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Algerian extra hard cheese of Klila: a review on the production method, and microbial, organoleptic, and nutritional properties

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Abstract

This paper reviews the traditional practice of Klila production, its microbiological, physicochemical and nutritional properties and aims to raise awareness of Klila. The main objective of this review is to highlight the typicality of Klila and to propose a form of labelling that could help promote it. The Klila is a traditional extra hard cheese from southern Algeria. Nomadic tribes produce it from goat, sheep, or cow milk. Curdled milk is obtained by spontaneous fermentation. It is churned to recover the butter. The co-product, a sour, fat-free milk: Lben, undergoes a moderate heat treatment to get a fresh cheese which, after a dehydration process, gives the Klila. The chemical composition of this product varies regarding fat content. It has a very low water content (less than 10%) and comes in very hard pieces of varying size and irregular shape. The dry matter, for instance, can vary from 33 to 95%. Water availability (Aw) varies from 0.32 to 0.467. Fat rate can vary a lot from region to region from 9.5 to 29.3 g/100 g of cheese. The protein rate also varies a lot: between 29.9 and 71.4 g/100 g of cheese. The lactose concentration can range within 1.2 to 2.4 g/100 mL. The microbiological quality of Klila depends mainly on the quality of the raw milk used and all hygienic factors that surround milk production. The physicochemical conditions that prevail inside Klila are not favourable for the microbial growth. The Klila is an example of adaptation of the nomads' lifestyle in the Algerian Sahara who use it as a culinary adjunct for nutritional and therapeutic purposes. The Klila can be grinded to be put as ingredient in "Zrizri" dessert with dates and clarified butter (smen). Some people prefer to consume fresh Klila with dates and green tea.

Keywords: Klila, Algerian traditional dairy product, Extra hard cheese, Physicochemical properties, Microbial quality

Introduction

For more than 10,000 years, dairy products and among them, human beings have daily consumed cheeses [1]. This long association results from the coevolution between breeders and animal herds in a specific environment. As such, a strong traditional savoir-faire was progressively developed. From now on, it is an important feature of humankind essential to preserve [2, 3]. In Algeria, many local kinds of cheeses are produced, differing from place to place according to their name, the process—which is frequently complex—, the dairy cattle, etc. They are characterized by specific organoleptic—texture, aroma—and nutritional features particularly appreciated by consumers. In some cases, cheeses are also used by nomadic tribes as "a sort of" medicine drug to cure diseases [4].

Among Algerian cheeses, Klila has been consumed everywhere in the Maghreb area. Authors indicate a

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probable origin dating back to Antiquity, knowing that local consumption certainly changed a lot from time to time [5]. Elsewhere throughout the world, some similar cheeses are made even if their local denomination varies from place to place: Jameed and Arish-Kishk or Trachanasen are, respectively, consumed in the regions surrounding the Persian Gulf and in the Middle East. Ayib and Ahaggar are products from Ethiopia and Niger. In Asia, Klila like cheeses are called Chhanna, Öröm, Pastillas De Leche or Tikkamarin [6].

Klila is considered as a traditionally farmhouse made cheese. Local know-how certainly contributes to the specificity of the cheese features, namely its sensory and nutritional characteristics. The nutritional value of Klila is particularly interesting for the human diet: the protein rate is high (Min: 29.88%–Max: 71.37%), whereas the fat (Min: 9.54%–Max: 29.33%) and salt concentrations are comparatively low (Min: 0.33–Max: 1.70%) and salt concentrations are comparatively low (Min: 0.33–Max: 1.70%). Because of the fermentation step, lactose is completely metabolised; and the draining of the curd leads to very low moisture contents (< 10%) which prevent the cheese from any subsequent contaminations [6, 7]. Indeed, the shelf life can reach 2 years or more [4, 7, 8]. Klila consumption is recommended to people suffering from metabolic diseases such as diabetes or high cholesterol levels, especially Klila made with milks from goat grazing *Trigonella foenum-graecum* L, an aromatic herb also called fenugreek or locally, el halba.

At the end of the process, in some areas, women keep the Klila cheese in goatskin sacks called Mezwed [6, 9]. This form of storage is adapted to the nomadic trade of the Saharan tribes, which prevailed for centuries until recently. Today, Klila is generally stored in glass jars or in tulle bags. It is freshly consumed or after drying everywhere in Algeria, whatever the rural or urban location [10, 11]. The geographical delimitation of the regions where Klila is made appears in Fig. 1. Klila is produced and consumed in different regions (Called "Wilayas") in Algeria: Guelma, Souk-Ahras, Oum El Bouaghi, Batna and Khenchela [11]; Chellala and Souk Ahras [7]. Recent studies also revealed that Klila was made, consumed or just known in Naâma (Ain sefra), Bordj Bou Arreridj and Tebessa [4, 12, 13]

In the countryside, Klila is usually consumed once or twice a week, regardless of whether it is farmhouse or purchased [2, 13]. Despite the positive arguments, local cheese consumption has been declining for many years [8]. There are many reasons for this: livestock farming is becoming less important, which leads to a drastic reduction in milk production. In the meantime, not many cheese farmers are setting up. The lifestyle

