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Review

Cheeses of Turkey: 2. Varieties ripened under brine

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Abstract – Although a large number of traditional brined cheese varieties are produced in Turkey, very few are manufactured on an industrial level. The most popular brined cheese in Turkey is Beyaz peynir; other varieties produced at substantial levels include Otlu, Mihalic, Urfa, Malatya, Gaziantep, Hellim, Orgu, Ezine and Dil. Local production of these cheeses has increased significantly and some of them can be found readily throughout Turkey. The volume of milk used in the manufacture of traditional cheese varieties in Turkey is fairly high. Therefore, there is a need to fully understand the microbiological, chemical and biochemical changes that occur in traditional cheeses during processing and/or ripening, so that industrialisation of these products would be possible. This review describes the manufacturing practices, and microbiological and biochemical/chemical properties of traditional Turkish brined cheeses. The description of Beyaz peynir is updated, but other brined varieties are discussed initially.

cheeses of Turkey / brine / white cheese / proteolysis / microbiology / ripening

摘要 – 土耳其干酪 2: 盐水成熟干酪的种类。摘要 尽管在土耳其传统盐水干酪的品种很多, 但工业化生产的品种较少。其中最受欢迎的是 Beyaz peynir 干酪, 其次是 Otlu、Mihalic、Urfa、Malatya、Gaziantep、Hellim、Orgu、Ezine 及 Dil 干酪。这些干酪在当地的产量逐年增加, 有的干酪品种已经在全国范围内生产。在土耳其, 用于生产传统干酪的原料奶的消耗量相当大。因此, 有必要全面地了解传统干酪加工和成熟过程中微生物、生化和化学变化, 使这些产品的工业化生产成为可能。本文介绍了传统土耳其盐水干酪的制作工艺, 以及其微生物学、生物化学特性。着重介绍了 Beyaz peynir 干酪的最新研究进展, 并对其它品种的盐水干酪进行了回顾。

土耳其干酪 / 盐水 / 白干酪 / 蛋白水解 / 微生物学 / 成熟

Résumé – Fromages de Turquie : 2. Variétés affinées en saumure. Bien qu'un grand nombre de variétés traditionnelles de fromages affinés soient produites en Turquie, très peu d'entre elles le sont au niveau industriel. Le fromage affiné en saumure le plus populaire en Turquie est le Beyaz peynir ; d'autres variétés produites à des niveaux substantiels incluent les fromages Otlu, Mihalic, Urfa, Malatya, Gaziantep, Hellim, Orgu, Ezine et Dil. La production locale de ces fromages a augmenté significativement et certains d'entre eux peuvent être trouvés facilement partout en Turquie. Le volume de lait utilisé dans la fabrication des variétés de fromage traditionnelles en Turquie est assez élevé.

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Il y a donc besoin de bien comprendre les changements microbiologiques, chimiques et biochimiques qui interviennent dans les fromages traditionnels au cours de la fabrication et/ou de l'affinage de façon à rendre possible l'industrialisation de ces produits. Cette revue décrit les pratiques technologiques et les propriétés microbiologiques et biochimiques/chimiques des fromages turcs traditionnels saumurés. La description du Beyaz peynir est actualisée, mais d'autres variétés saumurées sont présentées pour la première fois.

fromage de Turquie / saumure / pâte fraîche / protéolyse / microbiologie / affinage

1. INTRODUCTION

Brined cheeses are manufactured mainly in Mediterranean and Balkan countries, including Turkey. They are produced under different names, i.e., Beyaz peynir (Turkey), Feta (Greece), Bjalo Salamureno Sirene (Bulgaria), Domiati (Egypt), Teleme (Greece, Romania, Turkey), Iranian White (Iran) and Beli Sir U Kriskama (former Yugoslavia) [33]. Some local varieties ripened under brine are also produced in the above-mentioned countries. Some examples in Turkey are Urfa, Gaziantep, Malatya, Orgu, Mihalic, Ezine, Dil, Otlu and Hellim (Fig. 1); Sfela, Batzos, Kalathaki Limnou in Greece [9]; Gibna beyda in Sudan, Mish in Egypt, Nabulsi in Jordan, Mudaffara in Sudan and Middle Eastern countries, Akawi in Lebanon and Syria [2]. In general, these cheeses have no rind and a salty and slightly acidic taste which arise from storage in a dense brine (12 to 18% NaCl) and the action of lactic acid bacteria during ripening, respectively. Therefore, salt and acid are the critical parameters for conservation of these types of cheese and are checked periodically during maturation to ensure the quality of the cheese.

The cheeses were produced originally from sheep's or goats' milk, but recently, cows' milk or mixtures of these types of milk are used. Since the lactation period of sheep or goats is shorter than that of cows, the use of cows' milk has increased gradually. However, some types of brined cheeses are produced in Turkey from sheep's milk only. Ezine cheese is produced from milk of the Sakiz breed in Ezine county of Canakkale, which has obtained a designation "Controlled Geographical Origin". Also, Urfa cheese is made traditionally from Awassi sheep's milk in the Sanliurfa region.

2. BEYAZ PEYNIR (TURKISH WHITE BRINED CHEESE)

2.1. Chemical and technological aspects

Beyaz peynir is the most popular cheese variety in Turkey, representing about 60% of the country's total cheese production; its manufacture dates back thousands of years [72]. The classical product is generally cubical or rectangular in shape with no rind [33]. Although no specific definition of Beyaz peynir is available in the Turkish Standards (TS) based on its moisture content, some researchers have defined the product as semi-hard [73, 74] or semi-soft [19]. According to the present Turkish Standards, Beyaz peynir is divided into four groups based on the % fat-in-dry matter (FDM):

- full-fat (minimum 45 g·100 g^{-1} FDM);
- semi-fat (30–44 g·100 g^{-1} FDM);
- low-fat (20–29 g·100 g^{-1} FDM); and
- non-fat (< 20 g·100 g^{-1} FDM).

The production technology and chemical, microbiological and biochemical properties of Beyaz peynir were reviewed by Hayaloglu et al. [33]. The manufacturing protocol for Beyaz peynir shows similarities to Feta cheese-making, with slight differences. Cows', sheep's, goats' milk or

Figure 1. Some varieties of brined cheeses produced in Turkey. 1: Mihalic, 2: Ezine, 3: Urfa, 4: Diyarbakir Orgu, 5: Malatya, 6: Dil, 7: Otlu, and 8, 9: Beyaz peynir.

mixtures of these are used in the manufacture of Beyaz peynir. The average yield of Beyaz peynir made from sheep's milk is 26–28 kg·100 kg^{-1} [20], while the yield from goats' or cows' milk is 15–16 kg·100 kg^{-1} [33]. Raw milk is used widely in the manufacture of classical Beyaz peynir by small dairies but, in some parts of Turkey, where hot climatic conditions prevail, the product is made from heat-treated milk (e.g., 65–68 °C for 5–30 min or 80 °C for 1–2 min) [72]. In industrial-scale cheese-making, raw milk has largely been replaced by pasteurised milk (72 °C for 15 s) [71].

