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قسم البيولوجيا الخلوية والجزيئية

Department of Cellular and Molecular Biology

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THEME

Characterization of the quality of a traditional and local *DOUTH* cheese from the El Oued region

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Abreviations list

GM: Goat milk

CN: Casein

α_{s1}-CN : α_{s1}-casein

α_{s2}-CN :α_{s2}-casein

β-CN : β-casein

κ-CN :κ-casein

CLA: conjugated linoleic acid

MUFA: monounsaturated fatty acids

PUFA: polyunsaturated fatty acid

MCFA: medium chain fatty acid

MCP: Milk coagulation properties

TR: traditional rennet

GMO: genetically modified organism

MCA: milk-clotting activity

PA: proteolytic activity

TGA: Traditional goat abomasum

EDCH: Eladhel cheese

OACH:Oued-Elallenda cheese

RHCH:Robbah cheese

EGCH:El-Ogla cheese

EDGR: Eladhel goat rennet

OAGR: Oued-Elallenda goat rennet

RHGR: Robbah goat rennet

EGGR: El-Ogla goat rennet

FTIR :Fourier-transform infrared spectroscopy

XRD: X-ray deffraction

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Summary

Part II: Materials and Methods

Part III: Results and discussio

First part: Characteristics of the biological material

Second part : Characteristics of *DOUTH* cheeses

Abstract

The objective of this study is the characterization of a traditional local cheese (*DOUTH*); made with goat milk and coagulated with dried and salted caprine abomasum from four (04) region of the Wilaya of El Oued. To achieve this goal, we analyzed the raw and mineral composition of the traditional coagulant in parallel with *DOUTH* cheeses. In addition, we completed the study with FTIR analysis, X-ray diffraction, microstructure and sensory analysis. The analysis of the crude composition of goat milk from the different regions showed a significant difference between all parameters ($p<0.05$). The physicochemical and mineral results of TGA (traditional goat abomasum) showed a significant difference between most of the parameters whose high value of DM (dry matter), proteins and ashes were respectively (90.76±0.1%), (24±0.4%) and (14.1±0.3%). FTIR spectra of TGA links appear OH, CH, C=O and C-O. For X-ray diffraction, we were showed the presence of some minerals, which is compatible with mineral composition. Regarding *DOUTH* cheese, The physicochemical and mineral results, high values of DM, proteins and ashes were respectively (55.54±1.44%), (58.06±0.38%), (7.50±0.1%) and ashes (7.50±0.1%) with Ca (9.97±0.04%). The high value of the yield was recorded in the RHCH (Robbah) region with (18.25±1.06%). FTIR spectra of *DOUTH* cheeses in different regions, links appear (OH, CH, C=O and C-O). For XDR, all *DOUTH* cheeses had an amorphous structure. The microstructure of *DOUTH* cheeses related to the type of milk and duration of storage, we were showed that the EDCH (Eladhel cheese) and OACH (Oued ellenda) cheeses had a fewer and larger pores compared to other cheeses. All cheeses were characterized by a pasty (from 7.45 ± 4.71 to 12.6 ± 4.29) and rough (from 8.95 ± 4.69 to 11.45 ± 2.74) texture. Finally, it is important to conclude that the use of TGA in the coagulation of goat milk gave us a good cheese yield, a good content of proteins and minerals such as calcium and an acceptance by the most tasters due to their specific texture and aroma. In addition, *DOUTH* cheese seems to have good quality, hence the importance of labeling it.

Keywords: Caprine abomasum, *DOUTH* cheese, goat milk, enzymatic coagulation

Résumé

Le but de cette étude est de caractériser le fromage traditionnel local (*DOUTH*) ; Fabriqué à partir de lait de chèvre et caillé avec de la caillette de chèvre séchée et salé provenant de quatre (04) districts de l'Etat de l'Oued. Pour atteindre cet objectif, nous avons analysé la composition brute et minérale du caillé traditionnel en parallèle avec les fromages *DOUTH*. De plus, nous avons complété l'étude par une analyse FTIR, une diffraction des rayons X, une microstructure et une analyse sensorielle. L'analyse de la composition brute du lait de chèvre de différentes régions a montré une différence significative entre tous les facteurs ($P < 0,05$). Les résultats physicochimiques et minéralogiques de l'ATG ont montré une différence significative entre la plupart des paramètres dont les valeurs élevées pour la DM, les protéines et les cendres étaient respectivement (90,76±0,1%), (24±0,4%) et (14,1±0,3%). Les spectres FTIR des liaisons TGA OH, CH, C=O et CO sont présentés. Par diffraction des rayons X, nous montrons la présence de certains minéraux, ce qui est cohérent avec la composition minéralogique. Concernant le fromage *DOUTH*, les résultats ont été physico-chimiques et minéralogiques, avec des valeurs élevées respectivement pour la MS, les protéines et les cendres (55,54±1,44%), (58,06±0,38%), (7,50±0,1%) et les cendres (7,50±0,1%). 0,1%) avec du calcium. (9,97 ± 0,04 %). La valeur de rendement la plus élevée a été enregistrée dans la région RHCH (18,25 ± 1,06 %). Les spectres FTIR des fromages *DOUTH* sont présentés dans différentes régions (OH, CH, C=O et CO). Pour le XDR, tous les fromages *DOUTH* avaient une structure amorphe. La microstructure des fromages *DOUTH* dépend du type de lait et de la durée de conservation, et nous avons constaté que les fromages EDCH et OACH ont des pores moins nombreux et plus grands que les autres fromages. Tous les fromages étaient caractérisés par une texture pâteuse (de 7,45 ± 4,71 à 12,6 ± 4,29) et une rugosité (de 8,95 ± 4,69 à 11,45 ± 2,74). Enfin, il est important de conclure que l'utilisation du TGA dans le caillage du lait de chèvre nous a donné un bon rendement fromager, une bonne teneur en protéines et en minéraux tels que le calcium, et une acceptation par la plupart des dégustateurs en raison de sa texture et de son arôme particulier. De plus, le fromage *DOUTH* apparaît de bonne qualité, d'où l'importance de son étiquetage.

Les mots clés : Caillette caprine, fromage *DOUTH*, lait de chèvre, coagulation enzymatique

الملخص

الهدف من هذه الدراسة هو توصيف الجبن المحلي التقليدي(DOUTH) ؛ مصنوع من حليب الماعز ومتخثر بأبوماسوم الماعز المجفف والمملح من أربع (04) مناطق ولاية الوادي. ولتحقيق هذا الهدف، قمنا بتحليل التركيبة الخام والمعدنية لمادة التخثر التقليدية بالتوازي مع أجبان DOUTH. بالإضافة إلى ذلك، أكملنا الدراسة بتحليل FTIR وحيود الأشعة السينية والبنية المجهرية والتحليل الحسي. أظهر تحليل التركيب الخام لحليب الماعز من المناطق المختلفة وجود فرق معنوي بين جميع العوامل $(P<0.05)$. أظهرت النتائج الفيزيائية والكيميائية والمعدنية لـ TGA فرقًا كبيرًا بين معظم العوامل التي كانت قيمتها العالية للـ DMوالبروتينات والرماد على التوالي (90.76±0.1%)، (24±0.4%) و(14.1±0.3%). تظهر أطيافFTIR ل TGA لروابط OHو CHو C=O و C-O بالنسبة حيود الأشعة السينية، تبين لنا وجود بعض المعادن، والتي تتوافق مع التركيب المعدني. فيما يتعلق بجبنDOUTH ، كانت النتائج الفيزيائية والكيميائية والمعدنية، حيث كانت القيم العالية للـ DM والبروتينات والرماد على التوالي (55.54±1.44%)، (58.06±0.38%)، (7.50±0.1%) والرماد (7.50±0.1%) مع الكالسيوم. (9.97±0.04%). سجلت أعلى قيمة للمحصول في منطقة RHCH بنسبة (18.25±1.06%). تظهر أطياف FTIR لأجبان DOUTH في مناطق مختلفة (OH, CH, C=Oو C-O). بالنسبة إلى XDR، كانت جميع أنواع أجبان DOUTH ذات بنية غير متبلورة. تتعلق البنية المجهرية لأجبان DOUTH بنوع الحليب ومدة التخزين، وقد تبين لنا أن أجبان EDCH و OACHتحتوي على مسام أقل وأكبر مقارنة بالأجبان الأخرى. تميزت جميع أنواع الجبن بملمس فطيرة (من 7.45 ± 4.71 إلى 12.6 ± 4.29) وخشنة (من 8.95 ± 4.69 إلى 11.45 ± 2.74).
أخيرًا، من المهم أن نستنتج أن استخدام TGA في تخثر حليب الماعز أعطانا محصولًا جيدًا من الجبن، ومحتوى جيدًا من البروتينات والمعادن مثل الكالسيوم، وقبولًا من قبل معظم المتذوقين نظرًا لقوامها ورائحتها الخاصة. بالإضافة إلى ذلك، يبدو أن جبن DOUTH ذو نوعية جيدة، ومن هنا تأتي أهمية وضع العلامات عليه.

الكلمات المفتاحية: كابرين أبوماسوم، جبن دوث، حليب الماعز، التخثر الأنزيمي

Introduction

Goat milk (GM) is one of a neutraceutical health drink, it is rich in mineral and vitamin content and has creamy texture, it is used as the replacer for number of the supplements which are people consume daily. GM is quite better as compared to that of cow milk because of its easy digestibility (**Sachin *et al*.,2017)**. GM is traditionally accepted as a wholesome and nutritious dairy drink rich in protein, calcium, minerals, phosphorus, niacin, and thiamine **(Wang *et al*., 2023)**.The unique nutritional and functional properties of goat milk proteins have attracted attention, including higher digestibility, buffering capacity and alkalinity compared to cow milk **(ALKaisy *et al*., 2023)**.

The transformation of milk into cheese occurs under the influence of many physicochemical, biochemical and microbiological processes (**Lepilkina and Grigorieva, 2023)** . Cheese is a product obtained via the acidic or enzymatic destabilization of casein, or more commonly, through a combination of both processes **(Neviani *et al*., 2024)**. Cheese is one of the oldest manufactured foods in the human diet. Indeed, the main interest of converting milk into cheese is to preserve the basic components of milk while creating new products with palatable taste, different sensorial characteristics, bioactive compounds, and high nutritional value, it is recognised as an essential source of protein, fat, and other nutrients **(Atik and Huppertz, 2023; Leulmi *et al*., 2023**).

For coagulating agents of animal origin, there are studies which prove the effectiveness camel rennet (**Boudjenah-Haroun *et al*., 2011; Boudjenah-Haroun *et al*., 2014; Hattem *et al*., 2017)**, goat rennet **(Zhang and Wang, 2007)** and chicken pepsin (**Benyahia-Krid *et al*., 2016**) in the coagulation of cow milk. Recently, **Bouras (2023)** valued the extract of goat rennet in the coagulation of cow, goat and camel milks by optimizing the pH and coagulation temperature and by manufacturing fresh cheese with different formulations.

In Algeria, local dairy products including cheeses have been disappearing because of the industrialization of the majority of traditional preparation methods for many original products. Algerian traditional cheeses are divided into different classes including: processed cheeses (*Medghissa*), ripened cheeses (*Bouhazza*), hard cheeses (*Klila*, *Takammart*), and fresh cheeses (*Ighounane*, *Mechouna, Jben***) (Tabet *et al*., 2023)** . In region of El Oued, *DOUTH* cheese is a traditional fresh cheese but not well known and not labeled. The physicochemical study of *DOUTH* cheese was initiated by **Zaater (2012)** who used salty and dry caprine abomasum from the Omzebaid and El Megurane regions. *DOUTH* cheese is a fresh cheese made in different regions of El Oued made with goat milk and traditionally coagulated by a salted and dried caprine abomasum. In this context, our work aims to study on the one hand the traditional coagulant which is based on a salted abomasum. on the other hand, *DOUTH* cheese from different regions of El Oued is studied: Robbah, El Ogla, Oued Ellenda and Hassi Khalifa (El Adhel) at the level:

-Crude and mineral composition;

-Microbiological analysis;

-FTIR and X-ray diffraction analysis;

-Microstructure;

-Sensory analysis.

The following manuscript is composed of three parts:

-The first part is a bibliographical synthesis on goat milk, milk coagulation and traditional cheese in Algeria;

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

-The third part is devoted to the results and discussion. It includes the results obtained on the characterization of the biological material (goat milk and traditional goat abomasum) and detailed results of the characterization of *DOUTH* cheeses.

Part I

Bibliographic

Chapter I

Goat milk

Goat milk (GM) has been known for thousands of years, with goats being first bred in the Middle East about 10,000 years ago **(Ouerghi *et al.*, 2022)**. This milk has played an important role in human nutrition and the development of civilizations throughout history **(Perez-Caballero *et al.*,2023)**. GM has characteristics that make it different from cow's milk **(Carriedo *et al.*,2022)**. It is one of the rare foods that is suitable for different age groups **(Moualek *et al.*, 2023)**. GM production is more sustainable than cow milk production, as goats require less water and food **(L. A. M. de Oliveira *et al.*, 2022)**. the milk of the goat as a minor dairy species. Compared with cow milk, goat milk has higher dry matter content, better digestibility, and lower allergenicity, and is a good source of many bioactive ingredients **(Li *et al.*, 2023)**. GM is being consumed more than that of other species.

Most GM is consumed fresh. Traditionally, in developed countries goat milk is transformed in dairy products, but drinking milk consumption is slowly growing due to its recognised benefits to human health. Goat cheese manufacture corresponds to 1.97% of worldwide cheese production (25.9 ×106 tons**)** **(Fresno *et al.*, 2023)**. GM products have received much attention since they are perceived as favourable for a well-balanced diet and health maintenance due to their high nutritional value. Although most dairy products consumed in the world come from cow milk, goat milk occupies the third position (2.3%), its production being economically important in many countries.

Nowadays, several goat milk-based products are available in the market, including yoghurt, cheese, fermented milk, goat milk powder, among others, most of them prepared through advanced processing technologies **(dos Santos *et al.*, 2023)**. It is also used in preparing some dishes and desserts **(Khan *et al.*, 2022)**. Moreover, unique qualities of goat milk are due to its physiological and biochemical properties, often described as quite superior to those found in cow milk **(dos Santos *et al*,.2023)**.in this chapter, we will discuss the study of the functional properties and the chemical composition (protein, fat, vitamins, minerals, etc.) and effect of different factors on them for goat milk (GM).

1. Essentials components of goat milk

Goat milk has a similar composition with other types of milk **(Mohsin *et al.*, 2019)**. it is composed of various components, each with a molecular structure that contributes to its distinctive properties and functionalities. Understanding the molecular makeup of these components is crucial for comprehending the interactions between them and the overall characteristics of goat milk. The nutritional benefit of milk lies in its richness in basic nutrients (proteins, lipids and carbohydrates) but also in calcium, vitamins and trace elements (**Moualek *et al.*, 2023).**

1.1. Micelle of casein

Casein (CN) is among the most prevalent proteins in milk and is crucial for developing functional milk products **(*GA et al., 2022*)**, CNs are the major components (70–80%) of goat milk protein (**Sun *et al.,* 2023)**. CN is a heterogeneous protein. It is made up of several fractions. It is a phosphoprotein present in milk as a micelle. CN is relatively insoluble and forms a gel-like structure when precipitated from milk. CN is slowly digested in the stomach, making it an ideal source of sustained-release protein (**ALKaisy *et al.,* 2023**). In turn, goat milk casein consists of four principal proteins: α_{s1}-casein (α_{s1}-CN), α_{s2}-casein (α_{s2}-CN), β-casein (β-CN), and κ-casein (κ-CN).

1.1.1.α-caseins:

goat milk has lower αS1-casein content **(Sun *et al.,* 2023)**. The αS1-casein production levels in different goats may vary greatly due to the high polymorphism of the CSN1N1 gene that encodes the αS1-casein. Various levels of αS1-casein synthesis in goat's milk have been described, ranging between 0 and 3.5 g/L for null alleles (N, O) and strong alleles (A, B, C, H, L, M), respectively. The genetic polymorphism of the goat αS1-casein has been shown to substantially affect the chemical composition and technological properties of the milk **(Mohsin *et al.,* 2023)**.

As far as αS2-CN is considered the chief casein protein that belongs to the family of secretory calcium-binding phosphoprotein, αS2-CN generally comprises 223 amino acids and its molecular mass is 25.5 kDa when analyzed with chromatography. It exists predominantly as a monomer, with intramolecular disulfide bonds maintaining its unique tertiary structural shape. It makes up around 10–12.5% of the GM casein portion. It has been shown that the high degree of polymorphism in the αS2-CN genes found in goats significantly affects the concentration of αS2-CN in GM. The seven alleles associated with αS2-CN of GM are A, B, C, D, E, F, and O. The O allele is related to an undetectable quantity of milk αS2-CN and the D allele is linked with a decreased content of αS2-casein. Previous studies have shown that genetic polymorphisms impact goat milk’s technological characteristics and composition. A higher concentration of αS2 casein present in GM provides better sites for interaction with k-carrageenan, which improves the firmness of the cheese texture (**Nayik *et al.,* 2022**).

1.1.2. β-caseins

β-casein is the most abundant in goat milk. β-caseins are considered to be a crucial component of total GM casein, contributing 54.8% of total casein. When compared with other types of casein, more genetic variants are observed in β-casein and it is more complicated to differentiate them through gel electrophoresis. There is a total of four variants of β-casein (i.e., A, B, C, and D). Alkaline gel electrophoresis can help in differentiating the A variant from the B, C, and D variants, whereas acid gelelectrophoresis differentiates the A variant from each other. The molar mass of the primary structure of β-CN is 23,980 g mol−1 (**Nayik *et al.*, 2022).**

1.1.3. κ-casein

κ-casein is the sole component of GM-CN, from which the determination of the entire amino acid sequence is carried out. The structure of k-casein consists of polymers mixtures together held by intermolecular disulfide bonds. A and B are considered to be two genetic variants of k-casein **(Nayik *et al.*, 2022)**.