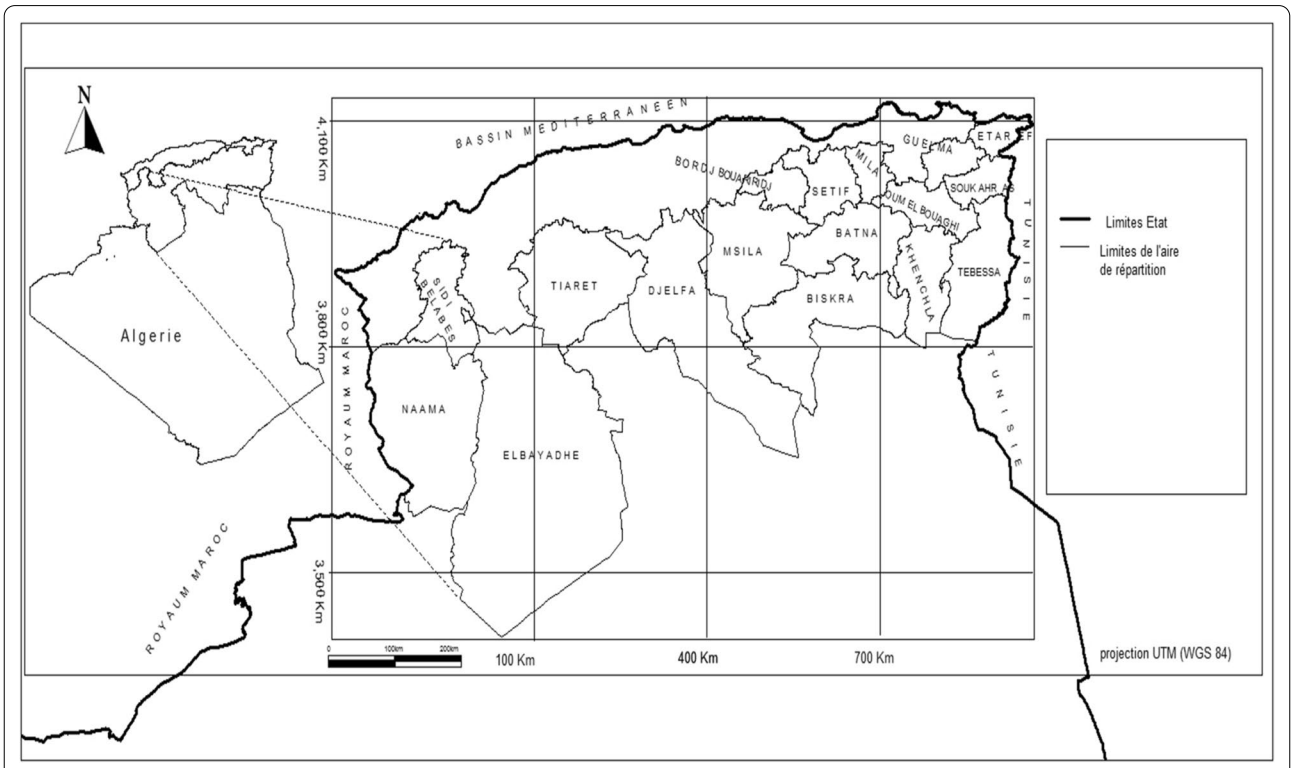

Fig. 1 Geographical delimitation of the Klila production

and consumption of the Algerian have also changed. Nowadays, Algerians prefer to buy imported industrial products, which are easier to find and cook, rather than local artisanal foods. Klila is more than a simple cheese; it represents the synthesis of the inhabitants' history of the southern Algerian arid and semi-arid areas. These regions are characterized by particular pedo-climatic conditions with sandy or rocky soil, sparse xerophytic vegetation, rainfall of less than 200 mm per year and very high temperatures where evapotranspiration into the atmosphere can be 150% higher than rainfall. People in drylands depend on the land for their food and livelihoods, mainly through agriculture and pastoralism.

Climate change has direct impacts on livelihoods, food and water security, land degradation, and biodiversity in dryland regions. Solutions for the protection of these regions must address both water, land, and vegetation, but more importantly, human resources and their know-how and adaptive genius by enhancing their environmental advantages and traditional practices [14]. For these reasons, it is essential to protect and promote the traditional products of these regions in order to maintain their dietary diversity and ancestral methods, especially those of dairy production. There is a renewed interest in local products in Algeria illustrated by the publication of many scientific articles [6, 10, 15].

The main objective of this paper is to have the Klila recognized as a traditional cheese typical of arid regions, an essential step to propose, in the future, a label for this traditional Algerian cheese.

We have structured this review into four chapters: The traditional practice of Klila making, the chemical composition and physicochemical properties of Klila; microbiological aspects of Klila and nutritional and organoleptic properties.

The Klila making, a traditional practice

Klila is the product obtained by the following general steps: the milk is abroad allowed to curdle (spontaneously by its adventitious flora). The curdled milk obtained is churned. The result is butter and leben (a sour skimmed milk). The leben is slightly heated so that it turns and the whey separates from the dry matter. After draining and lightly pressing the cheese, a fresh, fat-free cheese is obtained. This cheese can be consumed fresh or dried in the sun to make Klila: an extra hard cheese.

The type of milk used leads to different appearances (Fig. 2). The Sun bleaches and disinfects cheese. The ultraviolet rays combined with oxygen eliminate stains, sanitize the cheese and make it light. If the cheese is dried in the sun for a long period, it tends to turn yellow, due to the Maillard reaction, which can lead to browning. In a previous work, a sensory analysis carried out with trained judges, cheeses were easily discriminated according to their crumbliness, fat content, degree of rancidity and aftertaste. The sensory analysis also showed that cow's milk Klila was preferred to cheeses made from ewe's milk and goat's milk.

In Figs. 3 and 4, we have summarized the successive steps of the cheese making.