Standardisation of the casein-to-fat (C:F) ratio is not common in classical Beyaz peynir production but it is widely employed in industrial production; for a high quality Beyaz peynir, a C:F ratio of 0.8:0.9 was reported to be optimum [7]. To the best of our knowledge, increasing the total solids level in cheese milk is not used in industrial Beyaz peynir production. Yetismeyen [82] reported that proteolysis in Beyaz peynir produced from UF-concentrated milk was slowed down, leading to a longer ripening period to attain the desired organoleptic characteristics in the final product.

The milk used in the production of Beyaz peynir is generally coagulated by commercial calf rennet, but the increased consumption of cheese has led to an increase in the demand for rennet while there has been a decrease in the number of young animals available for slaughter to produce the enzyme extract [64]. Therefore, other suitable coagulants, including proteinases from microorganisms, have become more popular in the manufacture of Beyaz peynir (Tab. I).

Salting is another factor affecting the composition and ripening of Beyaz peynir. In general, the higher the level of NaCl in brine, the lower the rate of proteolysis in Beyaz peynir [55, 72]. Guven et al. [28] ripened Beyaz peynir in brine containing

Table I. Impact of milk coagulant on the properties of Beyaz peynir.

Coagulant	Impact on cheese	References
Fromase and Rennilase using *Rizomuchor miehei*	No effect on cheese yield, acidity, dry matter or fat but faster proteolysis.	Yesilyurt [81]
Microbial coagulant using *R. miehei*	Proteolysis faster (ripening index of 24.0%) than cheese made using calf rennet (ripening index of 16.2%).	Yetismeyen et al. [84]
Fromase 46T (using *R. miehei*) Rennilase 150L (using *R. miehei*) Maxiren 50 (using *Kluyveromyces marxianus* var. *lactis* by recombinant DNA technology) Liquid commercial rennet (90% chymosin and 10% pepsin)	The fastest ripening was obtained in the cheese made from Fromase followed by Rennilase, calf rennet and Maxiren.	Saldamli and Kaytanli [64]
Chicken pepsin or mixtures (50:50 or 70:30) of chicken pepsin and calf rennet	No differences observed in the sensory and overall chemical quality of the cheeses.	Uysal et al. [78]

12, 14, 16 or 18 g NaCl·100 g^{-1} water at 7 °C for 9 weeks. The authors found that the brine concentration affected the pH, TCA-soluble nitrogen and hydrolysis of β-casein, but showed no effect on the level of water-soluble nitrogen and the hydrolysis of α_{s1}-casein. The organoleptic properties of cheese ripened in a 12 g NaCl·100 g^{-1} brine was the most preferred. Alternative salting methods (i.e., adding salt to the milk or the curd before pressing) or partially substituting NaCl by other salts, such as KCl or $MgCl_2$, have been found to be promising in laboratory-scale Beyaz peynir production but these methods are not common yet in industrial applications [4, 26, 27].

2.2. Microbiological and biochemical aspects

Lactic acid bacteria are predominant in Beyaz peynir, and the main isolates are *Lactococcus lactis* subsp. *lactis*, *Lc. lactis* subsp. *cremoris*, *Lactobacillus casei* subsp. *casei*, *Enterococcus faecalis* var. *liquefaciens* and *Leuconostoc paramesenteroides* (now *Weisella paramesenteroides*) with *Lc. lactis* subsp. *lactis*, at 2.6×10^6 cfu·g^{-1}, being the dominant species encountered [36]. With continued ripening, the numbers of lactococci decrease and species of lactobacilli (e.g. *Lb. casei* subsp. *casei*) become dominant in Beyaz peynir. A similar trend in the profile of lactic acid bacteria of Beyaz peynir was observed by Karakus et al. [45].

Many species of starter microorganisms have been used in the manufacture of classical Beyaz peynir, and many combinations have been tested to establish the best match of composition and properties with the characteristics of this variety of cheese [24]. Determination of the technological properties of the natural flora of cheese is important in the selection of a balanced combination of starter bacteria to obtain the best texture, aroma/flavour and body in cheese. The enzymatic activities of the natural lactic flora should be the prime criterion in deciding the starter bacteria for cheese-making. Durlu-Ozkaya et al. [16] isolated the dominant lactic acid bacteria in mature Beyaz peynir made from ewe's milk and evaluated the technological properties of the isolated bacteria. These authors concluded that whole cells of *Lc. lactis* subsp. *lactis* and enterococci showed

lipolytic and proteolytic activities. Strains differed in terms of their acidifying and caseinolytic activity. Most of the enterococci isolates showed tyrosine decarboxylase activity; lactobacilli exhibited weak antibacterial activity against food-borne pathogens. Similarly, Karakus [44] found that *Lc. lactis* subsp. *lactis* and citrate-positive *Lc. lactis* subsp. *lactis* isolated from Beyaz peynir had strong acidifying activity but the acid-producing capacity of *Lb. casei* and *Lb. plantarum* isolated from the same samples was weak. Karakus [44] also noted that the proteolytic activity of lactobacilli was lower than that of lactococci. Gursel et al. [23] investigated the potential of freeze-shocked thermophilic *Lactobacillus* species (*Lb. delbrueckii* subsp. *bulgaricus* or *Lb. helveticus*) as adjunct cultures for Beyaz peynir production. They demonstrated that ripening was accelerated by the incorporation of freeze-shocked *Lactobacillus* spp., especially *Lb. helveticus*, without impairing the body and texture of the final product. It was reported that *Lb. sake* LS-9 used in combination with *Lc. lactis* ssp. *lactis* in the manufacture of Beyaz peynir produced a good quality cheese unless the level of inoculum was high [5]. Recently, Yilmaztekin et al. [85] investigated the potential of incorporating *Bifidobacterium* BB-12 and *Lb. acidophilus* LA-5 as adjunct cultures in Beyaz peynir production. The authors reported that the numbers of both probiotic bacteria decreased gradually throughout the 90-day ripening. However, Kasimoglu et al. [46] maintained that the counts of *Lb. acidophilus* were high enough for a claimed therapeutic effect in vacuum-packed Beyaz peynir.

The combinations of starter cultures used in the production of Beyaz peynir are listed in Table II. Some strains of *Lc. lactis* subsp. *lactis* and subsp. *cremoris* are salt-tolerant and have high proteolytic activity and/or acid-forming capacity, but yoghurt starter bacteria and most species of lactococci die out early during the maturation of Beyaz peynir.

