkoscan

-pH meter

- Precision Balance

- Gereber centrifuge

- Stirrer

- Thermometer

- Water bath

- Muffle furnace

-Flame emission spectrometry

- Optical emission spectrometry

- Atomic absorption spectrometry

- Kjeldah machine

- Environmental scanning electron microscope

I.2.1 Small material

Beakers, volume tricflasks, vacuum flasks, graduated pipettes, precision burettes, pipettes pastor, filter cloth, test tube rack, magnetic bars, knife, wash bottle, test tubes sterile tests, sterile bottles, gloves, erlenmeyer flask, graduated cylinder, spatula, cooking pot.

I.2.2 Chemical products

Solvents: HCL, boric acid, lactic acid, distilled water.

Salts: NaCL, NaOH, $CaCl_2$.

II Methods

In the following part, we will explained the different methods of the parts announced in the experimental diagram of the study.

Part I: Study of the raw material

I.1 Physico-chemical characterization of milks

The physico-chemical characterization is carried out on camel milk, goat and cow milk

The measured physico-chemical parameters are: pH, titratable acidity, density, total dry matter or total dry extract and protein content. All measurements have been carried out in 3 tests. In order to determine the physic-chemical parameter of milk, we used a quick analysis by means of a Milcoscan device, the latter being an automatic milk analysis device by spectrometer infrared means, it displays the results on its digital screen (figure 06).

Figure06: Milcoscan machine

I.2 Extraction of coagulating enzymes

The extraction was carried out according to the protocol used by **Wangoh *et al.* (1993) (figure 07)**. After and defrosting cut the dry camel abomasum into slices of 1 cm^2, a maceration is done in a 6% NaCL solution (1:10, weight/volume) containing acid boric more than 2% for 4 consecutive days at 5°C. Then the mixture is filtered and centrifuged at 1500 rpm for 15 minutes. Reduce the pH of the supernatant from 5.5 to 4.7 with 1N HCL and the extract was kept at 25°C for 24 hours to activate the zymogen. Then the pH was then increased to 5.5 with 1N NaOH then centrifuge the mixture to obtain the extract final rennet (**appendix 01**).

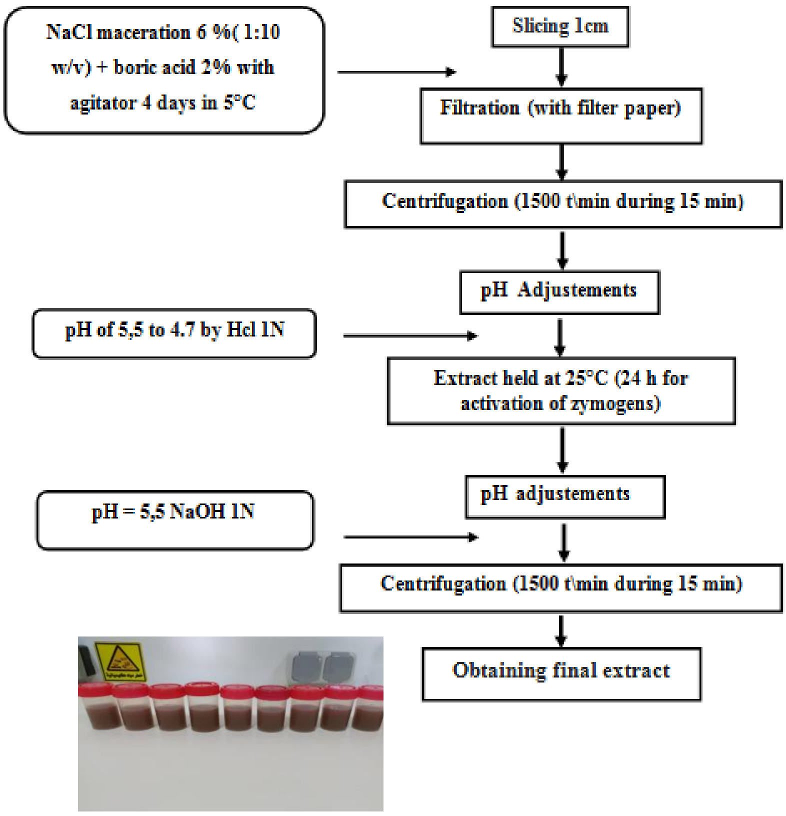


Figure 07: Camel rennet extraction protocol **(Wangho *et al.*, 1993)**

I.3 Characterization of camel rennet

I.3.1 Coagulant activity

Coagulant activity (CAU) or rennet unit RU is defined by the quantity of enzyme contained in 1ml of enzymatic solution which can coagulate10 ml of Berridge substrate **(Berridge, 1955)** in 200s at 30°C. The technique consists of adding to the milk, 1ml of the enzymatic extract followed by homogenization (3 turns), then noting when visible casein flakes are formed on walls of the test tube **(Mahaut *et al.*, 2003).**

$$\mathbf{C.A.U = 10 \times V / ct \times Q}$$

C.A.U: coagulating activity unit

V: volume of standard used (ml)

Q: volume of coagulating extract (ml)

tc: coagulation time (seconds)

I.3.2 Coagulation time

Clotting time is the point at which first droplets of whey appear on surface of gel, the coagulum becomes rigid and no longer flows on walls of tube. It is carried out direct on 10 ml of raw milk maintained at 35°C in a water bath, and then 1ml of enzymatic solution is added. In enzymatic clotting, the setting time is between 25 and 30min **(FAO 199; Alais, 1974).**

I.3.3 Coagulating strength

coagulant strength of an enzyme extract or a coagulating enzyme represents the volume of coagulated milk per unit of enzyme extract, in 40min, at 35°C and pH= 6.4 **(Nouani *et al.*, 2009).**

$$CS = (2400 \times V) / (t \times v)$$

CS: Coagulation strength

V: Volume of adjusted milk (ml)

v: Volume of the enzymatic solution (ml)

t: Fresh milk coagulation time in minutes (m)

I.4 Protein content

The Kjeldahl method is the reference method for dosage of total nitrogen for the food domain. It consists in performing a complete mineralization of molecules organic, transforming nitrogen present into ammonia which can be dosed by different techniques **(Guillou *et al.*, 1976).** The detail of the method is cited in appendix 02

Protein content = Total content × coefficient (6.25)

I.5 Specific activity

The specific activity is expressed by the ratio between the coagulant activity of the extract enzymatic and the protein level of this enzymatic extract and expressed in R.U/ mg **(Nouani *et al*., 2009).**

Part II Study of cheese yield

II.1 Pasteurization of milk

Fresh pasteurized milk is heated to 63°C for 30 minutes **(Al-zoreky and Almathen, 2021)**. The purpose of pasteurization is to eliminate all pathogenic germs present in milk **(Laurent, 2015).**

II.2 Manufacture diagram of fresh cheese with enzymatic coagulation

In this part, we have followed a diagram of the manufacture of fresh cheese with camel rennet by comparing with microbial rennet in optimal conditions (pH= 6.15 / T=38C) for camel rennet and (pH= 5.42/ T=38) for microbial rennet. These optimum points are taken from the study which is worked on the optimization of the pH and temperature of pasteurized camel-goat milk coagulated with camel and microbial rennets (**Cherifi *et al.;* 2022)** (figure 08)**.** The objective is to study the cheese yield according to the nature of the rennet (liquid and freeze-dried), and on the other hand, to set the preferred volume and weight to be prevelved for the manufacture of the cheese.

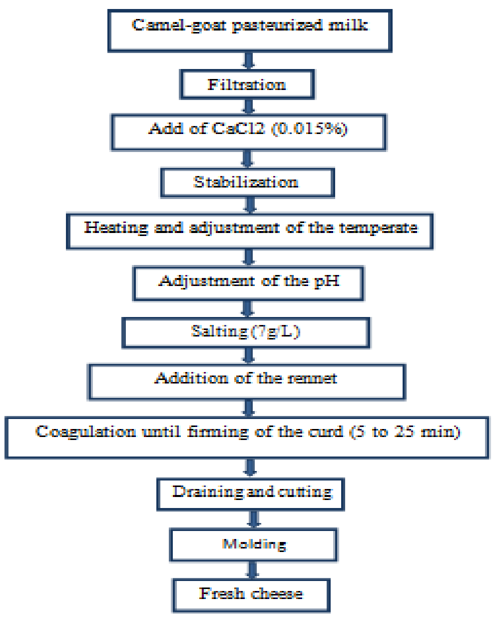


Figure 08: Fresh cheese manufacture diagram

II.3 Optimization of cheese yield according to the nature of the rennet

Cheese yield is calculated by the following rule:

Yield = weight of cheese (g) / volume of milk (ml) *100

II.3.1 Liquid nature of rennet

The value of the first volume (V1) of liquid camel and microbial rennets was 1mL subsequently, we added 0.5mL each time up to the value of the last volume **(V6)** (table n°04).Obtaining the best added volume for the coagulation of camel-goat milk (50% camel milk and 50% goat milk) was linked to two criteria:

- The coagulation time which does not exceed 30 min.,

- The texture of the curd.

Table n°04: Volumes used in the optimization of cheese yield

Used volume of liquid rennet(Camel and microbial) (m/L)	Values
V 1	1
V 2	1.5
V 3	2
V 4	2.5
V 5	3
V 6	3.5

II.3.2 Freeze-dried rennet

The value of the first weight (W1) of freeze-dried camel and microbial rennets was 0.08 g/L .Subsequently, we added 0.04 g/L each time up to the value of the last volume **(W6)** (table n°05). Obtaining the best added weight for the coagulation of camel-goat milk (50% camel milk and 50% goat milk) was linked to two criteria mentioned above.

Table n°05: Weighs used in the optimization of cheese yield

Used weights of freeze-dried rennet(camel and microbial) (g/L)	Values
W 1	0.08
W 2	0.12
W 3	0.16
W 4	0.2
W 5	0.24
W 6	0.28

Part III: Study of acidifying power on milk

In this part, we will study and know the acidifying power of mesophilic and thermophilic lactic bacteria on the coagulation on the one hand of camel milk and goat milk alone. In other hand, we will study the acidifying power of lactic bacteria on camel + goat milk mixture.

III.1 Preparation of mesophilic and thermophilic acid lactic bacteria

The isolation of mesophilic lactic bacteria was made from marketed Lben. Whereas , thermophilic lactic acid bacteria were isolated from marketed Yugurt.

It is important to point out that the two samples (Lben and yogurt) do not contain either flavoring or added sugars so as not to influence on the one hand the acidifying power and the other hand on the sensory profile or the fresh cheese by the following.

III.2 Study of acidifying power on milk alone and milk mixture

The experimental and details method wish summarize the steps used in the study of the acidifying power of lactic acid bacteria is schematized in the figure 09.

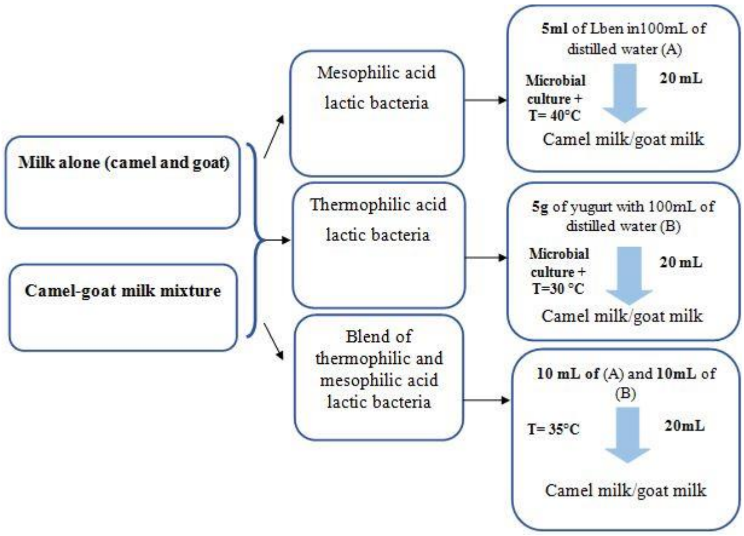


Figure 09: Diagram of acidifying power on milk

Part IV: Manufacture and characterization of fresh cheeses

IV.1 Manufacture of fresh cheeses

Concerning the manufacture of fresh cheese, first, we used the recommended volume and weight previously studied of camel rennet and microbial rennet. In addition and based on the study of the acidifying power of lactic acid bacteria, we were interested in the production of fresh cheese with mixed coagulation (rennet + lactic acid bacteria). Table n° 06 summarizes the different formulation manufactured.

Table n° 06: Different formulation of fresh cheeses

LCC	LMC	FDCC	FDMC
Fresh cheese with liquid camel rennet	Fresh cheese with liquid microbial rennet	Fresh cheese with Freeze-dried camel rennet	Fresh cheese with Freeze-dried microbial rennet

The diagram used for the manufacture of various formulations (04) announced above is schematized in figure 10.

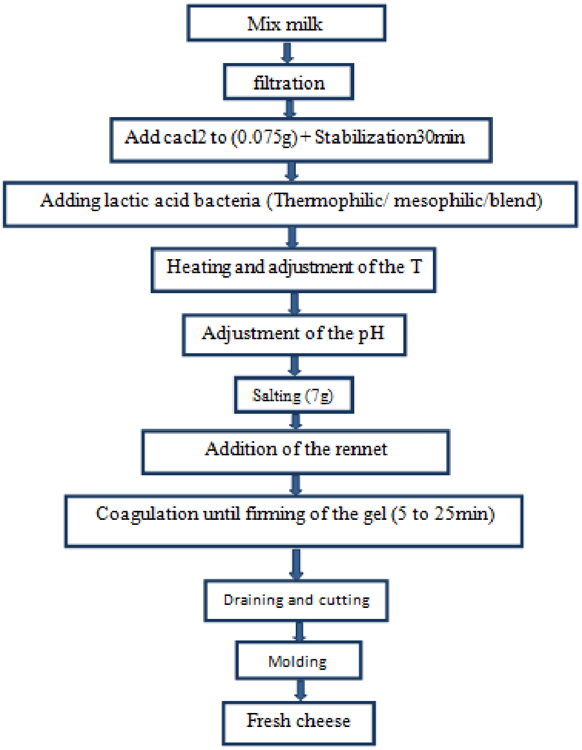


Figure 10: diagram of the manufacture of fresh cheese by mixed coagulation

IV.2 Characterization of fresh cheese

The characterization of the four (04) formulations of fresh cheeses is done on the raw and mineral composition, microstructural analysis and sensorial profile analysis.

