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**Review**

# Characteristics of major traditional regional cheese varieties of East-Mediterranean countries: a review

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**Abstract –** Traditional cheeses represent a heritage and are the result of accumulated empirical knowledge passed on from generation to generation. Pedoclimatic conditions in most parts of the East-Mediterranean and neighbouring countries are characterised by relatively small and irregular precipitations, hot and dry summers, and a largely hilly terrain. Such environmental conditions are not very favourable for cattle but suitable for sheep and goats. Thus, the majority of traditional cheeses in these countries were – and most of them still are – made from the milk of these two animals. The relatively high ambient temperature, the lack of refrigeration facilities and the fact that most of the cheeses were produced in family enterprises or in small artisanal units led the cheese market to be dominated (> 50%) by "white brined cheeses" (WBC), which are ripened and stored under brine until consumption, e.g. Feta, Domiati and Beyaz-Peynir. WBC have no rind, no gas holes and are soft to semi-hard with an acidic (pH ~ 4.5), salty and, some of them, piquant taste. To improve keeping quality, the drained curd of some WBC is additionally scalded at very high temperatures (90–100 °C), e.g. Halloumi and Nabulsi. Traditional cheeses of the region also include *pasta filata* semi-hard cheeses (e.g. Kashkaval), the curd of which after draining and acidification (pH ~ 5.2) is subjected to a texturising process (heating, kneading and stretching at ~ 75 °C). They usually have a flat-cylindrical shape, no holes and straw-yellow to yellow colour. Whey cheese production (e.g. Myzithra, Manouri, Lor, Anari, Urda and Skuta) was developed very early in this area, since the whey from sheep's and goat's milk cheese is very rich in protein. The yield can be improved if the milk of these small ruminants and/or cream is added to the whey.

**East-Mediterranean cheese / white brined cheese / whey cheese / *pasta filata* cheese / goat's cheese / ewe's cheese**

**摘要 – 地中海东部国家传统区域性干酪的主要特性：综述。**传统干酪是一种经验知识积累而成的文化遗产。地中海东部的大部分地区及相邻国家多为丘陵地形, 其气候特点为相对少和不规则的降水, 夏季少雨和干热。这种环境条件不利于奶牛养殖, 但适合绵羊和山羊的饲养。因此, 这些国家生产的传统干酪一直以绵羊奶和山羊奶干酪为主。由于环境温度较高又缺少冷藏设施,大多数干酪还是以家庭和小作坊式生产, 由于白卤干酪 (WBC) 如 Feta, Domiati, Beyaz-Peynir 干酪是在盐水中成熟和贮藏, 使得该类产品占据主要的干酪市场 (> 50%)。WBC 是无皮、无气孔的软质到半硬质干酪, 具有酸味 (pH ~ 4.5) 和咸味, 一些干酪还有辛辣味。为了改进质量, 一些白卤干酪将排出的凝块经高温热烫 (90–100 °C) 处理后回填到凝乳中, 如 Halloumi 和 Nabulsi 干酪。这些区域性的传统干酪包括 *pasta filata* 半硬质干酪 (如 Kashkaval 干酪), 其排出的凝块酸化后 (pH ~ 5.2) 在 75 °C 左右进行组织化处理 (加热、捏合、拉伸)。这些干酪通常做成轮状、无孔, 颜色从淡黄到黄色。在这个地区乳清干酪 (如 Myzithra、 Manouri、Lor、Anari、Urda、Skuta)

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的生产历史悠久, 由于绵羊奶和山羊奶干酪排出的乳清富含蛋白, 因此, 如果将羊奶和 (或) 奶油添加到回收乳清中, 可以提高干酪的产量。

**地中海东部干酪 / 白卤干酪 / 乳清干酪 / *pasta filata* 干酪 / 山羊奶干酪 / 绵羊奶干酪**

**Résumé – Caractéristiques des principales variétés de fromages traditionnels régionaux des pays de l'est méditerranéen : une revue.** Les fromages traditionnels représentent un héritage résultant des savoirs empiriques accumulés et transmis de génération en génération. Les conditions pédoclimatiques dans la plupart des pays de l'est méditerranéen et ses voisins sont caractérisées par des précipitations relativement faibles et irrégulières, des étés chauds et secs et un terrain généralement vallonné. De telles conditions environnementales ne sont pas favorables pour les bovins mais conviennent bien aux ovins et caprins. La majorité des fromages traditionnels de ces pays ont été ou sont encore fabriqués à partir du lait de ces deux espèces. La température ambiante relativement élevée, le manque de réfrigération et le fait que la plupart des fromages sont produits dans des petites unités (familiales ou artisanales) font que le marché du fromage est dominé (> 50 %) par des fromages blancs saumurés qui sont affinés et conservés dans la saumure jusqu'à consommation, par exemple le Feta, le Domiati, le Beyaz-Peynir. Les fromages blancs saumurés n'ont pas de croûte ni de trous, ils ont une texture molle à demi-dure, et un goût acide (pH ~ 4,5), salé et pour certains d'entre eux piquant. Pour améliorer la qualité de conservation, le caillé égoutté de quelques fromages blancs saumurés est chauffé à des températures très élevées (90–100 °C), comme par exemple le Halloumi et le Nabulsi. Les fromages traditionnels de la région incluent aussi des fromages à pâte filée demi-dure (par exemple le Kashkaval), dont le caillé est soumis à des procédés de texturation (chauffage, découpage, filage à ~ 75 °C) après égouttage et acidification (pH ~ 5,2). Ils ont généralement une forme plate cylindrique, pas de trous et une couleur jaune-paille à jaune. La production de fromage de lactosérum (par exemple Myzithra, Manouri, Lor, Anari, Urda, Skuta) a été développée très tôt dans cette région, puisque le lactosérum de fromage de lait de brebis et de lait de chèvre est très riche en protéines. Le rendement peut être amélioré si du lait de ces petits ruminants et/ou de la crème sont ajoutés au lactosérum.