Recently, Hayaloglu [29], who compared the performance of four single strains of lactococci (UC317, NCDO763, HP or SK11) used as starters in the manufacture of Beyaz peynir, found no difference between the cheeses in terms of acid degree value (ADV) but the development of pH and proteolysis (soluble nitrogen fractions) in the cheeses made with these strains were different during 90 d of ripening. Each strain of *Lactococcus* contributed to proteolysis in different ways and released different levels of soluble nitrogen and free amino acids in the cheese matrix [29]. Qualitatively and quantitatively different peptide profiles in the pH 4.6-soluble fraction were evident of Beyaz peynir made with different strains of lactococci, as shown Figure 2 [34]. It was proposed that the different peptide profiles were due to different cell envelope-associated proteinases in the lactococcal strains used. Urea-PAGE of the pH 4.6-insoluble fraction of Beyaz peynir made with defined strains of lactococci indicated that α_{s1}-casein was hydrolysed more rapidly than β-casein [34]. However, only slight differences between cheeses made with different strains of lactococci were detected by urea-PAGE (Fig. 3). Hayaloglu et al. [35] investigated the influence of various *Lactococcus* strains on biochemical changes in Beyaz peynir throughout ripening. The level of peptides in the cheeses increased throughout ripening as determined by RP-HPLC of the 70% ethanol-soluble or -insoluble fractions of the cheeses and the cheeses were grouped by principal component analysis (PCA) and hierarchical cluster analysis (HCA) based on the type of starter and stage of ripening (Fig. 4). The use of a starter culture and the strain of starter influenced the individual amino acid profile of Beyaz cheese [35]; Leu, Glu, Phe, Lys and Val were the

Table II. Starter organisms used in the manufacture of Beyaz peynir (with permission of Toufeili and Ozer [72]).

Blends of organisms	Inoculation level (mL·100 mL^{-1})
Ent. durans 41770 + *Lb. delbrueckii* subsp *bulgaricus* CH2	1.0
Lc. lactis subsp. *lactis* + *Lc. lactis* subsp. *cremoris* + *Leu. mesenteroides* subsp. *cremoris*	NR[1]
Lc. lactis subsp. *lactis* + *Lc. lactis* subsp. *cremoris* + *Lb. sake*	1.0
Lc. lactis subsp. *lactis* + *Lc. lactis* subsp. *cremoris* + *Lb. plantarum*	1–2.0
Lb. delbrueckii subsp. *bulgaricus* + *Str. thermophilus* (1:1)	0.5–1.0
Lc. lactis subsp. *lactis* + *Lc. lactis* subsp. *cremoris*	2.0
Lc. lactis subsp. *lactis* + *Lc. lactis* subsp. *lactis* biovar. *diaceytlactis* + *Lb. casei* (1:1:1)	2.0
Lb. casei + *Lc. lactis* subsp. *lactis* (1:1)	0.5–2.0
Lc. lactis subsp. *lactis* S1 + *Lb. plantarum* L8 + *Ent. durans* C2O	NR
Lc. lactis subsp. *lactis* CH + *Ent. durans* CH + *Ent. faecalis* CH + *Lb. delbrueckii* subsp. *lactis* CH	NR
Lc. lactis subsp. *cremoris* + *Lc. lactis* subsp. *lactis* (R707) + *Lb. helveticus* LH100[2] + *Lb. delbrueckii* subsp. *bulgaricus* LB12[2]	NR
Lc. lactis subsp. *cremoris* + *Lc. lactis* subsp. *lactis* + *Lb. casei*	2.0
Lc. lactis subsp. *lactis* + *Lc. lactis* subsp. *cremoris* + *Bif. bifidum* BB12 + *Lb. acidophilus* LA5	1.0

[1]NR = not reported.
[2]Used as heat shocked culture at a rate of 2 g·100 mL^{-1}.

predominant amino acids in all cheeses at day 60 (Fig. 5).

High lipolytic activity in Beyaz peynir is not a characteristic property, but the use of weakly lipolytic strains of the lactic acid bacteria is desirable. Guler and Uraz [21] found that myristic (C_{14}), palmitic (C_{16}), stearic (C_{18}) and oleic ($C_{18:1}$) acids were the principal free fatty acids in commercial Beyaz peynir samples (n = 30). More recently, Ozer et al. [55] demonstrated that the level of long-chain free fatty acids in Beyaz peynir made with *Lc. lactis* subsp. *lactis* and subsp. *cremoris* plus microencapsulated *B. bifidum* BB-12 and *Lb. acidophilus* LA-5 as adjunct cultures was much higher than the short- or medium chain FFAs.

Akalin et al. [3] who evaluated the contribution of organic acids to flavour development in Beyaz peynir throughout 12 months of ripening, found that lactic acid accounted for 95% of the total organic acids during the early stages of ripening, but after 9 and 12 months of ripening, butyric acid constituted 20 and 27%, respectively, of the total organic acids in the same cheeses.

Kaptan et al. [42] monitored the accumulation of biogenic amines in Beyaz peynir made by incorporating *E. faecium* and *E. faecalis*, combined with a commercial lactococcal culture over a 6-month period. During ripening, the concentrations (mg·kg^{-1}) of biogenic amines varied as follows: cadaverine, 62.25–87.95; putrescine, 83.38–88.51; phenylethylamine 52.94–127.74; tyramine, 172.34–273.25 and tryptamine, 13.05–17.07. With the exception of phenylethylamine, none of the biogenic amines exceeded its toxic threshold.

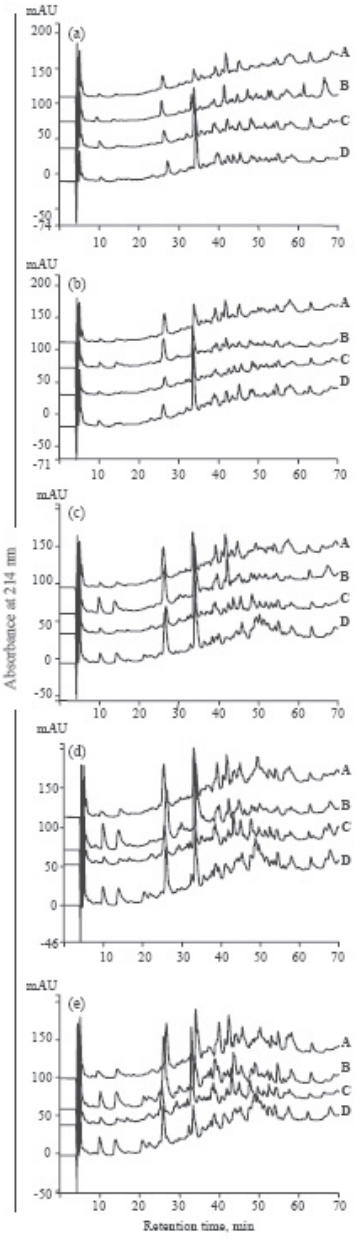

Figure 2. RP-HPLC profiles of the pH 4.6-soluble fraction of Beyaz peynir made using: A: *Lc. lactis* subsp. *lactis* UC317; B: *Lc. lactis* subsp. *lactis* NCDO767; C: *Lc. lactis* subsp. *cremoris* HP or D: *Lc. lactis* subsp. *cremoris* SK11 after 1 (a), 15 (b), 30 (c), 60 (d) and 90 (e) days of ripening. (From Hayaloglu et al. [34], reprinted by permission of International Dairy Journal, Copyright © Elsevier B.V., 2004.)