Step 1. After milking, the milk is filtered through a thin piece of tissue (Houak).
Step 2. The milk is kept at rest for 20 to 24 h in a vat called "Rawaba". In between, it has to be preserved from any sudden tremor.
Step 3. A production of lactic acid by the adventitious lactic bacteria causes the curdling of the milk. This curd is called in Arabic "Rayeb" or "Raïb".

In fact, depending on the season, the curd can be obtained in two different ways. Extreme

Fig. 2 Appearance of Klila cheese following the used milk. **A**: Klila made with goat milk. **B**: Klila made with ewe milk. **C**: Klila made with cow milk

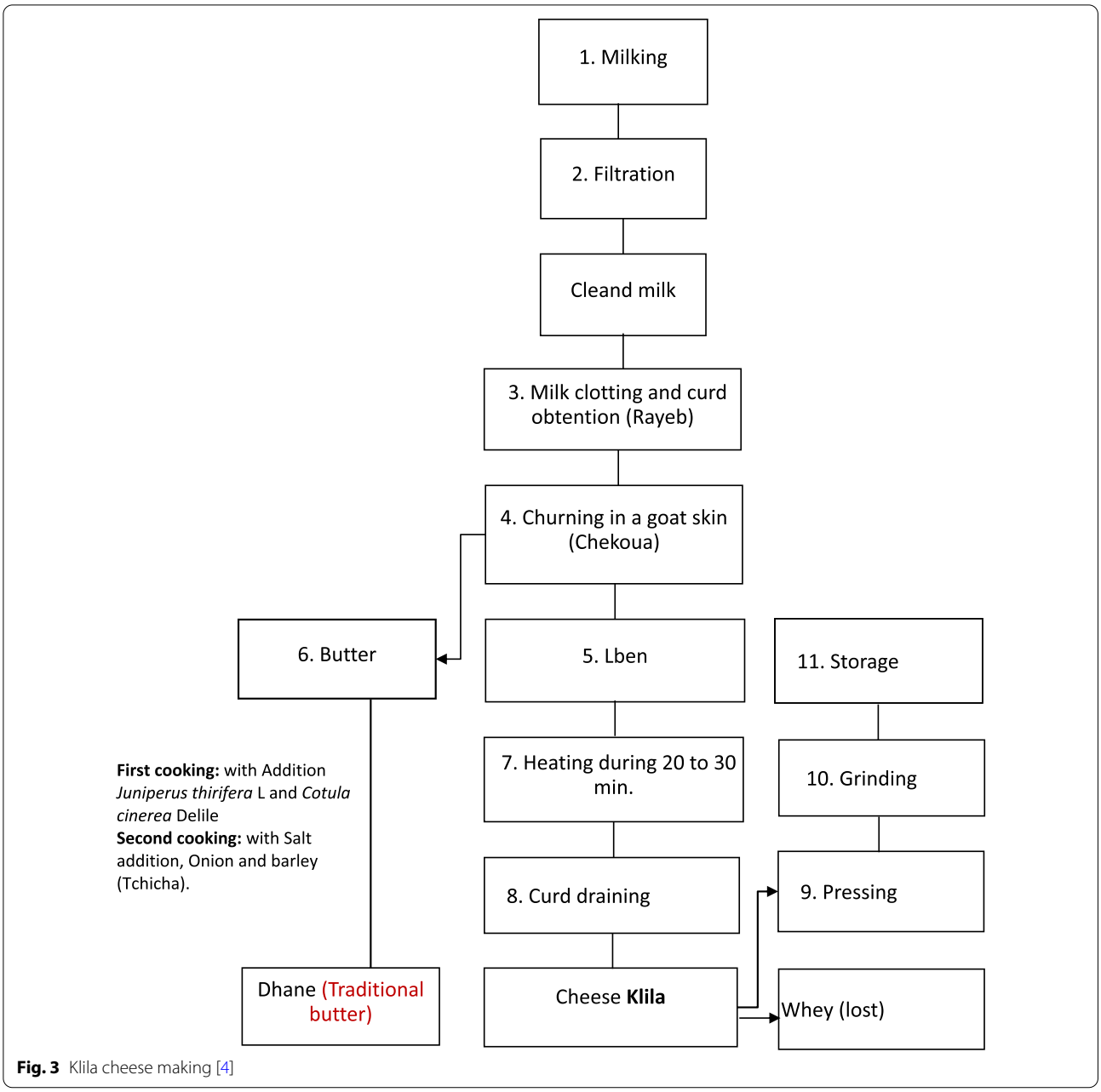

Fig. 3 Klila cheese making [4]

temperatures—cold or hot—are known to affect the acidification stage and, consequently, the shelf life of the cheese. They lead to the development of mould and excessive drying of the curd. For these reasons, the cheese is preferably (but not exclusively) produced in the spring (in situ survey findings).

In summer, the morning milk is mixed with the milk from the previous evening milking. The ambient temperature allows the microbes to grow quickly.

In winter, the morning milk is mixed with a little volume of sour milk from the day before (Lben, see below). The vat is kept near to a heat source (oven or other).

Step 4. The acidified milk is then shaken during 15 to 30 min in a traditional churn called "Chakoua"—a goat or sheep skin sack. The churning causes the separation of the butter from the acidulous skimmed milk.