**fromage de l'est méditerranéen / fromage blanc saumuré / fromage de lactosérum / fromage à pâte filée / fromage de chèvre / fromage de brebis**

## 1. INTRODUCTION

Traditional cheeses represent a cultural heritage and are the result of accumulated empirical knowledge passed from generation to generation. Every traditional cheese is connected to the territory of its origin and to the prevailing pedoclimatic conditions.

Since pedoclimatic conditions dictate the types of animals kept for milk production, it would be natural for the local traditional cheeses to be made from the milk of autochthonous breeds. Also, the pedoclimatic conditions dictate the botanical flora and, of course, the botanical composition of grass on which the living of these animals is based. In turn, the botanical composition of the pasture affects the organoleptic properties of the cheeses produced, especially their flavour, particularly when they are manufactured from raw milk [12].

The pedoclimatic conditions in most parts of East-Mediterranean countries are characterised by relatively small and irregular precipitations, hot and dry summers, and largely hilly terrain. Such an environment does not favour easy cereal production and development of rich pastures capable of meeting the roughage requirements of raising dairy cattle. However, it is suitable for sheep and goats, which are mostly raised in a nomadic or semi-nomadic system based on native pasture and crop residues [9, 10].

The majority of dairy products, including cheeses, in these countries were – and most of them still are – made from the milk of these two small ruminants, the lactation period of which lasts only for about seven months. Due to the seasonality of the milk production and to the high demand for cheese, nowadays some of the traditional cheeses are also made from cow's milk. However, their flavour and texture are different from the original ones.

The relatively high ambient temperature, the lack of refrigeration facilities, the difficulties of milk transportation and the fact that the cheeses were home-made or artisanal led to a domination (> 50%) of the cheese market by the group of brined cheeses, which are ripened and preserved under brine until their consumption.

Nowadays, manufacturing conditions and refrigeration facilities have changed very much, the microbial quality of the milk has improved, and cheese milk pasteurisation and use of commercial starters for fast curd acidification are widely applied. Despite all this progress, brined cheeses continue to be the typical and most consumed group of cheeses in the East Mediterranean and in some neighbouring countries.

This review does not try to replace existing reviews on individual cheese varieties produced within this area. It is rather a concise survey of the principal cheese groups, which are widely made and consumed in all East-Mediterranean and neighbouring countries. It is focused on the main characteristics of the cheeses of each group, as well as the critical points of their manufacturing process.

## 2. CHEESES RIPENED IN BRINE

Brined cheeses are the most important family of cheeses for East-Mediterranean and neighbouring countries. The cheeses of this family may be very similar but also rather different in respect of manufacturing protocols, composition and organoleptic as well as mechanical properties, etc. However, all of them have the characteristic of being ripened and stored in brine until their consumption.

Because of this diversity and according to manufacturing protocols and other characteristics, the cheeses of this family can be divided into two groups: (a) cheeses, the curds of which are not subjected to any heat treatment, which may be collectively called 'white brined cheeses', and (b) cheeses, the curds of which are subjected to various heat treatments, which will be discussed briefly under the head 'miscellaneous brined cheeses'.

Nevertheless, it is understood that, despite the group to which it belongs, each cheese has its own characteristic and distinct organoleptic properties, and some particularities in its making technology.

### 2.1. White brined cheeses (WBC)

This is the most numerous group. They are produced in all countries of the region under various names: Feta, Telemes (Greece); Telemea/Branza de Braila (Romania); Bjalo salamureno sirene/Bjalo sirene (Bulgaria); Bieno sirenje (FYROM); Mohant (Slovenia); Sjenicki, Homoljski, Zlatarski, Svrljiški (Serbia); Pljevaljski, Polimsko-Vasojevaski, Ulcinjski (Montenegro); Travnicki/Vlasicki (Bosnia-Herzegovina); Beyaz peynir, Edirne peyniri (Turkey); Liqvan, Iranian white (Iran); Brinza (Israel); Akawi (Lebanon); Domiati, Mish (Egypt). WBC represent the most popular cheeses consumed in the region. Traditionally, they were mainly made from sheep's and goat's milk. As the milk fat of these species does not contain carotenoids, the resulting cheeses are white in colour, hence giving the name to this cheese group.