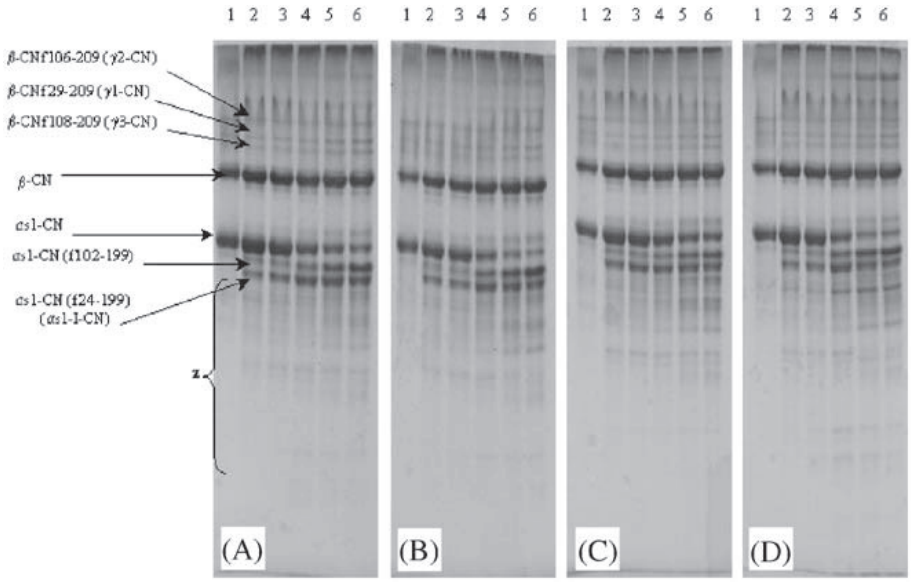

Figure 3. Urea-polyacrylamide gel electrophoretograms of the pH 4.6-insoluble fraction of Beyaz peynir made using: (A) *Lc. lactis* subsp. *lactis* UC317; (B) *Lc. lactis* subsp. *lactis* NCDO763; (C) *Lc. lactis* subsp. *cremoris* HP or (D) *Lc. lactis* subsp. *cremoris* SK11. Lane 1: Na-caseinate; lanes 2–6: cheeses after 1, 15, 30, 60 or 90 days of ripening, respectively. (From Hayaloglu et al. [34], reprinted by permission of International Dairy Journal, Copyright © Elsevier B.V., 2004.)

3. OTLU CHEESE (HERBY CHEESE)

Otlu cheese is a very famous brined cheese variety in Turkey and its popularity has been increasing gradually. The cheese has long been produced traditionally in eastern cities, particularly in Van province. Otlu cheese is produced using herbs which give the cheese a characteristic appearance and aroma/flavour. These herbs belong to the species of *Allium*, *Thymus*, *Silene*, *Ferula*, and *Anthriscus nemorosa*, the local names of which are, Sirmo, Kekik, Siyabo, Heliz and Mendo, respectively [14, 69]. Addition of herbs to the cheese is an essential step in the production process in order to obtain a characteristic flavour or to extend the shelf-life of the cheese. Otlu cheese is ripened in brine or in earthenware or plastic containers using dry-salting. In the past, dry-salted cheeses were ripened underground; however, at present, this method of salting has been replaced by brining [14, 17]. It was reported that the use of different herbs and their level significantly influence the chemistry, biochemistry and sensory characteristics of Otlu cheese. The manufacturing technology and its characteristics were reviewed extensively by Hayaloglu and Fox [31].

4. URFA CHEESE

Urfa is a brined, semi-hard cheese variety, produced particularly in the south-east of Turkey. The cheese is made from raw sheep's or cows' milk or a mixture of these milks [57]; it has a conical shape, a salty taste and a white colour. It has gained an economic value and popularity and

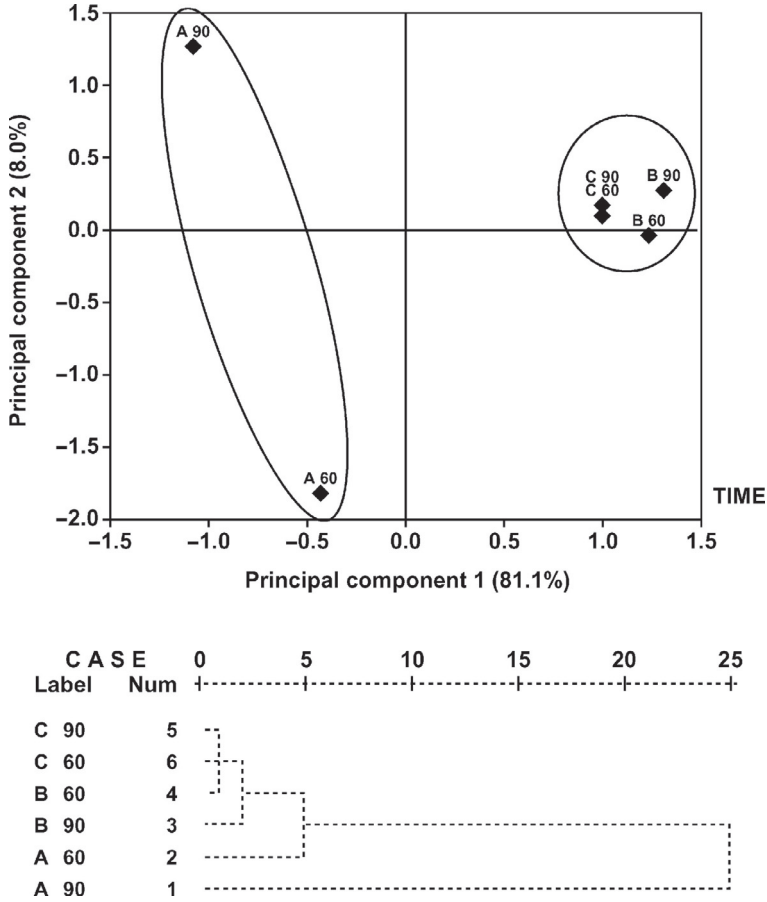

Figure 4. Principal component (top) and hierarchical cluster (bottom) analyses of chromatographic data from RP-HPLC profiles of the 70% ethanol-insoluble fractions of Beyaz peynir made with starter culture systems SF (A), 763SK11 (B), and 317HP (C). Cheeses: SF = starter free; 763SK11 = *L. lactis* ssp. *lactis* NCDO763 plus *L. lactis* ssp. *cremoris* SK11; 317HP = *L. lactis* ssp. *lactis* UC317 plus *L. lactis* ssp. *cremoris* HP. (From Hayaloglu et al. [35], reprinted by permission of Journal of Dairy Science.)