The butter is further transformed into Dhane (or Dhen), a typical product resulting from two cooking

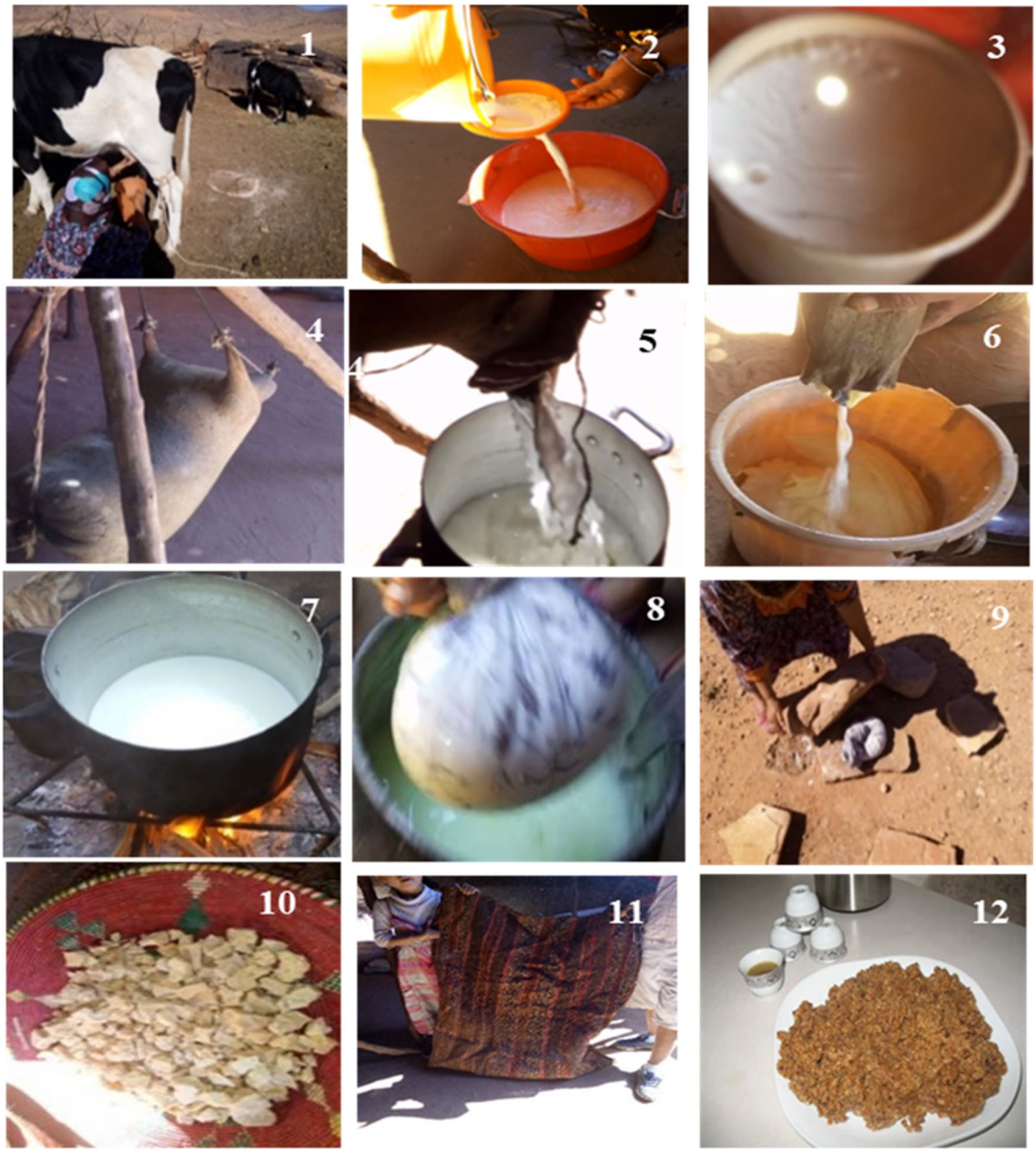

Fig. 4 Illustration of the main steps of the Klila cheese making. **1** Milking, **2** Filtration, **3** Clotting, **4** Churning, **5** Lben, **6** Butter, **7** Cooking, **8** Draining, **9** Pressing, **10** Grinding, **11** Storage, **12** Zrizri

steps. To obtain Dhane, salt, Juniperus leaves and cotula flowers (*Juniperus thirifera* L. and *Cotula cinerea* Delile) are added. After cooking, the supernatant is removed and the liquid filtered. The butter is then cooked again with barley semolina and onions. The semolina is finally removed from the liquid and mixed with dates, cooked and eaten as main lunch called "Tadiba". The remaining liquid is the Dhane butter.

Step 5. The acidulous skimmed milk (or buttermilk) named Lben is heated at a temperature ranging from 60 to 80 °C during 20 to 30 min—some measures made by the authors were even close to 87 °C. After cooling, the curd is drained in a tissue sack and pressed between a flat stones. The shape of the product looks like a pancake [4].

Step 6. The cheese is finally dried which gives it a "stone like" structure [11].

It is noteworthy that Klila cheese making is quite similar whatever the region in Algeria [4, 6, 7, 15]. In detail, however, some differences can be observed. For instance, Mattiello et al. [13] indicate in their review (Typical dairy products in Africa from local animal resources) that clotting can also result from the addition of animal rennet followed by a step of pressing. Mennane et al. [13] confirmed this observation for the making of the Moroccan Klila. In this case, the curd is also grinded and mixed with whey, dates, butter, spices or barley wheat. Then, the mixture is divided into small balls to be dried by the sun. The resulting product is called "war biscuit", a food stock appreciated by nomadic tribes [13]. Figures 3 and 4 summarize the successive steps of the cheese making.