#### *2.1.1. Cheese-making process*

WBC are made from raw (where permitted), pasteurised (e.g. 72 °C × 15 s or 63 °C × 30 min) or thermised (where permitted, e.g. 65 °C × 5 min or equivalent) ewe's, goat's, buffalo's or cow's milk or, often, from mixtures of milks. The great majority of WBC are rennet coagulated and brine-salted cheeses, although some of them are dry-salted (e.g. Feta) or the salt is added directly to the cheese milk (e.g. Domiati). Yoghurt was the traditional starter culture for many WBC. Nowadays, various cultures are used as starters: thermophilic cultures such as yoghurt, mesophilic cultures or various combinations of mesophilic and thermophilic cultures. In raw milk cheeses the native microflora of the milk may be used for acidification [1, 8, 20].

It is difficult to give a single flow-chart for the preparation of all WBC but a general and simplified one could be as follows:

- filtration and (maybe) standardisation of cheese milk (C/F 0.72–0.75 for ewe's ± goat's milk or 0.75–0.8 for cows milk);
- pasteurisation (e.g. 72 °C × 15–20 s / 63 °C × 30 min) or thermisation (e.g. 65 °C × 5 min);
- addition of $CaCl_2$ and starters at 30–35 °C;
- renneting with commercial or artisanal rennet;
- cutting after 50–60 min or more into 1–3-cm cubes;
- rest for 10–15 min;
- moulding into rectangular/square or cylindrical moulds;
- draining (usually under pressure, some without pressure);
- cutting the curd into the final cheese dimensions;
- salting (mostly in brine, some with dry salt);
- packaging in open containers and additional salting with dry salt;
- pre-ripening at 16–18 °C for 5–15 d (until pH reaches a value of 4.6 or lower);
- sealing of the containers and storage at 4 °C or a little higher.

Key points for the manufacture of WBC are the following:

(a) Curd acidification at the appropriate rate and time is necessary during the early stages of cheese making (curdling, draining). Lactic acid production during these stages is of vital importance. Too slow or too low acidification may not suppress the growth of microorganisms able to cause early gas blowing. This is a defect associated mostly with raw milk cheeses. On the other hand, too fast or too high curd acidification leads to excessive drainage, lower yield and dry, hard and grainy cheeses without cohesion, especially when goat's or cow's milks are used for cheese-making.

(b) pH development during ripening. For most of the WBC, it is essential that about 24 h after coagulation pH is lower than 5.0, moisture is $< 600\ g{\cdot}kg^{-1}$ and salt-in-moisture content (S/M) is $\sim 25\ g{\cdot}L^{-1}$. The cheeses should be transferred to the cold room (4–5 °C) only when their pH attains a value of ~ 4.6 or lower, moisture level is $\sim 550\ g{\cdot}kg^{-1}$ and S/M higher than $50\ g{\cdot}L^{-1}$.

(c) A sufficient quantity of brine must be added to the containers to ensure that all cheese blocks are totally submerged. The salt content of the brine must be at least 2% higher than the S/M of the cheese [2].

#### *2.1.2. Characteristics*

The colour of WBC is of course pure white (porcelain-white, marble-white or snow-white) when they are made from sheep's, goat's or buffalo's milk. However, their colour ranges from off-white to yellowish when they are made from cow's milk. When cow's milk is used, as the consumers expect a white-coloured cheese, in some countries (and when permitted) some 'decolourants' (e.g. chlorophylls, titanium dioxide) or other treatments are used to cover or eliminate the yellowish colour.

WBC have no rind. No gas holes or other openings should be present in the cheese mass except, sometimes, for small mechanical openings; the presence of small or large gas holes is taken as a defect. The texture of WBC is smooth, soft and crumbly but still sliceable and some of them may become brittle when old.

Their shape varies, as it is associated with that of the container. Usually cheese blocks are rectangular or cubic and weigh 250–1000 g or more. The cheeses are packed in containers of various sizes. The most common are rectangular tinned or lacquered metal containers or plastic containers holding 15–18 kg each. The containers are usually filled with brine but, in some countries (especially in small artisanal units), cheese whey containing 80–100 $g \cdot L^{-1}$ salt is used for filling. An old traditional practice, which still survives in some countries, was to mature and keep the cheeses in wooden barrels holding about 40–50 kg. In that case the cheese blocks have a sphenoid shape. For retail marketing, cheese blocks (0.5–1.0 kg) may also be packed after ripening in plastic bags under vacuum without brine or in plastic containers with brine, which keeps the freshness of the cheese.

### 2.1.3. *Biochemistry of ripening and compositional changes*

The variety of milks and technologies used for their manufacture, together with the existing official specifications for each cheese in each country do not permit one to give an average composition of WBC. Roughly, their moisture varies between 500 and 580 $g \cdot kg^{-1}$, protein is higher than 170 $g \cdot kg^{-1}$, fat-in-dry-matter (FDM) is 450–500 $g \cdot kg^{-1}$ and S/M 55–90 $g \cdot L^{-1}$ or even more. The pH lies between 4.0 and 5.0 but for most is 4.2–4.8. pH values lower than 4.0 make the cheese very acid and maybe brittle. Values higher than 5.0 are not proper and safe for good keeping quality of WBC [1, 8, 33].