can easily be found in markets throughout Turkey. In the traditional production method, raw milk is coagulated using calf rennet at 30–32 °C for 45 to 60 min; the coagulum is cut into 1 cm cubes and then drained in triangular moulds, called "*parzin*", which contain 250–400 g of curd. The parzins have finer pores than regular cheese cloth and whey removal may not be complete in less than 12 h at room temperature. Following gravity drainage, the cheese blocks are scalded in their own whey at 90–95 °C for about 2–3 min to make the cheese more elastic and safer. Afterwards, the cheese blocks are dry-salted overnight at room temperature and transferred to brine containing 15% NaCl [57, 59]. The mean chemical composition of ripened and unripened Urfa cheese is given in Table III. Substantial variations have been reported in the salt and dry matter content of Urfa cheese

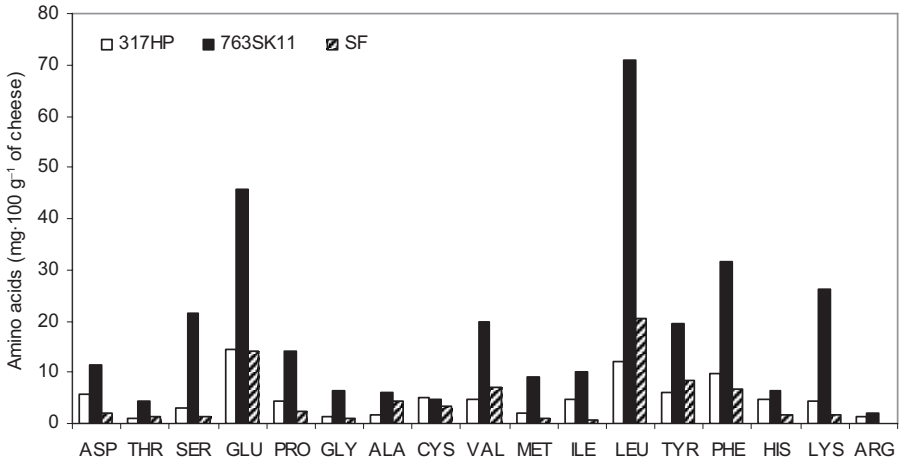

Figure 5. Concentrations of individual free amino acid in 60 days-old Beyaz peynir made with starter culture systems 317HP (open bars), 763SK11 (solid bars), and SF (striped bars). Cheeses: SF = starter free; 763SK11 = *L. lactis* ssp. *lactis* NCDO763 plus *L. lactis* ssp. *cremoris* SK11; 317HP = *L. lactis* ssp. *lactis* UC317 plus *L. lactis* ssp. *cremoris* HP. (From Hayaloglu et al. [35], reprinted by permission of Journal of Dairy Science.)

Table III. Chemical composition and pH of ripened and unripened Urfa cheese.

	Unripened cheese (n = 29)[1]		Ripened cheese (n = 44)[2]	
Variables	Range	Mean	Range	Mean
Dry matter (%)	27.3–47.9	36.5	36.5–64.3	50.1
Fat (%)	4.1–27.8	17.7	13.1–30.1	23.2
Fat-in-dry matter (%)	12.0–64.1	47.0	35.9–72.4	46.5
Protein (%)	10.8–26.4	16.8	9.1–28.8	17.0
Salt (%)	0.1–0.3	0.2	2.8–11.5	7.8
pH	4.5–6.0	4.9	4.0–6.9	5.3
Titratable acidity[3]	0.3–1.2	0.9	0.2–1.3	0.7
WSN[4]	–	–	2.6–26.3	9.6
TCA-SN[4]	–	–	3.5–7.5	5.1
PTA-SN[4]	–	–	0.6–5.7	3.0

[1]From Akin and Sahan [6].
[2]From Atasoy and Akin [11].
[3]Expressed as g lactic acid per 100 g of cheese.
[4]Expressed as % of total nitrogen.

during ripening. The cheese is very salty with a salt-in-dry matter content in the range 21 and 23% at day 90 [58]. Limited proteolysis occurs in Urfa cheese, probably due to scalding of the cheese curd and/or the high concentration of NaCl [11, 55, 58, 59]. Microbial counts are quite high in Urfa cheeses made from raw milk; total bacterial counts are 9.7 log cfu·g^{-1} at 1 d and 8.1 log cfu·g^{-1} at 90 d. Total bacterial counts are reduced by pasteurizing the cheese milk to 6.8 log cfu·g^{-1},

by scalding of the curd to 7.2 log cfu·g^{-1} and a combination of these processes to 5.4 log cfu·g^{-1} [55]. Scalding of the curd at 95 °C for 3 min reduces the counts of some pathogens, including *Yersinia enterocolitica, Escherichia coli* O157:H7, *Shigella flexineri* and *Salmonella enteritidis* during the early stage (30 d) of ripening; however, the growth of *Staphyloccus aureus* and *Bacillus cereus* is not affected by scalding of the curd or by brine concentration (12.5, 15.0 or 17.5%) [59]. The authors concluded that the high concentration of NaCl ($\geqslant$ 15%) may suppress the development of the desired cheese aroma/texture characteristics. Also, it is not always possible to prevent the growth of pathogens by brining or scalding. Therefore, they recommended that pasteurized milk with a suitable starter culture should be used and precautions should be taken to avoid contamination during milking, transportation and all stages of cheese-making. Ozer et al. [58], who used ultrafiltration in the manufacture of Urfa cheese, found that this technique produced a cheese comparable with cheese made using the scalding method in terms of texture and structure.