In additionally, Studies indicated that casein content in Algerian goat milk ranges from 3.2% to 3.6%, slightly higher than in cow's milk (**Boulila *et al.*, 2022); Benchabane *et al.*, 2023)**. This variation can be influenced by factors like breed, diet, and lactation stage. Goat milk casein forms spherical structures called micelles, with κ-casein acting as the outer shell and α- and β-caseins packed within. This structure, smaller than in cow's milk, might facilitate better digestibility and mineral absorption **(Rahmania *et al.*, 2023)**. Representative HPLC profiles of proteins in goat milk are shown in (Figure 1).

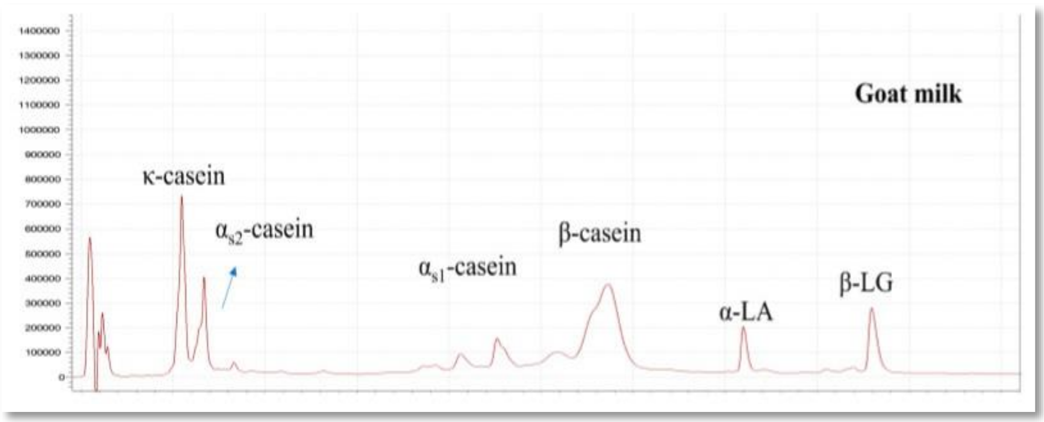


Figure 01. HPLC profiles of proteins in goat milk.**(Li *et al.*, 2022).**

1.2. Fats

The average fat particle size of goat milk is smaller than that of cow milk (**Wang *et al.*, 2023)**, are an essential component determining goat milk's superior absorption. Tiny globules of fatty acids and more significant titers of short-chain fatty acids are generally observed in GM that are easily assimilated and digested. Medium-chain fatty acids found in GM, such as caprylic, capric, and caproic acid, aid in the reduction of cholesterol by limiting its deposition and enhancing its mobilization in tissues. GM triacylglycerols account for 98% of total fat, similar to other milk, with cholesterol, phospholipids, monoand diacylglycerols, and free fatty acids accounting for the remaining 2%. Caprylic, capric, and caproic fatty acids account for

15% to 18% of all fatty acids found in GM. The size range of fat globules is around 1–10 µm, and the fat globule ratio smaller than five µm constitutes a more significant proportion (more than 80%) of GM. The quantity of conjugated linoleic acid (CLA) and essential fatty acids in GM is also a significant variation in free fatty acids. Compared with other milk, GM contains higher essential fatty acids such as arachidonic, linoleic acid, and conjugated linoleic acid **(Nayik *et al.*, 2022)**.

GM exceeding cow milk in monounsaturated fatty acids (MUFA), and polyunsaturated fatty acid esters (PUFA) goat milk exceeding cow milk in monounsaturated fatty acids (MUFA), and polyunsaturated fatty acid esters (PUFA) **(Wen *et al.*, 2023)**. The different fat components and their composition present in goat milk are given in table 01.

Table 01. Different components of fats in GM (**Marcinkoniene and Ciprovica. 2023).**

Fatty acid	Crossbreeds	Saanen	Latvian Native
Fat content	3.81±0.73a	3.40±1.34a	2.96±0.59a
C4:0 butyric acid	0.10±0.00b	0.12±0.05a	0.10±0.00b
C6:0 caproic acid	0.10±0.00b	0.12±0.05c	0.10±0.01b
C8:0 caprylic acid	<0.10c	0.10±0.00d	<0.10c
C10:0 capric acid	0.26±0.09d	0.18±0.05d	0.20±0.13d
C12:0 lauric acid	0.12±0.05efg	0.10±0.00f	0.10±0.01efg
C14:0 myristic acid	0.26±0.06f	0.24±0.24f	0.22±0.08f
C16:0 palmitic acid	0.96±0.17g	0.92±0.35g	0.74±0.16g
C18:0 stearic acid	0.62±0.13h	0.56±0.26h	0.48±0.10h
C18:1t9 trans-elaidic acid	0.10±0.00ijk	0.10±0.01ijk	0.10±0.00j
C18:1c9 oleic acid	0.90±0.31j	0.80±0.42j	0.68±0.10j
C18:2n6 linoleic acid	0.13±0.05k	0.12±0.05k	0.10±0.00k
Other fatty acids	0.10±0.00k	0.12±0.05l	0.10±0.00k
Total saturated fatty acids (SAFA)	2.52±0.39l	2.28±0.73l	1.96±0.46l
Total monounsaturated fatty acids (MUFA)	1.02±0.35m	0.88±0.42m	0.76±0.10m

Total polyunsaturated fatty acids(PUFA)	0.12±0.05n	0.12±0.05n	0.10±0.00n

1.3. Minerals

Mineral elements present in goat milk are essential for human health and development as they play a key role in meeting the nutritional and developmental needs of the body, especially in children. These elements include both macro elements such as K, Na, Ca, P, and Mg, as well as minor elements such as Zn, Fe, Cu, Mn, Mo, and B, and trace elements such as Co and Cr. The presence of these mineral elements in milk influences various milk properties **(Pan *et al.*, 2023)**. Between 0.70 and 0.85%, goat milk has a greater mineral content than cow milk. In comparison to human milk, goat milk has notably high levels of calcium and phosphorus. It also has higher levels of potassium, magnesium, and chloride than cow milk. When compared to human milk, goat milk has a lower iron concentration and a greater zinc and iodine content.

However, goat milk has a higher iron bioavailability than cow milk because the higher nucleotide content promotes better absorption in the stomach. Due to the high MCFA content or soluble protein ratio in goat milk, the selenium concentration in goat milk is higher than that in cow milk and is more bioavailable. For instance, goat cheese retains the majority of its zinc and manganese because they coexist with casein, whereas varying amounts of calcium, magnesium, and phosphorus are found in the soluble phase (33%, 66%, and 39%, respectively), and are therefore not retained in the curd **(Jareda *et al.*, 2023)**. The different mineral components present in goat milk are given in table 02.

Table 02. mineral concentrations of goat milk compared to cow milk (per 100 g) (**Rai *et al.*, 2022)**.

Minerals (mg)	Goat milk	Cow milk
Potassium (K)	181	152
Chloride (Cl)	150	100
Calcium (Ca)	134	122
Phosphorus (P)	121	119
Sodium (Na)	41	58
Sulphur (S)	28	32

Magnesium (Mg)	16	12
Selenium (Se)	1.33	0.96
Zinc (Zn)	0.56	0.53
Iron (Fe)	0.07	0.08
Iodine (I)	0.022	0.021

1.4. Vitamins

GM has unusually high concentrations of vitamins A and B (excessive amounts of thiamine(B1), riboflavin(B2), and pantothenic acid (B5)), but is completely devoid of carotene. The reason goat milk is whiter than cow milk is because beta-carotene is converted to retinol. it is less vitamin E, folic acid, and vitamin B12 than cow milk **(Jareda *et al.*,2023)**.

1.5. Water

Water constitutes approximately 87-88.5% of goat milk **(Lakhal *et al.*, 2023; Park *et al*. 2023; Patel *et al.*,2023)**, acting as a medium for dissolving and transporting other components. While water content can vary in both types, goat milk typically holds 1-2% more water than cow milk **(Haenlein. 2023)**.

2. Effect of different factors on the components of goat milk

As for other milk species, goat milk composition can vary with breed, lactation stage, physiological aspects, storage and especially, feed composition. It is also known that genetic factors, environmental conditions and agricultural practices can considerably affect biochemical composition, technological properties and bacteriological quality of goat milk (**Wm Dos Santos & Acg Gomes.**, **2023**).

Various factors can influence the composition and properties of goat milk, including breed, diet, stage of lactation, and processing methods in Table 03.

Table 03: Factors affecting the components of goat milk

Factors	Effect on Goat Milk Components	References
Breed	The breed of goat significantly influences protein yield and milk quality, with Alpine and Saanen goats having higher protein yields and higher protein content than Nigerian dwarf and pygmy goats, respectively.	**(Park *et al.*,2023)**

(Follows)

Factors	**Effect on Goat Milk Components**	**Reference**
Breed	The breed of goat significantly influences protein yield and milk quality, with Alpine and Saanen goats having higher protein yields and higher protein content than Nigerian dwarf and pygmy goats, respectively. Protein: Boer goats have higher protein content (3.5-4%), while Saanen goats have lower protein content (3-3.5%). - α-s1 casein: Higher content in Saanen and Murciano-Granadina breeds. - κ-casein: Variable content, impacting micelle stability.	**(Kumar *et al*.,2022)**
	Fat: Saanen goats tend to have higher fat content (4-5%), while Boer goats have lower fat content (2-3%).	**(Ahmad *et al*,.2023)**
	Lactose: Lactose content typically remains around 4.5-5% across breeds, with minimal variation.	**(Kumar *et al*., 2022)**
Diet	- Fat content: Dietary fat supplementation in the ruminant diet is known to be a good strategy to increase beneficial milk fat compounds such as polyunsaturated fatty acids (PUFA) and conjugated linoleic acid (CLA).	**(Pajor *et al*., 2023)**
	- Protein content: Specific supplements, like flaxseed oil, may increase α-s1 casein.	**(Sepehrmanesh *et al*., 2022)**
	Nutrition plays a crucial role in the protein yield and quality of goat's milk. A high-protein diet produces higher milk, while a deficiency in nutrients can negatively affect the milk's quality. The animal's diet also influences milk quality. High-quality forage, probiotics, and omega-3 fatty acids can improve milk composition.	**(ALKaisy *et al*., 2023)**

(Follows)

Factors	Effect on Goat Milk Components	Reference
diet	Nutritional deficiencies: Deficiencies in essential minerals or vitamins can affect milk yield and composition, highlighting the importance of balanced nutrition.	**Sejian *et al.*, 2023)**
lactation stage	Goat's milk's composition and properties vary at different lactation stages, affecting its nutritional value and benefits. -Goat colostrum: the first milk produced after birth, contains immunoglobulins and high levels of protein, fat, vitamins, and minerals. - Early lactation: milk has higher protein, minerals, and fat.	**(ALKaisy *et al.*, 2023)**
Processing	- Homogenization: Affects fat globules, impacting texture and protein-fat interaction. - Pasteurization: May influence protein interactions and micelle stability.	**(Bansal *et al.*, 2023)** **(Galanis *et al.*, 2023)**
Other factors	High levels of stress caused by factors such as rough handling, environmental disturbance, or social disruption can lead to variations in milk composition and properties. Stress-related changes in milk composition can include changes in fat composition. - Animal health: Goat health and welfare significantly impact the protein yield and quality of milk. Stress and poor nutrition can lead to lower protein content, while mastitis can affect milk quality and composition. Nutritional imbalances and metabolic disorders can cause changes in milk fat content, pH, and lactose levels, affecting taste, nutritional value, and processing properties and milk quality.	**(Nava-Salazar *et al.*, 2023)** **(ALKaisy *et al.*, 2023)**

Chapter II

Milk coagulation and coagulation enzymes

The transformation of milk into cheese occurs under the influence of many physicochemical, biochemical and microbiological processes **(Lepilkina and Grigorieva., 2023)**. Milk coagulation is a complex process that plays a crucial role in the production of various dairy products, such as cheese and yogurt. (**Dobozi *et al*., 2023)** and in the digestion of milk products (**Yang *et al.*, 2024**).

Milk coagulation properties (MCP), which includes milk coagulation time, curd firming time, and curd firmness, are an important factor in determining the yield and quality of cheese **(Zhang *et al.*, 2023)**. Milk coagulation can be contributed to enzymatic action, acidification, or a combination of both. Products such as cheese commonly use milk-clotting proteases **(Mohsin *et al.*,2023**). In this chapter, we will discuss about the milk coagulation (mechanism of milk coagulation and The factors affecting it) and milk coagulation enzymes (Definition and Types of enzymes involved in it).

1.Milk coagulation

1.1. Milk coagulating mechanism

In the presence of digestive enzymes (e.g., chymosin and pepsin), κ-casein on the surface of casein micelles is hydrolyzed, resulting in coagulation of casein micelles. Compared to cow milk, a shorter coagulation time and weaker curd consistency of goat milk during chymosin-induced coagulation have been observed, which has been explained by a lower casein content, lower αs1-casein content and larger casein micelle size .With a higher β-/αs-casein ratio, sheep milk is very sensitive to chymosin and tends to coagulate faster than cow or goat milk .In addition, sheep milk generally produces firmer curds and has a slower rate of syneresis due to a higher casein and colloidal calcium content**(Yang *et al* ,. 2024).**

Milk coagulation can be activated by many types of biochemical and physical processes. The most common coagulating agent at dairy plants is the rennet, which contains the chymosin enzyme. Chymosin starts the primary phase of milk coagulation, the proteolytic phase, breaking down the biochemical bond between the two amino acids phenylalanine and methionine, respectively, at positions 105 and 106 of the κ-casein protein chain. The event causes the destabilization of milk micellar structure. Later, during the secondary phase of coagulation, destabilized micelles precipitate and aggregate into a gel. The cutting of the gel into pieces, which is normally made during the cheesemaking processes, is the starting point of a phenomenon named syneresis, during which the network formed by the aggregated micelles facilitates whey expulsion and finally the formation of the fresh curd **(Pazzola, 2019)**.

1.2. Types of milk coagulation

The coagulation of milk is primarily induced using two mechanisms: enzymatic and acid coagulation or a combination of both. Both processes result in a gel-like structure, which ultimately forms the basis of numerous dairy products **(Dobozi *et al.*, 2023).**

1.2.1. Enzymatic coagulation

Enzyme-induced coagulation occurs when enzymes, such as rennet or pure chymosin, break down the casein micelles, leading to the formation of a protein network **(Dobozi *et al.*,2023)**. Enzymatic coagulation has a direct influence on the curd firmness and consequently on the yield obtained (**Beux *et al.*, 2023)**. Milk-clotting enzymes, having fulfilled their main function — milk coagulation — partially pass into cheese and, along with enzymes of starter microorganisms and plasmin, participate in proteolytic processes during cheese ripening **(Lepilkina and Grigorieva., 2023)**. Figure 02 illustrates the mechanism of the milk-clotting enzyme process.

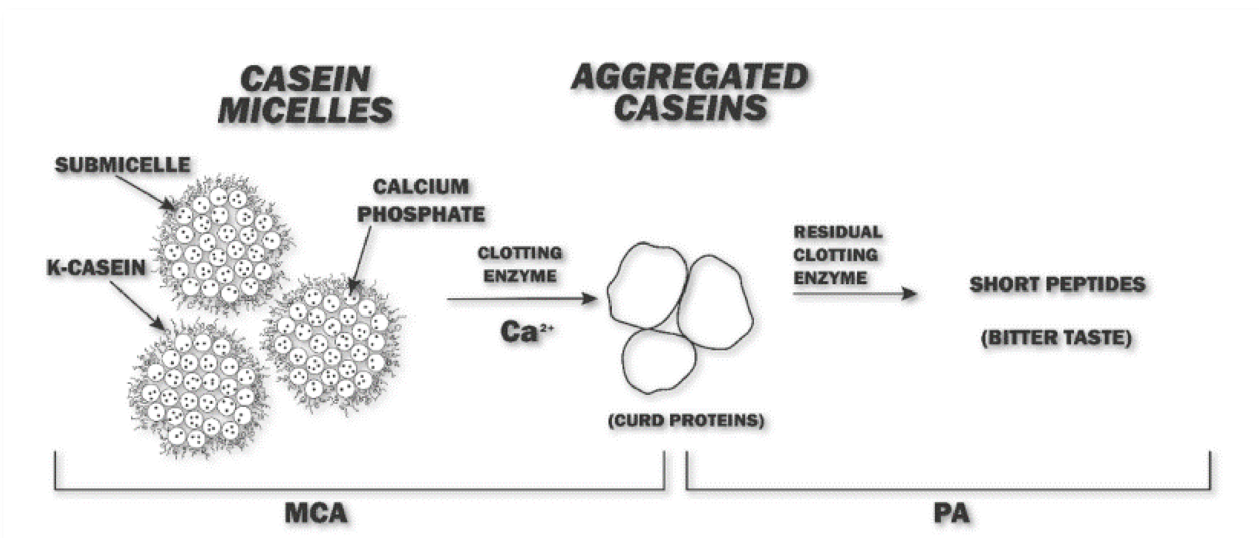


Figure 02. Degradation of caseins by clotting enzyme and development of bitter peptides. MCA = Milk-clotting activity, PA = Proteolytic activity (**Nicosia *et al.*, 2022).**

1.2.2. Acid coagulation

The acid coagulation is triggered by the reduction of milk's pH, which destabilizes the casein micelles and leads to aggregation and subsequent network formation **(Dobozi *et al.*, 2023)**. The acid coagulation of milk is the basis for a wide diversity of cultured dairy products. Acidification directly impacts the stability of casein micelles, reducing their charge, dissolving some of the insoluble calcium phosphate crosslinks and modifying internal bonding between proteins. The formation of aggregates and ultimately gels occurs at some critical point when electrostatic repulsion is reduced and is not sufficient to overcome attractive forces, like hydrophobic interactions. Acid-induced milk gels increase in stiffness with time due to on-going bond formation between casein particles within the network. In gels made from heated milk, an increase in the loss tangent parameter is observed for a short period after gelation; this phenomenon is due to the loss of insoluble calcium phosphate crosslinks within the casein particles that are already forming the gel matrix **(Lucey, 2016)**.