Because of the low pH, the high salt content and the relatively short ripening period, biochemical changes are not extensive during ripening. Mature cheese still contains lactose (~ 10 $g \cdot kg^{-1}$) [35]. For most of them the proteolysis index ([water-soluble N/total N] × 100) lies between 10 and 25% [1, 8, 18, 32, 53] and the level of total free amino acid content ranges from 1 to 7 $g \cdot kg^{-1}$ cheese [20, 29, 49].

In spite of the differences in making technology and temperatures of ripening and storage applied for each particular type of WBC, it is clear that the rate of moisture loss is high for 15–30 d after manufacture and slows down during the rest of the ripening and storage period. This is due (a) to salt uptake from the brine, (b) to acidity development with concomitant reduction of casein hydration as pH reaches its isoelectric point, and (c) to proteolysis, which is intense during that time. It is estimated that in Feta cheese more than 30–50% of $\alpha_{S1}$-CN is hydrolysed during this period [38], resulting in gradual disintegration of the casein network, loss of moisture held in its interstices, and cheese body softening.

The lack of curd cooking, the high moisture content, the low pH during drainage, which favours coagulant retention in the curd, the low pH of the cheese and the relatively high salt content favour the activity of chymosin during ripening contrary to that of plasmin. Gross proteolysis in WBC is mediated by the residual coagulant. Electrophoretic studies showed that $\alpha_{S1}$-CN is hydrolysed much faster and much more extensively than β-CN [29, 38]. In 60- to 90-d-old cheeses residual $\alpha_{S1}$-CN is only 30–40% of the original, while 85–90% of β-CN remains intact. The contribution of extracellular proteinases of the starters is negligible, as was revealed by electrophoretic studies of cheeses made with various starter microorganisms [21].

In contrast, proteinases and peptidases released by starter bacteria as well as by NSLAB are responsible for the production and accumulation of medium- and small-size peptides and free amino acids (FAA) during ripening and storage. The rate of their production is high again during the first 2–3 weeks and decreases when cheeses are transferred into the cold room. The amount of these soluble nitrogenous compounds depends on the species of starter microorganisms and their combination, which were found to also affect the HPLC peptide profile and FAA pattern [21]. It should be noted that, during ripening and storage in brine, some of these water-soluble compounds selectively migrate into the brine [37].

Similarly to proteolysis, lipolysis in WBC is not very extended. The level of total free fatty acids (FFA) ranges between 2 and 4 $g \cdot kg^{-1}$ cheese, including acetic acid. Besides the kind of cheese milk and the age of the cheese, various other factors can affect the concentration and pattern of FFA. Cheeses made from raw milk or milk heat-treated in sub-pasteurisation conditions tend to contain higher amounts of FFA, because indigenous milk lipase remains intact or is not totally inactivated, respectively. Although usually starters have low lipolytic activity, some of them tend to increase the concentration of FFA in cheese, as does drainage of the curd at relatively high temperature (e.g. 21 °C). Increased concentrations of FFA were found when traditional artisanal rennet or rennet pastes were used [1, 17, 28, 41]. Generally, the concentration of volatile fatty acids is higher in cheeses made from sheep's or goat's milk than in those from cow's milk. Despite the milk used, acetic acid is the dominant volatile carboxylic acid [1, 3, 8, 30, 34, 50]. It can be formed from fermentation of lactose by lactic acid bacteria, but also as a result of citrate and lactate metabolism or as a product of amino acid catabolism [36].

#### *2.1.4. Microbiology*

As with many other cheeses, the microbial quality and safety of WBC is influenced by the quality of the raw milk, the thermal treatment of cheese milk, the extent of microbial contamination during processing (especially during salting), the rate of salt absorption and its final concentration in cheese moisture (S/M), and pH development during ripening. As mentioned earlier, WBC are characterised by low pH and high S/M. These two main factors controlling the type and number of microorganisms in cheese play a vital role in respect of safety and also affect the metabolic pathways leading to flavour development in WBC [1, 15].

Although a small proportion of WBC are still made from raw milk without addition of starter cultures, the great majority of WBC are nowadays made from pasteurised milk with added starter cultures composed of mesophilic cocci, thermophilic cocci and thermophilic rods [1, 20, 47]. Therefore, the predominant lactic microflora in fresh cheese consists of these starter microorganisms, the number of which increases rapidly during the first days and remains relatively high during cheese ripening in the warm room (16–18 °C). Later on, the populations decline significantly, especially those of mesophilic cocci, which are gradually replaced by salt-resistant NSLAB bacteria, mainly lactobacilli and enterococci [21, 56].

As far as non-lactic microflora is concerned, many genera of moulds and yeasts are also found in WBC as well as micrococci and coliforms. Coliforms usually disappear along with maturation of WBC. However, they produce $CO_2$ and $H_2$ and – either alone or in concerted action with some yeasts, which also produce $CO_2$ from lactose – are responsible for early gas blowing, a defect usually associated with the use of raw cheese milk of poor quality and cheese processing at high environmental temperatures. The presence of coliforms and yeasts in cheese milk does not necessarily lead to this defect. Early gas blowing appears and is serious when two factors coexist: (a) the initial number of microorganisms associated with this defect is relatively large ($> 10^5$–$10^6 \cdot mL^{-1}$ milk) and (b) the rate of curd acidification by the starter culture is very slow or insufficient to suppress their growth [2].