IV.2.1 Raw and mineral composition

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 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, fat was measured by the Van Gulik method and ash was determined by total incineration

The mineral composition of goat and camel cheese can be measured using flame emission spectrometry, optical emission spectrometry and atomic absorption spectrometry. Those methods measures the concentration of different minerals in cheese such as calcium, magnesium, potassium, sodium, iron, zinc, and copper.

IV.2.2 Microstructural analysis

The purpose of this analysis was to visualize 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 alarge 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 an atmosphere saturated with glutar-aldehyde 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).**

IV.2.3 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 characterization relates to the appearance and texture; smell and taste with aroma. It was made with 25 '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. Appendix3 .

Statistical analysis of data

The statistical analysis of the physico-chemical and sensory results of the four fresh chesses formulations is carried out with the Minitab software (Minitab Inc, State College, PA).And with Anova test (student σ 95%).

Part III

Results and discussion

In this study, our objective is to valorize camel rennet on the one hand and on the other hand to manufacture and characterize different formulation of fresh cheeses based on camel-goat milk by comparing with microbial rennet.

First part: Study of the raw material

I.1 Physicochemical characteristics of milk

Table 07 presents the values of the different physicochemical parameters of camel milk, goat milk and cow milk.

Table n° 07: Physicochemical characteristics parameters of milks

Parameters	CM	GM	Cow milk
pH	6.20±0.10	6.33±0.11	6.90±0.02
Specific gravity at 20°C (g/cm^3)	1.027±0.001	1.037±0.004	1.037±0.004
Total solids (g/L)	100±0.8	173.8±0.7	117±0.10
Protein(g/L)	30.6±0.5	42.3±0.5	38.6±0.5
Lactose (g/L)	32.6±0.5	63.6±0.5	58.6±0.5
Fat (g/L)	35.3±0.5	58.3±0.5	10.6±0.5
Ash (g/L)	5±0.00	9.3±0.5	9 ±0.00

CM: Camel milk**.** **GM:** Goat milk

For CM, and according to the results show in the table, notice that the pH of CM 6.20±0.10 is lower that cow milk 6.90±0.02. In addition, the total solids which is 100±0.8g/L is also lower compared to cow milk. This decrease is caused by the protein and lactose content.

With regard to fat, the value of CM 35.3±0.5g/L is clearly higher than cow milk. Moreover total mineral content is low compared to cow milk.

In the literature, it is important to note that there is a difference between the different results reported by the authors. Regarding pH, **Shemsia. (2009)** reported a pH of 6.64; this value is higher than our result. For total solids, the value was reported by **Bouras *et al.* (2022)** is 106.18g/L; which is close to our results.

Regarding proteins, **Hadef *et al.* (2018**) gave a higher protein value which is 33.7g/L. These differences are due to the season, the stage of lactation and the number of calvings.

Regarding lactose, **Alaoui. (2019)** reported that a value of 43.7g/L. the latter is raised to our result; this can be explained by the animals nutrition, type of plants on which the animals live **(Alloui-Lombarkia *et al.*, 2007).**

Finally, the fat value according to **El-Hosseny *et al*. (2018)** is 37.5g/L; these values are equal to the results obtained.

Concerning GM, the pH value 6.33±0.11 was lower compared to cow milk 6.90±0.02. In addition, the total solids of GM was higher 173.8±0.7g/L compared to cow milk 117±0.10g/L and this is due to the greater amount of protein and mainly lactose. On the other hand, the fat content is much higher 58.3±0.5g/L than cow milk 10.6±0.5g/L.

The physiochemical properties of GM reported by **Wu *et al*. (2020)** provided a pH value of 6.7. It is considered close to the obtained value, and this simple difference is due to the season factor. As for the protein content, **Mudruk *et al.* (2022)** found a value of 31g/L which is lower than the value reported in our result. While the total solids 173.8±0.7g/L is higher than that reported by **Mayer *et al.* (2012)** which is 122.4g/L. This difference is due to several factors, including the breed, the feeding system, the stage of lactation and the climatic conditions in which the animals are reared **(Arrichiello *et al.*, 2022).**With regard to fat, the value was high, unlike what was reported by **Antonenko *et al*. (2019)** which is 43.2g/L. The differences may be due to the quality and quantity of feeds, stage of lactation, all influence the average percentage of goat milk fat **(Getaneh *el al.*, 2016).** Finally, with regard to lactose, its value was high, in contrast to what was reported by **Stocco *et al.* (2022),** which is 44.8g/L.

Table 08 presents the values of the different physicochemical parameters of camel-goat milk mixture.

Table n° 08: Physicochemical characteristics parameters of camel-goat milk mixture

Parameters	Camel-goat milk mixture (50%/50%)
pH	6.13±0.05
Specific gravity at 20°C (g/cm^3)	1.030±0.001
Total solids (g/L)	135.5±0.02
Protein (g/L)	40.0±0.00
Lactose (g/L)	48.00±0.00
Fat (g/L)	50.02±0.00
Ash (g/L)	7.00±0.00

According to the result mentioned above, it is important to point out that the addition of GM to CM has a positive effect on the modification of the physicochemical parameter, mainly total solids.

I.2 Characteristics of camel and microbial rennet

Table 09 presents the values of the different characteristics parameters of camel and microbial rennet.

Table n°09: Different characteristics parameters of camel and microbial rennets.

Parameters	Camel rennet (CR)	Microbial rennet (MR)
Coagulant activity (RU/mL)	5.32±0.69	15.86±1.37
Coagulating strength (SU)	1/52038.16	1/53262.31
Protein (mg/mL)	15.4±0.00	15±0.00
Specific activity (RU/mg)	0.34±0.04	1.05±0.09

According to (table 09), we have noticed that the coagulant activity of camel rennet is lower than microbial rennet with an equal protein content, which results in a different specific activity. Moreover, the coagulant strength of two type of rennet are close.

Enzymatic extract of camel rennet obtained as described by **Wangoh *et al*. (1993)** protocol has a liquid texture and a light brown color. It is characterized by a protein content of 15.4±0.00mg/mL. This value is higher than that found by **Boudjenah-Haroun. (2012)** which is (1.54 mg/mL). The camel rennet coagulant activity is 5.32±0.69 RU.mL. This result is higher than the values of **Siboukeur *et al.* (2005)** (0.155 RU.mL), **Mahboub. (2009)** (0.081±0.003 RU.mL), and **Boudjenah-Haroun. (2012)** (0.360±0.02 RU.mL). Specific activity and coagulant strength are respectively 0.345±0.04 RU.mg and 1/52038.16 SU. Coagulating activity of camel enzymatic extracts is influenced by animal age however, the animal diet has an influence on the enzymatic content of dromedary abomasum as mentioned by **Boudjenah- Haroun *et al.* (2013). Mahboub *et al.* (2012)** studied the influence of the storage temperature on the coagulant activity of camel enzymatic extracts and shows that freezing at -20°C and refrigeration at +4°C are recommended in cheese production.

Recently, **Bouras *et al*. (2022)** reported coagulant activity is 111.12 RU.mL, coagulant strength 1/4166.67 SU, protein content of 15.4±0.00 mg/mL and specific activity 7.21±0.03 RU.mg.

Table n°10: Performance of camel and microbial rennets at coagulation

Rennet	**Coagulation time (s)**		
	Camel milk	**Goat milk**	**Cow milk**
CR	79.66±27.79	32.66±6.42	46.66±12.42
MR	33.33±1.52	18.66±2.88	10.33±1.52

Regarding the coagulant time, it appears that camel rennet reacts better with GM (32.66±6.42s) compared to Cow milk and CM (46.66±12.42s, 79.66±27.79s respectively).Regarding microbial rennet, coagulation fastest with cow milk with a time of (10.33±1.52s).

Second part: Optimization of cheese yield (effect of the nature of the rennet)

II.1 Camel rennet

Table 11 presents the cheese yield according to the different volumes used in the case of the liquid camel extract and the different weights in the case of freeze-dried camel extract.

Table n°11: Yield of fresh cheeses coagulated with liquid and freeze-dried camel rennet

Camel rennet			
Liquid camel rennet (mL)	**Cheese yield (%)**	**Freeze-dried camel extract (g)**	**Cheese yield (%)**
1	18.9±0.10	0.08	16.58±0.2
1.5	17.67±0.11	0.12	15.88±0.12
2	25.88±0.08	0.16	19.28±0.15
2.5	12.91±0.14	0.20	16.50±0.09
3	15.14±0.10	0.24	19.01±0.13
3.5	9.33±0.13	0.28	16.87±0.11

At the level of liquid camel rennet, we noticed that cheese yield varies with the volumes used in the coagulation of camel-goat milk mixture. The best yield (25.88±0.08%) is observed with a volume of 2mL. In addition, it is important to note that increasing the volume of the camel extract did not give us maximum yield.

With regard to the freeze-dried camel rennet, we again noticed a variation in the cheese yield. The best yield (19.28±0.15%) is recorded with 0.16g of rennet. Whereas, we can deduce that increasing the weight used in the mixed milk also did not give maximum yield.

Finally and according to our tests, we can deduce the following:

- Obtaining the best yield does not lead to obtaining a good cheese texture;
- The variation in the volume (liquid) or the weight (freeze-dried) of the camel rennet led to the variation in the texture of the cheese (figur11).

In conclusion and according to the criteria used in our study (coagulation time and coagulum texture), we propose the following values for the production of fresh cheese from camel-goat milk mixture:

1. Liquid camel extract**: 2mL**
2. Freeze-dried camel extract**: 0.2g**

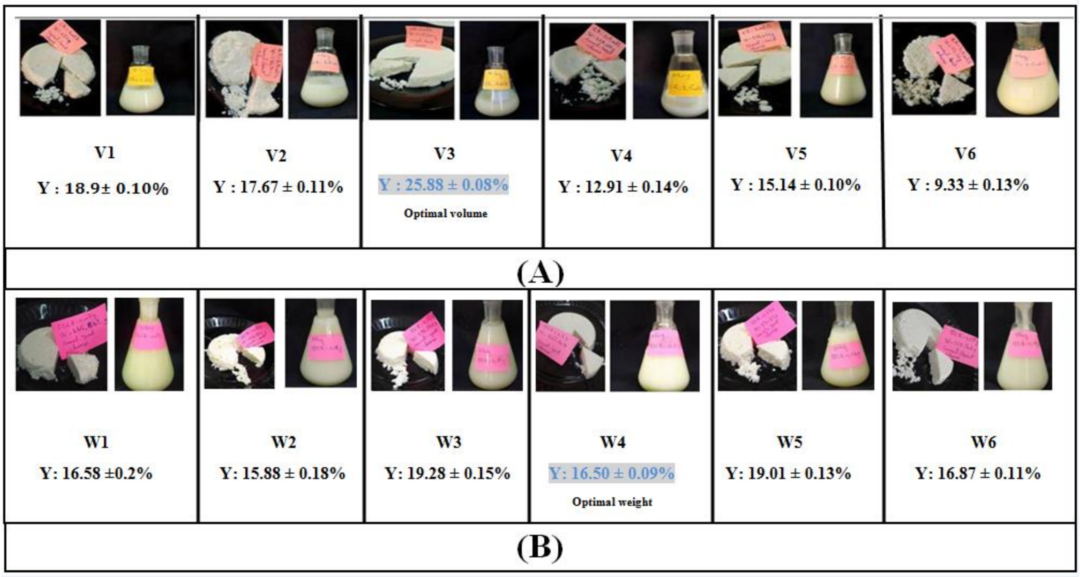


Figure11: Fresh cheese coagulated with liquid camel rennet (A) and freeze-dried camel rennet (B)

II.2 Microbial rennet

Table 12 presents the cheese yield according to the different volumes used in the case of the liquid microbial rennet and the different weights in the case of freeze-dried microbial rennet.

Table n°12: Yield of fresh cheeses coagulated with liquid and freeze-dried microbial rennet

Microbial rennet			
Liquid microbial rennet (mL)	**Cheese yield (%)**	**Freeze-dried microbial rennet(g)**	**Cheese yield (%)**
1	7.81±0.12	0.08	9.79±0.14
1.5	9.54±0.15	0.12	14.04±0.12
2	12.16±0.10	0.16	14.44±0.12
2.5	14.48±0.12	0.20	14.92±0.07
3	13.28±0.14	0.24	12.95±0.2
3.5	15.34±0.11	0.28	10.00±0.15

At the level of microbial rennet, we noticed that cheese yield varies with the volumes used in the coagulation of camel-goat milk mixture. The best yield (15.34±0.11%) is observed with a volume of 3.5mL. In addition, it is important to note that increasing the volume of the microbial rennet give us maximum yield.

With regard to the freeze-dried microbial rennet, we again noticed a variation in the cheese yield. The best yield (14.92±0.07%) is recorded with 0.2g of rennet. Whereas, we can deduce that increasing the weight used in the mixed milk did not give maximum yield .

Finally and according to our tests, we can deduce the following:

- Obtaining the best yield does not lead to obtaining a good cheese texture.
- The variation in the volume (liquid) or the weight (freeze-dried) of the microbial rennet led to the variation in the texture of the cheese (figure12).