1.2.3. Mixed coagulation

Two phenomenon are used in mixed coagulation: acidification, which involves utilizing lactic ferments to convert lactose into lactic acid in order to precipitate isoelectric caseins, and the addition of the coagulant enzyme. Temperatures between 28 and 32°C are necessary for this coagulation process **(Remache *et al*., 2020)**.

1.3. Effect of environmental factors on milk coagulation

Cheese-making process includes decisive factors determining the variability of cheese types: raw milk rather than heat treated milk and use of starters, milk temperature at coagulation, type and amount of coagulant, broken curd size, drainage and pressing process (washing curd, curd heat treatments), pressing conditions, dry salting or brine practices, size of the cheese, ripening conditions (washing rind or not, place, etc.) **(Fresno *et al.*,2023)**. Several factors such as chemical composition (protein and fat), mainly concerning casein and its fractions, concentration of the coagulant enzyme, temperature of coagulation, somatic cell content, pH, and environmental factors may influence coagulation. The milk composition may change seasonally **(Beux *et al*., 2023)**.

1.3.1. Temperature

Most milk coagulation enzymes, like rennet and chymosin, have an optimal temperature range between **30-40°C (86-104°F)**. Activity decreases due to enzyme denaturation (deactivation), potentially resulting in uneven curd formation **(Fox, 2023)**. Milk coagulation shows a high dependence on temperature. It is known that temperature affects both the enzymatic and non-enzymatic phase of aggregation during milk coagulation, and it was found that this effect is far greater on the secondary phase, i.e., on the aggregation reaction itself. The temperature of the milk affects protein aggregation to a large extent and increasing temperature increases the rate of gel firming (aggregation rate). found that lowering the coagulation temperature results in a finer protein network, and that a higher temperature increases the strength of the gel and the gel firming rate. However, goat cheeses usually fall into the group of fresh or white unripened cheeses and soft cheeses, because of their fragile rennet gel, and the coagulation temperature in their production is lower than for the hard type of cheeses. The effect of high temperatures on the components of goat milk, especially on proteins, is different compared to the effect they have on cow milk, so high heat treatments of milk can be applied in the production of goat cheese. The application of high temperatures causes the denaturation of whey proteins and the formation of coaggregates, whereby these components are incorporated into the cheese mass, which contributes to the increase of goat cheese yield and improves its biological value (**Hovjecki *et al.*, 2022)**.

1.3.2.pH

Enzymes generally have a specific pH range where they function best. For rennet, the optimal range is around **6.6-6.8**. Above optimal, Milk casein becomes insoluble, preventing curd formation **(McSweeney, 2023**). The influence of milk pH on coagulation time is very pronounced. Lowering the pH from 7.0 to 5.2 shortens the RCT, with the optimal pH for hydrolysis of κ-casein in the range of 5.1–5.3. The most important effects of lowering the pH of milk are the dissolving of micellar calcium phosphate, reduction in the net charge of the casein as well as dissociation of caseins from micelles. Additionally, it has been reported that limited pH lowering leads to an increase in the gel firming rate **(Hovjecki *et al.*,2022)**.

1.3.3.Calcium and sodium ions

Calcium ions Play a crucial role in binding rennet to casein, initiating coagulation. Increased calcium concentration generally accelerates coagulation. **Sodium ions** Can compete with calcium for binding sites, potentially inhibiting coagulation.

1.3.4.Milk composition

Fat and protein content can influence coagulation time and curd firmness. Moreover, milk proteins play critical roles in milk coagulation, although the detailed reason remain yet unknown. The total concentration of milk protein in bovine mature milk is about 36 g/L. The milk protein in bovine milk can be mainly classified as caseins (~80%), whey proteins (~16%), and milk fat globule membrane (MFGM) proteins (1–4%). The important roles of caseins in milk coagulation has been widely studied. For example, lower relative κ-CN content in poor coagulation (PC) and non-coagulation (NC) milk has been related to the negative correlation between κ-CN content and casein micelle size. Next to protein composition, also post translational modification (PTM) of caseins seems to affect the MCP **(Zhang *et al.*, 2023)**.

In general, a higher concentration of fat in milk occurs in colder seasons. Thermal stress, associated with high temperature and relative humidity, harms milk production and composition and presence of inhibitors Some milk components and natural inhibitors can hinder enzyme activity, different sources and types and concentration of the coagulant enzyme may have varying sensitivities to environmental factors, it may affect milk capacity of coagulation **(Beux et *al.*,2023)**.

2.Milk coagulation enzymes

2.1. Definition of coagulating enzymes

Milk clotting enzyme is an enzyme complex that contains many enzymes: chymosin or rennin and protease which are the major enzymes used in the cheese industry. Moreover, it contains other important enzymes such as pepsin and lipase. Milk clotting enzymes facilitate milk clotting and also control cheese yield, texture, and favor. Cheese is a milk derivative that is rich in protein, fat, sodium, and calcium. It is produced by adding the starter culture and milk clotting enzyme. The type of milk-clotting enzyme plays a vital role in milk coagulation and cheese maturation as it has a significant impact on the quality of the produced cheese **(Dobozi *et al.*, 2023)**. there are different types of commercial and/or traditional rennet (TR), depending on their origin (animal, plant, microbial and recombinant technology) and physical state (liquid, powder and paste) (**Salık *et al.*, 2023)**.

There are two types of coagulating enzymes:

Chymosin, Single polypeptide chain (~36 kDa) with two domains: N-terminal catalytic domain and C-terminal β-barrel domain (**McSweeney, 2023**), it includes **peptidase A** and **peptidase B**, influencing cheese ripening and flavor development **(Law and Tamime, 2010)**.

Pepsin, Larger and more acidic than chymosin, exhibiting broader proteolytic activity beyond casein cleavage (**Fox, 2023**).

Additionally, the enzymatic (rennet-induced) coagulation of milk can be divided into two phases: (1) hydrolysis of the micelle-stabilizing protein, κ-casein, (2) aggregation and gelation of the rennet-altered micelles, with the development of a particulate gel **(Fox *et al.*,2017)**.

2.2. Types of coagulating enzymes

2.2.1. Animal enzyme

The traditional milk clotting enzyme used in the cheese industry is rennet, a substance derived from the fourth layer of a young (10-30 days-old) calf stomach. The primary component of rennet is chymosin (80-90%), with a lesser amount of pepsin, but their actual proportions vary depending on the calf age. Due to the continual increase in global cheese consumption, calf rennet is unable to meet the growing demands in cheese production. A number of researchers have been exploring rennet substitutes and some of which have been applied to industrial-scale cheese production, including chicken, bovine, fungal rennet **(Arbita and Zhao, 2023)**. Most European cheese use animal rennet for coagulating milk **(Hirpara *et al.*, 2021)**.

2.2.2. Vegetable enzyme

Plant-based milk coagulants offer alternatives to cater to the currently available coagulants' issues including religious and vegetarian restrictions. The composition of vegetable-based rennet alternatives in the cheese may also be a feasible solution for consumers who avoid foods containing genetically modified organism (GMO)-derived ingredients. The plant proteases for milk coagulation can be derived from various parts of plants such as fruits, leaves, flowers, seeds, latex, and rhizomes. Some coagulants are even extracted from unusable parts of plants. For example, *Solanum elaeagnifolium*, known as silverleaf nightshade, has milk-clotting properties despite negatively impacted the crop yield. The utilization of plant-based coagulants for milk coagulation, particularly in cheese production, has gained interest due to issues associated with animal and microbial rennet. Plant proteases, including aspartic, serine, and cysteine proteases, possess milk-clotting properties and can be found in various plant sources (**Mohsin *et al.*, 2023)**.

Extracted from plants like artichoke thistle, structurally different from animal chymosin but exhibiting similar milk-clotting activity. (**Wang *et al*., 2023)**. **Liu et al in 2023،** Determined the high-resolution crystal structure of papain in complex with κ-casein, revealing the specific interactions responsible for its milk-clotting activity. **Yang *et al* in 2023**, Used computational modeling to identify potential new plant enzymes with milk-clotting properties, expanding options for cheesemakers.

2.2.3. Microbial enzyme

The most widely used microbial rennet substitutes are Miehei coagulant (*Rhizomucor miehei* proteinase), Pusillus coagulant (*Rhizomucor pusillus* proteinase), and Parasitica coagulant (*Cryphonectria parasitica* proteinase), which have a three-dimensional structure similar to chymosin. Miehei coagulant dominates the market for microbial coagulants. It is capable of hydrolysing, in the same way, as the Phe105–Met106 bond of κ-casein and is less proteolytic than the native form (**(Mohsin *et al.*,2023)**. *Rhizomucor miehei* structurally identical to animal chymosin. (**McSweeney,2023**). Microbial coagulants offer an advantage in the adherence to kosher, halal, and vegetarian dietary principles. However, they have drawbacks including low specificity, high thermal stability, lower milk-clotting activity (MCA)/proteolytic activity (PA) ratio compared with calf rennet, and a higher likelihood of imparting bitterness to cheese. Genetically engineered chymosin can be used alongside animal chymosin to meet market demands for quantity and quality. The chymosin gene can be expressed in a proper plant host to produce greater quantities and higher quality chymosin than from an animal source. Nevertheless, the use of genetically modified organisms (GMOs) in their production raises ethical concerns related to consumer acceptance, labelling requirements, and potential long-term effects on human health and the environment **(Mohsin *et al.*,2023).**

2.2.4. Recombinant enzyme

Produced using genetically modified microorganisms expressing chymosin gene. Identical to animal chymosin in structure and function, offering a pure and consistent alternative **(*Barry and Tamime., 2010*)**.

2.3. Function of coagulating enzymes

2.3.1. Curd formation

The primary function of milk coagulation enzymes is to hydrolyze specific bonds within casein (break down kappa-casein), causing it to aggregate into a gel-like network, forming the curds. This curd separation from whey initiates the cheesemaking process (**Dobozi *et al.*, 2023).**

2.3.2. Texture development

The type and activity of the enzyme influence the size, firmness, and elasticity of the curds, impacting the final texture of the cheese. For example, chymosin in animal rennet creates a smoother texture compared to some microbial alternatives.

2.3.3. Flavor precursors

Enzymes like peptidase A and B present in rennet contribute to flavor development during ripening by breaking down casein further, releasing peptides contributing to cheese's unique taste profile.

2.3.4. Ripening acceleration

Some enzymes, like those in GDL (Glucono-δ-lactone), can gradually reduce milk pH, creating a favorable environment for starter cultures and accelerating initial stages of ripening

2.4. Use of coagulating enzymes in goat cheese

Ren (2010) conducted a study on goat cheese production using fresh goat milk. The milk was pasteurized, fermented, and flavored with calcium chloride and chymosin (1: 100,000 strengths, calf rennet enzyme; Zhengzhou Universe Food Ingredient Limited Company, Henan, China; CAS No. 9001-98-3). The curds were cut into cubes, weighed, and salt was added. The cheese was pressed for 6 hours, then matured in an incubator at 11.5°C with 70% relative humidity. After 7 days, the cheese was divided into fan-shaped pieces and allowed to mature for up to 60 days (**Jia *et al.*,2021)**.

Goat Milk samples were heated to 35°C, mixed with a rennet solution (80 ± 5% chymosin and 20 ± 5% pepsin; diluted to 1.2% (wt/vol) in distilled water), and tested on a lactodynamograph. After coagulation, samples were cut and cooked for 30 minutes. After further cutting, the curd was separated from the whey using a funnel and a metallic net. Whey was collected and weighed, and the composition of the whey was assessed using an infrared spectrophotometer (**Pazzola *et al.*, 2019)** .

Anevato is a soft cheese made from goat or ewe milk or a mixture of both. Cheese made from raw goat milk showed the highest counts of most microbial groups in drained curd (lactic-rennet coagulation at 18–20°C for 12 h followed by draining for 24 h), when the pH was 4.28. During cold storage for 60 days, cheese pH did not change and numbers of most microbial groups declined while yeast counts increased by 1.2 log cycles. Anevato cheese made from raw goat milk showed higher counts for all microbial groups except yeasts, more intense hydrolysis of αs1- and β-casein and higher flavor scores than if made from pasteurized or thermized milk, while the aroma and texture were not influenced by milk heat treatment **(Medina and Nuñez, 2017).**

Chapter III

Traditional cheese in Algeria

Traditional cheeses represent an integral part of each country's national heritage, where each unique cheese variety serves as an authentic reflection of its region of origin, incorporating local resources and age-old customs **(Senoussi *et al*., 2024).**

In Algeria, the consumption of dairy products is an old tradition linked to livestock farming, since dairy products are made by means of ancient artisanal processes, using milk or mixtures of milk from different species. There is a wide variety of artisanal dairy products, their denomination as well as their manufacturing process differing from one region to another. These products also differ in their taste and their consistency **(Leksir *et al*., 2019).** In this chapter, we will discuss the characteristics of cheese in Algeria and the challenges of its production.

1.Cultural significance of cheese in Algeria

Cheese is considered a symbol of generosity and hospitality in Algerian culture (**Boualem *et al*,.2019**). Cheese is traditionally offered to guests as a welcome gesture. Cheese is used in many traditional Algerian dishes, such as couscous and tajine. Cheese is an integral part of many Algerian celebrations and festivities. Algerian traditional cheeses are divided into different classes including: processed cheeses (Medghissa), ripened cheeses (Bouhazza), hard cheeses (Klila, Takammart), and fresh cheeses (Ighounane, Mechouna, Jben) (**Leksir *et al*,.2019**).

2. Economic importance of traditional cheesemaking

Traditional cheesemaking is a vital source of income for many families in Algeria, particularly in rural areas (**Azzi *et al*.,2020)**. The cheesemaking industry contributes to the national economy by providing employment opportunities and generating value addition (**Ghorab *et al*., 2021**). Traditional cheesemaking is an important part of Algeria's cultural heritage, contributing to tourism and local development (**Djebbar *et al*., 2020).** The diversity of Algerian traditional cheeses reflects its rich culture and history, offering a unique experience for cheese enthusiasts. Traditional cheese production plays a crucial role in providing job opportunities and income in rural areas, boosting agricultural production, and stimulating local economies (**Benamara *et al*., 2016; Ghorab *et al*., 2021).** Dominated by women, the industry offers them opportunities for empowerment, achieving financial independence, and enhancing gender equality **(Khoualdi et al., 2015; Khoualdi., 2017).** The industry faces challenges like limited funding and government support, weak organization and marketing, and unhygienic practices **(Derouiche and Medjoudj, 2019).** These challenges can be overcome by investing in production technique development and product quality improvement, strengthening cooperatives, and supporting local and international product marketing **(Ghorab *et al*., 2021).**

3. Characteristics of traditional Algerian cheeses

3.1. Djben

Jben is among the most famous traditional varieties, the production method of which remains in use today, and its consumption is increasing due to its pleasant sensory and nutritional properties. *Jben* is a traditional cheese widely made and enjoyed throughout the country, especially in the east. *Jben* is a traditional fresh cheese, made from raw milk (sheep milk or goat milk or cow) of ruminant curdled by coagulating enzyme of vegetable or animal origin after a stage of spontaneous acidification (**Tabet *et al.*, 2023)**.

3.2. Klila (fresh and dry)

"*Klila*" is a fermented cheese produced empirically in several regions of Algeria. It is the most popular traditional cheese and its artisanal manufacturing process is still in use today. The processing consists of moderate heating of "*Lben*" (55–75 °C) until it becomes curdled, and then drained in muslin. The cheese obtained is consumed as it stands, fresh, or after drying. When dried (2 to 15 days depending on the season), it is used as an ingredient after its rehydration in traditional culinary preparations. In its dehydrated form, it can be kept for several years at room temperature, in terracotta jars or goatskin bags.

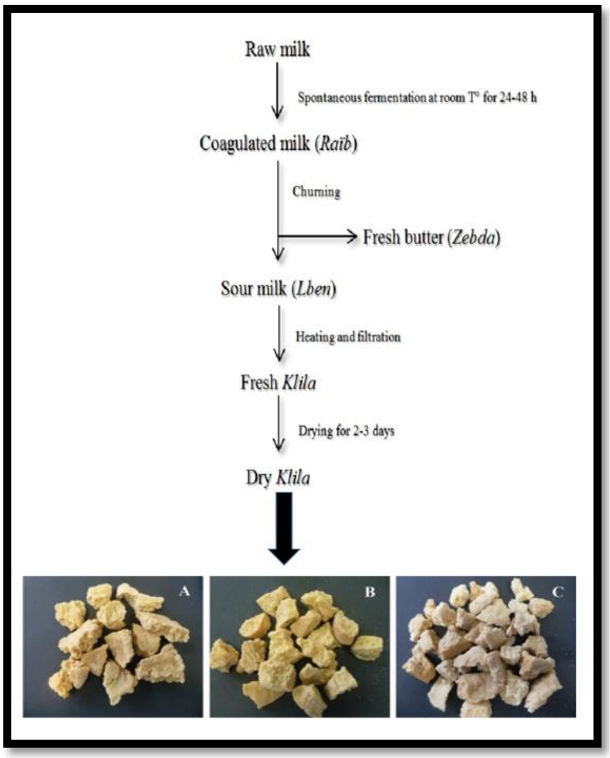


Figure 03. Klila cheese processing steps with use deferent type of milk (A: made with goat milk. B: made with ewe milk. C: made with cow milk). (**Benlahcen *et al.*, 2017; Benamara *et al.*, 2022).**

3.3. Takemmarit

It is a traditional cheese made only from goat milk, and it is made by women according to traditional methods in the regions of "M'zab" especially in the wilayates (districts) of Ghardaia and Naama (northern central and northern west of Algeria). "*Kemariya*" is a cheese that is often eaten as a dessert during the festive seasons with honey, peanuts, and served with mint tea. It is coagulated by vegetable or animal rennet and is also made from cow and camel milk. Due to the high demand for this cheese, it is increasingly produced by small factories in semi-industrial processes to be sold both in traditional markets and in some supermarkets of northern Algeria (**Leksir *et al.*, 2019)**.