It should be pointed out that nowadays milk quality has improved and its transportation is largely done under refrigeration. Additionally, in most countries WBC are produced in medium- and large-capacity cheese-plants, where milk pasteurisation and use of starters for fast curd acidification are common practices. All these, together with using automated equipment, which reduces contamination, cooling facilities for lowering temperature in draining and salting rooms, and the application of refrigeration during transportation and storage of the cheeses, have contributed not only to the improvement of the quality and safety of the final product but also made possible the production of cheeses with salt content lower than before, as high salting was traditionally used rather for preservation purposes than for taste improvement.

#### *2.1.5. New trends*

WBC processing, as addressed above, describes the traditional manufacturing protocol. However, contemporary demands for standard quality and safety, as well as growing distribution of cheeses of this group, have led to the introduction of changes in processing and packaging, at least by the large cheese-making plants. The quality of WBC is thus enhanced but more effort must be made, especially in the case of artisanal and farmhouse cheeses.

Among the changes introduced the following can be pointed out: (a) Milk is controlled for consistent composition, microbial and somatic cell counts, and presence of antibiotics and other undesirable compounds. It is advisable to increase awareness among small producers of the microbiological hazards and their impact on cheese quality and safety. (b) Milk is standardised for casein to fat ratio and pasteurised. (c) Commercial starter cultures are used in order to have a direct control of the ripening process. The use of commercial starters is suggested to all cheesemakers not having the appropriate facilities to produce their own cultures. (d) Mechanisation is introduced in order to avoid contamination of the curd and fresh cheese during handling and reduce labour costs. Computer control systems are applied to follow and change processing parameters more easily. (e) The HACCP (hazard analysis of critical control points) concept is implemented by large- and medium-size plants, regarding a proactive approach as the most appropriate way to improve quality and safety and avoid defects. (f) Refrigeration is used throughout the storage and distribution chain.

Innovation is also introduced in respect of packaging. WBC were – and still are – sold mainly by weight ('à la coupe'). However, the trend for pre-packaged cheese, that offers more convenience and safety and responds to consumer habits, is also growing in the case of WBC. Demand for WBC as 'gourmet', 'ethnic' or 'speciality' products is rising in European, American and other markets, thus making the use of individual packaging for direct consumer purchase a must. Flexible plastic packaging and re-closable rigid plastic containers are both used; a rectangular shape fits the form of cheese blocks well, but also provides space-saving geometry. Irrespective of the packaging material and shape, the surface of WBC must be kept moist. Therefore, the packaging must contain some brine. Sometimes WBC are stored and marketed in glass jars: small cheese pieces are covered by olive oil; flavouring with spices offers an alternative option.

## 2.2. Miscellaneous brined cheeses (MBC)

The common characteristic of MBC is that their curds, after draining/pressing, are heat-treated at high temperatures (95–100 °C) or their curds, after acidification (pH 5.2–5.4), are subjected to a special texturisation process (*pasta filata*-type), which involves heating, kneading and stretching in hot (~ 75 °C) whey or brine. Heat treatment of the curds at the above temperatures considerably reduces the microflora of the cheese (starter and NSLAB), changes the time of microbial cell lysis, influences the dynamics of the various members of microbial groups, and leads to extensive denaturation of residual coagulant retained in the curd. Thus, in contrast to the WBC, where the residual coagulant is the main proteolytic agent, plasmin is of particular importance for these cheeses since it is a heat-stable enzyme.

All the above factors limit to some extent the biochemical reactions which occur in cheeses during ripening. Because of the high heat treatment, MBC are relatively 'safe' and many are consumed within a few days after manufacture. Otherwise, they are stored under brine for ripening and later consumption.

Traditionally, these cheeses are made from raw sheep's and/or goat's milk. Nowadays some of them are also made from pasteurised cow's milk with starter addition. Since these cheeses are produced only in some countries of the area, they will be discussed very briefly. However, literature will be provided in respect of their manufacturing protocols, composition and biochemistry of ripening, as well as organoleptic and rheological properties.

### *2.2.1. Cheeses whose curd is heated at high temperatures*

This type of cheeses is popular in Cyprus (Halloumi), Southeast Turkey (Hellim, Urfa, Malatya) and in Syria and neighbouring countries (Halloumi, Nabulsi, etc.). Traditionally they were made mostly from raw sheep's or goat's milk or their mixtures. However, nowadays pasteurised cow's milk and starter cultures are also used for some of them. The most well-known cheese of this group is Halloumi, the making technology of which is in brief as follows:

Raw milk is clotted with animal rennet at 33–34 °C and the curd cut into 1-cm cubes. After resting for about 10 min, curds are scalded under constant stirring at about 40 °C within 15 min and transferred to the hoops for draining, usually under pressure. The pressed curd is cut into pieces of 10 × 15 × 3 cm, transferred to their own hot deproteinated whey and heated up to 90–95 °C for 30 min under stirring. The cooked curd is not stretched, as in *pasta filata* cheeses, but is drained and cooled on a table and sprinkled with medium-size grain salt and crushed dry mint (*Mentha viridis*) leaves (compulsory) before being folded in half. Next day, these blocks are packed in plastic bags for immediate marketing. Alternatively, they are piled into containers and salted whey is poured into the container until the blocks are covered. This way they can keep for months. It should be noted that the rheological and sensory properties of the fresh cheese change significantly during storage [7, 13, 14, 16, 19, 24, 27, 39, 42–46, 51].