In conclusion and according to the criteria used in our study (coagulation time and coagulum texture), we propose the following values for the production of fresh cheese from camel-goat milk mixture:

1 . Liquid microbial rennet**: 2mL**

2. freeze-dried microbial rennet**: 0.2g**

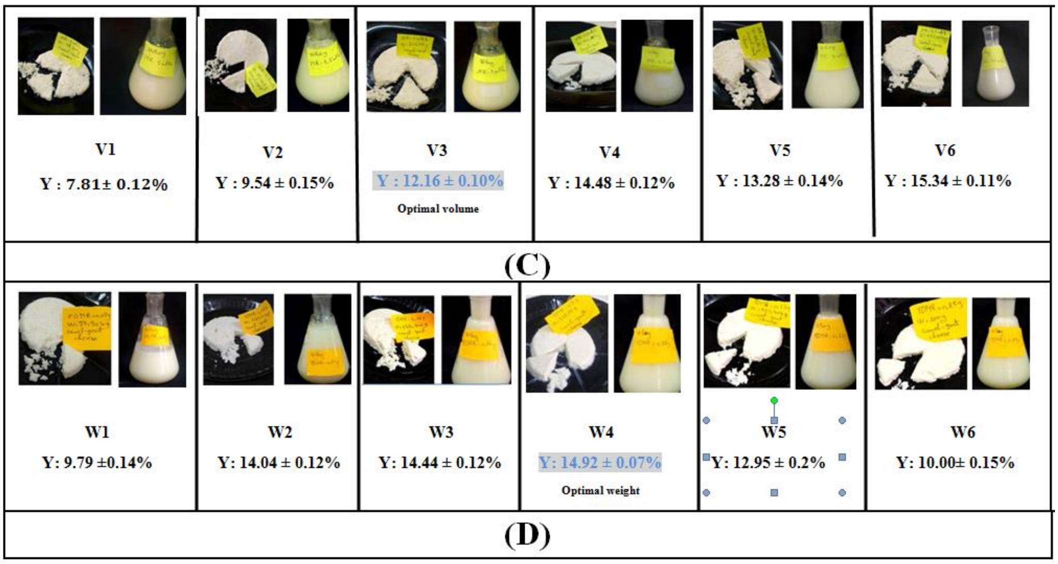


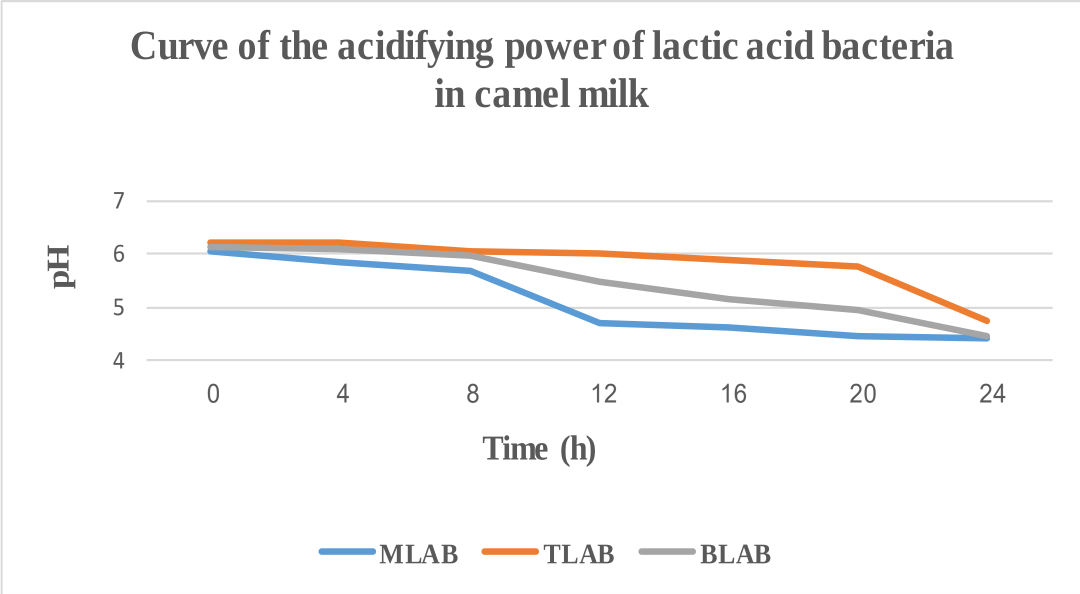
Figure12: Fresh cheese coagulated with liquid microbial rennet (C) and freeze-dried microbial rennet (D)

According to our results, we can say that camel rennet in liquid or freeze-dried state is a competitor to microbial rennet in the valorization of fresh cheese based on camel-goat milk mixture.

Third part: Study of the acidifying power of milk (blended of mesophilic and thermophilic acid lactic bacteria)

III. 1 Acidifying power of lactic acid bacteria in camel milk

Figure 13 presents curve of the acidifying power of lactic acid bacteria (mesophilic and thermophilic, blend of mesophilic and thermophilic) in camel milk



MLAB: Mesophilic lactic acid bacteria**; TLAB:** Thermophilic lactic acid bacteria
BLAB: Blend lactic acid bacteria

Figure 13: Curve of the acidifying power of lactic acid bacteria in camel milk.

The curves represent the changes of pH value of pasteurized camel milk in terms of time.

After adding mesophilic acid lactic bacteria, we observed: slight change in pH value after 4h then decrease to 4.7 after 12 h.

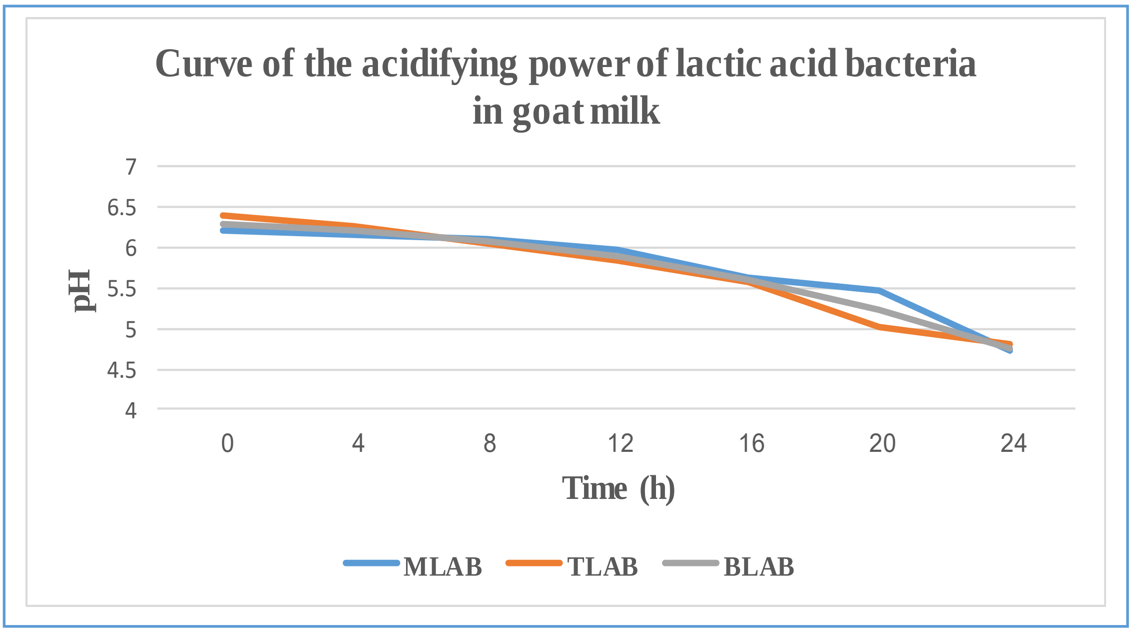
After adding thermophilic bacteria, we observed: the pH value changes after 8p.m., falling to 4.73.

At the end of the acidification, the mesophilic bacteria and the mixture of bacteria have reduced the final pH which is lower than that recorded for the thermophilic bacteria.

In the literature, **Benkerroum *et al.* (2011)** used lactic acid bacteria to prepare soft cheese from pasteurized camel milk. In his experience, the acidification of pasteurized camel milk was faster because the pH dropped to less than 5 after 4 h at room temperature and in the presence of lactic ferment (streptococcus thermophilus and Lactobacillus bulgaricus). In comparison with the results obtained, we noticed that the aptitude for acidification of pasteurized camel milk is slow. According to **Lorenzen *et al.* (2011)** glutamate transferase and phosphatase present in pasteurized camel milk may also be lactoperoxidases. Which confirms that pasteurized camel milk takes a longer fermentation period, which is due to thermoprotective proteins **(konuspayeva *et al*., 2019).**

III .2 Acidifying power of lactic acid bacteria in goat milk

Figure 14 presents curve of the acidifying power of lactic acid bacteria (mesophilic,thermophilic ,blend of mesophilic and thermophilic bacteria) in goat milk



MLAB: Mesophilic lactic acid bacteria**; TLAB:** Thermophilic lactic acid bacteria
BLAB: Blend lactic acid bacteria

Figure 14: Curve of the acidifying power of lactic acid bacteria in goat milk.

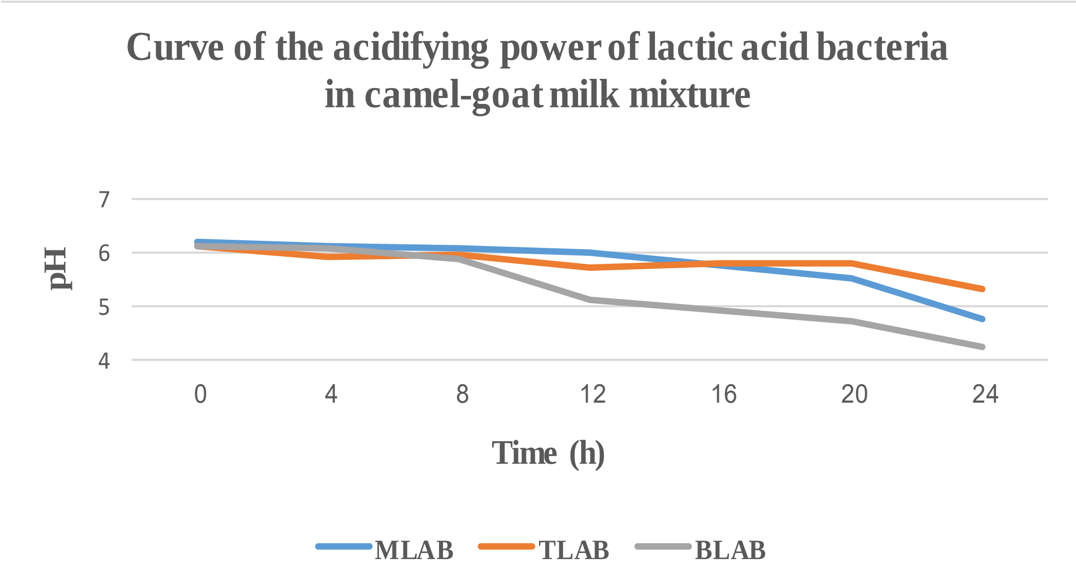
The curves represent the changes of pH value of pasteurized goat milk in terms of time.

The initial pH before the addition of lactic ferment is between (6.2 and 6.4). We noticed a gradual decrease in mesophilic, thermophilic bacteria and the blend of lactic acid bacteria. The ability of acidification achieved in the same way for thermophilic and mesophilic bacteria and blend. It is important to point out that the average final pH is 4.7 for all the lactic ferments.

Menezes *et al.* (2022) reported that the pH value in their experiments is 4.72 in pasteurized goat milk in the presence of a lactic ferment for 6h at a temperature of 43°C. So this value is close to the value we obtained during the same period, since it reached 6.01 and continued to decrease until it reached 4.76 after 24h at room temperature. These values obtained in pasteurized goat milk are different from the pH value in raw goat milk using a lactic ferment. **Litopoulou *et al.* (1992)** found that by adding lactic acid bacteria the pH value decreased to 4.5. From these results, we can say that milk pasteurization does not negatively affect the acidification capacity of goat milk.

III .3 Acidifying power of lactic acid bacteria in camel-goat milk mixture.

Figure 15 presents curve of the acidifying power of lactic acid bacteria (mesophilic, thermophilic, blend of mesophilic and thermophilic) in camel-goat milk mixture.



MLAB: Mesophilic lactic acid bacteria**; TLAB:** Thermophilic lactic acid bacteria
BLAB: Blend lactic acid bacteria

Figure 15: Curve of the acidifying power of lactic acid bacteria in camel-goat milk mixture.

The curves represent the variations of pH value of pasteurized camel-goat milk mixture in terms of time. We noticed the acidification of the mixed milk only started after 8h.