3.4. Bouhezza

This is a traditional, soft-ripened cheese from the eastern regions of Algeria (Oum El Bouaghi, Khenchela, Batna…) once famous because of an important practice of extensive goat and sheep farming. Originally, "Bouhezza" was traditionally the product of the processing of goat milk and ewes, but the current trend seems to be towards the use of cow milk. The cheese is obtained after the transformation of the "Lben" in a "skinbag" or a "Chekoua" made of goatskin previously treated with salt and juniper. This cheese is made without rennet, suffers no heat treatment; the self-regulation of manufacturing is based on the salt and the acid produced by the indigenous microflora of milk. They contribute to protect the product regarding the contamination flora and pathogenic germs, and thus keep cheese safely. Draining, salting, and refining "Bouhezza" are performed simultaneously in the "Chekoua" for a period of 2 to 3 months. During the ripening period, "Lben" and milk are added to the contents of the "Chekoua." The Chekoua is suspended in a ventilated area or in the shade. At the consumption stage, the cheese is kneaded with the adjunction of red pepper powder, which gives it a particular characteristic **(Medjoudj *et al.*, 2017; Leksir *et al.*, 2019).**

Figure 04. "*Bouhezza*" processing steps (**Boudalia *et al.*, 2020)** .

3.5. Adghess

Adghess is a fresh cheese frequently made in the region, especially in rural areas. This cheese is very popular with the people of the region of Oum El Bouaghi; however, its preparation depends mainly on the availability of the raw material and the livestock of each family. Its production remains less widespread, and its practice does not go beyond the areas of origin. The maximum storage period was 6 days at a temperature between 4°C and 6°C. The traditional diagram of Adghess cheese-making is illustrated in Figure 1. The maximum storage period, as determined by the survey, was six days. (**Derouiche *et al.*,2023).**

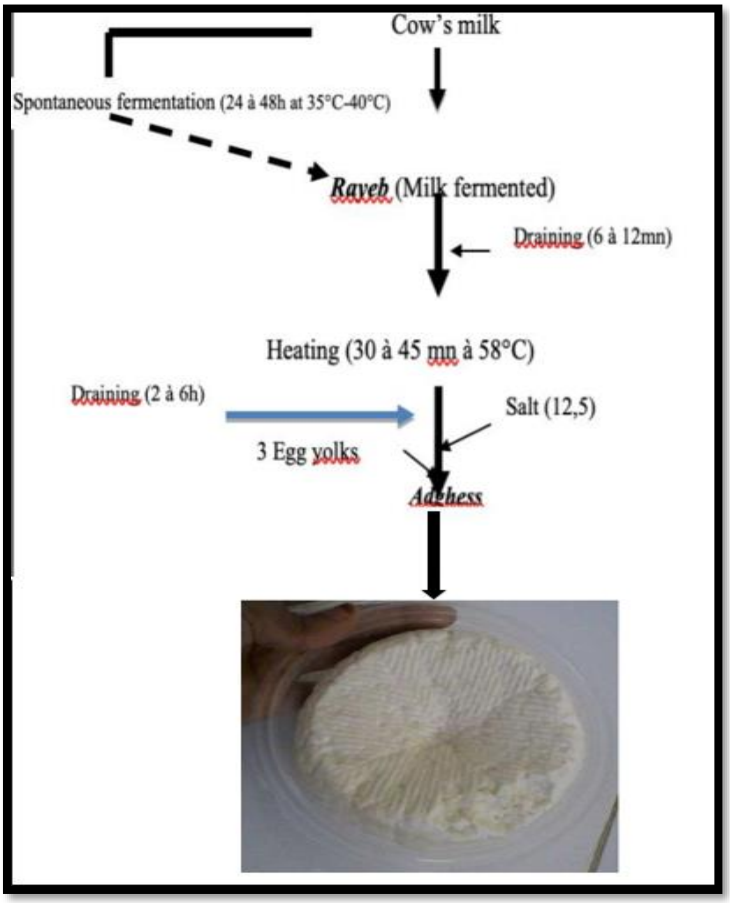


Figure 05. Adghess processing steps **(Derouiche *et al.*, 2023)**

3.6. *DOUTH* cheese

Jben is a traditional Algerian cheese made by the Souafa people in El-Oued region. They create five fresh Jben cheese échantillons using a traditional method. The process involves preparing a cheese mixture, adding a small amount of preservative, pressing the cheese to release enzymes, and leaving the cheese for about 24 hours. The cheese is then pressed into a piece of parchment paper, separating the lactose and the cailles. The cheese is then placed in a round mould and pressed (**Ben Omor *et al.*, 2013**).

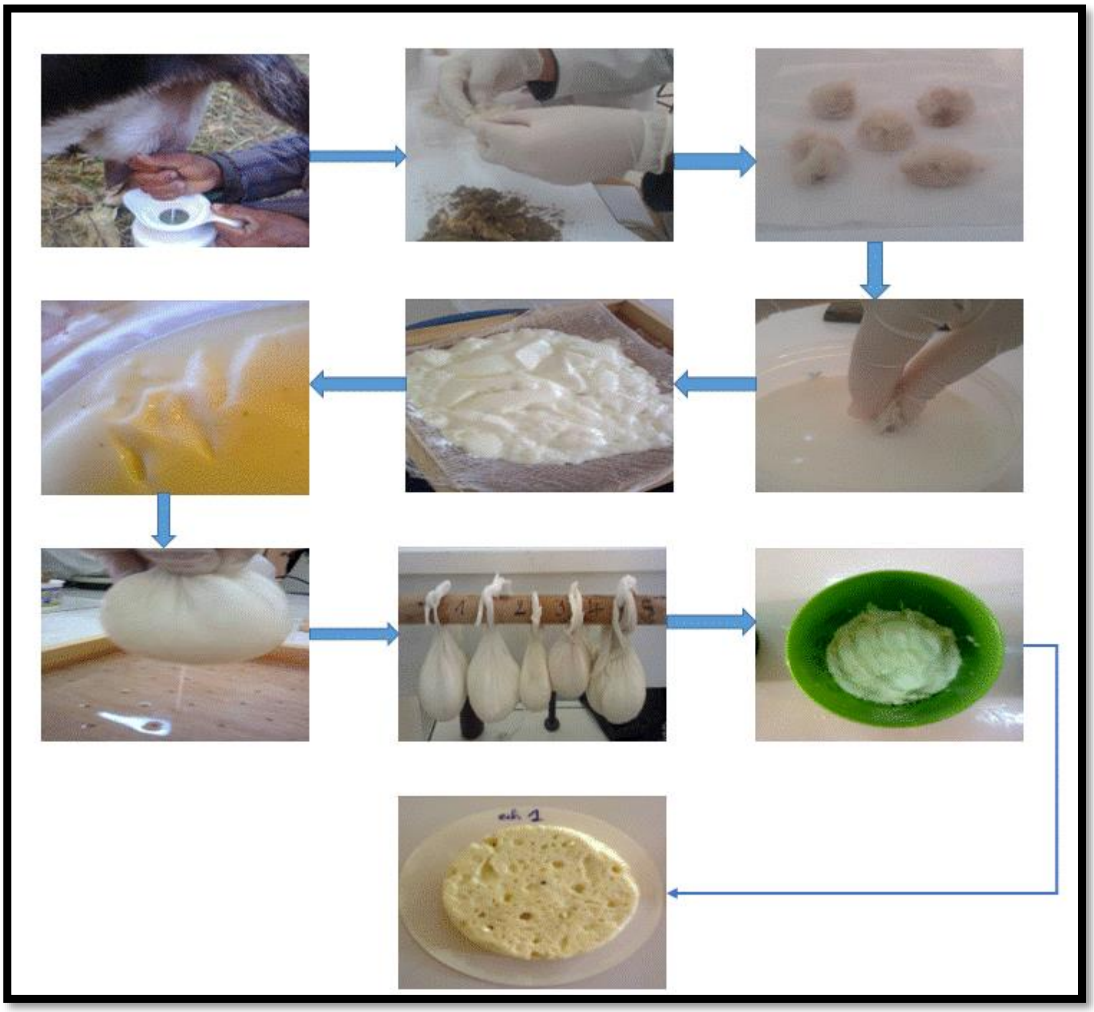


Figure 06. *DOUTH* cheese processing steps (**Ben Omor *et al.*, 2013**).

Algerian traditional cheeses showcase remarkable diversity, classified based on various factors. Figure 07 presents the classification of some traditional cheese in Algeria.

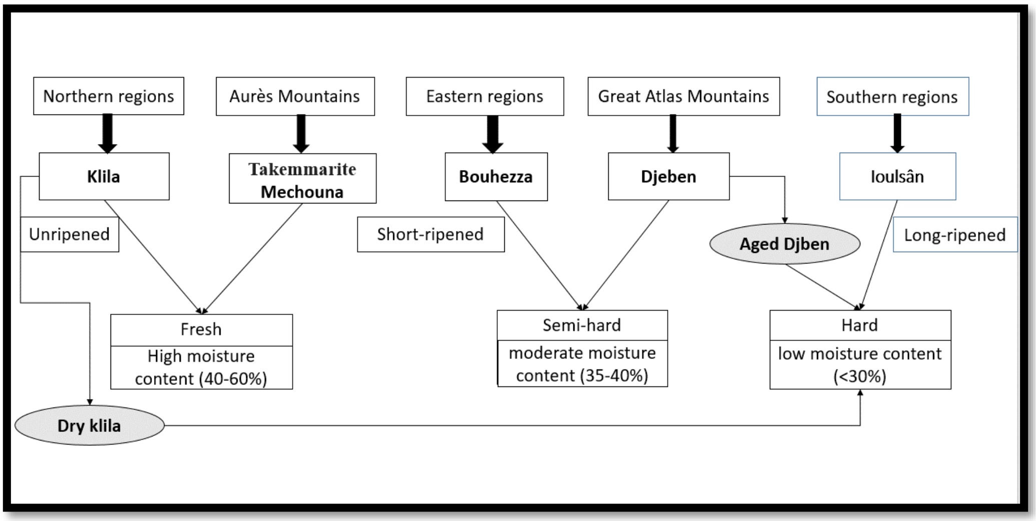


Figure 07. Classification of some traditional cheese in Algeria

4. Factors influencing cheese characteristics

- ✓ **Milk composition:** fat content has an important influence on the melting characteristics of cheese (**Atik and Huppertz. 2023)**. Curd firmness and cheese yield in general increase with protein content, and lactose influences sweetness and acidity. Different milk types (cow, sheep, goat) possess varying fat, protein, and lactose content, impacting texture, flavor, and aroma. Seasonal variations in the composition and quality of milk, particularly those in late lactation, have a significant influence on curd formation as well as on cheese yield and composition with subsequent impact on cheese sensorial and physicochemical quality (**Galli *et al.,* 2023)** .
- ✓ **Microflora:** Different microbial cultures introduced during production contribute to specific flavors, aromas, and textures **(McSweeney *et al.,* 2017).** Takammart's unique flavor, for example, is attributed to its specific fermentation process. The specific microbial community introduced during production plays a crucial role in cheese development, affecting acidity, texture, and aroma **(McSweeney *et al.,*2017; Medjoudj *et al.,*2017).**
- ✓ **Salting:** Salting amount and timing affect moisture content, texture, and preservation. Djben's salty flavor is a direct result of its salting technique **(Benkerroum, 2013)**. Salting techniques, including amount and timing, influence moisture content, texture, and preservation **(Benkerroum, 2013; Oliszewski *et al*., 2007).**
- ✓ **Ripening conditions:** Temperature, humidity, and duration of ripening significantly impact flavor, texture, and aroma development. Ioulsân's long ripening period in dry conditions contributes to its unique crumbly texture and concentrated flavor **(Khoualdi, 2017).** Temperature, humidity, and duration of ripening significantly affect flavor, texture, and aroma development **(McSweeney et al., 2017; Leclercq-Perlat *et al*., 2019).**
- ✓ **Regional variations:** Local ingredients, traditional practices, and climatic conditions influence cheese characteristics. The use of spices in Bouhezza from Constantine and the specific fermentation process of Takammart in the M'zab Valley are examples of regional variations **(Benamara *et al*., 2016; Ghorab *et al*., 2021)**. Traditional practices, local ingredients, and climatic conditions contribute to regional specialties **(Benamara et al., 2016; Derouiche and Medjoudj, 2019).**

5. Challenges and Opportunities facing traditional cheeses

5.1. Challenges

-Limited funding and government support: The traditional cheese industry lacks adequate funding and government support for production technique development and product quality improvement **(Benamara, 2016).**

-Unhygienic practices: Many traditional cheese workshops lack proper hygiene practices, potentially impacting product safety **(Derouiche and Medjoudj, 2019).**

-Weak organization and marketing: The industry struggles with weak organization and marketing, limiting access to local and international markets **(Khoualdi *et al.*, 2015).**

-Competition from industrial products: Traditional cheese faces stiff competition from lower-priced industrial products **(Ghorab *et al.*,2021).**

5.2. Opportunities

-Growing demand for natural products: Rising consumer demand for natural and traditional products presents a growth opportunity for the industry **(Benamara. 2016).**

-Rich diversity of Algerian cheese: Algeria boasts a wide variety of traditional cheeses, offering a distinct competitive advantage in local and international markets **(Derouiche and Medjoudj. 2019)**.

-Potential for production development: Leveraging scientific research and modern technologies holds immense potential for production technique development and quality improvement **(Khoualdi *et al.*, 2015).**

-Cooperatives: Cooperatives can play a crucial role in supporting the industry by providing funding, training, and technical assistance **(Ghorab *et al.*, 2021).**

5.3. Role of cooperatives

-Financing: Cooperatives can provide necessary funds for equipment, raw materials, and workshop infrastructure improvements.

-Training: Training programs on modern production techniques and food safety practices can be offered to cheesemakers.

-Technical assistance: Cooperatives can offer technical support to improve product quality and production techniques.

-Marketing: They can work on marketing traditional cheese products in local and international markets.

5.4. Economic and social impacts of cheesemaking

-Job creation: The industry provides employment opportunities, particularly in rural areas.

-Local economy boost: Traditional cheesemaking contributes to the local economy by stimulating agricultural production and increasing income.

-Cultural heritage preservation: As part of Algeria's cultural heritage, the industry helps preserve the community's cultural identity.

Part II

Material and methods

This study was carried out at different laboratories:

-Educational laboratory of the Faculty of Nature and Life Sciences, University of El Oued;
-Educational laboratory of chemistry and physics of the exact sciences faculty, University of El Oued;
-Laboratory Center for Research and Physio-Chemical Analysis (CRAPC) in Ouargla and Bousmail;
-Private quality control and compliance laboratory FATILAB, El Oued.

The objective of this study is the characterization of a traditional local cheese (*DOUTH*); made with goat's milk and coagulated with dried and dirty caprine abomasum from four (04) region of the Wilaya of El Oued).