For this type of cheese the most crucial step of processing is the time/temperature profile within each cheese block during the cooking step. The whole mass of curd needs to be cooked well at the above-mentioned temperature. Otherwise, the colour and the texture in the core of each block will be different from the rest of the cheese. The uniform cooking depends strongly on the dimensions of the blocks; therefore the curd blocks are small and flat [44].

The technology of Nabulsi cheese differs somewhat from that of Halloumi-type cheeses. After pressing, the curd is cut into pieces of ca. 4 × 8 × 2 cm or 10 × 10 × 2 cm which are boiled in brine (150–200 g salt·$L^{-1}$) until they float to the surface of the brine. A cheesecloth bag containing ground mastic (*Pistacia lentiscus*) and mahaleb seeds (*Prunus mahaleb*) is at the same time hung in the boiling brine. This process usually requires 5–15 min. Then the curd pieces are taken out of the brine, placed on a table and reshaped. After cooling, they are placed in containers, which are filled with the brine in which the cheese was boiled [22, 55, 57].

#### *2.2.2.* **Pasta filata-*type cheeses in brine***

The making technology of these cheeses differs from country to country but the general steps followed are these described in *pasta filata* cheeses (Kashkaval-type). What distinguishes these cheeses from *pasta filata*-type cheeses is their shape and the fact that they are consumed while fresh or are kept in brine.

Several cheeses of this type are made but the most popular are the braided cheeses, known as Örgü (Eastern parts of Turkey), Mujaddal or Mudaffara (Syria and neighbouring countries) cheeses. For all these cheeses, the curd is left to acidify (pH ~ 5.2) and then is stretched and shaped into a loop (70–75 °C), which is finally split into either thin or thick strands to form the braid of the final cheese [14, 25, 55]. In contrast, for Civil cheese (Turkey) skim milk is left to acidify (pH ~ 5.4) before being warmed to ~ 30 °C and renneted. The temperature is slowly increased under continuous stirring. The curd is formed at ~ 50 °C. At ~ 70 °C the curd starts to form in threads; then, it is taken out from the vat with a paddle and hung to be stretched by its own weight [58].

## 3. *PASTA FILATA* CHEESES

*Pasta filata* (PF) cheeses have a long tradition in most East-Mediterranean and neighbouring countries. In many of them PF cheeses are highly consumed and in some are the second most popular cheese group after white brined cheeses. Kashkaval-type cheeses are the best-known PF cheeses, made for centuries in this area. In most countries of the area they are called simply Kashkaval with small differences in spelling. However, variations of that name exist, such as Kashar (Albania), Kašar (Turkey), or Kasseri (Greece).

Traditionally, they were produced from raw sheep's (± goat's) milk and fewer from buffalo's or cow's milk or a mixture of milks. Since the manufacturing technology has been adapted to suit the local conditions and practices, it presents some differences, although small, from country to country. These differences include the kind of milk used and its thermal treatment, the use of culture and its composition, the curd scalding before acidification, the way of salting the curd and final cheese, etc. In spite of the above differences, the manufacture of Kashkaval-type cheeses consists of two distinct, independent stages: (a) production of the curd and its acidification, and (b) texturising of the acidified curd, which involves heating, kneading and stretching by soaking in hot water or in brine.

### 3.1. Cheese-making process

After filtration, milk is pasteurised (e.g. 72 °C × 15–20 s), cooled to 32 °C, inoculated with starter and coagulated by rennet for 30–40 min. The curd is cut (6–8-mm cubes), left for about 10 min to settle to the bottom of the vat or stirred for about 5 min, and then scalded to 42 °C for 35 min. Scalding may be omitted for higher acidity milk or for some types of Kashkaval made with sheep's milk. Curds collected from the bottom of vats are pressed by hand, cut into large blocks, pressed and left to be acidified (to ripen).

Curd acidification to a certain extent is of importance since it results in the characteristic fibre-like structure of the final cheese. Also, the lactic acid produced during acidification inhibits the growth of some unwanted microorganisms (gas-forming, etc.), which may result in a cheese with defects. The acidified curd is ready for further processing when its pH value is close to 5.2–5.3 for sheep's milk, or a little higher (5.4–5.5) for cow's milk Kashkaval [5, 31].

In the traditional procedure, the native microflora of raw milk was used for curd acidification, which is not a very controllable procedure. Because of this, in many countries, the use of pasteurised milk and starter cultures has been introduced into commercial practice in order to control and shorten the time of curd acidification and standardise the quality of Kashkaval cheese. Usually, thermophilic cultures (yoghurt) are used, but also combinations of thermophilic and mesophilic cultures are applied at a level ranging from 0.1 to 1% [5, 26, 31, 54].