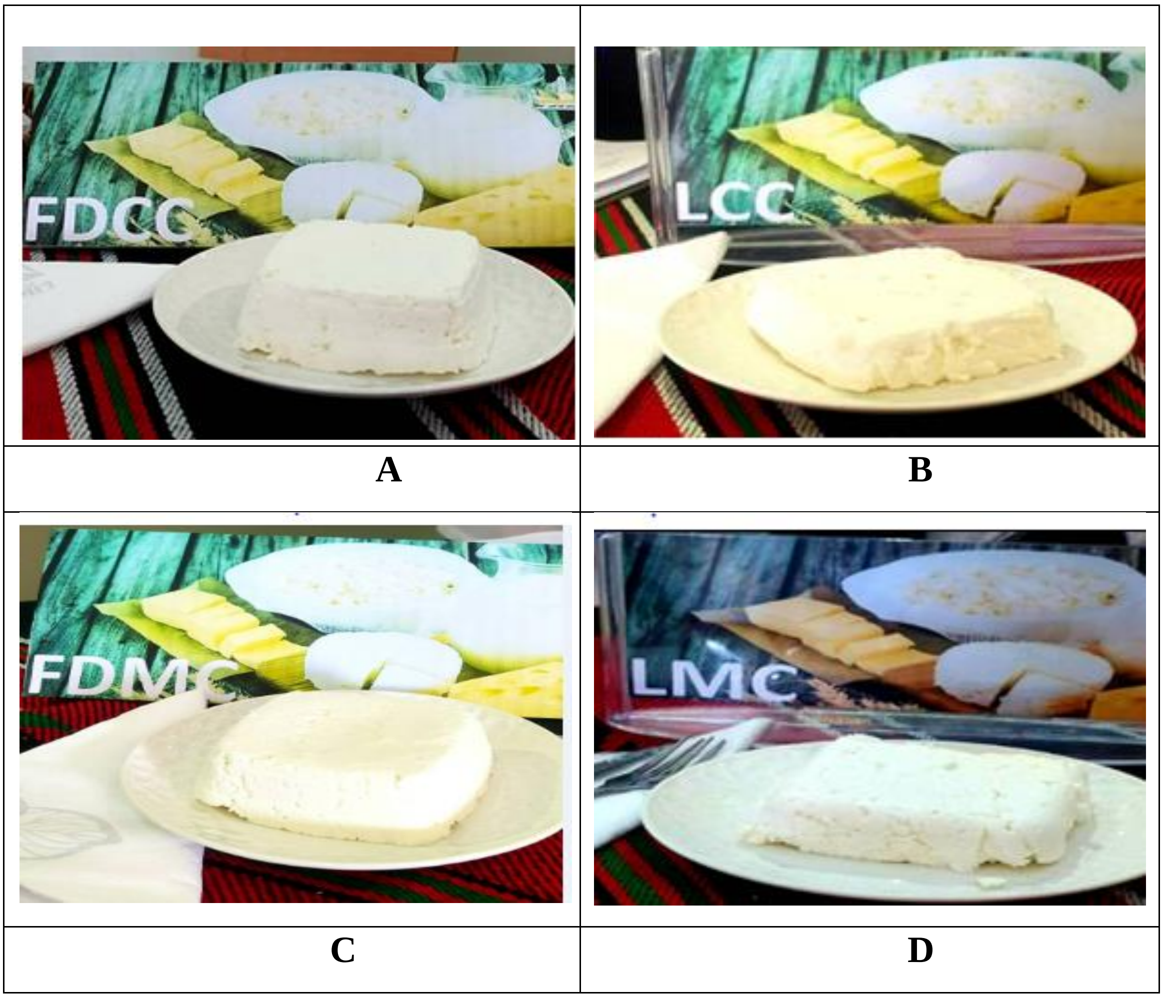
There is an important signal that blend (mesophilic and thermophilic) has an impact on the speed of the fermentation of milk.

In addition, we have recorded that the final pH values are between 4.26 and 4.76.

In conclusion, we can say that for mesophilic ferments, camel milk does not have a repressive effect on the fermentation from which we obtained the same final pH values between the camel-goat milk mixture and the goat milk alone. As far as thermophilic ferments are concerned, the mixture between camel milk and goat milk modified the kinetics of the fermentation in comparison with the milks alone. As a result, it is important to point out that the fermentation of the camel-goat milk mixture in the presence of the blend of bacterial ferments gave us the lowest pH; which encouraged us to choose this mixture in the manufacture of fresh cheeses.

Fourth part: Characterization of fresh cheeses

The photos that represent the four (04) formulations of fresh cheese are illustrated in (figure 16)



A: FDCC (Freeze-dried camel rennet cheese), **B:** LCC (Liquid camel rennet cheese), **C:** FDMC (Freeze-dried microbial rennet cheese), **D:** LMC (Liquid microbial rennet cheese)

Figure 16: Four (04) formulations of fresh cheese

IV.1 Characterization of fresh cheeses

Table 13 presents the values of the different physicochemical parameters of fresh cheese made from camel-goat milk mixture, using liquid and freeze-dried camel rennet.

Table n°13: Different physicochemical parameters of fresh cheese made from camel-goat milk mixture .Using liquid and freeze-dried camel rennet.

Parameters	FDCC	LCC	*P* value
pH	4.3±0.00	4.2±0.01	**
Total solids (%)	36.22±1.8	25.66±0.5	**
Protein (%)	17.2±2.1	10.3±1.4	*
Pr/TS (%)	47.48±1.5	40.14±2.0	*
Fat (%)	13.38±0.9	9.92±1.0	*
Fat/TS (%)	35.98±0.5	38.65±1.9	*
TEFD (%)	77.19±0.9	82.52±0.1	**
Ash (%)	0.98±0.03	1.14±0.07	NS
Yield (%)	21.40±0.09	24.50±0.1	**

LCC: Liquid camel rennet cheese, **FDCC:** Freeze-dried camel rennet cheese.

Presented values are the means of three replicate trials.NS: Non-Significant, (**): P <0.01,

(*): P (0.01-0.05) (Student‘s t-test).

According to the statistical analysis, we noticed that most of the physicochemical parameters between FDCC and LCC cheeses present a significant difference (P<0.05).

Table 13 shows the physicochemical properties of fresh cheese made from a mixture of camel and goat milk using liquid and freeze-dried camel rennet. Regarding the pH, we noted an average pH value of 4. This value is in agreement with that found during the study of the acidifying power of the mixture of lactic ferments. On the other hand, the total solids value of FDCC is 36.22±1.8%; while in LCC cheese is 25.66±0.5%. We can deduce that freeze-dried rennet gave us better coagulation.

Moreover, the Pr/TS ratio is higher in FDCC cheese than LCC (47.48±1.5% and 40.14±2.0% respectively). On the other hand the Fat/ST ratio, we recorded a higher value in LCC cheese compared to FDCC cheese (38.65±1.9% and 35.98±0.5%, respectively).On the other hand. Based on the two criteria recommended by **Codex alimentarius (1978)** which are the TEFD and the fat content, our cheeses are classified as partly skimmed soft cheese (FDCC) and skimmed lean soft cheese (LCC).At the end. We recorded higher yield in LCC cheese than in FDCC cheese (24.50±0.1% and 21.40±0.1% respectively).

According to **EL-Gendy. (2018)** cheese prepared from camel milk had 35.74% total solids when prepared by the traditional method using thermophilic lactic ferment and rennet chymosin. In our results, the total solids of FDCC is 36.22±1.8%, this value is higher than LCC 25.66±05%. In fact, we have noticed that the freeze-drying of camel rennet chymosin has a positif effect on the total solids value of the cheese.

In addition, Pr/TS ratio is 47.48±1.5% for FDCC and 40.14±2.0% for LCC. We can say that the coagulation by the freeze-dried camel rennet gave a higher value for the proteins. **Charles *et al.* (2010)**, found that the protein value is 16.2±0.1%, when used rennet coagulant and pasteurized cow milk. As for **Khan *et al*. (2004)** found that protein content is 17.67±1.528% in pasteurized camel milk cheese when using citric acid and rennet.

Bouras *et al.* (2023) prepared a cheese from the mixture of camel and goat milk using liquid from the camel rennet, the results of the analysis of the cheese showed that a fat content is 9.7±0.4%. While **Sant'Ana *et al.* (2013)**, found that the fat value is 16.44±0.73% in cheese made from pasteurized goat milk, and 17.78±1.48% in cheese made from a mixture of pasteurized milk (goat and cow), when it is added mesophilic cultures and commercial rennet. This means that the amount of fat in cheese varies depending on the type of milk used in making.

On the one hand the ash is 0.98±0.03% in the FDCC and 1.14±0.07% for LCC. **Al-Zoreky *et al.* (2021)**, recorded ash value that is 0.73±0.05% in cheese prepared by pasteurized camel milk with commercial and freeze-dried starter culture.

Through these results, we conclude that the use of freeze-drying gives a yield close to what we obtained in the case of liquid enzyme. Freeze-dried rennet is the best option because of its characteristics, which are represented in the long retention period and also the preservation of all enzyme quality characteristics.

Table 14 presents the values of the different physicochemical parameters of fresh cheese made from camel-goat milk mixture .Using liquid and freeze-dried microbial rennet.

Table n°14: Different physicochemical parameters of fresh cheese made from camel-goat milk mixture.Using liquid and freeze-dried microbial rennet.

Parameters	FDMC	LMC	*P* value
pH	4.4±0.00	4.4±0.00	**
Total solids (%)	43.55±1.2	31.6±0.5	**
Protein (%)	17.93±1.7	13.85±0.9	*
Pr/TS (%)	41.17±1.1	43.82±1.3	NS
Fat (%)	21.71±0.2	9.63±1.4	**
Fat/TS (%)	49.85±0.16	30.47 ±2.7	**
TEFD (%)	72.1±0.4	75.68±0.2	**
Ash (%)	0.99±0.06	1.24±0.02	*
Yield (%)	15.96±0.1	13.55±0.01	**

LMC: Liquid microbial rennet cheese, **FDMC**: Freeze-dried microbial rennet cheese.

Presented values are the means of three replicate trials.NS: Non-Significant, (**): P <0.01,

(*): P (0.01-0.05) (Student‘s t-test).

According to the statistical analysis, we noticed that most of the physicochemical parameters between FDMC and LMC cheeses present a significant difference (P<0.05).

Table 14 shows the physicochemical properties of fresh cheese made from a mixture of camel and goat milk using liquid and freeze-dried camel rennet. Regarding the pH, we noted an average pH value of 4.4±0.0.This value is in agreement with that found during the study of the acidifying power of the mixture of lactic ferments. On the other hand, the total solids value of FDMC cheese is 43.55±1.2%; while in LMC cheese is 31.6±0.5%. Moreover, the Pr/TS ratio is higher in LMC cheese than FDMC (43.82±1.3% and 41.17±1.1% respectively). On the other hand the Fat/TS ratio, we recorded a higher value in FDMC cheese compared to LCM cheese (43.55±1.2% and

31.6±0.5%, respectively). On the other hand based on the two criteria recommended by **Codex alimentariuse (1978)** which are the TEFD and the fat content, our cheeses are classified as soft and partially skimmed cheese (FDMC) and soft and lean or skimmed cheese (LMC).At the end. We recorded higher yield in FDMC cheese than in LMC cheese (15.96±0.1% and 13.55±0.01% respectively).

The physicochemical analysis carried out by **Bouras *et al.* (2023b)** reported that fresh cheese made from a mixture of camel and goat milk by liquid microbial rennet without the use of lactic ferment contains the value of total solids, fat and protein (45.2±0.09%, 18.7%1.25 and 23±0.7% respectively). In connection with our results, we conclude the effect of freeze-drying on the total solid of cheese made from camel-goat milk mixture with liquid rennet and a blend of lactic bacteria. **Saima *et al.*, (2003)** found that cheese made from camel milk only with using of microbial rennet contains 97.04% of total solids without fat and 78.38% of total protein. According **Abou-Soliman *et al.* (2020)**, they reported that the highest protein content of fresh cheese made from camel milk and coagulated with transglutaminase (80 units).

IV.1.1 Sensory profile

Table 15 presents the results of sensory analysis of fresh cheese LCC (liquid camel rennet cheese) and FDCC (freeze-dried camel rennet cheese).

Table n°15: Results of sensory analysis of fresh cheese LCC (liquid camel rennet cheese) and FDCC (freeze-dried camel rennet cheese)

Parameters	FDCC	LCC	*P* value
Cheeses appearance and texture			
Smooth	12.36±1.86	11.79±2.10	NS
Rough	4.16±2.75	2.14±0.2	NS
Sandy	3.96±0.7	1.8±0.5	NS
Spreadable	4.88±3.74	6.88±4.67	NS
Creamy	11.76±1.71	10.16±3.76	NS
Pasty	1.68±1.54	1.48±4.9	*
Smell			
Lactic smell	8.08±4.96	9.74±3.58	NS
Animal smell	2.94±0.9	3.54±1.06	NS
Grass	0.76±2.06	0.64±1.75	NS
Taste and aroma of cheese			
Salt	4.66±2.36	6.92±3.46	NS
Soft	10.08±3.60	11.24±2.65	NS
Bitter	0.44±0.09	3.64±1.22	*
Taste of butter	4.1±1.3	4.24±1.22	NS
Cheese preference	40%	32%	

Presented values are the means of three replicate trials. NS: Non-Significant, (*): P (0.01-0.05) (Student's t-test).

According to the statistical analysis, we noticed that most of the sensory parameters between FDCC and LCC cheeses do not show a significant difference (P>0.05).

The results of sensory analysis of fresh cheese LCC (liquid camel rennet cheese) and FDCC (freeze-dried camel rennet cheese),shown in (table15). All the sensory characteristics of the cheeses were evaluated from 0 to 15 scales.

For texture, FDCC cheese is very smooth and creamy with a score of (12.36±1.86/15 and 11.76±1.71/15 respectively).

On the other hand, it seems to have a weakly rough texture with 4.16±2.75 and also weakly spreadable with 4.88±3.74, compared with LCC.

While LCC cheese is texture very smooth 11.79±2.10 and very creamy 10.16±3.76. In addition, it is characterized by a medium spreadable 6.88±4.67 and medium pasty texture 8.48±4.9, we can say that camel rennet (liquid and freeze-dried) has a high quality effect on the texture of cheese.

For smell, the two types of cheese have an average lactic smell of 8.08±4.96/15 for FDCC cheese and 9.74±3.58/15 for LCC cheese.

In terms of taste and aroma, LCC and FDCC cheeses are characterized by a moderately acid taste. In addition, LCC cheese is moderately salty with 6.92±3.46/15, while FDCC cheese is lightly salty with a score of 4.66±2.36/15.

In the literature, **Mbye *et al.* (2022)** reported that camel milk cheeses are smoother and less grainy than cow milk cheeses, and this effect is mainly due to the very low percentage of beta-casein in the CM (3.5% of the total casein). In addition **Al-zoreky *et al.* (2021)** reported that CM cheese has creaminess compared to other milks, and this is due to the low fat content in camel milk. In our study and for the two cheese formulations, we still recorded a texture very smooth and pasty and weakly sandy texture.

On the other hand, with regard to the manufacture of fresh cheese made from camel milk and goat milk mixed, **Bouras *et al.*(2023)** indicated that the use of chicken pepsin in the manufacture of cheese with a mixture of camel milk and goat milk gives a moderately spreadable and pasty texture (9.55±2.11, 7.05±1.15 respectively).

In addition, **Bouras *et al.* (2023)** reported that making fresh cheese from a mixture of camel milk and goat milk with the use of liquid camel rennet give a slightly smooth, rough and pasty texture with score 4.25±1.64, 4.6±0.72 and 2.85±0.99 respectively. Related to our study, we noticed that adding a mixture of acid lactic bacteria modified the sensory attributes.

From the sensory profile, we can deduce that the use of freeze-dried camel rennet has no significant influence on the sensory attributes of fresh cheese made from camel-goat milk mixture.