5. HELLIM CHEESE

Hellim or Halloumi cheese is produced mainly in Cyprus but also in Middle Eastern countries (Syria, Lebanon, etc.), Greece and Southern Turkey [37, 63]. Currently, the cheese has international merit [62]. Hellim cheese has a semi-hard and elastic texture, a slight rind, no holes or openings. It is easily sliceable and its colour varies from white (when sheep's or goats' milk is used) through yellowish (when cows' milk is used in its production) [22, 51]. Typical Hellim cheese is manufactured from either sheep's or goats' milk or mixtures of these two milks, but cows' milk is commonly used for its production, probably due to the scarcity of sheep's or goat's milk in the production area [10, 61]. The fresh cheese has a characteristic flavour and is preserved in brine for more than 30 d. The manufacturing procedure for Hellim is similar to that for Cypriot Halloumi cheese (for details refer to Papademas [60]). Hellim cheese is sold in the markets as vacuum-packaged pieces weighing ca. 250 g. The chemical composition of Hellim made from raw or pasteurized milk is: moisture, 46.1% and 43.6%; fat, 25.6% and 28.6%; fat-in-dry matter, 47.5% and 50.7%; pH, 6.0 and 5.7; salt, 3.9% and 3.4%; protein, 19.3% and 19.6%; WSN (as % of total N), 4.6% and 5.5%, respectively [22]. Guven et al. [25], who studied the effect of rennet concentration on proteolysis in Hellim, showed that α_{s1}-casein is degraded slowly during 60 d of ripening, but β-casein is hydrolyzed more rapidly than α_{s1}-casein; this may be attributed to high pH (6.4–6.5) of Hellim cheese [25].

6. MALATYA CHEESE

Malatya cheese is made traditionally from raw sheep's or cows' milk or mixtures of these milks, and no starter culture is used. The traditional cheese-making practice is still used in farms and villages. Recently, some cheesemakers have used pasteurized milk and added a starter culture to standardize production. Scalding at 80–90 °C is the usual practice in Malatya cheese-making which gives the curd an elastic and compact texture after pressing; the physical, chemical and sensory characteristics of the cheese are also affected by scalding. The manufacturing protocol for the cheese is similar to that for Hellim, with minor differences. In the traditional method, raw cows' milk is coagulated at 32 °C using calf rennet in about 45 min. The coagulum is cut into 1–2 cm cubes and stirred for about 30 min, and then transferred to cloth bags and left to

drain for 30 min without pressing. The bags, which contain approx. 250 g of curd, are tied up and moulded as a ball, and then pressed between wooden blocks for 2 h. The cheeses are scalded at 85 to 90 °C for 3 to 5 min by means of dipping in their own whey and the cheese blocks are then re-pressed between the wooden blocks for 3 min and cooled immediately to room temperature. Afterwards, the cooled blocks are immersed in brine (10–12% NaCl) and ripened in metal or plastic containers for at least 60 d at 6–8 °C. Malatya cheese can also be consumed fresh and unsalted. Fresh Malatya cheese is semi-hard, with no openings or holes, is elastic and sliceable. Its taste is milky or creamy and is yellowish in colour. The chemical composition of cheese made from raw or pasteurized milk is as follows: moisture 60.6% and 60.2%, fat-in-dry matter 44.7% and 43.3%, salt 2.7% and 2.2%, protein 15.2% and 14.6%, pH 6.0 and 5.7, respectively (Hayaloglu et al., unpublished). Hayaloglu and Brechany [30], who investigated the influence of pasteurization prior to cheese-making and scalding temperature (60, 70, 80 or 90 °C) on the volatiles formed in Malatya cheese during ripening, found that raw milk cheese contained higher levels of acids, esters and lactones and lower levels of aldehydes and sulfur compounds than pasteurized milk cheeses. Raw milk cheeses contained higher levels of pentanoic acid, 2-methyl propanoic acid, 2-propen-1-ol, 2-propenal, 3-methylbutyl butanoate and 1-hydroxy 2-propanone than pasteurized milk cheeses at the end of ripening. The results suggested that the pasteurization of cheese milk had a greater effect on the volatiles in cheese than the scalding temperature [30].

7. MIHALIC (KELLE) CHEESE

Mihalic is made from raw sheep's milk in Bursa and Balikesir provinces. The name "Mihalic" is an old name of Karacabey, county of Bursa, and it is known that the cheese has been produced in these areas for at least 250 years. Mihalic is a hard, brined cheese, is slightly acidic, very salty, has regular openings (2–4 mm) and a 3–4 mm rind [41, 76]. Raw or pasteurized sheep's milk is coagulated at 32–35 °C using home-made calf or commercial rennet in wooden barrels named "*polim*" of 100–250 L capacity. Coagulation requires 60 to 90 min and the coagulum is cut into pieces the size of a grain of rice using a nailed wooden rod. The curds are stirred continuously and rested for 10–15 min. Then, the curds are cooked gradually at 45 °C by adding boiling water and rested for another 10–15 min. Afterwards, the curds are transferred to a cotton cloth for whey drainage; the cloth is tied up and hung for complete draining which takes 3–8 h. Nowadays, the curd is pressed using 50 kg weights for each 250 kg of cheese milk, probably to shorten the draining period. The cloth containing the curd is pierced periodically with a needle to accelerate wheying off. The formation of regular openings in the cheese occurs at this stage and this is one of the unique characteristics of Mihalic. The drained curd is cut into 3–5 kg blocks and brined in 18% NaCl for 3 d, then in 20% NaCl for the next 2 d and finally in 22% NaCl for 15–30 d. The cheese blocks are placed carefully on the bottom of a wooden barrel containing a layer of coarse salt; then the cheese blocks are covered with 20–22% NaCl brine and the barrels are closed with a wooden lid. The cheese is ripened in the barrels in a cold room for about 3 months [53, 65, 77]. Mihalic is sold as vacuum-packed pieces weighing about 250 to 300 g. The yield in Mihalic is 20–22% from sheep's milk [18] or 10–12% from cows' milk [53, 71]. The chemical composition of the cheese is given in Table IV. The cheese is characterized by high levels of salt and dry matter; the high level of salt delays ripening of the cheese (WSN (as %

Table IV. Chemical composition and pH of unripened (1 or 2 d) and ripened (90 d) Mihalic cheese.

	Ozcan [53][1]		Oner and Aloglu [52][2]	
Variables	2 d	90 d	1 d	90 d
Water (%)	44.9	31.4	42.3	39.8
Fat (%)	29.0	32.0	22.3	22.3
Fat-in-dry matter (%)	51.8	46.6	38.6	37.4
Protein (%)	17.5	20.7	22.7	23.0
Salt (%)	4.1	7.9	4.5	9.9
pH	5.8	5.1	5.2	5.4
Titratable acidity[3]	0.5	1.0	1.5	1.1
WSN (% of TN)	15.3	24.6	4.2	5.9
ADV	3.0	6.2	–	–

[1]Raw cows' milk was used.
[2]Raw goats' milk was used.
[3]Expressed as g lactic acid per 100 g of cheese.

of TN) is 5.9% at 90 d). Due to inconsistency in the results in the literature, further studies are needed to better understand the basic characteristics of Mihalic cheese.