The ripened (acidified) curd is cut into long thin slices and texturised. According to traditional methods, which require intensive manual labour, the curd slices are placed into wooden or metal perforated baskets, immersed in hot water (~ 75 °C) and manipulated with a wooden stick until a homogenous compact structure is obtained. The curd, while hot, is transferred onto a table and kneaded by hand, partially salted with fine salt, and moulded. While in the mould, cheeses are transferred to warm rooms (< 18 °C and RH 80–85%) and, after 24 h, are salted with medium-size grain salt. After 2–3 days the moulds are removed and the cheeses salted again. Cheese salting and turning last for 2–3 weeks (5–7 saltings). Then cheeses are washed with warm water, then cold water, dried and piled 6–7 together. They are left to ripen for about 2–3 months in the same room or they are transferred to a lower temperature room (12–15 °C, RH 85%). Finally, they are kept at 2–4 °C. Their shelf life is about 12 months or maybe more [5, 31].

The traditional technology described above leads certainly to a high sensory quality product but it is laborious and raises the production costs. Therefore, it has gradually been modified. Now, in large factories, cutting of ripe curd, heating, kneading, stretching, salting and moulding are all mechanised. Salting is done only once, during kneading of the curd; sometimes, additional salting is carried out either with brine or with dry salt.

Despite the technology used, heat treatment of the curd during texturising has a preservative effect on the final cheese, enabling raw milk of poor microbiological quality and relatively high acidity to be processed. So, it is not by coincidence that this type of cheese has been widely produced for many centuries in the area.

### 3.2. Characteristics

The typical form of Kashkaval-type cheeses is flat cylindrical (diameter:

~ 30 cm and height: 10–13 cm), weighing 7–8 kg, although in some countries they are smaller (~ 4–5 kg). Additionally, and besides the typical shape, rectangular cheeses (~ 30 × 10 × 10 cm) are produced in some countries from cow's milk. Their rind is smooth, thin and light yellow to amber-coloured. The cheese mass is light yellow or straw yellow to yellow, depending on the milk used. The texture of all Kashkaval-type cheeses is laminar, elastic, very close with visible layers, occasionally with random slots but without gas holes [23, 31].

### 3.3. Composition

The variability in the gross composition of Kashkaval-type cheeses arises from the fact that the processing technology is subject to many variations in respect of the type of milk used and its standardisation to a certain casein/fat ratio, the degree of heat treatment either during scalding or the texturisation process, the degree of ripening and the age of marketed cheese. Finally, various national standards also exist. Moisture lies between 350 and 440 $g \cdot kg^{-1}$, fat from 245 to 280 $g \cdot kg^{-1}$, protein from 210 to 270 $g \cdot kg^{-1}$, salt from 25.2 to 46.7 $g \cdot kg^{-1}$ and pH is 5.1–5.7 [5, 23, 52].

### 3.4. Biochemical changes during ripening

Proteolysis is not very intense in Kashkaval-type cheeses. The proteolysis index ([water-soluble N/total N] × 100) is around 20%, although some extreme values such as 10% or 30% are found in the literature. It should be mentioned that a significant part of soluble N (~ 25–30% of the soluble N of mature cheese) is produced during curd acidification and, consequently, is partly lost into the water or brine during the texturisation process. The total free amino acid content ranges from 2.2 to 4.5 $g \cdot kg^{-1}$ cheese [4, 11, 40, 54].

In Kashkaval-type cheeses $\alpha_{s1}$-CN is hydrolysed during curd acidification by the residual rennet much more than β-CN. However, during the texturisation process, the residual rennet is inactivated to a great extent; thus, during ripening the hydrolysis of β-CN by plasmin becomes significant as it is deduced from the presence of strong γ-CN bands in electrophoretograms [4, 11].

Lipolysis in this type of cheese is not very intense either. The concentration of FFA in mature (3 mo) cheeses lies between 1 and 3 $g \cdot kg^{-1}$, although this value may rise up to 5–6 $g \cdot kg^{-1}$ in much older cheeses [11].

## 4. WHEY CHEESES (WC)

Traditionally, the cheeses of this family were manufactured mostly from whey of sheep's and goat's milk cheeses, not only because the majority of cheeses in the region were made from the milk of these two animals, but also because this whey is much richer in protein and fat as compared with cow's milk cheese whey. As the production of sheep's and goat's milk cheeses is seasonal, the production of WC is seasonal as well. However, some WC are manufactured from cow's milk cheese whey throughout the year. Irrespective of the kind of whey used, yield of whey cheeses is higher when made from the whey of hard or *pasta filata* cheeses than that of soft cheeses [6].

Whey cheeses are produced in most East-Mediterranean countries under various names: Myzithra, Anthotyros, Manouri, Xynomyzithra (Greece), Urda (Serbia, Romania, Israel), Lor, Jaji (Turkey), Anari (Cyprus), Skuta, Puina (Croatia), Karichee (Lebanon), Double cream (Syria), etc.

### 4.1. Cheese-making process

Most of them are heat- and/or acid-coagulated cheeses and their technology varies in respect of the raw material (kind of whey) used, the eventual addition of milk and/or cream to the whey to be processed, and the traditional recipe.