Table 16 presents the results of sensory analysis of fresh cheese LMC (liquid microbial rennet cheese) and FDMC (Freeze-dried microbial rennet cheese)

Table n°16: Results of sensory analysis of fresh cheese LMC (liquid microbial rennet cheese) and FDMC (freeze-dried microbial rennet cheese)

Parameters	FDMC	LMC	*P* value
Cheeses appearance and texture			
Smooth	3.32±2.00	5.76±3.72	NS
Rough	11.56±2.85	6.1±3.07	NS
Sandy	9.76±4.12	5.5±2.19	NS
Spreadable	1.4±0.2	3.04±1.05	NS
Creamy	0.6±0.05	3.4±0.2	**
Pasty	1.8±0.09	3.96±0.08	**
Smell			
Lactic smell	9.32±2.73	9.82±4.22	NS
Animal smell	5.24±1.11	6.48±2.40	NS
Grass	0.56±0.05	1.6±0.03	**
Taste and arome of cheese			
Acid	8.36±4.71	7.16±4.98	NS
Salt	7.88±2.92	6.84±1.14	NS
Soft	6.08±4.08	6.02±3.73	NS
Bitter	0.84±0.05	4.54±1.80	NS
Taste of butter	2.32±0.06	4.74±1.00	NS
Cheese preference	12%	16%	

Presented values are the means of three replicate trials. NS: Non-Significant, (**): P <0.01 (Student‘s t-test).

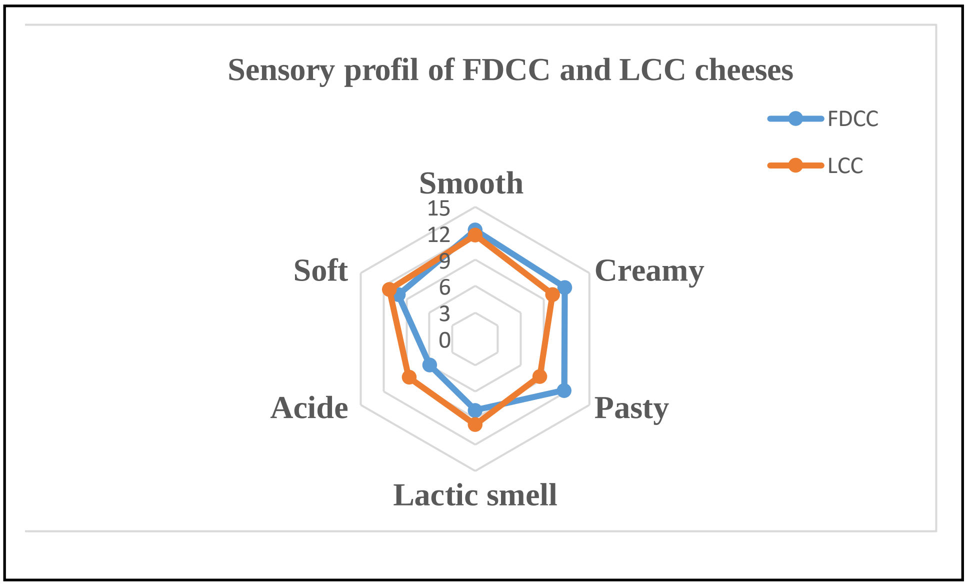
According to the statistical analysis, we noticed that most of the sensory parameters between FDMC and LMC cheeses do not show a significant difference ($P>0.05$).

The results of sensory analysis of fresh cheese LCC (liquid microbial rennet cheese) and FDMC (freeze-dried microbial rennet cheese) are present in (table 16). All the sensory characteristics of the cheese were evaluated from 0 to 15 scales. In terms of texture, FDMC is very rough with a score of 11.56±2.85/15. We can say that the freeze-drying of the microbial rennet has an effect on the roughness of fresh cheese made from camel-goat milk mixed. While, the average sandy test score 9.76±4.12/15, and also the same score recorded with LMC forming 5.5±2.19/15. For smell, the two types of cheese have an average lactic smell of with a score of 9.32±2.73/15 for FDMC and 9.82±4.22/15 for LMC. In terms of taste and aroma, FDMC and LMC cheese are characterized by a moderately acid taste with a score of (8.36±4.71/15, 7.16±4.98/15 respectively), also by a moderately salty taste of 7.88±2.92/15 for FDMC and 6.84±1.14/15 for the LMC.

According to **Bouras *et al.* (2023),** LCC is weakly soft, spreadable and creamy with a score of 1.6±0.34, 3.35±0.79 and 1±0.58, respectively. On the other hand, its texture was a little coarse with 8.3±2.72 and pasty with 6.35±1.76. In our study, milk made from freeze-dried microbial rennet (FDMC) had a very rough texture with 11.56±2.85/15 and moderately sandy with 9.76±4.12/15. We have noticed that freeze-drying leads to an increase in the rough texture of the cheese. Regarding salinity, **Bouras *et al.* (2023)** reported that salinity was determined in fresh cheese made from a camel-goat milk mixture using liquid microbial rennet. By relating it to our results, we can say that freeze-drying did not significantly affect the salinity of fresh cheese.

From the sensory profile, we can deduce that the use of freeze-dried microbial rennet has no significant influence on the sensory attributes of fresh cheese made from camel-goat milk mixture.

In conclusion, we can present sensory profile of FDCC and LCC in (figure17), FDMC and LMC (figure 18)



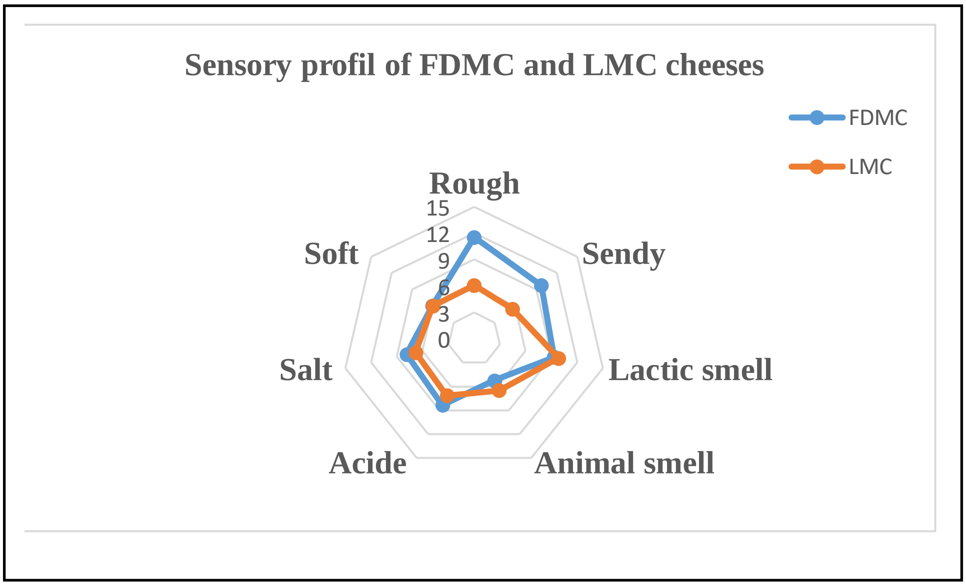
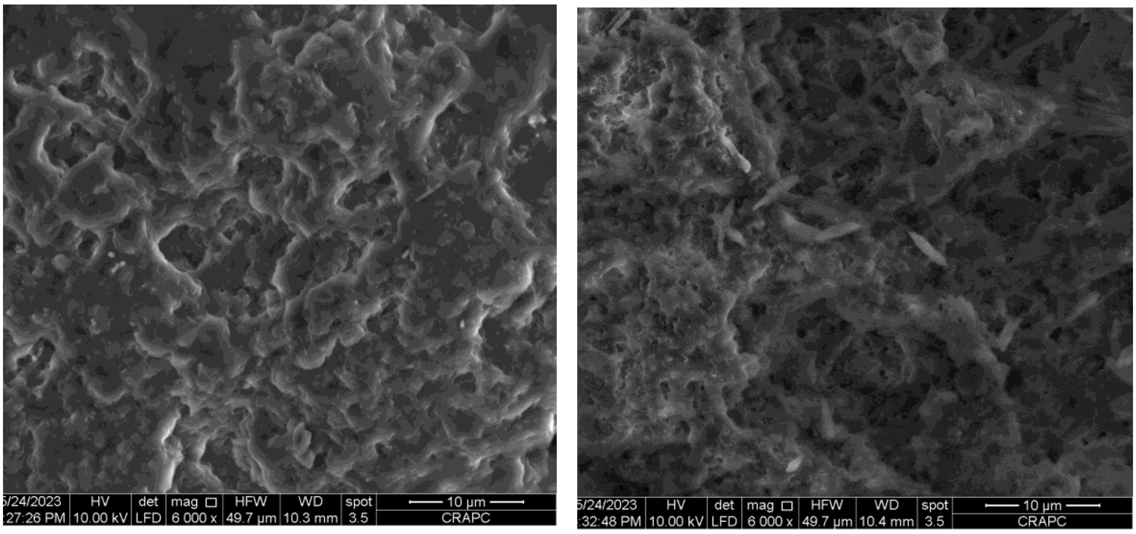


Figure18: Sensory profile of FDMC and LMC

On the scale of cheese preference, FDCC 40% and LCC 32% cheeses are more accepted by tasters than FDMC and LMC cheeses with a score of 16% and 12% respectively.

IV.1.2 Microstructure of fresh cheeses

Figure 19 presents the microstructure of cheese made with liquid camel rennet (LCC) and freeze-dried (FDCC).



LCC cheese

FDCC cheese

Figure19: Microstructure of cheeses LCC and FDCC

Image 19 shows the microstructure of cheese made with liquid camel rennet (LCC) and freeze-dried (FDCC). We noticed that the type of coagulation (mixture) influences the appearance of the protein network of casein. Both types had a continuous network of proteins. Moreover, we can say that the micrographs of FDCC and LCC cheeses gave us an idea about the texture of fresh cheese (rough and creamy). Compared with the sensory profile, the presence of a more cohesive casein network and fewer pores led to a creamier and less rough texture.

The microstructural analyzes of **Bouras *et al.* (2023)** showed that using only liquid camel rennet to make cheese from camel and goat milk results in a cheese with many small pores. It has a thick protein network. In our study, mixed coagulation has an effect on the microstructure of cheese. **Boudjnah-Haroun (2012)** showed that the microstructure of camel milk cheese produced from camel rennet has a compact and uniform structure. Projectively with the results of our study, the sensory analyzes of the two formulations (FDCC and LCC) are tuned to the microstructure analyzes (roughness and creaminess).

Figure 20 presents the microstructure of cheese made with liquid camel rennet (LMC) and freeze-dried (FDMC).

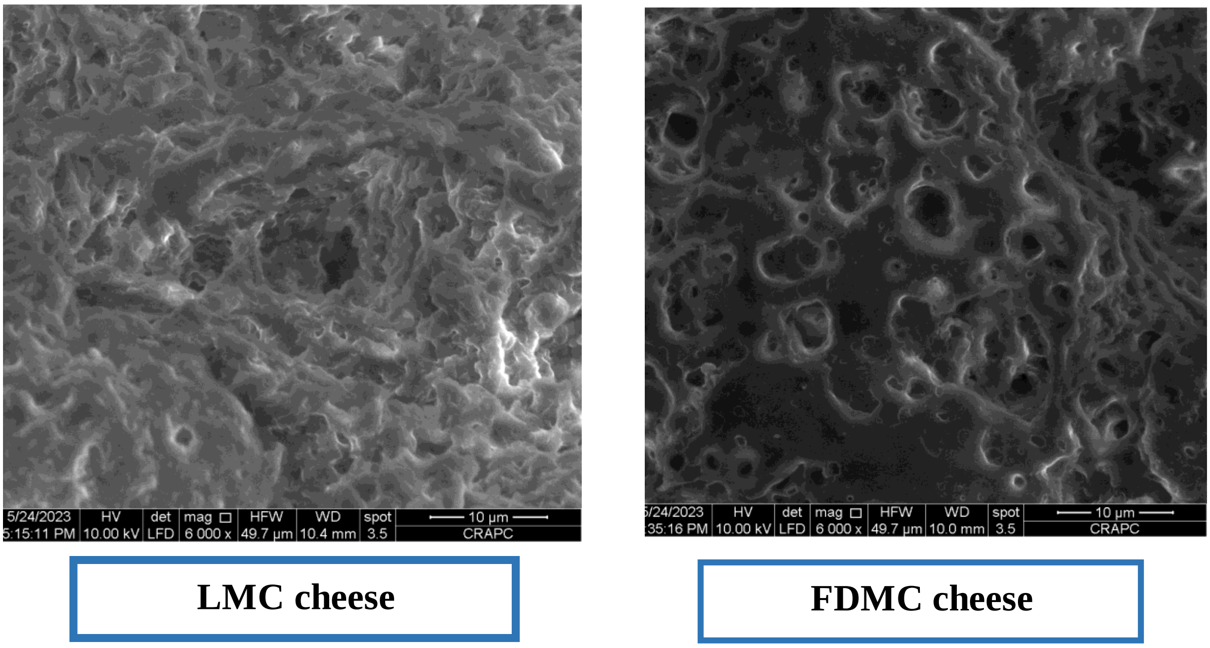


Figure20: Microstructure of cheeses LMC and FDMC

Image 20 shows the microstructure of cheese made with liquid microbial rennet (LMC) and freeze-dried (FDMC).We noticed that LMC cheese has a cohesive casein network compared to FDMC cheese. In addition, the micrographs of FDMC and LMC cheeses are in agreement with our sensory profiles, of which FDMC cheese is characterized by a highly rough texture (higher number and diameter of pores) and weakly creamy (the casein network is less cohesive).

Microstructural analyzes by **Bouras *et al.* (2023)** showed that the use of liquid microbial rennet in the manufacture of cheese from camel and goat milk results in a cheese with fewer pores and a larger diameter. It has a thicker protein network.