Cheeses similar to Klila include "Jameed", which is preferably made from sheep's or goat's milk, but can also be made from cow's and camel's milk. It is prepared from "Lben", by heat treatment; the draining is done on a cloth, and the product is salted, kneaded, and then dried in the form of large solid balls or other forms [16]. Chhana is a cheese that is based on the lactic coagulation of milk to recover the curd after separation of the whey. This cheese is preferably prepared with cow's milk, which gives a cheese with a smooth texture and a sweet taste. Another example, "Paneer", a popular indigenous dairy product in India, resembles a variety of unripened soft cheese that is used in the preparation of a variety of culinary dishes and snacks. It is made by coagulating milk with heat and acid, trapping almost all the fat, casein complexed with denatured whey protein and some of the salts and lactose. The paneer has a marbled white appearance, a firm, cohesive and spongy body, a tight texture and a sweet-acid-nutty flavour. The preparation of paneer using different types of milk and various techniques results in a wide variation in the physicochemical, microbiological and sensory quality of the product [17].

Chemical composition of Klila

The chemical composition of Klila can differ widely. This is partly justified by the type of milk used—i.e. goat, sheep or, cow—and the savoir-faire during the making of the cheese. The other factors are well known: lactation step, genetic, sanitary aspects, feeding, hygiene, edaphic characteristics [15]. However, it is difficult to identify relationships between parameters to evaluate their influence, solely and globally.

The dry matter, for instance, can vary from 33 to 95% [11]. It is explained by the duration of the draining step. The longer, the dryer [10]. It was also proven that edaphic factors and feeding influence strongly the final dry matter level [18].

To our knowledge, water availability (Aw) was seldom measured. Benamara et al. [4] indicated that the Aw of cow, goat and sheep milk Klila was, respectively, equal to 0.320, 0.467 and 0.368. According to the authors, these so low values are explained by the intensity of the cooking step and the duration of the pressing and the drying steps. Generally, foods with Aw bellow 0.6 are preserved from microbial contaminations and developments [19].

Fat rate can vary a lot from region to region. This parameter depends on the season, feeding practices and the cattle race. The concentrations measured range from 9.5 to 29.3 g/100 g of cheese (data obtained from Klila analysis coming from 11 different locations).

Benamara et al. [4] determined the fat on dry matter rate (F/DM) of cow, goat and sheep milk Klila: they were, respectively, equal to 27.18, 21.41 and 31.03%. These values are in accordance with those obtained by Leskir [11]. For these authors, the F/DM ratio ranges between 21 and 31%. The protein rate also varies a lot: between 29.9 and 71.4 g/100 g of cheese [10]. For example, [11] obtained the following measures for cow, goat and sheep milk cheeses: 70.5, 67.4 and 65.8%, respectively. This parameter is known to be strongly influenced by the quality of the animal feeding, especially the nitrogen intakes. The crossing of protein and fat parameters with seasonal, feeding and breeding practices explain the discrepancies observed between the Klila produced throughout Algeria [15]. Even if the protein rate tends to diminish during lactation to re-augment just before the drying up, the quantity and the quality of the feeding is not regular enough to guarantee constant cheese yields [20].

The ash rate is less provided and variable [10]. Harrati [7] measured a concentration close to 1.7 g/100 g of cheese, whereas, according to [12], this rate was equal to 0.33%. This difference can be partially explained by the quantity of Lben used for the cheese making [8]. Among ashes, sodium, phosphor, calcium and potassium were specifically evaluated (Table 1). It is noteworthy that the wide differences indicated in this table are justified by the type of Klila analysed, dry or fresh, and the milk used [2].

Concerning the lactose rate, Harrati [7] indicated that the concentration can range within 1.2 to 2.4 g/100 mL, probably following the way to produce Klila and the location. This hypothesis was confirmed by [21]. Even if the presence of lactose in the cheese can be seen as dangerous (risk of late blowing), the very low Aw value preserves the cheese from any further defect.

The acidification step results from the activity of the wild lactic acid bacteria present in the raw milk. The presence of these bacteria—quantitatively and qualitatively—is influenced by hygiene practices during milking and the type of milk used—cow, goat, ewe [22]. They settle in the milk but are not necessarily selected. Contrary to back slopping practices [3], Klila cheese making are not linked from day to day. Hence, only the

Table 1 Chemical composition of Klila produced from different milk

Constituents	Type of milk used for Klila making (Min–Max)				Origin not specified	References
	Ewe milk Klila	Goat milk Klila	Cow milk Klila	Mixing milk (Ewe, Goat)		
Dry matter (%)	36.71–94.51	35–94.97	32–98	90.87	89.35–90.30	[4, 7, 11–13]
Moisture (%)	7.77		8.67	9.13	9.70–12.55	[7, 11, 14]
Aw (%)	0.368	0.467	0.320			[4]
Fat (%)	29.33	20.33	9.54–25.33		13.84–21.01	[2, 4, 7, 13, 14]
Fat/dry matter (%)	31.03	21.41	27.18			[4]
Protein rate (%)	70.5	65.8	29.88–88.3		53.86–71.37	[7, 13, 14]
Ash rate (%)	0.33–2.4	0.33–0.35	0.33–0.55		0.70–1.70	[7, 12, 13]
Salt (%)			0.21		0.50–0.55	[13, 14]
Calcium (%)	0.13	0.26	0.22		0.43–0.59	[2, 7]
Phosphorus (%)	0.30	0.18	0.33		0.31–0.37	[2, 7]
Lactose (%)					1.53–1.92	[7]
Potassium (%)	0.11	0.27	0.23			[2]
pH	4.25–4.67	4.46–4.60	3.87–4.57	4.57	4.07–5.6	[4, 11–15]
Acidity (°D)	25.43–71	42.15–63 ± 2	34.71–88	43	45–167.4	[11–13, 15]
Lactic acid (%)	0.694	1.008	1.210		3.91–4.23	[4, 13]

most adapted bacteria to the ambient conditions have the possibility to overwhelm other microbes [23].