The general manufacturing procedure is as follows: After filtration to remove any existing curd particles, the whey is heated preferably in circular cheese vats under continuous stirring. The rate of heating is such as to attain 88–92 °C in 40–45 min. The rate of heating is of importance as well as the rate of stirring. The first small particles of denaturated whey proteins appear at temperatures around 80–82 °C or a little lower, depending on the kind of whey, its acidity and the proportion of the whole milk added. At this stage, heating is speeded up until the whey reaches the final temperature, but stirring is greatly delayed and finally stopped when a very thin layer of aggregated particles is formed at the surface of the whey. It should be noted that the final temperature is lower when whey cheeses are to be consumed fresh, whereas a higher temperature is selected when the cheeses are to be air-dried. The coagulum – while floating on the whey surface – is left for 15–20 min at the selected final temperature to lose part of its moisture (i.e. to be cooked). Consecutively, the curd is gradually scooped and placed into moulds for drainage, which can be completed within 3–5 h. Cheeses are then transferred to the cold store for several hours and are ready to be marketed, as fresh. Otherwise, after draining the cheeses are salted and kept in well-ventilated cool rooms, until they obtain moisture < 400 $g \cdot kg^{-1}$ [6, 48].

When whey is the sole raw material, the particles of denaturated proteins are small, yield is low and cheese flavour is bland and may be semi-sweet. In order to improve the yield and quality, whole milk and/or cream are added to the whey during heating. The percentage added depends on the type and quality of the cheese intended to be produced. Usually, 30–50 $mL \cdot L^{-1}$ whole milk is added; however, for higher quality cheeses, milk percentage could be 10% or higher and cream may also be added. The co-precipitation of milk caseins with denaturated whey proteins results in larger grains – which are collected more easily – higher fat and protein content of the product and, of course, higher yield.

Milk is added to the whey when it has reached 65–70 °C, in one or several batches, while cream is added preferably first or with the first batch of milk. Salt may also be added (10–15 $g \cdot L^{-1}$) to the whey at 73–75 °C. An acidification agent is also added (it is usually needed in the case of cow's cheese whey) to help denaturation and final precipitation of the whey proteins. It is applied in the form of an aqueous 100 $g \cdot L^{-1}$ solution of citric acid at the rate of 6 $mL \cdot L^{-1}$. This quantity decreases the pH to about 5.2. If the pH is significantly lower, denaturation of whey proteins is faster but very small grains are formed, which cannot be easily collected. The acidification agent is added at the final temperature and before the stirring is stopped.

### 4.2. Composition

The differences in composition of the whey, according to the type of cheese and the kind of cheese milk, combined with the fact that whey can be used either as the sole raw material or as a mixture with full-fat milk and/or cream, lead to a large variability in whey cheese composition. However, for most fresh WC moisture is 650–700 $g \cdot kg^{-1}$, fat 70–150 $g \cdot kg^{-1}$, protein 90–140 $g \cdot kg^{-1}$, salt 6–8 $g \cdot kg^{-1}$, lactose 35–45 $g \cdot kg^{-1}$ and pH 5.5–6.0. For cheeses made with addition of large amounts of milk and cream moisture is 480–600 $g \cdot kg^{-1}$, fat 350–400 $g \cdot kg^{-1}$, protein 90–110 $g \cdot kg^{-1}$, salt 6–8 $g \cdot kg^{-1}$, lactose 55–58 g·kg$^{-1}$ and pH 5.5–6.0 [6,13, 23].

### 4.3. Characteristics

For cheeses made from whey alone or enriched with small amounts of milk, the shape is that of the container used for the package. However, the shape of higher fat WC is cylindrical, nearly spherical or that of a truncated cone. Their colour is pure white to off-white. Of course, they have no rind and no gas or other holes. Most of them are grainy, except for the high-fat cheeses, whose texture of which is soft, smooth and creamy.

## 5. HARD AND SOFT CHEESES

In addition to the major cheese groups presented above, quite a number of hard and soft cheeses are produced in the region. Some of them have a long tradition, such as Kefalotyri, Ras/Rumi/Roomi, Paški, Selam, Mihalič, etc. Others are 'copies' of Central-European cheeses (e.g. Gruyère-type cheeses), which are made from cow's as well as from sheep's milk. Although they were introduced in some countries nearly a century ago, they may not be characterised as real traditional cheeses.

Moreover, some soft, especially fresh acid curd cheeses are traditionally produced within the area. Apart from fresh cheeses, a small number of soft cheeses ripened for several months, usually in clay pots underground, are of local interest.

Taking this area as a whole and with few exceptions, the consumption of both hard and soft cheeses is much lower than that of the major cheeses presented above.

## 6. CONCLUSIONS

The present review shows that the cheese-making tradition in the East-Mediterranean countries is significantly driven by the pedoclimatic conditions of the region. Sheep's and/or goat's milk, level of salt, level of acidity, treatment at high temperatures of the curd (*pasta filata* cheeses) or the whey (whey cheeses) and ripening and storing in brine (brined cheeses) are some of the characteristics that enable local cheeses to be conserved at the high environmental temperatures prevailing, if not consumed fresh.

Nowadays, cow's milk is produced in larger quantities, manufacturing conditions and refrigeration facilities have changed very much, microbial quality of the milk has improved, and cheese milk pasteurisation and use of commercial starters are widely applied. However, consumer preferences have changed only little. Thus, brined cheeses continue to be by far the major cheese group produced and consumed in the region.

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