Conclusion

Fresh cheese is one of the best types of cheese that contains large amounts of essential substances and minerals that the body needs, in addition to taste and flavor.

The aim of this work is to study the effect of rennet and lactic ferment on the physicochemical analyzes and the sensoryl properties and microstructure of fresh cheese made from camel milk 50% and goat milk 50% mixture.

First, allowed us to obtain the results of the physico-chemical characteristics of mixed camel milk and goat milk: pH (6.13 ± 0.05), specific gravity (1.030 ± 0.001) g/cm^3, fat (50.02 ± 0.00) g/l, protein level (40.0±0.00)g/l, and lactose (48.00±0.00) g/l, total solids (135.50±0.02)g/l.

In this study, we extracted camel rennet and investigated its effect on cheese making, where rennet was used in its liquid and freeze-dried form, the characterization of camel rennet, giving a coagulant activity of 5.32±0.69 RU/mL and a coagulant strength equal to 1/52038.16 SU.

On the other hand, we examined the acidification power of a mixture of starter cultures (thermophilic and mesophilic). From our results, we conclude that the use of a mixture of lactic ferments gives better acidifying power in the milk mixture that is used.(pH=4.26).

In addition, the physicochemical properties of fresh cheese made from liquid camel rennet (LCC) and cheese made from freeze-dried camel rennet (FDCC) were studied. The total solids, protein, fat and yield values are respectively 36.22+1.8%, 17.2+2.1%, 13.38+0.9% and 16.50+0.09% for FDCC and 25.66+0.5%, 10.3+1.4%, 9.92+1.0% and 25.88+0.08% for LCC.

Sensory analyzes showing that the two formulas had a soft, spreadable and creamy texture.

Finally, and according to the results obtained, we can say that the nature of the camel rennet (liquid or freeze-dried) influences the physico-chemical composition of the fresh camel-goat cheese. Regarding the sensory profile and microstructure no influence.

On the other hand, the use of the mixture of mesophilic/thermophilic ferments in the manufacture of cheese seems to have a positive effect on the sensory characteristics.

In conclusion, and in terms of preference, the FDCC formulation seems the most preferred by nearly 40% of tasters.

Bibliographic references

A

- Abbas,S., Hifsa,A.,Aalia,N., &Lubna, S. (2013). Physico-chemical analysis and composition of camel milk. International Research, 2(2), 85-98.Adlerova, L., Bartoskova1, A. and Faldyna, M. Lactoferrin: a review.VeterinarniMedicina, 53, (9): 457–468, 2008.
- Abd Elhamid, A. M., & Elbayoumi, M. M. (2017). Influence of bee pollen on the bioactive behavior, sensory and physicochemical properties of white cheese made from camel and cow milk mixture. Journal of Food and Dairy Sciences, 8(11), 419-424.
- Abou-Soliman, N. H. I., Awad, S., & El-Sayed, M. I. (2020). The impact of microbial transglutaminase on the quality and antioxidant activity of camel-milk soft cheese. Food and Nutrition Sciences, 11(03), 153.
- Adela Bidot Fernández. 02 October 2019. Chemical Composition of Goat Milk: Revision Bibliografica.
- Ahmed A.I., Mohammed A.A., Faye B., Blanchard L., Bakheit S.A., 2010 - Assessment of quality of camel milk and gariss, north Kordofan State, Sudan. Research Journal of Animal and Veterinary Sciences, 5(1): 18 – 22.
- Alais , C. Linden G., 1997. Abrégé de biochimie alimentaire. 4ème Ed. Masson, 248p.
- Alais, C.1974 Principes des Techniques Laitières : Science du lait. 3rd ed. sepec, Paris, p. 513.
- Alaoui Ismaili M, Saidi B, Zahar M, Hamama A, Ezzaie R. 2019. Composition and microbial quality of raw camel milk produced in Morocco. Journal of the Saudi Society of Agricultural Sciences 18: 17–21.
- Alloui-Lombarkia, O., E. H. Ghennam, A. Bacha and M. Abededdaim. 2007. Caractéristiques physico-chimiques et biochimiques du lait de chamelle et séparation de ses protéines par électrophorèse sur gel de polyacrylamide. Renc. Rumin. 14: 108.
- Almena-Aliste, M., & Mietton, B. (2014). Cheese classification, characterization, and categorization: a global perspective. Cheese and Microbes, 39-71.
- Al-Zoreky, N. S., & Almathen, F. S. (2021). Using recombinant camel chymosin to make white soft cheese from camel milk. Food Chemistry, 337, 127994.

- Amigo, L.; Fontecha, J. Milk—Goat Milk. In Encyclopedia of Dairy Sciences, 2nd ed.; Fuquay, J.W., Ed.; Academic Press: San Diego, CA, USA, 2011; pp. 484–493, ISBN 978-0-12-374407-4**.**
- AMIOT et COL, (2002). Composition, propriétés physicochimiques, valeur nutritive, qualité technologique et techniques d'analyse du lait In VIGNOLA C.L, science et technologie du lait
- Amroune Meriem.,2019; Substitution de la présure animale par un autre coagulant d'origine végétale (chardon de marie, silybum marianum) (essai de coagulation sur différents lait).(Mémoire); Université Abdelhamid Ben badis Mostaganem.
- Anema SG, Lee SK, Klostermeyer H. 2005. Effect of pH at heat treatment on the hydrolysis of κ-casein and the gelation of skim milk by chymosin. LWT Food Science and Technology, 40: 99-106.
- Antonenko, P. P., Chumak, S. V., & Chumak, V. O. (2019). Physical and chemical composition of goat milk during smallholder production in the conditions of the natural and agricultural zone of the Steppe of Ukraine.
- Arrichiello, A., Auriemma, G., & Sarubbi, F. (2022). Comparison of nutritional value of different ruminant milks in human nutrition. International Journal of Functional Nutrition, 3(4), 1-10.
- Attia H, Bennasar M and Fuente BT. Study of the fouling of inorganic membranes by acidified milks using scanning electron microscopy and electrophoresis: I. Membrane with pore diameter 0.2 µm. Journal of Dairy Research.1991; 5:39-50.

B

- Bakry, I. A., Yang, L., Farag, M. A., Korma, S. A., Khalifa, I., Cacciotti, I., & Wang, X. (2021). A comprehensive review of the composition, nutritional value, and functional properties of camel milk fat. *Foods, 10*(9), 2158.
- BASSUONY, Neamat I., ABDEL-SALAM, A. F., ABDEL-GHANY, Zeinab M., et al. Effect of camel milk on microbiological and chemical quality of soft cheese. Journal of Food and Dairy Sciences, 2014, vol. 5, no 2, p. 63-77.
- BENDIMERAD N,(2013). Caractérisation phénotypique technologique et moléculaire d'isolats de bactéries lactiques de laits crus recueillis dans les régions de l'Ouest Algérien. Essai de fabrication de fromage frais type «Jben.» [Thèse de Doctorat]: Aboubekr Belkaid de Tlemcen 255 p.

- Benkerroum, N., Dehhaoui, M., El Fayq, A., & Tlaiha, R. (2011). The effect of concentration of chymosin on the yield and sensory properties of camel cheese and on its microbiological quality. *International journal of dairy technology*, *64*(2), 232-239.
- Berodier F, Lavanchy P, Zannoni M, Casals J, Herrero L and Adamo C. Guide d'évaluation olfacto-gustative des fromages à pâte dure et semi-dure. LWT-Food Science and Technology. 2003; 30:653-664.
- Bhatia, S., & Tandon, D. (2021). Nutritional, therapeutic and functional aspects of goat milk based products fortified with fruit beverages. *Journal of Pharmacognosy and Phytochemistry*, *10*(4S), 04-16.
- Boudjenah, S. (2012). Aptitudes à la transformation du lait de chamelle en produit diveres: effet des enzumes coagulantes extraites de caillettes de dromadaires (Doctoral dissertation, Universite Mouloud Mameri).
- Boughellout, H. (2007). La coagulation du lait par la pepsine du poulet. Université Mentouri Constantine.
- Bouras, B., & Aïssaoui-Zitoun, O. (2022). Optimization of flocculation and clotting time of camel milk with camel and goat rennets, and chicken pepsin in comparison with cow milk using response surface method (RSM). Emirates Journal of Food and Agriculture.
- Bouras, B., Aïssaoui-Zitoun, O., Benyahia, F. A., Djeghim, F., Djema, S., & Zidoune, M. N. (2023). Manufacture and characterisation of fresh cheese made from mixed milk of camel and goat.
- Bouras, B., Aïssaoui-Zitoun, O., Benyahia, F. A., Djeghim, F., Djema, S., & Zidoune, M. N. (2023). New Formulation and Characterization of Fresh Camel and Goat Milk Cheese Coagulated with Chicken Pepsin.
- Bradley RLJ, Arnold EJR, Barbano DM, Semerad RG, Smith DE and Viries BK. Chemical and physical methods. In Standard Methods for the Examination of Dairy Products. American Public Health Association, Washington DC, USA: Marshall RT Edition. 1993,pp 433-516.
- Berridge. N. J. (1945). The purification and crystallization of rennin. Biochemic Journal, 39, 179- 186.

- Brezovečki, A., Čagalj, M., Filipović Dermit, Z., Mikulec, N., Bendelja Ljoljić, D., & Antunac, N. (2015). Camel milk and milk products. *Mljekarstvo: časopis za unaprjeđenje proizvodnje i prerade mlijeka*, *65*(2), 81-90**.**
- Brulé G, Lenoir J, Remeuf F.1997. La micelle de caséine et la coagulation du lait. In : Les agents de transformation du lait. Le fromage. Eck A and Gillis J C. Edition Tec et Doc Lavoisier.Paris: 7-41.
- Buffa, M., Trujillo, A. J., & Guamis, B. (2001). Rennet coagulation properties of raw, pasteurised and high pressure-treated goat milk. Milchwissenschaft, 56(5), 243-246.

C

- Cayot P, Lorient D. 1998. Structures et Technofonctions des Protéines du Lait. TEC & DOC Lavoisier: Paris; 363 p.
- Chandan, R.C., Attaie, R. and Shahani, K.M., 1992. Nutritional aspects of goat milk and its products. Proc. V. Intl. Conf. on Goats. New Delhi, India. Vol. II. Part I. pp.399420**.**
- Charles O.R. Okpala; John R. Piggott; Carl J. Schaschke (2010). Influence of high-pressure processing (HPP) on physico-chemical properties of fresh cheese. , 11(1), 0–67.
- CODEX ALIMENTARUSE : alimentaire CODEX STAN A-6-1978

D

- D’urso, S., Cutrignelli, M. I., Calabrò, S., Bovera, F., Tudisco, R., Piccolo, V., & Infascelli, F. (2008). Influence of pasture on fatty acid profile of goat milk. *Journal of Animal Physiology and Animal Nutrition*, *92*(3), 405-410.
- Dalgleish DG. 1992. The enzymatic coagulation of milk. Advanced Dairy Chemistry Proteins, 1: 579–619.
- Dell’Orto, V., D. Cattaneo, E. Beretta, A. Baldi, and G. Savoini. 2000. Effect of trace element supplementation on milk yield and composition in camels. Int. Dairy J. 10:873–879.
- Diacono, E., Faye, B., Meldebekova, A., & Konuspayeva, G. (2008). Plant, water and milk pollution in Kazakhstan. In *Impact of Pollution on Animal Products* (pp. 107-116). Springer Netherlands.

- Dickson, H.R.P. (1951). The Arab of the Desert. London, George Allen & Unwin Ltd. Pp: 409–446.
- DSA DE EL OUED. (2019). Service des statistiques.
- Duhaiman, A. S. (1988). Purification of camel milk lysozyme and its lytic effect on Escherichia coli and Micrococcus lysodeikticus. *Comparative Biochemistry and physiology. B, Comparative Biochemistry*, *91*(4), 793-796.

E

E. Kondyli; C. Svarnas; J. Samelis; M.C. Katsiari (2012). *Chemical composition and microbiological quality of ewe and goat milk of native Greek breeds., 103(2-3), 194–199***.**

- El-Bakry, M., & Sheehan, J. (2014). Analysing cheese microstructure: A review of recent developments. Journal of Food Engineering, 125, 84-96.
- El-Bendary M. A., Moharam Maysa E. and Ali Thanaa H. (2007).Purification and characterization of milk-clotting enzyme production by Bacillus sphaericus. Journal of Applied Sciences Research, 3 (8): 695-699.
- El-Gendy, M. H. (2018). Impact of manufacturing processes on the industry soft cheese from camel milk. J. Biol. Chem. Environ. Sci, 13, 491-510.
- El-Hatmi, H., Jrad, Z., Salhi, I., Aguibi, A., Nadri, A., & Khorchani, T. (2015). Comparison of composition and whey protein fractions of human, camel, donkey, goat and cow milk. *Mljekarstvo/Dairy*, *65*(3).
- Elhosseny M, Gwida M, Elsherbini E, Abu Samra R, Al Ashmawy M. 2018. Evaluation of physicochemical properties and microbiological quality of camel milk from Egypt. Journal of Dairy, Veterinary & Animal Research 7(3):92 – 97
- Ereifej, K. I., Alu'datt, M. H., AlKhalidy, H. A., Alli, I., & Rababah, T. (2011). Comparison and characterisation of fat and protein composition for camel milk from eight Jordanian locations. *Food Chemistry*, *127*(1), 282-289.

F

- FAO. 1995. Lait et Produit Laitier Dans la Nutrition Humaine. Organisation des Nation Unies Pour L'alimentation et L'agriculture, Rome, p.269.

- Farah, Z. (1993). Composition and characteristics of camel milk. *Journal of Dairy research*, *60*(4), 603-626.
- Fauquant, C., Briard-Bion, V., Leconte, N., Guichardant, M., & Michalski, M. C. (2007). Membrane phospholipids and sterols in microfiltered milk fat globules. *European Journal of Lipid Science and Technology*, *109*(12), 1167-1173**.**
- Faye, B., & Bengoumi, M. (2018). *Camel clinical biochemistry and hematology* (pp. 173-216). Cham (Switzerland): Springer**.**
- FOX PF, GUINEE TP, COGAN TM, MCSWEENEY PLH. Fundamentals of Cheese Science, second edition by Springer New York, 2017.
- Froc J., 2001 : Des jus de fruits ou de plantes pour faire du fromage. INRA mensuel n°110,41-42.