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

Part one: study of biological raw materiel

1.Goat milk

1.1. Crude composition analysis

2. Traditional goat abomasa (TGA)

2.1. Steps of preparation of TGA

2.2. Crude and mineral composition analysis of TGA

2.3. Infrared /diffraction X-ray analysis

Part two: cheese-making of *DOUTH* cheese

1.Steps of manufacture of *DOUTH* cheese

Part three: Characteristics of *DOUTH* cheese

1. Crude and mineral composition analysis

2. Microbiological analysis

3. FTIR /diffraction X-ray analysis

4.Microstructure analysis

5.Sensoriel profile analysis

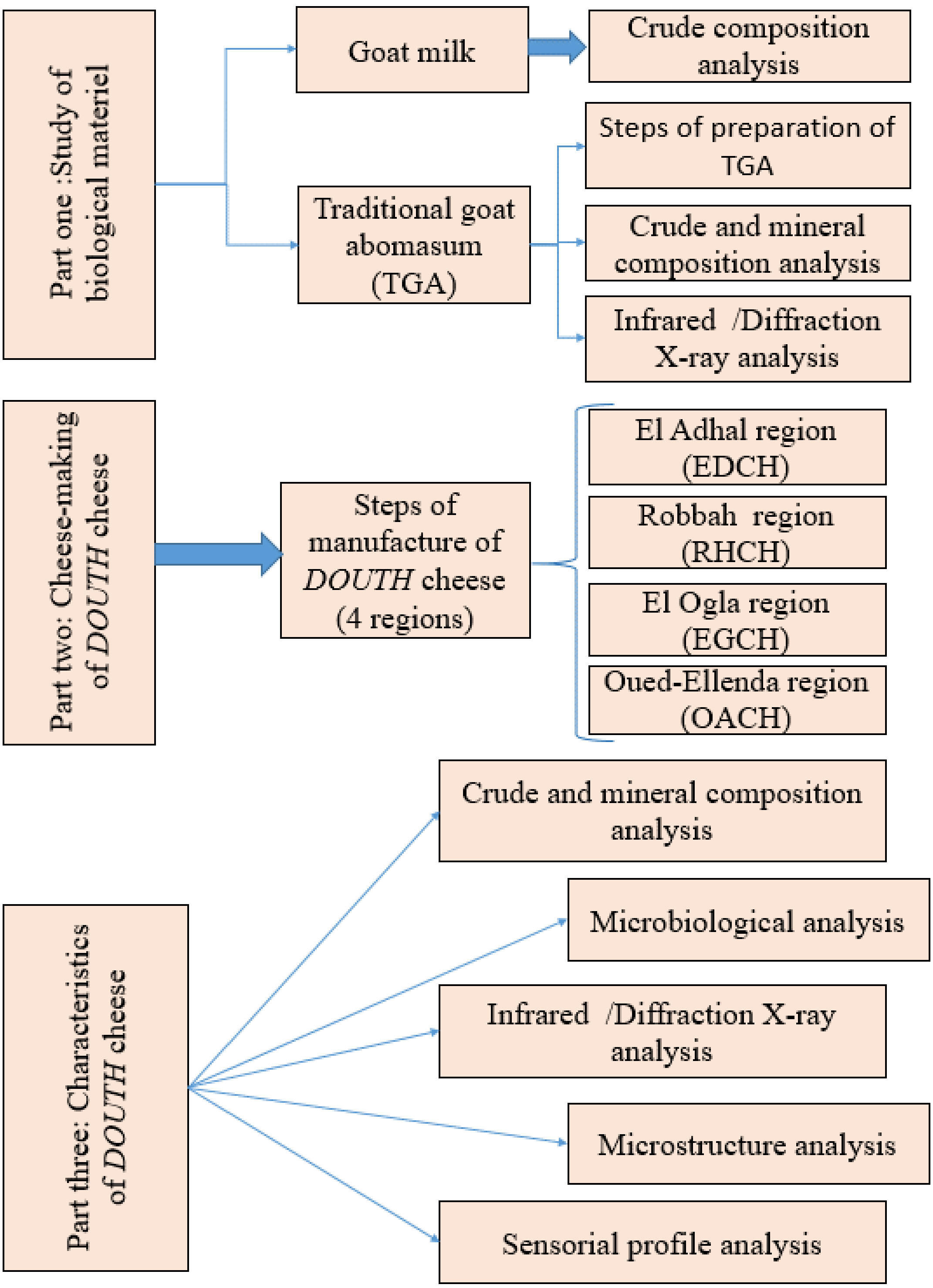


Figure o8. Experimental diagram of the study

I. Study regions

In our study, we selected four regions (Oued Allenda, Robbah, El Ogla, Hassi Khelifa (El-Adhal)) which are presented in Figure 08.

Figure 09. Geographical location of study areas

II. Materiel

II.1. Biological materiel

II.1.1. Goat milk

The goat milk used in our study was brought back to leaving four regions: Hassi Khalifa (Eladhal), Robbah, Elogla and Oued-Elalanda. All the samples of the milks (1l of each region) were collected from a single livestock from goat. All details that concern the breed of the checked, the age and the lactation stadium are announced in Table 04.

Table 04. Details of the goat

Samples	Breed	Old	Diet	Breeding method	Regions	Original figure
01	*Arbia*	5 years	-dry date - fodder -Wheat Bran	Intensive	Hassi Khalifa (El-Adhal)	

02	*Arbia*	4 years	-Peels of vegetables and fruits -Dry bread - fodder	Intensive	Robbah	
03	*Arbia*	4 years	-fodder -dried clover	Intensive	Elogla	
04	*Arbia*	3 years	-Fodder -dried clover	Intensive	Oued-Elalanda	

II.1.2. Traditional goat Abomasa (TGA)

The TGA used in our study was brought back to leaving four regions: Hassi Khalifa (Eladhal), Robbah, Elogla and Oued-Elalanda. It was collected 4-7 g of the samples of the TGA. All details that concern the region of the samples, the age and the quantity are announced in Table 05.

Table 05. Properties of TGA

Region	Duration of storage	Quantity	Figure

RHGR	6 month	1g	
OAGR	2 year	3g	
EDGR	1year	2g	
EGGR	8 month	1.5g	

II.2. Machines

The different machines used during our study are as follows: Precision balance, Balance (KERN), Milco Scan (Master Pro touch), pH meter (inoLab), IR, Dessicator (Clatronic), Sterilization autoclave, Freezer -10°C, Refrigerator at + 4°C, Stirrer (Lab Tech), Incubation oven and X-ray diffraction.

II.3. Small materiel

The manipulations required the use of the following small equipment: micropipette (1000 µl), beaker, burette graduated with support, dropper, cylindrical graduated cylinder without spout, capsule in aluminum, disposable tip, boite pétrie, pasteur pipette, test tube holder, scissor, wash bottle of distilled water, sterile flasks, Erlenmeyer flask, spatula, watch glass, pipette, sterile boxes, filter paper and glass funnel.

II.4. Chemical product and reagents

Solvents and Reactive: soude (NaOH), acide sulfurique, alcool iso amylique, alcool, Chloride de calcium (CaCl2), distilled water, ultra-pure water, HCl, KH2PO4, Na2HPO4, Glutraldehide 25% and phénophtaléine.

III. Method

Part one: Study of the biological material

I.Goat milk

I.1 crude and mineral composition of goat milk

The crude characterization was carried out on goat milk and The measured physio-chemical parameters are: pH, 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.

II.Traditional goat abomasum (TGA)

II.1. Preparation steps of TGA

TGA was prepared from a newborn kid of goat. The stages of TGA preparation are presented in Figure 09. It is important to note that the preparation methodology was the same in all regions of the study.

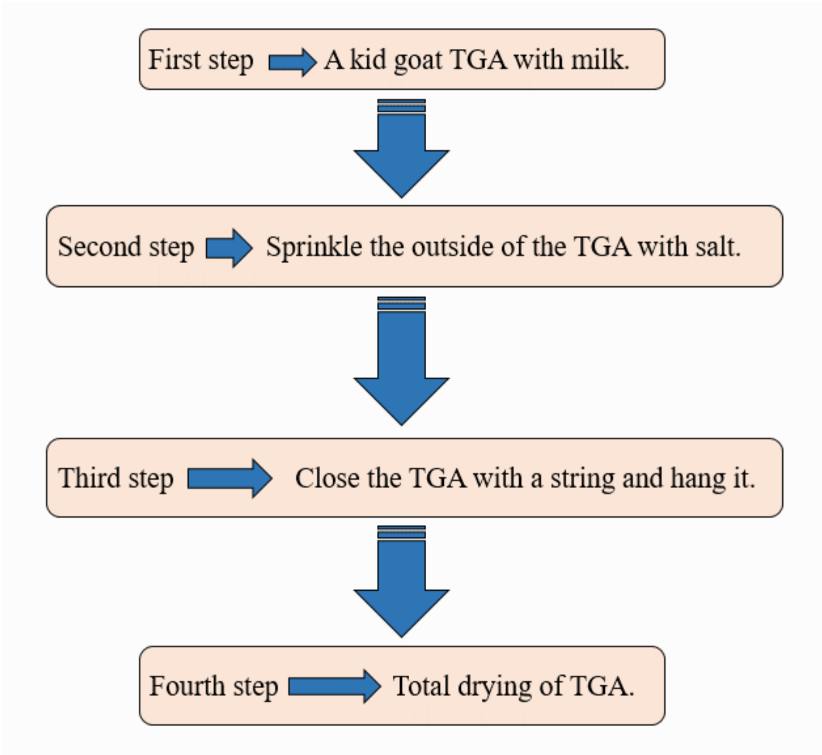


Figure 10. preparation steps of TGA

II.2. Crude and minerals composition

The crude composition of TGA is carried out according to the techniques described by **AOAC (2016)** the PH is determined by dissolving 1g of newly made TGA in 10 ml of distilled water using a digital PH meter (Inolab,Germany)(before each measurement, the pH meter electrode is cleaned with tap water, then rinsed with distilled water and dried with paper).The dry matter content is determined by drying 1g of TGA in an oven (Binder , France) at 105 for 24 h.ash content is determined by total incineration of the dry materiel at 550 for 7 h .The total nitrogen content was carried out according to Kjeldahl method (Buchi,Easy Kjel ,France) and protein content was deduced from total nitrogen content by multiplying by a conversion factor of 6.38.fat content was determined according to Van Gulik method (Funke Gerber centrifugal, Germany).The mineral elements (Ca, P, Na ,K ,Mg, Fe, Mn and Cu) were measured separately using an atomic absorption spectrophotometer (Thermo scientific ,ICE 3000).The measurement of physicochemical parameters and minerals was carried out in triplicate .

II.3. FTIR spectra and X-ray diffraction analysis

1g of TGA powder was used for each sample.

II.3.1. FTIR

FTIR spectra of TGA were obtained using FT-IR spectrum (Agilent Technologies, carry 630, USA).TGA was placed directly on top of the crystal and either pressed down onto or measured without pressing. Spectra were recorded at 20 °C from 4000 to 450 cm at a normal resolution of 8 cm with an accumulation of 4 scans for each spectrum. The background spectrum, which contains the absorptions of molecules present in the air,was scanned at the beginning of measurement by pouring the ATR cell with distilled water. The saine procedure was used for scanning blank spectra, with contains the absorption of distilled water.After each. measurement, the ATR crystal was thoroughly washed with ethanol and distilled water and then dried. The data detect in the transmission mode. For each experiment, three replications were performed (**Felfoul *et al*, 2022b; Razi *et al* ,2024**).

II.3.2. X-ray diffraction

The XRD profiles of DOUTH cheese were investigated using powder X-Ray Diffractometer (PROTO AXRD, USA). The theta angle was adjusted, ranging from 5° to 50°, while the scanning rate remained constant at 1 °/s. Operating voltage was 40KV (**Razi *et al* ,2024**)

Part two: Cheese-making of *DOUTH* cheese

III.1. Steps of manufacture of *DOUTH* cheese

They made four samples of *DOUTH* cheese in this region Elogla, Robbah, Oued El allenda and Hassi Khelifa (Eladhal). The manufacturing diagram of *DOUTH* cheese is shown in figure 10.

Figure 11. Manufacture of *DOUTH* cheese

III.2. Optimization of cheese yield

Cheese yield is expressed by the quantity of cheese obtained from a given quantity of milk (often 100 L or 100 Kg). It is of great interest in industry cheesemaker, since he judges for a given type of cheese, whether the manufacturing conditions are carried out under good conditions **(Ramet, 2011)**.

Cheese yield is calculated by the following rule:

$$\boxed{\text{Yield} = \text{weight of cheese (g) / volume of milk (ml)} * 100}$$

Part three: characterization of *DOUTH* cheese

IV .1. Crude and mineral composition analysis

The crude composition of *DOUTH* cheese is carried out according to the techniques described by **AOAC (2016)** the PH is determined by dissolving 1g of newly made *DOUTH* cheese in 10 ml of distilled water using a digital PH meter (Inolab, Germany). Titratable acidity expresses the number of grams of lactic acid present in a milk sample. It consists of neutralization by sodium hydroxide (N/9) of the acidic components in the presence of a colored indicator which is phenolphthalein.The dry matter content is determined by drying 3g of *DOUTH* cheese in an oven (Binder , France) at 105 for 24 h. Ash content is determined by total incineration of the dry materiel at 550 for 7 h .The total nitrogen content was carried out according to Kjeldahl method (Buchi,Easy Kjel ,France) and protein content was deduced from total nitrogen content by multiplying by a conversion factor of 6.38.Fat content was determined according to Van Gulik method (Funke Gerber centrifugal, Germany).

The mineral elements (Ca, P, Na, K, Mg, Fe, Mn and Cu) were measured separately using an atomic absorption spectrophotometer (Thermo scientific, ICE 3000). The measurement of physicochemical parameters and minerals was carried out in triplicate.

TEFD is the percentage of water content in the defatted cheese. That is to say:

$$\frac{\text{weight of water in cheese}}{\text{Total weight of cheese} - \text{fat in cheese}}$$

IV.2. Microbiological analyze

For the microbiological quality of milk, we determined the overall quality represented by the research and enumeration of the total mesophilic flora and the hygienic quality which includes thermotolerant coliforms; as well as the health quality which will focus on the research of Salmonella, Staphylococcus aureus with coagulase + and Listeria monocytogenes based on the recommended Algerian standard **(JORA n° 39 2017)**.

IV.2.1. Preparation of the stock solution and its dilutions

In a sterile bottle, add 10 mL of the milk to be analyzed with a quantity of TSE diluent equal to 9 x v (mL). The stock solution is left to stand for 15 to 30 minutes for the bacteria to revive. This solution represents the dilution of 10-1 **(JORA n° 38 2014)**. From the stock solution (dilution 10-1), further dilutions are made to facilitate counting. The successive dilutions are obtained by introducing 1 mL of the previous solution using a sterile Pasteur pipette into a test tube containing 9 mL of TSE.

IV.2.2. Enumeration of Escherichia coli

1ml of the dilution is introduced into a sterile Petri dish, then 15 ml of VRBL agar is poured into the dish with homogenization. Finally, we incubate at 44°C for 24 hours +/- 2 h. Thermotolerant coliforms present purplish colonies with a diameter equal to or greater than 0.5 mm. **(JORA n°75 2017).**

IV.2.3. Enumeration of coagulase Staphylococcus aureus +

1mL of the dilution is taken aseptically and placed in a kneaded dish; and the supercooled Baird Parker RPF medium is poured. The boxes are incubated at 37°C for 18h to 24h. Suspicious colonies are gray to black surrounded by an opaque fibrin halo **(JORA 2015)**.

IV.2.4. Search for Salmonella

The search for Salmonella is carried out in three main stages **(JORA 2015)**

- **Non-selective pre-enrichment**

25mL of the milk to be analyzed is taken using a micropipette, then into a bottle sterile, complete with 225mL of TSE. The mixture is incubated at 37°C for 24 hours.

- **Selective enrichment**

Two media are used: Rappaport Vassiliadis medium (RV) and Selenite Cystine medium (SC), this involves transferring 0.1 mL of the enriched solution into a tube containing 10 mL of RV medium and into a tube containing 10 mL of SC environment. The RV and SC tubes are incubated at 42°C and 37°C, respectively, for 18 to 24 hours.

- **Selective isolation**

Two media are concerned: XLD agar (Xylose-lysine-Deoxycholate) and Hektoen agar. A drop of enriched solution taken from the RV medium culture is inoculated (spread by streaks). Another is seeded in a dish poured with Hektoen agar. The same operation is carried out from the culture of the SC medium. The boxes are then incubated at 37°C for 18 to 24 hours. They can be reincubated if necessary. Suspect colonies are red with a black precipitate of iron sulfide in the center on XLD and green colonies with a black center on Hektoen which become completely black at the end of incubation.

IV.2.5. Testing for Listeria monocytogenes

The number of Listeria in milk is generally low, so their detection requires prior enrichment of the bacteria.

-Two successive enrichments from the stock solution, first in Fraser

-Demi broth incubated for 24 hours ± 2 hours at 30°C, then in Fraser broth incubated for 24 hours ± 2 hours at 37°C;

-Isolation on a selective Oxford medium for 48 hours around 72 hours at 37°C.

IV.3. Infrared and diffraction X-ray

IV.3.1. Infrared

FTIR spectra of *DOUTH* cheeses were obtained using FT-IR spectur (Agilent Technologies, Carry630, USA).A slice of each type of *DOUTH* cheese was placed directly on top of the crystal and either pressed down onto or measured without pressing .Spectra were recorded at 20 C from 4000 to 450 cm at a normal resolution of 8 cm with an accumulation of 4 scans for each spectrum. The background spectrum, which contains the absorptions of molecules present in the air, was scanned at the beginning of measurement by pouring the ATR cell with distilled water.

The same procedure was used for scanning blank spectra, with contains the absorption of distilled water. After each. measurement, the ATR crystal was thoroughly washed with ethanol and distilled water and then dried. The data detected in the transmission mode. For each experiment, three replicates were performed **(Falfoul *et al.*, 2022b; Razi *et al.*, 2024)**.

IV.3.2. Diffraction X-ray

The XRD profiles of DOUTH cheese were investigated using powder X-Ray Diffractometer (PROTO AXRD, USA). The theta angle was adjusted, ranging from 5° to 50°, while the scanning rate remainde constant at 1 °/s. Operating voltage was 40KV (**Razi *et al.*,2024**).

IV.4. Microstructural analysis

The purpose of this analysis was to visualize the microstructure of the enzymatic gel based on the *DOUTH* cheese 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.5. Sensorial profile analysis

The objective of this analysis was to give the sensory profile of the DOUTH 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.

Statistical analysis of data

All experiments and analyses were carried out in triplicates and the obtained data were expressed as means ± standard deviation. Statistical analysis was performed using Minitab 19 software (Minitab Inc, State College, PA) using student's t-test with α=95%.

Part III

Results and discussion

The objective of this study is the characterization of a traditional local cheese (*DOUTH*); made with goat milk and coagulated with dried and dirty caprine abomasum from four (04) region of the Wilaya of El Oued.

First part: Characteristics of the biological material

1. Goat milk

1.2. Crude and mineral composition of goat milk

Table 06 presents the values of the different crude parameters of goat milk for 4 regions (EDGM, RHGM, EGGM, OAGM).

Table 06: Crude composition of milks (mean values ± standard deviation)

Parameters	**EDGM**	**RHGM**	**EGGM**	**OAGM**
pH	6.6 ± 0,00[a]	6.7 ± 0.03[b]	6.6 ± 0.00[c]	6.8 ± 0.01[d]
Specific gravity at 20°C (g/cm^3)	1.032 ± 0.23[a]	1.031 ± 0.05[b]	1.032 ± 0.00[c]	1.031 ± 0.00[d]
Dry matter (g/L)	190.39 ± 0,13[a]	150.91 ± 0.05[b]	130.19 ± 0.19[c]	140.62 ± 0.00[d]
Proteins (g/L)	40.2 ± 0.00[a]	30.9 ± 0.00[b]	30.7 ± 0.00[c]	30.7 ± 0.00[d]
Fat (g/L)	70.9 ± 0.05[a]	50.3 ± 0.00[b]	20.8 ± 0.00[c]	40.4 ± 0.00[d]
Lactose (g/L)	60.3 ± 0.00[a]	50.8 ± 0.00[b]	50.6 ± 0.00[c]	50.6 ± 0.00[d]
Ashes (g/L)	9 ± 0.00[a]	9 ± 0.00[b]	8 ± 0.00[c]	8 ± 0.00[d]

a, b, c and d: Letters indicate the significant difference of means in the same line ($P < 0.05$) (ANOVA test: Tukey test).