The metabolism of lactic acid bacteria allows the pH of Klila to reach values ranging within 4.25 to 4.99. As such, total titratable acidity, expressed in Dornic degrees, varies a lot: between 23 and 79.4°D [4, 11–13, 15, 24]. Klila is frequently designed as an acid cheese [4], even if, according to [25], this feature can change from one region to another.

During the Klila storage, lactic acid (and salts) concentrate decreases its water activity, and this helps to protect it from microbial spoilage [26].

Microbiological aspects of Klila

The microbiological quality of Klila depends mainly on the quality of the raw milk used and all hygienic factors that surround milk production.

Four main contamination sources must be controlled: the environment (litter, hay, cowpats, ground hygiene,

Table 2 Microbial composition of Klila (data expressed in colony forming unit per g)

Microflora	Type of milk used for Klila making (Min–Max)				Origin not specified	References
	Ewe milk Klila	Goat milk Klila	Cow milk Klila	Mixing milk (Ewe, Goat)		
Aerobic mesophilic microflora	2.28×10^3–10^9	3.01×10^6	2.22×10^3–1.73×10^5	1.3×10^3	01.24×10^3	[2, 4, 11–13, 15]
Total coliforms			$1.1.10^2$–2.25×10^3		01.98×10^3	[2, 10, 13, 15]
Faecal coliforms	< 5	< 5	< 5–1.85×10^3		0.84	[12, 15]
Fecal streptococci					2.13–1.78×10^6	[10, 12, 13]
Yeast and moulds	> 5.01×10^5	> 5.01×10^5	1.64×10^2– > 5.01×10^5		1.68×10^9	[4, 10, 15]
Lactic acid bacteria	9.54×10^4–2.69×10^5	4.89×10^3	$5.1.10^3$–1.41×10^6		3.09×10^4–4.74×10^7	[2, 4, 10, 13, 15]
Enterococcus	2.57×10^5	2.69×10^3	2.75×10^3			[4]
Anaerobic Spore forming bacteria	1×10	1.99×10^2	3.98×10^2			[4]
Bacillus	< 1.99	< 1.99	1.12×10^2			[4]
Bacillus cereus	< 5.01	< 5.01	4.62×10^3			[4]
Lactic acid streptococci			1.5×10^3			[13]
Lactococci			2.3×10^2			[13]

etc.), the air (dust, ventilation, etc.), the milking machine (biofilms) and the cleanliness of the mammary gland and especially the teat skin. As such, the microbial charge can be vary a lot, quantitatively and qualitatively (Table 2).

Concerning the total microbial count (aerobic mesophilic flora), we observed that this parameter was clearly influenced by the origin of the milk: ewe, goat or cow. For instance, it is observed that farmers are more attentive to the hygienic conditions of their cows during milking than farmers breeding ewesor goats (Benamara, personal uncommunicated results). Total coliforms generally originate from the biofilms settled inside the milking machine. They can be correlated with the faecal coliforms. Nevertheless, the link between these two microflora is not automatic. The levels observed and reported by [8]—between 1.1×10^2 and 2.7×10^3 CFU/g—are not so important.

Meribai et al. [12] and Guetouache and Guessas [15] enumerated the faecal coliform levels of goat, ewe and cow milk cheeses made in different farms in Bordj Bou Arreridj and Djelfa (Algeria). The counts were low: less than 1.85×10^3 CFU/g. In some cases, as referred by [11], total and faecal coliforms were never detected. This observation is explained by the strict hygienic conditions applied during milking. However, we can also indicate that these results were specifically gathered in farms in which the milk was used for Klila production. Farmers were hence aware of the necessity to respect hygiene conditions during milk production.

From a general point of view, the physicochemical conditions that prevail inside Klila are not favourable for the microbial growth: the pH is rather low and the acidity high, as indicated above. The low Aw also leads to the disappearance of many microbes [8]. Moreover, the barrier effect exerted by the lactic acid bacteria maintains the undesirable bacteria at low and even undetectable levels.

It can be surprising to find high levels of *Streptococci* (between 2.13 and 85.5×10^5 CFU/g) and among them rather high concentrations of *Enterococci* (2.69×10^3–2.75×10^3 CFU/g) [8]; even if Derouiche [13] also noted undetectable counts in the Klila analysed. Faecal streptococci can originate from many sources, enteric and environmental. As such, it can be difficult to identify the reasons of their presence in Klila. If hygienic problems can be put forward in some cases, we can also propose other explanations: for instance, the rustic abilities and the ubiquity of this microbial population or, the possible confusion between faecal streptococci and other lactic acid bacteria following the medium used [8].

Enterococci are frequently found in the core of raw milk cheeses, especially cheeses made in the countries surrounding the Mediterranean Sea [27]. They participate in the ripening step because of their abilities to resist to the drastic conditions found inside the products [4]. Their level is generally evaluated between 10^5 and 10^6 CFU/g, the most frequent species identified being *Enterococcus faecalis* and *Enterococcus faecium* followed by *Enterococcus durans*.

If the physiologic characteristics of these bacteria can change from strain to strain, they are often proteolytic and to a lesser extent lipolytic. Some strains have also the ability to metabolise citrate to produce diacetyle. According to Benamara et al. [4], the *Enterococcus* levels enumerated in ewe, goat and cow milk Klila were, respectively, equal to 2.57×10^5, 2.69×10^3 and 2.75×10^3 CFU/g. The three species identified, based on the 16S-DNA sequencing, were *E. faecium*, *E. durans* and *Enterococcus hirae*.