G

- García, V.; Rovira, S.; Boutoial, K.; López, M.B. (2014). Improvements in goat milk quality: A review. Small Ruminant Research, 121(1), 51–57.
- Gardner N, Champagne CP (2005) Production of Propionibacterium shermanii biomass and vitamin B12 on spent media. J Appl Microbiol 99:1236–1245.
- GAST M., MAUBOIS J.L., ADDA J., 1969. Le lait et les produits laitiers en Ahaggar. Centre Rech. Anthrop. Prehist. Ethno., Paris, F.
- Guillou, H., Pelissier, J. P. Grappin, R. (1976). Méthodes de dosage des protéines du lait de vache. Le Lait, 66, 143-175p.
- Getaneh, G., Mebrat, A., Wubie, A., & Kendie, H. (2016). Review on goat milk composition and its nutritive value. *Journal of Nutrition and Health Sciences*, *3*(4), 1-10.

H

- Haddadin, M. S., Gammoh, S. I., & Robinson, R. K. (2008). *Seasonal variations in the chemical composition of camel milk in Jordan. Journal of Dairy Research, 75(01)*.
- Hadef L, Aggad H, Hamad B, Saied M. 2018. Study of yield and composition of camel milk in Algeria. Scientific Study & Research: Chemistry & Chemical Engineering, Biotechnology, Food Industry 19 (1): 001 – 011

- Haenlein, G. F. W. (2001). Past, present, and future perspectives of small ruminant dairy research. *Journal of dairy science, 84*(9), 2097-2115.
- HAFIDE N. (2006). l'influence de l'âge, de la saison et de l'état physiologique des caprins sur certains paramètre sanguins. Mémoire de magister en science vétérinaires. Dép vétérinaires. BATNA.
- HAROUN, M. (2012). *aptitude à la transformation du lait de chamelle en produits dérivés; effets des enzymes coagulantes extraites de caillettes de dromadaires* (Doctoral dissertation, Université de Tizi Ouzou-Mouloud Mammeri).
- Hassani, M. I., Saikia, D., & Walia, A. (2022). Nutritional and therapeutic value of camel milk. *IJAR*, *8*(4), 01-05.
- Helmut K. Mayer; Gregor Fiechter (2012). Physicochemical characteristics of goat's milk in Austria – seasonal variations and differences between six breeds., 92(2), 167–177.
- Ho, T. M., Zou, Z., & Bansal, N. (2022). Camel milk: A review of its nutritional value, heat stability, and potential food products. *Food Research International*, *153*, 110870.
- Holt C. 1997. The milk salts and their interaction with caseins. In Advanced in Dairy Chemistry: Lactose, Water, Salts and Vitamins (Vol. 3). Chapman & Hall: London; 233-256.
- Horne, D. S. (1998). Casein interactions: casting light on the black boxes, the structure in dairy products. *International Dairy Journal*, *8*(3), 171-177.

I

- Ilboudo, A. J., Savadogo, A., Seydi, M. G., & Traore, A. S. (2012). Place de la matière azotée dans le mécanisme de la coagulation présure du lait. International Journal of Biological and Chemical Sciences, 6(6), 6075-6087.
- ISSELNANE.(2014). Caractérisation chromatographique et électrophorétique de l'extrait coagulant issu de caillettes de dromadaires adultes. Mémoire de magister en biologie, Université Mouloud mammeri de -Tizi-ouzo, Algérie.

J

- Jeantet, R., Croguennec, T., Schuck, P. and Brulé, G. (2008) Science des aliments : Technologie des produits alimentaires. Paris.
- Jilo, K., & Tegegne, D. (2016). Chemical composition and medicinal values of camel milk. *International Journal of Research Studies in Biosciences*, *4*(4), 13-25.

K

- Kamal, M., & Karoui, R. (2017). Monitoring of mild heat treatment of camel milk by front-face fluorescence spectroscopy. *LWT-Food Science and Technology*, *79*, 586-593.
- Kanawjia .S.K , Yogesh Khetra,2016., Cheese Technology .PDF.p62.
- Kappeler, S. (1998). *Compositional and structural analysis of camel milk proteins with emphasis on protective proteins* (Doctoral dissertation, ETH Zurich).
- Khalesi, M., Salami, M., Moslehishad, M., Winterburn, J., & Moosavi-Movahedi, A. A. (2017). Biomolecular content of camel milk: A traditional superfood towards future healthcare industry. *Trends in Food Science & Technology*, *62*, 49-58**.**
- Khan, H. A. I. D. E. R., Athar, I. H., & Aslam, M. U. H. A. M. M. A. D. (2004). Evaluation of cheese prepared by processing camel milk. Pakistan Journal of Zoology, 36(4), 323-326.
- Khaskheli, M., Arain, M. A., Chaudhry, S., Soomro, A. H., & Qureshi, T. A. (2005). Physico-chemical quality of camel milk. *Journal of Agriculture and Social Sciences*, *2*, 164-166**.**
- Koc A.B., Ozer B. Nondestructive monitoring of renetted whole milk during cheese manufacturing. Food Res. Int. 2008;41:745–750.
- Konuspayeva, G., Faye, B., & Bengoumi, M. (2022). Mineral status in camel milk: a critical review. *Animal Frontiers*, *12*(4), 52-60.
- Konuspayeva, G., Faye, B., & Loiseau, G. (2009). The composition of camel milk: a meta-analysis of the literature data. Journal of food composition and analysis, 22(2), 95-101.
- Konuspayeva, G., & Faye, B. (2019). Le fromage de chamelle: une révolution technologique et culturelle?. INRA.
- Konuspayeva, G., & Faye, B. (2020). Le lait de chamelle, de la tradition à la modernité.

- Konuspayeva, G., 2020. CM Composition and Nutritional Value. In: Al-Haj, O., B. Faye, and R.D. Agrawal, editors. Handbook of research on health and environmental benefits of camel products. Hershey, USA: IGI Global; p. 15–40.
- Kumar, S., Kumar, B., Kumar, R., Kumar, S., Khatkar, S. K., & Kanawjia, S. K. (2012). Nutritional features of goat milk—A review. *Indian Journal of Dairy Science*, *65*(4).
- Kuroda, M., Sasaki, K., Yamazaki, J., Kato, Y., & Mizukoshi, T. (2020). Quantification of the kokumi peptide, γ-glutamyl-valyl-glycine, in cheese: Comparison between cheese made from cow and ewe milk. Journal of dairy science, 103(9), 7801-7807.

L

- Lad, S. S., Aparnathi, K. D., Mehta, B., & Velpula, S. (2017). Goat milk in human nutrition and health–a review. International Journal of Current Microbiology and Applied Sciences, 6(5), 1781-1792.
- Lajnaf, R. (2020). Camel milk: nutritional composition, functionality and health benefits–a mini review. *Current Trends in Biotechnology and Microbiology*, *2*, 389-393.
- Laleye, L. C., Jobe, B., & Wasesa, A. A. H. (2008). Comparative study on heat stability and functionality of camel and bovine milk whey proteins. *Journal of Dairy Science*, *91*(12), 4527-4534.
- Laiño, J. E., Juarez del Valle, M., Savoy de Giori, G., and LeBlanc, J. G. (2013). Development of a high folate concentration yogurt naturally bio-enriched using selected lactic acid bacteria. *LWT Food Sci. Technol.* 54, 1–5.
- Laurent, S. (2015). Le livre blanc du Camembert. Fliofactory. p 34.
- Law, B. A., & Tamime, A. Y. (Eds.). (2011). Technology of cheesemaking. John Wiley & Sons.
- Levit, R., Savoy de Giori, G., de Moreno de LeBlanc, A., and LeBlanc, J. G. (2016). Evaluation of the effect of soymilk fermented by a riboflavin-producing *Lactobacillus plantarum* strain in a murine model of colitis. *Benef. Microbes* 8, 65–72.

- Lindmark Månsson, H. (2008). Fatty acids in bovine milk fat. *Food & nutrition research*, *52*(1), 1821.
- Litopoulou-Tzanetaki, E., & Tzanetakis, N. (1992). Microbiological study of white-brined cheese made from raw goat milk. Food Microbiology, 9(1), 13-19.
- Lo Piero A.R., Puglisi I. Et Petrone G., 2002 : Characterization of lettucine, a serine like protease from Lactuca sativa leaves, as a novel enzyme for milk clotting. J. Agric. Food Chem. 50: 2439- 2443.
- Lorenzen, P. C., Wernery, R., Johnson, B., Jose, S., & Wernery, U. (2011). Evaluation of indigenous enzyme activities in raw and pasteurised camel milk. *Small Ruminant Research*, *97*(1-3), 79-82.
- LORIENT D. et CAYOT P. (2000). Les propriétés technofonctionnelles des protéines du lait. Les protéines laitières: Intérêts technologiques et nutritionnels, 4éme Conférence Européenne d'ARILAIT, 7 November, Paris, France**.**
- Lucey, J. A., & Fox, P. F. (1993). Importance of calcium and phosphate in cheese manufacture: A review. *Journal of Dairy Science*, *76*(6), 1714-1724.

M

- Mahaut M, Jeantet R, Brule G. 2000. Initiation à la Technologie Fromagère . TEC & DOC Lavoisier: Paris ; 194 p.
- Mahaut.M, Jeantet R. et Brulé G., (2003). Initiation à la technologie fromagère. Paris, Lavoisier, Technique Et Documentation, Lavoisier, France;Pp 24-102.
- Mal G, Sena DS, Kishore N, Patil NV (2012) Comparative account of whey proteins in camel and cow milk. Indian Vet J 89(6):116–117.
- Mal, G., Suchitra, S. D. and Sahani, M. S. 2007. Changes in chemical and macro-minerals content of dromedary milk during lactation. Journal of Camel Practice and Research, 14(2): 195- 197.Malik, Ajamaluddin, et al. "A study of the anti-diabetic agents of camel milk." International journal of molecular medicine 30.3 (2012): 585-592.
- Mbye, M., Ayyash, M., Abu-Jdayil, B., & Kamal-Eldin, A. (2022). The texture of camel milk cheese: Effects of milk composition, coagulants, and processing conditions. Frontiers in Nutrition, 9, 868320.

- Meena, S., Rajput, Y. S., & Sharma, R. (2014). Comparative fat digestibility of goat, camel, cow and buffalo milk. *International Dairy Journal*, *35*(2), 153-156.
- Mehta, B. M. (2018). Microstructure of cheese products. Microstructure of dairy products, 145-179.
- Menezes, M. U. F. O., Bevilaqua, G. C., Ximenes, G. N. D. C., Andrade, S. A. C., Kasnowski, M. C., & Barbosa, N. M. D. S. C. (2022). Viability of Lactobacillus acidophilus in whole goat milk yogurt during fermentation and storage stages: a predictive modeling study. Food Science and Technology, 42.
- Mietton B, Gaucheron F, Salaun F. 2004. Minéraux et transformations fromagères. In Minéraux et Produits Laitiers, GAUCHERON F (ed). Lavoisier: Paris; 471-563.
- Mietton B., 1995 : La typologie des fromages, Symposium organisé par la fondation des Gouverneurs et le centre de recherche et de développement sur les aliments d'agricultures et Agroalimentaire Canada, octobre, 245p.
- Mistry, V. V., & Anderson, D. L. (1993). Composition and microstructure of commercial full-fat and low-fat cheeses. Food structure, 12(2), 13.

N

- Nouani, A., Dako, E., Morsli, A., Belhamiche, N., Belbraouet, S., Bellal, M. M., & Dadie, A. (2009). Characterization of the purified coagulant extracts derived from Artichoke Flowers (Cynara scolymus) and from the Fig Tree Latex (Ficus carica) in light of their use in the manufacture of traditional cheeses in Algeria. J. Food Technol, 7(1), 20-29p.
- Nilsson K., Abdelghani A., Burleigh S., Johansen L.B., Lindmark-Månsson H., Paulsson M., Glantz M. An investigation of the enzymatic cleavage of κ-casein in non-coagulating milk. Int. Dairy J. 2020;109:104754.

P

- Park YW, Juárez M, Ramos M, Haenlein GFW. Physico-chemical characteristics of goat and sheep milk. Small Rumin Res. 2007 Mar;68(1-2):88-113
- PARK, YW. (2006). Goat milk — chemistry and nutrition. In: Park Y.W, Haenlein. F.W. (Eds.), Handbook of Milk of Non-Bovine Mammals. Blackwell Publishing Professional, Oxford, UK / Ames, Iowa, p.34–58.

- Park, YW. (2010). Goat milk: composition,characteristics. *Encyclopedia of animal science*, *2*.
- Park, Y. W. (2017). Goat milk–chemistry and nutrition. Handbook of milk of non-bovine mammals, 42-83. - Haenlein, G. F. (2017). Why does goat milk matter?-A Review. Nutrition & Food Science International Journal, 2(4), 87-90.
- Powell, I. B., Broome, M. C., & Limsowtin, G. K. Y. (2011). Cheese starter cultures: General aspects. Encyclopedia of dairy sciences, 2, 552-558.
- Prosser, C. G. (2021). Compositional and functional characteristics of goat milk and relevance as a base for infant formula. *Journal of food science*, *86*(2), 257-265.