According to statistical analyses, it seems that the physicochemical properties of milks present a significant difference ($P < 0.05$) between all parameters. These results can be explained by the effect of some factors which influence the quality of GM. In First, the average pH value of GM from the same breeds (*Arbia*) was [6.71±0.1]. The pH value reported by **Bouras. (2023)** which was [6.76±0.04]; it is close compared to the recorded values. According to **Houssou *et al*, (2023)**, the variation in pH of milk can result from infection of the udder and due to the diet because pH depends on the nature of the fodder ingested by the animal and the availability of water, but also from genetic factors which have a great influence on variations in the pH of GM.

Regarding density, the observed values were from to [from 1.031 ± 0.00 g/cm^3 to1.032 ± 0.23 g/cm^3]. This value complies with the density values in the range [1.030 to 1.035] (**Houssou *et al*, (2023)**) and with the **FAO (1990)** standard for GM which oscillates between [1.027 and 1.035 g/cm^3].

Dry matter values were recorded varying between [130.19±0.19 to 190.39±0.13 g/L] for the milks, and the dry matter values were higher than the content of 150.8±0.3 g/L for indigenous breeds of GM in intensive breeding in the region of El-Oued studied by **Matallah *et al*. (2020)**.

The protein content was showed [from 30.7±0.00 g/L to 40.2±0.00 g/L]. **Bouras .(2023)** was reported 39.78±1.48g/L. This variation in proteins was very influenced by the genetic difference of breeds, species, rations, influences of lactation stage, mastitis and climate.

Regarding fat content, the values were recorded a content of [from 20.8±0.00 g/L to 70.9±0.05 g/L]. The observed averages for fat content are similar to the results obtained by **Bouras. ((2023)** for *Arabia* goats [46.5±2.5 g/L] in the El-Oued region.

The lactose content for GM was between [50.6±0.00g/L to 60.3±0.00 g/L]. This result was more than the results [46.25±0.75g/L] was reported by **Bouras. (2023).**

Ashes content was from [9 to 8 g/L] of milks. These results were superior to those reported by **Houssou *et al*. (2023)** whose goat breeding system was intensive.

Thus, according to **Houssou *et al*, (2023),** the components of GM are affected by several factors the seasons, the type of food and breed, size, weight, age and/or the environment (temperature, playtime), health of the animal and geographical origin.

2. Characteristics of TGA

2.2. Crude composition of TGA

Table 07 presents the values of physicochemical and mineral parameters of TGA in different regions (EDGR, RHGR, EGGR, OAGR).

Table 07: Crude and mineral composition of TGA (mean values ± standard deviation)

Parameters	**EDGR**	**RHGR**	**EGGR**	**OAGR**
Physicochemical properties				
pH	6.12 ± 0.05**a**	5.89 ± 0.03**b**	6.61 ± 0.03**c**	5.27 ± 0.04**d**
Dry matter (g/100g)	88 ± 1.0**a**	85 ± 0.9**b**	82 ±1.3**c**	90.76 ± 0.2**d**
Proteins (g/100g)	20 ± 0.1**a**	17 ± 0.00**b**	14 ± 0.9**c**	24 ± 0.4**d**
Ashes (g/100g)	14.10 ± 0.3**a**	10 ± 0.2**b**	12 ± 0.6**c**	5.95 ± 0.1**d**
Ca^{2+} (mg/100g)	0.29 ± 0.00**a**	0.17 ± 0.00**b**	0.12 ± 0.04**b,c**	0.1 ± 0.01**c**
P (mg/100g)	1.9 ± 0.02**a**	0.90 ± 0.07**b**	0.98 ± 0.00**b**	0.61 ± 0.02**c**
Na^+ (mg/100g)	$12*10^3$ ± 0.8**a**	$7*10^3$ ± 1.3**b**	$9*10^3$ ± 1.9**c**	$2*10^3$ ± 2.0**d**
K^+ (mg/100g)	11 ± 0.00**a**	6.15 ± 0.09**b**	9.27 ± 0.01**c**	5.3 ± 0.00**d**

Mg^{2+} (mg/100g)	< 0.06	< 0.06	< 0.06	< 0.06
Fe (mg/100g)	0.12 ± 0.01^{a}	0.9 ± 0.04^{b}	0.5 ± 0.00^{c}	0.1 ± 0.01^{a}
Mn (mg/100g)	< 0.06	< 0.06	< 0.06	< 0.06
Cu (mg/100g)	< 0.06	< 0.06	< 0.06	< 0.03

a, b, c and d: Letters indicate the significant difference of means in the same line (P < 0.05) (ANOVA test: Tukey test).

According to the statistical analysis, it appears that there is a significant difference (P < 0.05) between all the physicochemical parameters and most of the TGA minerals from the different regions of El Oued. It is important to say that these results were linked with the specificity of the TGA preparation.

Firstly, the average pH value of the TGA was [from 5.27 to 6.61], The maximum value recorded was with the EGGR region with (6.61 ± 0.03). Concerning Dry matter of the TGA samples were 86.44±3.27 (g/100g) the higher value of which was recorded with OAGR.The protein values were [from 14±0.9 to 24±0.4 g/100g]. It was recorded that OAGR and EDGR have the highest value compared to RHGR and EGGR.The Ashes ranges of TGA were [from 5.95±0.1 to 14.10±0.3 g/100g], and the highest value of TGA ashes was observed in the EDGR.

We can link these results with traditional practices or the method of preparation of TGA depending on the region:

-The method of preparation of TGA (the quantity of goat milk to add to the abomasum and the salt content);

-The duration of TGA storage.

The physicochemical and mineral characteristics of TGA in different regions of El Oued were analyzed for the first time in our study; which leaves comparison with other studies difficult: Finally; we can say that the results reported were closely linked with the tradition of the preparation of TGA at the level of El Oued

2.3. FTIR spectroscopy analysis of TGA

Figure 10 presents the FTIR spectra of TGA in different regions (EDGR, RHGR, EGGR, OAGR).

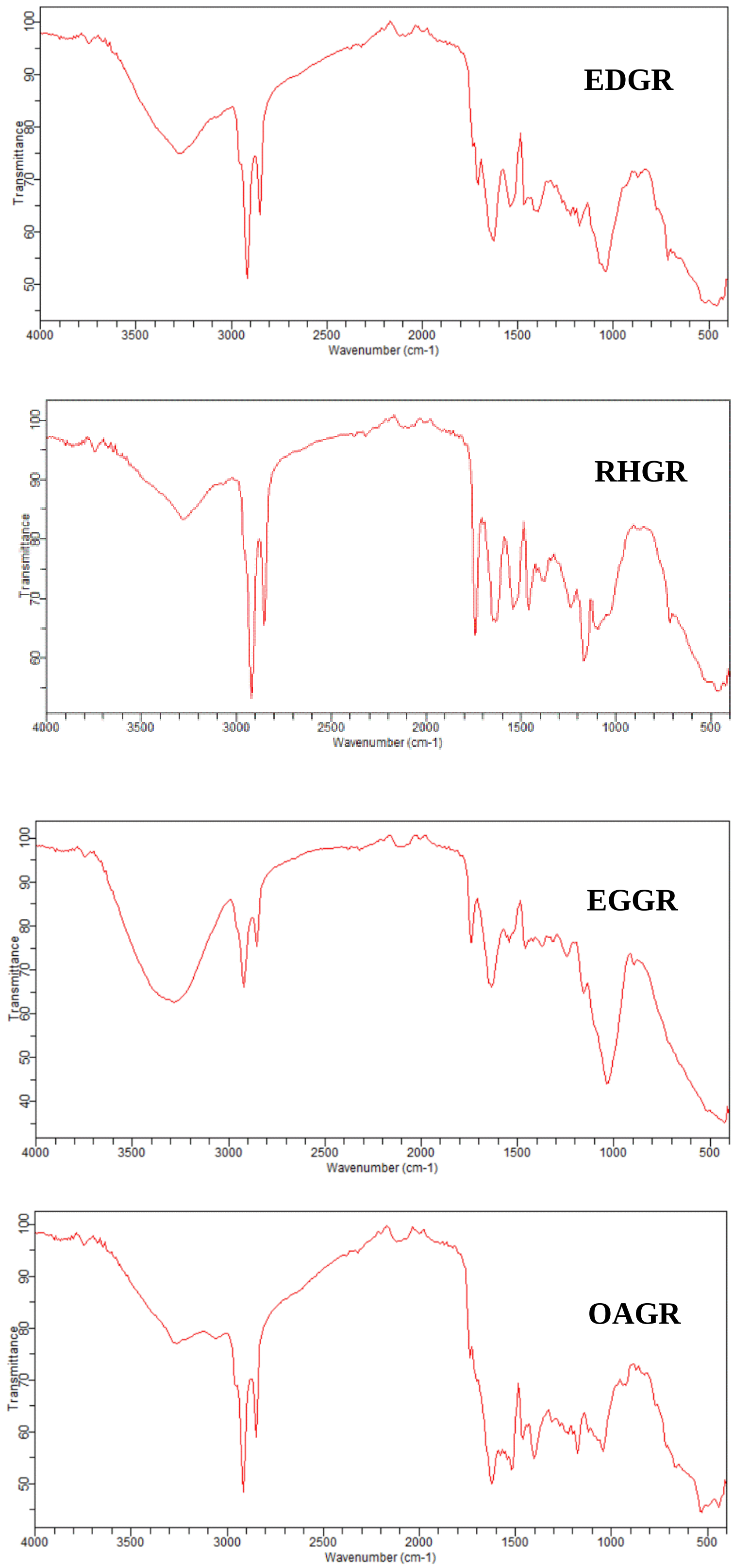


Figure 12: FTIR spectra of TGA

In EDGR, it can be observed a bending of OH in the region from 3100 to 3600. At 2800 to 3000 cm^{-1}a strong peak expressing CH. At 1600 to 1800 cm^{-1}, an appears that expresses O = C. at 900 to 1200 cm^{-1} detecting a medium C-O wave appears.

In RHGR, at 3100 to 3600cm^{-1}, we noticed a broad wave expressing OH. At 2700 to 3000 cm^{-1}, appeared an intensive peak of CH. At 1700 to 1800 cm^{-1}, C=O appeared and we can be observed a peak of C-O at 1100 to 1200 cm^{-1}.

In EGGR, at 3000 to 3700 cm^{-1} The appearance of a strong broad wave expressing OH.at 2900 to 3100 cm^{-1} we noticed a weak wave expressing CH.at 1600 to 1700 cm^{-1}, it can be detected an appearance of a mean wave expressing C=O and we can be observed a peak of C-O at 1100 to 1200 cm^{-1}.

In OAGR, we can be observed that asymmetric stretching CH which appears at 2800 to 3000 cm^{-1}. it can be detecting a broad wave expressing OH at 3200 to 3600 cm^{-1}; and a mean wave expressing C=O at 1500 to 1800 cm^{-1}.

In relation to the shelf life of TGA, we can say that the large bond of OH observed in the EGGR because it is less duration compared with other TGA.

FTIR analysis gave us an idea of the overall composition of TGA from different regions of El Oued.

2.4.X-ray diffraction analysis of TGA

This technique allows both to demonstrate the crystalline or amorphous nature of a solid or a powder, as well as to determine the different crystalline phases.

Figure 11 presents the X-ray diffraction spectra of TGA in different regions (EDGR, RHGR, EGGR, OAGR).

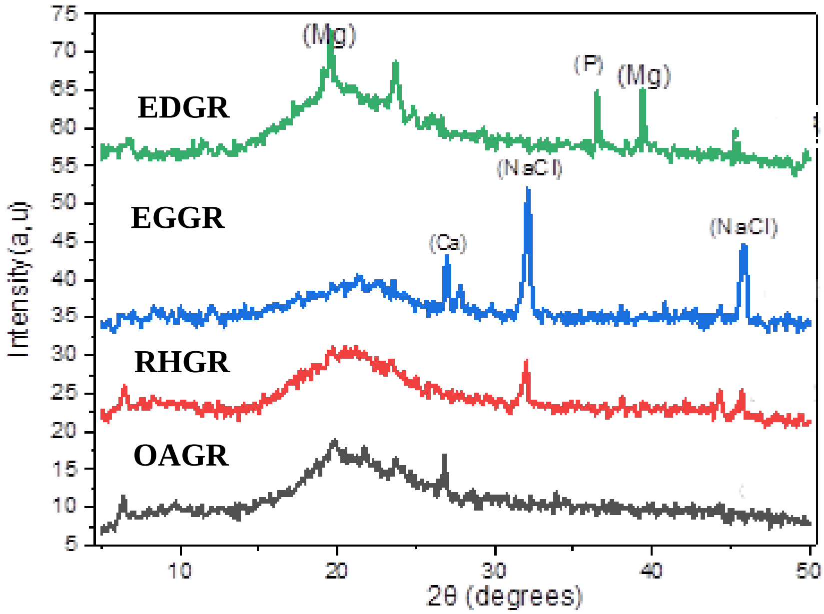


Figure 13: X-ray diffraction spectra of TGA

Figure 13 showed the typical XRD pattern of TGA diffraction peaks at 2Ө (0-50): 26.8°, 32.07°, 38.64°, 45.74°, 19°, 47, 23.58° and 74.80° and 36.2°, 39.5° The diffraction peaks were well synchronized with the JCPDS card (Joint Committee on Powder Diffraction Standards N°98-0036436 and 98-005-3815), which clearly indicated that Na-Cl-P-Ca-Mg seems had a crystalline nature and were present in the structure of the TGA.

Second part: Characteristics of *DOUTH* cheeses

2.1. DOUTH cheeses

The photos that represent the four samples of DOUTH cheeses are illustrated in figure 14.

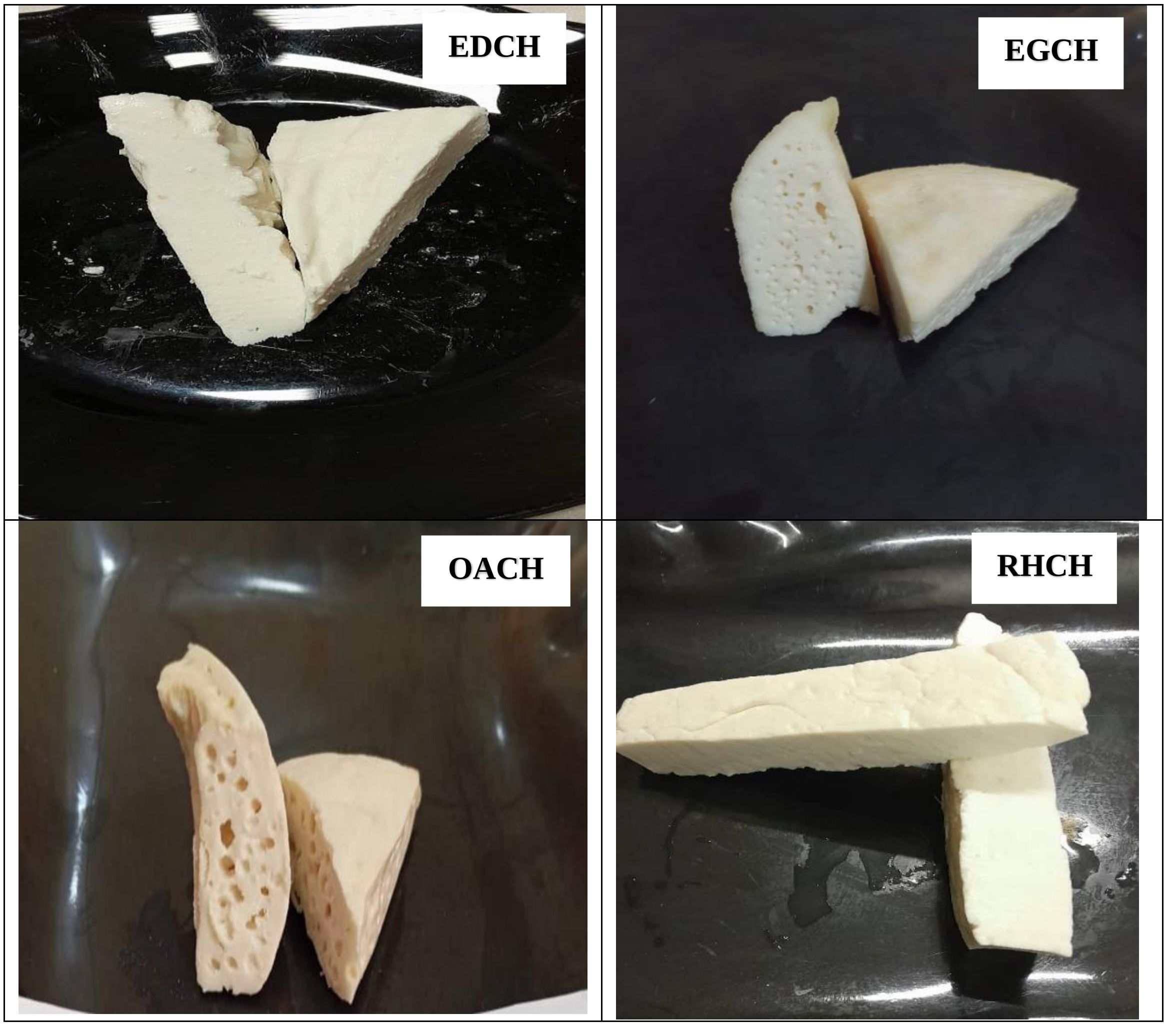


Figure 14: *DOUTH* cheeses

2.2. Crude and mineral composition

Table 08 presents the crude and mineral composition of *DOUTH* cheeses.