The number of lactic acid bacteria—with the MRS medium—was evaluated between 4.89×10^3 and 2.69×10^6 CFU/g [10]. Mesophilic lactobacilli are the most frequently bacteria enumerated in Klila. In a recent study, Benamara et al. [4] identified mainly *Lactobacillus plantarum,* (*Lactiplantibacillus plantarum*) followed by *Leuconostoc pseudomesenteroides, Pediococcus pentosaceus and Lactobacillus fermentum* (*Limosilactobacillus fermentum*). In brackets, we indicate the name of the bacteria in the new taxonomy [28].

In another study on the Lactic acid bacteria isolated from traditional Algerian dairy products by Guetouache et al. [29]. This work allowed the isolation and purification of 132 strains of Lactic acid bacteria belonging to the genus Lactobacillus with the following proportions *Lb. plantarum* (18.94%), *Lactobacillus casei* (18.18%), *Lb. fermentum* (21.97%), *Lactobacillus acidophilus* (12.88%), *Lactobacillus brevis* (14.39%), *Lactobacillus alimentarius* (03.03%), *Lactobacillus intestinalis* (06.06%) and *Lactobacillus helveticus* (04.56%). Among these isolated lactic acid bacteria, *Lb. fermentum, Lb. intestinalis and Lb. acidophilus* showed strong bactericidal activity against *Staphylococcus aureus.*

In a study on the hygienic, physicochemical and microbiological quality of fermented and traditional butters in different regions of Algeria by Mahamedi [27], the obtained results reveal that lactic acid bacteria have wide diversity. These LAB were represented by more than 20 different species belonging to the seven genera with the dominance of Leuconostoc (33%) and Enterococcus (19%), followed by Lactobacillus (17%), then Lactococcus (12%) and Pediococcus (10%), ending with Streptococcus and Weissella. In addition, a significant number of the isolated strains revealed considerable proteolytic, lipolytic, antagonistic and acidifying properties. The results were remarkable for: *Lc. dextranicum, Lc. pseudomesenteroides, Lb. acidophilus, Lb. plantarum, Lb. casei, L. lactis subsp. cremoris, L. lactis ssp. lactis biovar. Diacetylactis, Str. thermophilus* and

even some strains of enterococci (e.g. *E. faecalis* and *E. faecium*). Lactic acid bacteria enable the fermentation, maturation and development of texture and flavour of many fermented products. They may also have antimicrobial activity. Thanks to this last function, the prevention of pathogenic organisms and those responsible for the food deterioration is guaranteed. Therefore, isolated and identified species can be used as probiotic cultures in yoghurts, cheeses. Of course, some of them are already used on a large scale in the dairy industry (Table 3). Thus these lactic acid strains presented many interesting features, including sugar fermentation and proteolytic activities. These abilities are known to contribute positively to cheese ripening, texture changes, production of flavour compounds and its protection from antimicrobial substances.

Derouiche [13] also found lactic acid *Streptococci* and *Lactococci*. Nevertheless, for this latter population, the level was close to the detection limit, 2.3×10^2 CFU/g. The low levels of lactic acid bacteria in ripened Klila are not surprising: except some species—*Pediococcus* and some *Lactobacilli*—, the low Aw is unfavourable to the surviving of the majority of these bacteria. They only participate in the acidification step and are eliminated thereafter. Their possible role is limited to the release of their intracellular enzymes in the core of the cheeses, even if no information is available concerning the real effect of the enzymes in a so dry environment.

Anaerobic spore-forming bacteria (presumed *Clostridium butyricum*) were always found at low levels: between 10^1 and 3.98×10^2 CFU/g following the milk used for Benamara et al. [4]. They were never detected by Derouiche [13] and Benlahcen et al. [10]. The absence of these bacteria in the Klila tested is not surprising. Even if the redox potential is certainly convenient with their growth, Aw is too low. Moreover, the cattle are not fed with silage, a major source of anaerobic spore-forming bacteria.

Concerning the other bacterial flora, they were systematically counted at very low levels. This is even true for pathogens: according to Benamara et al. [4], the *Bacillus* population never exceeded 5.0×10^3 CFU/g. *Salmonella spp*, *Listeria monocytogenes* and *Staphylococcus aureus* were never detected [20]. Again, the physicochemical characteristics of Klila, and among them low pH and Aw are too drastic to support the growth of these microbes.

Yeasts and moulds were sometimes counted at high levels: 5.6×10^8 CFU/g [8], even if this population was generally enumerated at lower levels: $< 1.64 \times 10^2$ CFU/g [10]. Air contamination is the main explanation for the presence of these microbes in the milk and further in the cheese. Moulds being xerophilic and/or acidophilic

Table 3 Bacterial strains isolated from Klila cheese

Bacterial strains	Type of milk used for Klila making				References
	Ewe milk Klila	Goat milk Klila	Cow milk Klila	Origin not specified	
Lactobacillus plantarum	x	x	x	x	[4, 29, 30]
Enterococcus durans	x	x			[4]
Enterococcus hirae	x				[4]
Enterococcus faecium	x	x		x	[4, 25, 27]
Leuconostoc pseudomesenteroides		x	x	x	[4, 29, 27]
Pediococcus pentosaceus		x	x		[4, 29]
Lactobacillus fermentum			x		[4, 29]
Lactobacillus casei			x	x	[4]
Lactobacillus acidophilus			x	x	[4, 29]
Lactobacillus brevis			x		[4, 29]
Lactobacillus alimentarius			x		[4, 29]
Lactobacillus intestinalis			x		[4, 29]
Lactobacillus helveticus			x		[4, 29]
Lactobacillus paracasei			x		[30]
Lactobacillus plantarum / pentosus			x		[30]
Enterococcus faecalis				x	[25]
Leuconostoc dextranicum				x	[27]
Lactococcus Lactis Subsp. Cremoris				x	[27]
Lactococcus lactis subsp. lactis biovar diacetylactis				x	[27]

for a part of them, they can settle and increase as the pH and the Aw drop [10]. Moreover, the use of the goatskin "Chekoua" during churning is also probably an important source explaining the yeast and mould presence.