R

- Rabah, H., Carmo, F. L. R. D., & Jan, G. (2017). Dairy propionibacteria: versatile probiotics. *Microorganisms*, *5*(2), 24.
- Raghvendar S, Ghorui SK, Sahani MS (2006) Camel milk: properties and processing potential. In: Sahani MS (ed) The Indian camel. Publisher National Research Center on Camel, Bikaner, pp 59–73
- Raghvendar S, Tandon SN, Arora S, Sahani MS (2001) Milk enzymes in different breeds of Indian camel. Int J Anim Sci 16(1):85–87.
- Ramet J. 1985. La fromagerie et les variétés de fromages du bassin méditerranéen. Ed. Etude FAO. Production et santé animale, Roma (Italia). 187 p.
- Ramet, J. P. (1991). La transformation en fromages de lait de dromadaire. World Animal Rev, 67, 20-28.
- Raynal-Ljutovac K, Lagriffoul G, Paccard P, Guillet I, Chilliard Y. Composition of goat and sheep milk products: An update. Small Rumin Res. 2008 Sep;79(1):57-72.
- Remache, A., & Medjoudj, H. (2020). Détermination de la date limite de consommation (DLC) du fromage traditionnel algérien « Bouhezza» au cours de sa conservation par réfrigération.
- Ribas, J. C., Matumoto-Pintro, P. T., Vital, A. C. P., Saraiva, B. R., Anjo, F. A., Alves, R. L., ... & Zeoula, L. M. (2019). Influence of basil (Ocimum basilicum Lamiaceae) addition on functional, technological and sensorial characteristics of fresh cheeses made with organic buffalo milk. Journal of food science and technology, 56, 5214-5224.

- Richard.D.Foster (2012)In book: Cheese:types, Nutrition and Consumption (pp.269-289)Chapter: Nutritional Benefits in CheesePublisher: Nova Science.
- Roudj, S., Bessadat, A., & Karam, N. E. (2005). Caractérisations physicochimiques et analyse électrophorétique des protéines de lait de chèvre et de lait de vache de l'Ouest Algérien. Renc. Rech. Ruminants, 12p.

S

- Saadi, A. M., Ali, F. F., & Jasim, A. Y. (2019). Study of the soft cheese composition produced from a mixture of sheep and camel milk at different storage periods using the enzyme trypsin and calcium chloride. Ann Agri Bio Res, 24, 316-20.
- SAIDI, F., & TOUAHRIA, L. (2021). Optimisation des paramètres de coagulation du lait et essai de fabrication du fromage frais à base de lait en mélange par pepsine de poulet.
- Saikia, D., Hassani, M. I., & Walia, A. (2022). Goat milk and its nutraceutical properties. *Int J Appl Res*, *8*(4), 119-22.
- Saima I, Arain MA, Khaskheli M and Malik AH. Study of the Effect of Processing on the Chemical Quality of Soft Unripened Cheese Made from Camel Milk. Pakistan Journal of Nutrition. 2003; 2(2):102-105.
- Sakandar, H. A., Ahmad, S., Perveen, R., Aslam, H. K. W., Shakeel, A., Sadiq, F. A., & Imran, M. (2018). Camel milk and its allied health claims: a review. *Progress in Nutrition*, *20*(Supplement 1), 15-29**.**
- Sant'Ana, A. M. S., Bezerril, F. F., Madruga, M. S., Batista, A. S. M., Magnani, M., Souza, E. L., & Queiroga, R. C. R. E. (2013). Nutritional and sensory characteristics of Minas fresh cheese made with goat milk, cow milk, or a mixture of both. Journal of Dairy Science, 96(12), 7442-7453.
- Sanz sampelayo, M. R., Chilliard, Y., Schmidely, P., and Boza, J. (2007). Influence of type of diet on the fat constituents of goat and sheep milk. Small. Rumen. Res. 68, 42-63.
- Sawaya, W. N., Khalil, J. K., Al-Shalhat, A., & Al-Mohammad, H. (1984). Chemical composition and nutritional quality of camel milk. *Journal of Food Science*, *49*(3), 744-747.

- SELLAH, L. (2021). Etude comparative de l'activité coagulante de quelques plantes utilisées dans la fabrication du fromage en Algérie (Doctoral dissertation, Université Ziane Achour/Faculté des Sciences de la Nature et de la Vie).
- Shamsia, S.M., 2009. Nutritional and therapeutic properties of camel and human milks. Int. J. Genet. Mol. Biol. 2, 52–58.
- Shieh CJ., Phan Thi LA., Shih IL (2009).Milk-clotting enzymes produced by culture of Bacillus subtilisnatto. Biochem. Eng.Journal43:85-91.
- Siboukeur, O., Mati, A., & Hessas, B. (2005). Amélioration de l'aptitude à la coagulation du lait cameline (Camelus dromedarius): utilisation d'extraits enzymatiques coagulants gastriques de dromadaires. Cahiers agricultures, 14(5), 473-478.
- Singh, R., Mal, G., Kumar, D., Patil, N. V., & Pathak, K. M. L. (2017). Camel milk: an important natural adjuvant. *Agricultural research*, *6*, 327-340.
- Skeie, S. B. (2014). Quality aspects of goat milk for cheese production in Norway: a review. Small Ruminant Research, 122(1-3), 10-17.
- Soltani M., Sahingil D., Gokce Y., Hayaloglu A.A. Effect of blends of camel chymosin and microbial rennet (Rhizomucor miehei) on chemical composition, proteolysis and residual coagulant activity in Iranian Ultrafiltered White cheese. J. Food Sci. Technol. 2019;56:589–598
- Soumya N, Shilpashree B.G., Rajanna M., B.P Pushpa, Venkatesh M, Harini Venugopal, Heena Kauser. december 2021. GOAT MILK: COMPOSITION AND THERAPEUTIC ASPECTS
- Stocco, G., Dadousis, C., Vacca, G. M., Pazzola, M., Summer, A., Dettori, M. L., & Cipolat-Gotet, C. (2022). Predictive formulas for different measures of cheese yield using milk composition from individual goat samples. Journal of Dairy Science, 105(7),
- Sun, X., Yu, Z., Liang, C., Xie, S., Wen, J., Wang, H., ... & Han, R. (2023). Developmental changes in proteins of casein micelles in goat milk using data-independent acquisition-based proteomics methods during the lactation cycle. Journal of Dairy Science, 106(1), 47-60.

T

- Tadjine, D., Boudalia, S., Bousbia, A., Khelifa, R., MEBIROUK BOUDECHICHE, L., Tadjine, A., & Chemmam, M. (2019). Pasteurization effects on yield and physicochemical parameters of cheese in cow and goat milk. Food Science and Technology, 40, 580-587.
- TALANTIKITE K S. (2015). Purification et caractérisation d'une enzyme coagulant d'origine microbienne pour application en fromagerie., Université M'hamed Bougara Boumerdes.
- TITAOUINE, M. (2006). Considérations zootechniques de l'élevage du camelin dans le sud-est Algérien : influence du sexe et de la saison sur certains paramètres sanguins. Mémoire de magister en sciences vétérinaires, université de EL-Hadj Lakhdar, Batna, Algérie.
- Turkmen, N. (2017). The nutritional value and health benefits of goat milk components. In *Nutrients in Dairy and their Implications on Health and Disease* (pp. 441-449). Academic Press.
- Trujillo, A.J.; Casals, I.; Guamis, B. Analysis of Major Caprine Milk Proteins by Reverse-Phase High-Performance Liquid Chromatography and Electrospray Ionization-Mass Spectrometry. J. Dairy Sci. 2000, 83, 11–19.

V

- Van Wyk, J., Witthuhn, R. C., and Britz, T. J. (2011). Optimisation of vitamin B12 and folate production by *Propionibacterium freudenreichii* strains in kefir. *Int. Dairy J.* 21, 69–74.
- Veisseyre R. 1975. Technologie du lait: constitution, recolte, traitement et transformation du lait. . Edition troisième. Maison Rustique.
- Vigneux, M. P. B. (2017). Impact de l'homogénéisation partielle de la matière grasse du lait et de l'homogénéisation haute pression (HHP) du lait écrémé sur ses aptitudes à la transformation fromagère (Doctoral dissertation, Université Laval).
- Vignola. C., (2002). Science et technologie du lait : transformation du lait, fondation de tecknologie laitière du quaébec 1,12,14,15, p.

- Vorobjeva, L. I., Khodjaev, E. Y., & Vorobjeva, N. V. (2008). Propionic acid bacteria as probiotics. *Microbial Ecology in Health and Disease*, *20*(2), 109-112.

W

- Wangoh, J. Farah, Z. Puhan, Z. (1993). Extraction of rennet and its comparison with calf rennet extract. Milchwissenschaft 1993; 48: 322-5p.
- Wilson R T .1984 The Camel. 1st edn, Longman Group Ltd, Longman House Mill, Harlow Essex, UK, Pp. 223.
- Wu, C. S., Guo, J. H., & Lin, M. J. (2020). Stability evaluation of pH-adjusted goat milk for developing Ricotta cheese with a mixture of cow cheese whey and goat milk. Foods, 9(3), 366.

Y

- Yagil R (1982). Camels and camel milk. FAO Animal production and health paper, Rome, Italy, 1982. Pp. 69.
- Y.W. Park; H.I. Chukwu (1988). Macro-mineral concentrations in milk of two goat breeds at different stages of lactation., 1(2), 157–166. doi:10.1016/0921-4488(88)90032-6.

Z

- Zhao, D. B., Bai, Y. H., & Niu, Y. W. (2015). Composition and characteristics of Chinese Bactrian camel milk. *Small Ruminant Research*, *127*, 58-67.
- Zhao Z., Corredig M. Effects of pH-modification on the rennet coagulation of concentrated casein micelles suspensions. Food Chem. 2020;316:126199.
- Zhu, Yuying ; Wang, Jianmin ; Wang, Cunfang (2018). Research on the preparation, uniformity and stability of mixed standard substance for rapid detection of goat Milk composition. Animal Science Journal,

Appendix

Appendix N°01: Extraction of coagulating enzymes

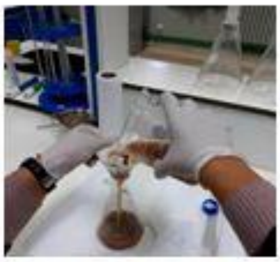
❖ Preparation of extraction solutions

✓Maceration NaCl 24g + boric acid 8g for 400 ml of distilled water in beaker 500 ml with slices of camela bomasum

✓To prepare 20 ml of HCl solution (1N), dissolve 1.64 ml of HCL and add distilled water up to 20 ml.

✓To prepare 100 ml of the NaOH (1N) solution dissolve 3.979 g of NaOH in 100

Pictures of camel rennet extraction



Appendix N°02: Method of Kjeldahl

- Mineralization

Mineralization is carried out using an excess of concentrated sulfuric acid, hot and in the presence of a mixture of catalyst (potassium sulfate, copper and selenium sulfate). In the presence of concentrated and hot sulfuric acid, carbon, oxygen, hydrogen and nitrogen of organic compounds are found in the form of CO_2, H_2O and NH_3. Sulfuric acid being in excess, we have:

$$2NH_3 + H_2SO_4 \text{ ---------------------------------- } > 2NH_4 + SO_4^{-2}$$

Total nitrogen is therefore obtained in the mineral form NH_4^+ (ammonium ion). During mineralization, sulfuric acid is partially decomposed and reduced to SO_2 and SO_3 which form irritating and toxic white fumes.

- **Distillation**

To transform the ammonium ions of the mineralizate into ammonia (NH_4^+ into NH_3), the mineralizate must be made alkaline with a large excess of a strong base which is 32% Na OH soda.

$$NH_4^+ \;\; OH \text{ ------------ } > NH_3 + H_2O$$

The ammonia is recovered by distillation: the alkalized mineralisate is heated, the NH_3 is released in the form of vapors which are condensed, which are captured by 4% boric acid and which are collected for the assay.

$$BO_3H_3 + 3NH_3 \text{ ----- } > H_2BO_3\,(NH_4)_3$$

- **Titration**

The fixed ammonia is titrated with hydrochloric acid (0.1N) in the presence of a Tashiro or RB color indicator (mixture of methyl red and methylene blue).

$$NH_3 + H^+ \text{ --------- } > NH_4^+$$

When the ammonia arrives in the boric acid, it alkalizes the medium which turns green. the calibrated solution of strong acid is then poured in to bring the indicator back to its sensitive hue.

Expression of results: **Total nitrogen = 1,40 x N x (Vi-V0) / P**

Appendix N° 03: Analysis of the sensory descriptor of fresh cheeses

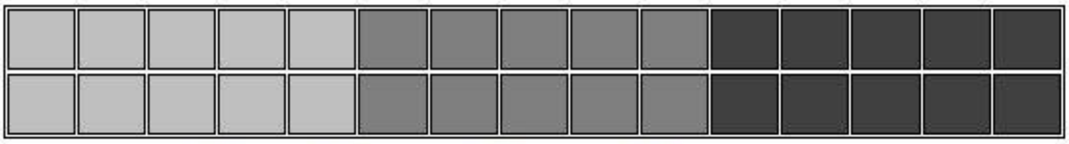
Analysis of the sonsory discriptors of fresh cheeses

First / Last name: **Date:**

You are asked to evaluate the characteristic of the fresh cheeses by giving a score from 0 to 15

(Appearance/ texture, smell/aroma, taste) depending on the scale and characteristic proposed. Be sure to analyze the cheeses in order, scale model:

nothing **average** **intense**



0 **5** **10** **15**

Cheeses appearance and texture						
	Smooth uniform texture	Rough texture	Sandy texture	Spreadable texture	Creamy texture	Pasty texture
FDCC						
FDMC						
LCC						
LMC						

	Smell of lactic	Smell of animal	Smell of grass	Smell sounds	Other specify
FDCC					
FDMC					
LCC					
LMC					

Taste and aroma of cheese : chew the sample and then evaluate the intensity of flavors					
	Acid	Salt	Soft	bitter	Taste of butter
FDCC					
FDMC					
LCC					
LMC					

Overall appreciation of the cheese						
	Bad	Moderately good	good	Very good	Rich in aroma (yes /no)	Duration intensity in the mouth
FDCC						
FDMC						
LCC						
LMC						

- Specify in seconds the intensity of (low intensity) $\leq$3sec (long intensity)up to $\geq$30sec

Cheeses preference				
Cheeses codes	**FDCC**	**FDMC**	**LCC**	**LMC**
Cheese preference				
Sort the cheeses according to preference				
List the characteristic(s) of your preference • Texture • Gout • Aroma				
What are the characteristics unpleasant things you felt • Texture • Gout • Aroma				