Table 08: Crude and mineral composition per 100g of *DOUTH* cheeses

Parameters	**EDCH**	**RHCH**	**EGCH**	**OACH**
Physicochemical properties				
pH	7.1 ± 0.05**a**	6.88 ± 0.08**b**	6.6 ± 0.09**c**	6.19 ± 0.06**d**
Titratable acidity (°D)	4 ± 0.0**a**	7.5 ± 0.7**b**	5.5 ± 0.7**a,b**	22 ± 1.41**c**
Dry matter (DM) (%)	55.54 ± 1.44**a**	48.6 ± 0.5**b**	48.03 ±1.17**b**	48.22 ± 0.26**b**
Moisture (%)	44.46 ± 1.44**a**	51.44 ± 0.5**b**	51.97 ± 1.17**b**	51.78 ± 0.26**b**
Proteins (%)	29 ± 0.2**a**	25 ± 0.8**b**	27 ± 0.6**c**	28 ± 0.1**a, c**
Proteins (%/DM)	52.21 ± 0.13**a**	51.44 ± 1.6**a**	56.25 ± 0.51**b**	58.06 ± 0.38**b**
Fat (%)	21 ± 0.00**a**	17 ± 0.16**b**	15 ± 0.00**c**	14 ± 0.27**d**
Fat (%/DM)	37.81 ± 0.00**a**	34.97 ± 0.32**b**	31.23 ± 0.00**c**	29.03 ± 1.03**d**
MFFB (%)	56.27 ± 0.21**a**	61.97 ± 0.11**b**	61.13 ± 0.07**c**	60.2 ± 0.05**d**
Yield (%)	15.75 ± 1.06**a**	18.25 ± 0.9**b**	11.25 ± 0.3**c**	10.75 ± 0.4**c**
Ashes (g/100g)	6.72 ± 0.3**a, b**	6.34 ± 0.7**b**	6.81 ± 0.4**a,b**	7.5 ± 0.1**a**
Ca^{2+} (mg/100g)	8.73 ± 0.00**a**	7.15 ± 0.01**b**	9.12 ± 0.00**c**	9.97 ± 0.02**d**
P (mg/100g)	6.86 ± 0.02**a**	5.33 ± 0.00**b**	5.22 ± 0.00**c**	7.11 ± 0.00**d**
Na^{+} (mg/100g)	251 ± 0.04**a**	230 ± 0.00**b**	190 ± 0.05**c**	223 ± 0.00**d**
K^{+} (mg/100g)	9.33 ± 0.00**a**	8.89 ± 0.03**b**	9.15 ± 0.01**c**	7.16 ± 0.03**d**
Mg^{2+} (mg/100g)	4.5 ± 0.01**a**	5.1 ± 0.00**b**	7.3 ± 0.00**c**	6.28 ± 0.00**d**
Fe (mg/100g)	1.2 ± 0.00**a**	0.8 ± 0.01**b**	1.9 ± 0.00**c**	0.7 ± 0.00**d**
Mn (mg/100g)	< 0.06	< 0.06	< 0.06	< 0.06
Cu (mg/100g)	< 0.06	< 0.06	< 0.06	< 0.06

a, b, c and d: Letters indicate the significant difference of means in the same line ($P < 0.05$) (ANOVA test: Tukey test).

The statistical analysis showed that there is a statistical difference between the physicochemical and mineral parameters of *DOUTH* cheeses. These results can be explained by the difference in the raw composition of the milks used from different regions and/or the TGA and their method of preparation.

According table 08, the pH values of *DOUTH* cheeses were varying between [6.19±0.06 to 7.1±0.05]. Compared to the pH of milk, we noticed the increase of pH in EDCH cheese; which explains the non-retention of lactic acid of milk during enzymatic coagulation with TGA. On the other hand, the lower pH value was recorded with OACH cheese, whose lactic acidity was [22 ± 1.41 °D]. These results can be explained by the presence of a lactic fermentation which was initiated during the cheese was buried under the sand.

Dry matter values recorded varying between [48.03±1.175% to 55.54±1.44%] for the *DOUTH* cheeses, this is justified by the difference in fat content between *DOUTH* cheeses. According to the results reported by **Bouras. (2023)** which were [36.79±0.1%to 46.95±0.9%] for fresh camel and goat milk cheeses; We noticed that our results were significantly superior.

DOUTH cheeses seems to have the protein contents with [51.44 ± 1.6 %to 58.06 ± 0.38%] and the minimum fat content was recorded with 37.81 ± 0.00 (%/DM) in OACH cheese. However, based on the MFFB, cheese paste can be classified into firm or semi-hard paste.

The high value of the yield was recorded in the RHCH region with 18.25 ± 1.06%. According to **Ben Omor *et al*., (2012),** they recorded a yield of 19.51 %. According to **Cipolat-Gotet *et al*. (2013),** cheese yield is influenced by two main factors: milk quality and cheese-making conditions.

It is important to point out that the use of TGA in a traditional way in the manufacture of *DOUTH* cheese; shows good coagulation of goat milk.

Average values of ashes were between [6.34 ± 0.7 g/100g to 7.50 ± 0.1 g/100g]. The high value of ashes was recorded with the OACH cheese which was 7.50±0.1%. Moreover; we recorded that OACH cheese was the richest in Ca; EDCH cheese was richest in Na and K; EGCH cheese lowest in P.

2.3. Microbial analysis

Tables 09, 10, 11 and 12 present the microbial analysis of *DOUTH* cheeses.

Table 09: Microbial analysis of EDCH cheeses

Parameters	**EDCH samples**					**Standard**		**Reference**
	1	**2**	**3**	**4**	**5**	**M**	**M**	
Escherichia coli	Ab	Ab	Ab	Ab	Ab	10^4	10^5	O.N.A.R N° 75 of 2017
Staphylococcus coagulase +	Ab	Ab	Ab	Ab	Ab	10^3	10^4	O.N.A.R N° 68 of 2014
Salmonella	Ab	Ab	Ab	Ab	Ab	Ab	Ab	O.N.A.R N° 44 of 2017

Listeria monocytogenes	Ab	Ab	Ab	Ab	Ab	100	100	ISO 11290-1

Ab: absence, O.N.A.R: official newspaper of the Algerian republic, m: minimum threshold, M: maximum threshold.

According to ONAR N°39 of 2017, EDCH cheese was of satisfactory microbiological quality.

Table 10: Microbial analysis of EGCH cheese

Parameters	**EGCH samples**					**Standard**		**Reference**
	1	**2**	**3**	**4**	**5**	**m**	**M**	
Escherichia coli	100	110	100	110	100	10^4	10^5	O.N.A.R N° 75 of 2017
Staphylococcus coagulase +	730	750	700	720	740	10^3	10^4	O.N.A.R N° 68 of 2014
Salmonella	Ab	Ab	Ab	Ab	Ab	Ab	Ab	O.N.A.R N° 44 of 2017
Listeria monocytogenes	Ab	Ab	Ab	Ab	Ab	100	100	ISO 11290-1

Ab: absence, O.N.A.R: official newspaper of the Algerian republic, m: minimum threshold, M: maximum threshold.

According to ONAR N°39 of 2017, EGCH cheese was of satisfactory microbiological quality.

Table 11: Microbial analysis of RHCH cheese

Parameters	**RHCH samples**					**Standard**		**Reference**
	1	**2**	**3**	**4**	**5**	**m**	**M**	
Escherichia coli	228	230	229	230	229	10^4	10^5	O.N.A.R N° 75 of 2017
Staphylococcus coagulase +	104	105	105	105	105	10^3	10^4	O.N.A.R N° 68 of 2014
Salmonella	Ab	Ab	Ab	Ab	Ab	Ab	Ab	O.N.A.R N° 44 of 2017
Listeria monocytogenes	Ab	Ab	Ab	Ab	Ab	100	100	ISO 11290-1

Ab: absence, O.N.A.R: official newspaper of the Algerian republic, m: minimum threshold, M: maximum threshold.

According to ONAR N°39 of 2017, RHCH cheese was of satisfactory microbiological quality.

Table 12: Microbial analysis of OACH cheese

Parameters	OACH samples					Standard		Reference
	1	2	3	4	5	m	M	
Escherichia coli	Ab	Ab	Ab	Ab	Ab	10^4	10^5	O.N.A.R N° 75 of 2017
Staphylococcus coagulase +	556	550	555	560	560	10^3	10^4	O.N.A.R N° 68 of 2014
Salmonella	Ab	Ab	Ab	Ab	Ab	Ab	Ab	O.N.A.R N° 44 of 2017
Listeria monocytogenes	Ab	Ab	Ab	Ab	Ab	100	100	ISO 11290-1

Ab: absence, O.N.A.R: official newspaper of the Algerian republic, m: minimum threshold, M: maximum threshold.

According to ONAR N°39 of 2017, OACH cheese was of satisfactory microbiological quality.

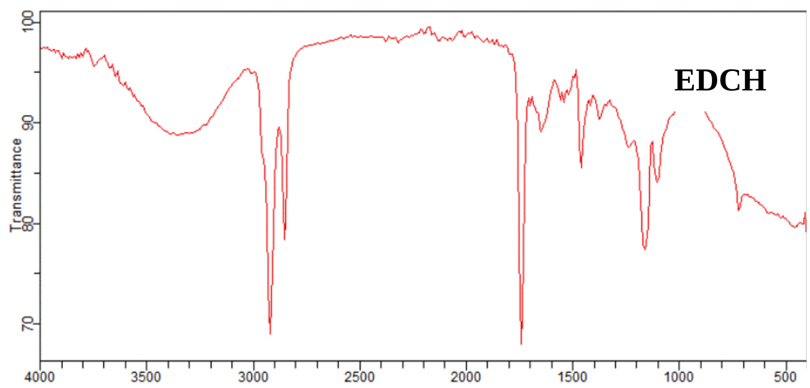
It is important to note that we have not observed the presence of pathogenic bacteria such as *Listeria monocytogenes* and *salmonella* for all *DOUTH* cheeses. In addition, in the case of *Staphylococcus* coagulase + and *Echerichia coli*, their presence was justified by the non-pasteurization of goat milk.

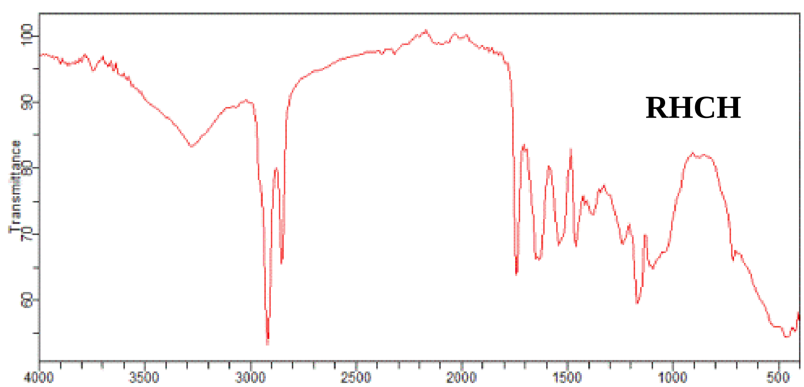
According to **Medjoudj *et al.* (2020)**, they recorded the presence of *Staphylococcus* in *BOUHAZZA* cheese. The microbiological quality of traditional raw goat milk cheese has been evaluated in previous investigations by **Bonilla-Luque *et al*. (2023)**.

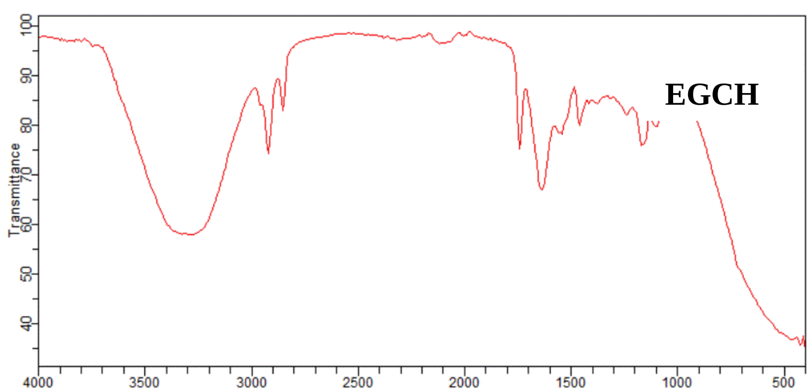
Finally, it is important to note that all the *DOUTH* cheeses analyzed had a satisfactory microbiological quality, which gave us an indication of the safety of *DOUTH* cheeses made traditionally in all regions of El Oued.

2.4.FTIR spectroscopy analysis

Figure 15 presents the FTIR spectra of DOUTH cheeses in different regions (EDCH, RHCH, EGCH, OACH).


EDCH
Transmittance
100
90
80
70
4000
3500
3000
2500
2000
1500
1000
500


RHCH
Transmittance
100
90
80
70
60
4000
3500
3000
2500
2000
1500
1000
500


EGCH
Transmittance
100
90
80
70
60
50
40
4000
3500
3000
2500
2000
1500
1000
500

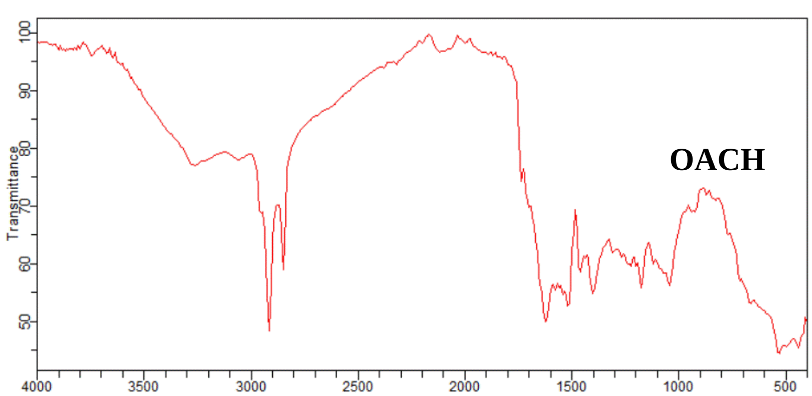

OACH
Transmittance
100
90
80
70
60
50
4000
3500
3000
2500
2000
1500
1000
500

Figure 15: FTIR spectra of *DOUTH* cheese.

In EDCH cheese, it can be observed a bending of OH in the region from 3200 to 3700. At 2800 to 3000 cm- ¹, two waves appeared, a strong one expressing CH. At 1700 to 1800 cm- ¹, an appears that expresses O = C. at 1100 to 1300 cm- ¹ detecting a medium C-O wave appears.

In RHCH cheese, from 3100 to 3700 cm- ¹ we noticed a broad wave expressing OH. At 2900 to 3100 cm- ¹ appeared a CH. From 1700 to 1900 cm- ¹, C=O appeared.

In EGCH cheese, at 3000 to 3700 cm- ¹ The appearance of a strong, broad wave expressing OH.at 2900 to 3100 cm- ¹ we notice a weak wave expressing CH.at 1600 to 1700 cm- ¹, it can be detected an appearance of a mean wave expressing C=O.

In OACH cheese, we can be observed that asymmetric stretching CH which appears at 2900 to 3000 cm- ¹. it can be detecting a broad wave expressing OH at 3200 to 3700 cm- ¹; and a mean wave expressing C=O at 1600 to 1700 cm- ¹.

In detail, a spectrum derived from a *DOUTH* cheeses exhibits distinctive bands as follows: 3700–3200 cm^{-1}, indicative of -OH and -NH stretching in proteins; 3000–2800 cm^{-1}, associated with C-H stretching in fatty acids; 1750–1650 cm^{-1}, reflective of -C=O in fatty acids and esters; and 1650–1450 cm^{-1}, involving both -C=O and –NH of amides I and II in proteins. **Tarapoulouzi *et al*. (2024)** reported that the vibrations result from various combinations within the peptide bonds and the secondary structure of casein protein, these results agrees positively with our results.

According to FTIR spectra, DOUTH cheeses contained a high percentage of water [44.46 ± 1.44 to 51.97 ± 1.17], EDCH cheese spectra has a low OH bond because the amount of water was low compared to other cheeses.

In terms of bibliography, FTIR analysis is another powerful analytical technique used for assessing the authenticity and cheese quality and providing valuable information for both research and industry applications (**Tarapoulouzi *et al*. 2024)**.

Finally, FTIR analysis supported the physicochemical analysis of *DOUTH* cheeses.

2.5. X-ray diffraction analysis

Figure 16 presents the X-ray diffraction spectra of cheeses in different regions (EDCH, RHCH, EGCH, OACH).