Sensorial quality

The Klila can be cut into small pieces to be stored in a sack called "Ghrara" or grinded to be put as ingredient in "Zrizri", a dessert made with Klila, dates and clarified butter (smen) consumed in Algeria. In this last case however, Klila needs to be first rehydrated before use [21].

Some people prefer to consume fresh Klila with dates and green tea. According to Moulay et al. [31], this cheese can be mixed with sugar, salt or spices. Frequently, especially during Ramadhan month (a religious duty of the Islamic religion), Klila is dipped in milk and consumed as a cool meal. In the past, it was also used to help sick people to recover from diarrhoea (Field survey by Benamara, 2016).

The sensory characterisation of Klila cheeses was not studied extensively. Benamara et al. [4] compared the organoleptic profiles of Klila made either with cow, ewe or goat milk. The three types of cheeses were clearly discriminated on the following descriptors: granular, fat, acid, rancid, aftertaste. Hence, not surprisingly, the type of milk used leads to different final products. A triangular test was also made revealing that the cow milk Klila was different from the goat milk products. Sheep milk Klila was not significantly different from the other cheeses. Generally, as indicated above, goat milk is more contaminated, the milking hygienic conditions being less controlled.

Therefore, the global sensory quality is variable, leading to either tasty or unpleasant products. Some aromatic and sapid compounds are concentrated in the liquid part of the cheese. It is the reason why they seem more intense. Differences of colour, as observed above (Fig. 2), are explained by the cooking temperature crossed with the different compositions of the milks used. For instance, the lactose rate, involved in the development of the Maillard reactions, is, respectively, equal to 48, 48 and 41 g/L for the ewe cow and goat milks. Hence, the latter is less susceptible to browning reactions than the former [32].

Sensory analysis of this type has not been extensively studied. So far, there is no in-depth work in Algeria in this context that has addressed the sensory aspect of Klila.

According to a master's study on Klila cheese made in Ain Sefra, the classification of three types of Klila cheese with the three origins (sheep, goat and cattle), showed that Klila cheese of sheep origin is the most granular, followed by Klila of goat and cattle origin, respectively. The difference in the grainy appearance between the three types of Klila is significant; the grainy appearance may be due to the type of microorganisms present in the milk that control the acidification and coagulation rate.

Although Klila is a lean cheese, a fatter taste is observed in the cheese of bovine, then caprine and ovine origin. Klila of goat origin is the most rancid, followed by that of bovine origin and finally Klila of sheep origin. This difference in rancidity is probably related to the composition of the milk of the three animals (state and type of fat, presence of lipases, etc.).

The rancid smell is due to the presence of butyric acid [33]. Depending on their concentration and perception threshold, the volatile fatty acids contribute more or less to the aroma of the cheese, or, in the case of some of them, confer a rancidity defect [34]. Spinnler,

The acidity aspect was also checked in this study and shows that the ranking of the three cheese varieties according to acidity is as follows: Klila of goat origin, Klila of bovine origin, Klila of sheep origin. Again, it can be understood that the type of microorganisms that acidify the product is not the same, either in number or in type, in the three types of milk.

Conclusion

Klila is a farmhouse made cheese that is consumed throughout the Maghreb area for centuries. This product is well adapted to the climatic and edaphic conditions of north Africa. The high protein rate, the low fat and salt concentrations (low Aw) are nutritionally interesting for the people living in south Algeria. Pathogens being unable to grow or to survive inside the Klila, so it can be stored for many months. Klila—as well as some other local products throughout the World—is exposed to the same difficulties: they are no more competitive. Thus, it is essential to gather as much knowledge as possible about the product to justify its richness and its cultural and ethnic significance. We need all the information for building a consistent approach of the Klila specificity. However, it is possible to maintain traditional food making close to industrials ways on condition that, the former bring to the consumer other values than the latter: rooting to the Algerian terroir, historical heritage, strong adaptation of the product to the edaphic particularities, know-how, etc. So, it is essential to obtain a label like that of traditional Bouhezza cheese (Oum El Bouaghi, east of Algeria) the first traditional dairy product to be labelled in Algeria. A labelled cheese must respect strict criteria concerning the quality and geographical origin of the milk, stages of production, proportions of its components (salt, fat, etc.). The process of labelling Klila must therefore begin with the establishment of specifications.

Abbreviations
Aw: Water availability; PDO: Protective denomination of origin; F/DM: Fat on dry matter rate.

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Author contributions
RNB carried out the field survey, the data analysis, and the preparation and writing of the manuscript. MB contributed to the design of the study and the writing of the manuscript. KI, BM-B contributed to the methodology. YD contributed to the writing of the manuscript, the methodology and the data analysis. All authors have read and approved the final manuscript.

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Data supporting the results of this study are available from the corresponding author Rym Nouria BENAMARA, upon reasonable request.

Declarations

Competing Interests
The authors declare that there is no conflict of interest.

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