8. EZINE CHEESE

Ezine cheese is a white brined variety with a rectangular shape, similar to Beyaz peynir (Turkish white cheese). The cheese is produced by small-scale producers called "*mandira*" in Ezine, a county of Canakkale, using a mixture of sheep's, goats' and cows' milk at levels of 50, 40 and 10%, respectively. However, this ratio of milks may vary according to the season. The cheesemaking season is from March to July, because sheep and goats give birth mainly in the spring. A designation "Protected Geographical Indication" for Ezine cheese was obtained in 2007 by the Association of Ezine Cheese Producers [1]. The manufacturing procedure for Ezine is similar to that for Beyaz peynir, but the geographical origin of the milk contributes some specialities to Ezine cheese. The milk, which is obtained from animals grazing on natural plant sources of Ezine, Bayramic, Ayvacik and some villages located in the north and west of Kaz Dagi (Mount Ida in Greek mythology) at an altitude of 1774 m, is used for the manufacture of Ezine cheese [43]. Many aromatic plants, including sweet marjoram (*Origanum marjorana* L.), oregano (*Origanum vulgare*), garden sage (*Salvia officinalis* L.), mint (*Mentha lonifolia* L), melisa (*Melisa officinalis* L.), thyme (*Thymus vulgaris* L.) and hundreds of other plant species grow on the Kaz Dagi. These plants play a crucial role in the development of the characteristic flavour of Ezine. Sea salt is used to brine Ezine and prevents softening and crumbliness in the cheese. The chemical and sensory properties of 22 samples of Ezine were studied by Karagul-Yuceer et al. [43]; moisture, titratable acidity, fat-in-dry matter, salt-in-dry matter were 48.2 to 56.9%, 0.73 to 2.13%, 49.3 to 58.8% and 5.6 to 11.9%, respectively. The authors reported that Ezine cheese is characterized by a rancid, cooked, creamy, whey-like, goaty, salty and sour flavour and taste, and a soft or semi-hard texture. Some minerals were determined in 22 samples of Ezine cheese by Isleten et al. [38] and their concentrations were found to be 298.9–1025.6, 27.4–60.5, 0–0.06, 0.04–0.58, 8.5–38.6, 0–0.24, 2.1–8.2 mg·100 g^{-1} for Ca, Mg, Mn, Cu, Al, Cr and Zn, respectively.

9. ORGU CHEESE

Orgu cheese is a brined variety produced in Diyarbakir province and its vicinity and it can be found in markets throughout Turkey. Its manufacturing protocol is similar to that for Kashar cheese, which is a pasta-filata type; however, it is ripened under brine, like Beyaz peynir, for more than 3 months [8]. The cheese is semi-hard and has a compact texture due to scalding and kneading, a salty taste and a yellowish colour. Orgu means "braided" like hair and kneading is performed after cooking the curds at 70–75 °C for 5–6 min. The cheese is manufactured mainly from sheep's milk from April to June and it is consumed fresh or after ripening under brine. Raw sheep's milk is coagulated at 33–35 °C using commercial calf rennet and the coagulum is cut after 30 to 120 min depending on the amount of coagulant added. The curds are transferred to a cloth bag (20 × 20 cm) and drained for 5–6 h. Then, the curd block is cut into pieces using a knife or a cutter and is held for development of the desired pH (5.0–5.1). The pieces of curd are cut again and scalded in water (or 3% NaCl brine) at 70–75 °C for 5 min. The scalded curd is stretched into strings 1 cm in diameter and three strings are wound together and cut into pieces approximately 10 cm in length. The pieces of curd are dry-salted, placed in a metal or plastic container and held overnight. The following day, the pieces of cheese are covered with 12–15% NaCl and the containers closed with a lid. The cheese is ripened in these containers in a cold room for at least 3 months [8, 75, 77]. The mean chemical composition of 29 samples of Orgu cheese was as follows: moisture 52.3%, fat 17.9%, protein 20.0%, salt 5.3% and titratable acidity 1.1% (lactic acid) [75]. Microbial counts (log cfu·g^{-1}) for Orgu cheese are high; total mesophilic bacteria 5.59 to 8.37, coliform 0 to 6.06, lactic acid bacteria 4.67 to 7.94, yeasts and moulds 3.30 to 7.45. Ozdemir et al. [54] reported that 16 samples of Orgu cheese contained the following elements (mean values, mg·100 g^{-1}) Ca (459.0), Na (2731.5), K (153.8), P (368.7) and Mg (40.8).

10. CIVIL CHEESE

Civil is produced as both an acid and rennet curd cheese and is very popular in eastern regions of Turkey. The cheese is produced in Caucasus countries and Armenia under the name "Cecil" [76]. It is characterized by a fibrous appearance, a low fat content and a plastic texture due to kneading during manufacture. Traditional Civil cheese is made from skim milk or whey. The cheese milk is pre-ripened overnight at about 15 °C to develop acidity by its natural microflora until pH 5.3–5.4 (0.5% lactic acid) is reached. The acidity can be adjusted to the desired pH by adding unripened skim milk. The acidity of the cheese milk affects its microbial quality [79] and textural characteristics. After the desired acidity has been reached, the skim milk is heated to 30 °C and calf rennet is added (4 mL per 100 L skim milk), with gentle stirring. Then, the temperature is increased, with gentle stirring, to 70 °C (curds form at about 50–53 °C) and the curds are collected using a paddle. The collected curds are placed on a table and kneaded by hand for 3–5 min. After kneading, the body of curds is hung from a platform for stretching under its own weight and the stretching process is repeated until the curd has a smooth, plastic and fibrous texture. Following stretching, the cheese is cut into 12 cm pieces and brined in 9% NaCl brine for ripening [67, 80]. The chemical composition of 15 samples of Civil cheese, determined by Sengul et al. [67], was as follows (mean values): moisture, 63.9%; fat-in-dry matter, 5.81%; salt, 0.2%; titratable acidity, 1.3% and total nitrogen (TN), 4.4%. The level