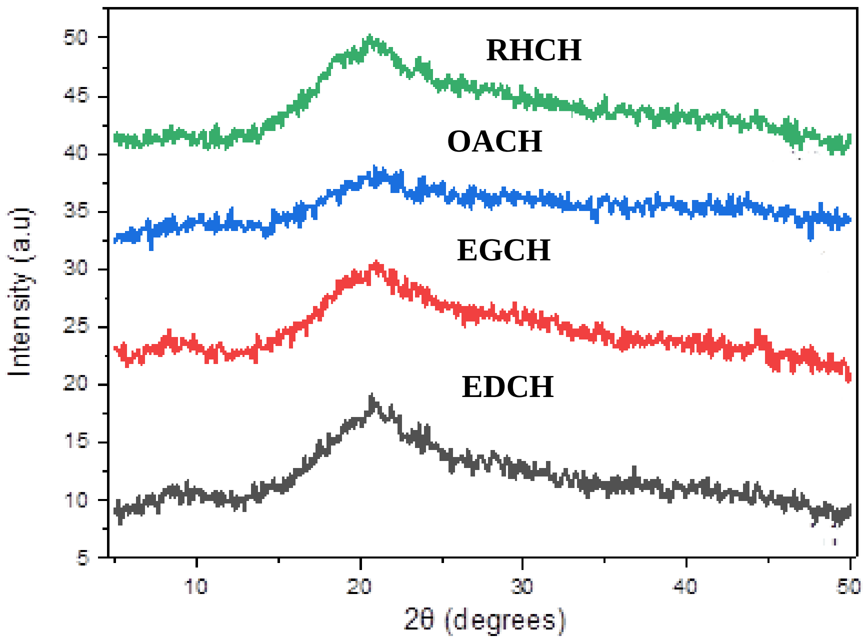


Figure 16: X-ray diffraction spectra of cheeses

Figure 14 showed the X-ray diffraction spectra of *DOUTH* cheeses from different regions of El Oued. The difference between a crystalline and amorphous phase is an ordered structure for one and disordered for the other. The X-ray diffraction pattern of cheeses (RHCH, OACH, EGCH and EDCH) was amorphous. It was made up of a very broad and diffuse line, indicating the absence of a structural unit which would repeat itself identical to itself at periodic intervals in the three dimensions.

2.6.Microstructure

Figure 15 presents the microstructure of *DOUTH* cheeses in different regions (EDCH, RHCH, EGCH, OACH.

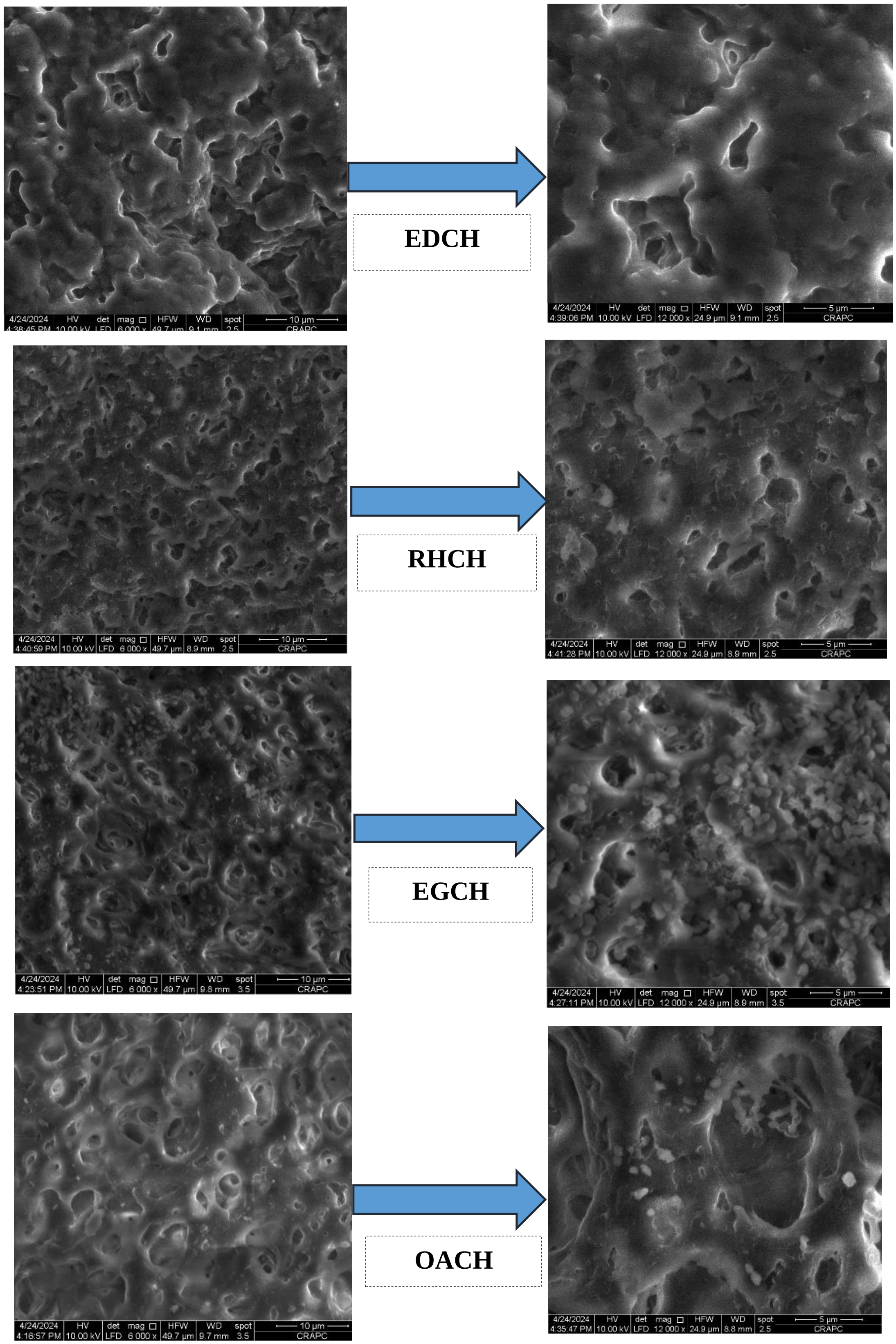

EDCH
RHCH
EGCH
OACH

Figure 17: Micrographs of *DOUTH* cheeses at 10µm and 5µm

Figure 17 showed the microstructure of *DOUTH* cheeses made with TGA at 10µm and 5µm.

First, it seems that the micrographs of EDCH and OACH seem to have fewer and larger pores compared to RHCH and EGCH .in this context, it is important to point out that EDCH and OACH were coagulated with TGA whose storage life was approximately one year, which justifies the similarity of the micrographs. Additionally, micrographs of DOUTH cheeses appear to have a continuous and compact protein network (casein); which was justified by the presence of enzymatic coagulation only.

From our results, we can deduce that the microstructure of the cheeses was closely linked to the type of milk; nature and quantity of the coagulating agent used.

In terms of bibliography, **Bouras *et al*. (2023)** reported that the nature of rennet had an effect on the casein network formation. On the other hand, **Wang *et al*. (2024)** reported that the number and diameter of pores were affected by the concentration of jujupe pulp coagulant enzyme.

2.7.Sensory profile

Table 10 presents the results of sensory analysis of *DOUTH* cheeses

Table 13: Results of sensory analysis of *DOUTH* cheeses

	EDCH	OACH	RHCH	EGCH
Cheese appearance and texture				
uniform smooth	9.7 ± 3.13[a]	10.2 ± 2.99[a]	9.95 ± 2.97[a]	8.95 ± 3.63[a]
Rough	11.05 ± 3.3[a]	9.95 ± 3.69[a]	11.45 ± 2.74[a]	8.95 ± 4.69[a]
Sandy	9.5 ± 3.26[a]	8.85 ± 3.7[a]	9.4 ±3.91[a]	6.25 ± 3.88[a]
Spreadable	4.65 ± 1.73[a]	2.4 ± 0.9[a,b]	1.55 ± 0.03[b]	1.5 ± 0.06[b]
Creamy	2.6 ± 0.06[a]	1.55 ± 0.09[b]	0.35 ± 0.09[c]	0.8 ± 0.05[d]
Pasty	12.6 ± 4.29[a]	7.45 ± 4.71[a]	10 ± 4.71[a]	10 ± 5.00[a]
Smell of cheese				
Lactic odor	11 ± 4.00[a]	10.3 ± 4.25[a]	9.5 ± 3.59[a]	10.45 ± 3.63[a]
Animal odor	8.6 ± 2.4[a]	4.9 ± 1.38 [a,b]	4.65 ± 1.76[b]	4.75 ± 1.43[a,b]
Grass odor	0.3 ± 0.04[a]	1.85 ± 0.24[b]	0.45 ± 0.07 [b,c]	0.65 ± 0.05[c]

Taste and aroma of cheese				
Sour	3.1 ± 0.49^{a}	4.7 ± 1.29^{a}	4.05 ± 1.96^{a}	6.1 ± 1.00^{a}
Salty	1.5 ± 0.12^{a}	2.85 ± 0.1^{b}	1.75 ± 0.64^{a}	2.5 ± 0.5^{a,b}
Sweet	7.75 ± 3.99^{a}	6.65 ± 2.69^{a}	7.7 ± 3.52^{a}	7.65 ± 3.43^{a}
Bitter	1.25 ± 0.01^{a}	3.4 ± 0.49^{b}	0.25 ± 0.09^{c}	1.1 ± 0.17^{a}
Buttery taste	9.8 ± 4.53^{a}	9.65 ± 4.12^{a}	6.4 ± 3.00^{a}	8.55 ± 4.38^{a}
Richness in aroma	90% (Yes)	90% (Yes)	80% (Yes)	75% (Yes)
Intensity of aroma	35% (Intense)	70% (Intense)	40% (Intense)	55% (Intense)
Cheese preference				
Texture	85%	95%	95%	75%

a, b, c and d: Letters indicate the significant difference of means in the same line ($P < 0.05$) (ANOVA test: Tukey test).

The results of sensory analysis of *DOUTH* cheeses was presented in table 13. All the sensory characteristics of the cheeses were evaluated based on the score 0 to 15.

According to the statistical analysis, we can say that in terms of the appearance of the texture of the cheeses .in terms that *DOUTH* cheeses did not present a significant difference ($P \geq 0.05$).These results can be explained by the absence of remarkable difference between the method of manufacturing *DOUTH* cheese between the regions of El Oued .In addition ,the recorded scores were linked to the almost homogenous characteristics of the coagulum obtained from the coagulation of goat milk with TGA .In terms of cheese odor, we did not record a significant difference ($P \geq 0.05$) for lactic odor. In addition, the testers noted an animal smell with EDCH cheese (8.6/15) compared to other *DOUTH* cheese.

Concerning taste and aroma, we did not record a significant difference ($P \geq 0.05$) between different sensory attributes. For acidity, EGCH cheese was moderately acidic with a score of (6.1±1.00) which was compatible with the pH and lactic acidity analysis. It is important to note that *DOUTH* cheeses did not have a salty or bitter taste, which explains why the high salt content of the TGA did not modify the taste of the finished cheese. In addition, TGA as a coagulant of animal origin and traditionally prepared, their proteolytic activity did not give us bitter-tasting peptides. Then EDCH cheese had the highest score (9.8/15) for the taste of butter, this was suitable with the high lipid content of goat milk. On other hand, the sensory attributes of texture were compatible with the microstructure and specifically the paste texture of DOUTH cheeses.

For cheese preference, we recorded that more than half of the tasters preferred all the *DOUTH* cheeses from the different regions of El Oued because of their characteristic texture.

In the literature, the sensory profile of cheese seems to have a relationship with the physicochemical composition of milk and specifically the lipid content; these were responsible for the texture of the cheese. **Sobral *et al*. (2023)** reported that the smaller fat globules of goat milk gave the cheese a soft texture.

Finally, after analyzing the sensory attributes, we can put the final sensory profile of DOUTH cheeses from different regions of El Oued (figure 18).

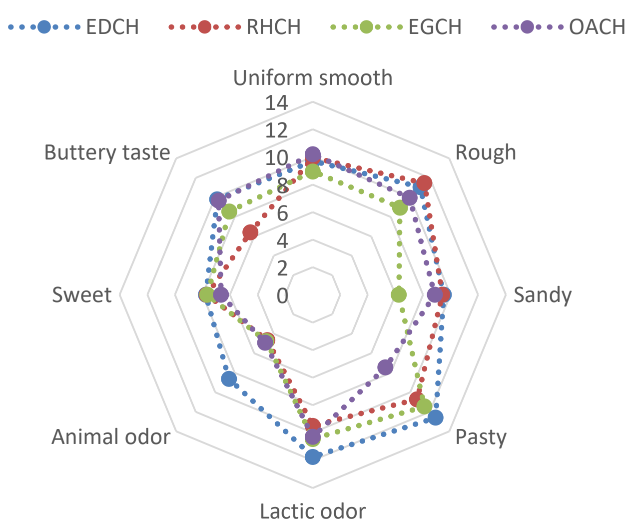


Figure 18: Sensory profile of *DOUTH* cheeses

Conclusion

DOUTH cheese is a traditional fresh cheese but not well known and not labeled in the region of El Oued. Our objective is to characterize *DOUTH* cheese and their traditional coagulant based on salted and dried caprine abomasum. In this context, our study is divided into two parts: the first part is the study of the raw material (goat milk and TGA); the second part is the study of quality of finished *DOUTH* cheese from four regions of El Oued.

First, with regard to the biological material, the physicochemical analysis of goat milk showed these results: fat content (from 20.8 ± 0.00 to 70.9 ± 0.05 g/L), pH (from 6.6 ± 0.01 to 6.8 ± 0.01) and protein (from 30.7 ± 0.00 to 40.2 ± 0.00 g/L)**.**

The physicochemical of TGA showed these results: the maximum value of pH recorded was with the EGGR region with (6.61 ± 0.03), concerning the higher value of dry matter which was recorded with OAGR. The protein values were [from 14±0.9 to 24±0.4 g/100g], and the highest value of TGA ashes was observed in the EDGR. Regarding the mineral composition, we recorded a significant sodium concentration (from $2*10^3 \pm 2.0$ to $12*10^3 \pm 0.8$ g/100g) due to the use of salt in the preparation phase of the caprine abomasun.

For FTIR, we noticed the difference in vibration between all TGA, especially the bond of OH. For XRD, we showed the presence of minerals; which is compatible with mineral composition of the TGA.

In the second part, regarding the physicochemical and mineral composition of *DOUTH* cheeses; we reported the following results: the dry matter and fat values were respectively 55.54 ± 1.44%, 37.81 ± 0.00 %/DM for EDCH cheese, the protein value was 58.06 ± 0.38%/DM for OACH cheese and the high yield value were 18.25 ± 0.9 % for RHCH cheese; the high concentration of minerals was observed for EDCH cheese compared with the other cheeses.

For FTIR, we detected the vibration C=O, OH (water) and C-H (fatty acid) for the all cheeses; and for DRX, it showed that all *DOUTH* cheeses had an amorphous structure.

At the microstructural scale, the micrographs obtained by the electron microscope environmental scanning showed that the EDCH and OACH cheeses were coagulated with TGA whose storage life was approximately one year, it had fewer and larger pores compared to other cheeses. The appearance of the micrographs was strictly linked to the type of milk, the nature of the coagulant and the type of coagulation.

In terms of sensory profile, we worked with scale 15. All *DOUTH* cheeses were characterized by a pasty (from 7.45 ± 4.71 to 12.6 ± 4.29), rough (from 8.95 ± 4.69 to 11.45 ± 2.74), and sandy (from 6.25 ± 3.88 to 9.5 ± 3.26) texture with the absence of sensation of bitterness among the tasters. Sensory profile analysis reinforced the microstructure of all *DOUTH* cheeses

As a perspective, it is important to complete this study with:

-Magnetic resonance (NMR) analysis of TGA and *DOUTH* cheese;

-Texture analysis (texturomrter) of *DOUTH* cheese;

-Vitamin composition.

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Appendix

Appendix 01: Study of biological materiel and *DOUTH* cheeses

1.Crude composition of goat milk

Milco Scan (Master Pro touch)

2.Crude and mineral composition of TGA

2.1. pH

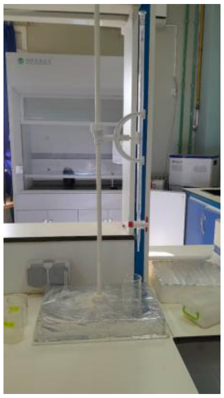
pH meter

3.FTIR spectra

FTIR spectroscopy

4.crude and mineral composition of DOUTH cheeses

4.1. Titratable acidity



Expression of results

Results expressed in grams of lactic acid per liter.

Acidity (g/l): The drop x 0.9

Results expressed in Dornic degree:

Acidity (°D): The drop x 10

4.2. Dry matter

The dry matter (DM) value is obtained by the following formula:

$$MS = \frac{(M' - M)}{(M'' - M)} * 100$$

M: the mass of the empty pottery caps (g).

M': the mass of the pottery caps and the residue after drying and cooling (g).

M'': the mass of the pottery caps with the sample before drying (g).

4.3. Ashes

4.4. 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 04: Analysis of the sensory descriptor of *DOUTH* cheeses

Analysis of the sensory descriptors of a fresh cheese

Name/First name: Date:

You are asked to evaluate the characteristics of the cheese by giving a score from 0 to 15 (Appearance/texture, Odor/Aroma, Taste) according to the scale and the characteristics proposed. Be sure to analyze the cheeses in order. Scale model:

None **Average** **Intense**

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

Cheese appearance and texture						
	Uniform -smooth	Rough	Sandy	Spreadable	Creamy	Pasty
EDCH						
RHCH						
EGCH						
OACH						

Smell of cheese: Smell and quickly note the intensity of the smell					
	Lactic odor	Animal odor	Grass odor	Odorless	Others to specify
EDCH					
RHCH					
EGCH					
OACH					

Taste and aroma of cheese: Chew the sample to assess the intensity of the flavors

	Sour	Salty	Sweet	Bitter	Buttery taste
EDCH					
RHCH					
EGCH					
OACH					

Overall appreciation of the cheese						
	Bad	Moderately good	Good	Very good	Rich in aromas (yes/no)	Duration of intensity in the mouth*
EDCH						
RHCH						
EGCH						
OACH						

*** Specify in seconds the intensity of (low intensity) ≤3sec (long intensity) up to ≥ 30sec**

Cheese preference

Cheese codes	**EDCH**	**RHCH**	**EGCH**	**OACH**
Cheese preference				
Mention the characteristic(s) of your preference • Texture • Taste • Aroma				
What unpleasant characteristics have you felt? • Texture • Taste • Aroma				

Thanks for your help