of proteolysis (as % of TN) was fairly low, i.e., WSN, 5.9%; TCA-SN, 4.3% and PTA-SN, 2.0% [67]. Similar results were obtained for 60 d [12] or 180 d-old Civil cheeses [80]. No substantial degradation of nitrogen fractions was shown by gel electrophoresis of Civil [67, 80]. It is fair to conclude from the data that hydrolysis of casein in Civil cheese is usually lower than in other brined varieties. Civil cheeses (n = 6) collected from retail outlets contained high levels of histamine and tyramine, with average values of 94.76 mg·100 g^{-1} and 138.16 mg·100 g^{-1}, respectively; these values were much higher than the acceptable limits [15]. In another study by Yetismeyen [83], Civil cheeses (n = 20) contained lower levels of biogenic amines, including tyramine (0.88 mg·100 g^{-1}), histamine (0.15 mg·100 g^{-1}) and cadaverin (0.22 mg·100 g^{-1}). Civil cheese had high microbial counts (as mean log cfu·g^{-1}), i.e., total bacteria, 8.47; yeasts and moulds, 6.3; lactic acid bacteria, 7.5 and coliform (in coliform-positive samples), 4.62 [66]. Sert and Kivanc [68] found high numbers of pathogenic and non-pathogenic contaminants in Civil cheese, including *S. aureus*, *E. coli*, coliforms, yeasts and moulds. Sengul [66] identified 72 strains of *Lactobacillus* isolated from Civil cheese; these were mainly *Lb. malefermentans* (20 isolates), *Lb. fermentum* (18 isolates), *Lb. parabuchneri* (17 isolates) and *Lb. vaccinostercus* (10 isolates).

11. DIL CHEESE

Dil is a semi-hard cheese with a characteristic fibrous texture. Its shape resembles a tongue, therefore, the name "*dil*", which means "tongue" in Turkish. It is usually made from pasteurized cows' milk to which a thermophilic lactic culture is added. The milk is coagulated at 33–35 °C for about 60 min. The coagulum is cut into small cubes, rested for 5–10 min and a portion (40% of the cheese milk) of whey is removed and the curds held for a further 30 min. Afterwards, the remaining whey is removed and the curds are pressed until the desired acidity (pH 5.0–5.2) is reached. The acidified curd is cut into pieces by hand or a cutter and cooked in hot water or 5% NaCl brine at 80–90 °C. The hot curd is kneaded and stretched to form longitudinal fibres. The elastic curd is extended manually, cooled in cold water and cut into cylindrical pieces, 2–3 cm in diameter and 8–15 cm long. The pieces are immersed in 10% NaCl brine at 25 °C. Salted Dil cheese is packaged under vacuum and sold, usually without ripening [49,77]. The mean chemical composition of 42 samples of Dil cheese was as follows: total solids, 50.4%; fat, 21.6%; protein, 25.8%; salt, 1.8% and titratable acidity, 0.7% (lactic acid). The pH of the samples ranged from 4.9 to 5.6 [49]. The proteolysis indices (as % of TN) were: WSN, 5.6 to 24.8%; TCA-SN, 2.7 to 9.6%; and PTA-SN, 1.5 to 3.7% [50]. This wide variation may be attributed to the low level of salt in the cheese and the unknown age of the samples analyzed.

12. GAZIANTEP CHEESE

Gaziantep cheese is a brined, semi-hard variety produced in southern Turkey. The cheese is sold immediately after production or immersed in brine for ripening. Gaziantep cheese is made from pasteurized cows', sheep's or goats' milk or mixtures of these milks; it has a spherical shape, with a diameter of 6–10 cm. After pasteurization, the cheese milk is cooled to about 35 °C and coagulated within 60 min. Then, the coagulum is cut into pieces, stirred and transferred to a cloth for draining by gravity. The curd is drained overnight or the curd is pressed by curling the cloth. Then, the curd is shaped by hand and scalded at 80-90 °C for 1 min

and shaped again [39, 48]. The curds are immersed in 20–25% NaCl brine for up to 1 year [47] and the cheese has a very salty taste. However, increasing the level of salt (> 20% NaCl brine) causes some textural [47] and hydrolytic and oxidative rancidity problems [48] in Gaziantep cheese. Reduction of the fat-in-dry matter content (FDM, 50.4, 33.4 or 13.5%) and scalding the curd at different temperatures (75, 85 or 95 °C) affected the rheological and functional properties of Gaziantep cheese [39, 40]. Reducing the fat-in-dry matter and increasing the scalding temperature improved the textural characteristics of the cheese, including hardness, gumminess, cohesiveness and springiness values, while these treatments reduced the meltability of Gaziantep cheese. The typical composition of 14 d-old Gaziantep cheese brined in 20% NaCl brine is 46.9% moisture, 8.9% salt, 24.2% fat and 17.1% protein [47].

13. MARAS CHEESE

Traditional Maras (also named Sikma) cheese is made from pasteurized sheep's or goats' milk. After pasteurization, the cheese milk is cooled to 30 °C for coagulation, and the coagulum is cut after 80 min into 3 cm cubes and pressed (20 kg weights per 100 kg milk) for about 60 min. The curd is held for about 10 h (or overnight) at 22–24 °C to develop acidity (1.0–1.4% as lactic acid). Then, the mass of curd is cut into small portions (5 × 3.5 × 2 cm) and cooked at 65–70 °C for 10 min. The cooked curds are shaped by hand and dry-salted. The following day, the cheese pieces are immersed in 12–13% NaCl brine and ripened at 6–10 °C for 2 months [70, 71]. Ninety day-old Maras cheeses were found to contain 42–45% moisture, 40–41% fat-in-dry matter, 14–15% salt-in-dry matter and 5.0–5.1 pH [71]. Ceylan et al. [13], who analyzed 34 samples of Maras cheese, found high counts of coliforms (4.0 to 7.4 $\log \text{cfu} \cdot \text{g}^{-1}$), total bacteria (5.9 to 8.7 $\log \text{cfu} \cdot \text{g}^{-1}$), and yeasts and moulds (2.7 to 6.4 $\log \text{cfu} \cdot \text{g}^{-1}$).

14. CONCLUDING REMARKS

More than 50 varieties of cheese are produced in Turkey [32]; however, brined cheeses are well established products in the diet of Turkish people. With the exception of a few varieties, most of the traditional brined cheeses have not yet been industrialised. Relatively little is known about the basic characteristics of the brined cheeses native to Turkey. Investigation and documentation of the basic parameters of brined cheeses, including texture/rheology, structure and sensory properties are important for achieving consumer-oriented modifications in these products (i.e., low-salt, reduced-fat analogues of brined cheeses). Although a number of studies have been undertaken to characterize Turkish brined cheeses, there are still many areas that need to be investigated further:

- The isolation, identification and characterization of microorganisms present in traditional brined cheeses made from raw or pasteurized milk should be studied and new starter culture combinations, including salt-tolerant strains, should be developed.
- Processing conditions such as brine concentration, temperature and pH should be optimized. Also, the kinetics of salt absorption and diffusion during the maturation of the cheeses needs to be fully understood in order to standardize the salting conditions.
- Products of proteolysis and lipolysis should be identified and these parameters should be used as selection criteria for starter culture combinations.
- Automation and mechanization techniques should be developed so that industrialization of traditional brined cheeses would be possible.

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