



A Research on Some Local Cheese Varieties Produced in Province of Balıkesir

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ABSTRACT

The aim of the research is to provide information on the production methods and some characteristic features of local cheeses produced in Balıkesir province and its districts, which are not widely included in the literature, most of which have geographical indications, are produced commercially in local dairies or homemade, and add economic value to the local people. Cheese has an important place in daily nutrition with its rich structure and digestibility in terms of protein, vitamins, minerals, and bioactive components. There are more than 50 local cheese varieties produced in different regions of Turkey, exhibiting diversity according to production methods, raw material characteristics, and regional factors. Balıkesir is a rich region in terms of cheese diversity. In the study, cheese types specific to Balıkesir, such as Manyas Kelle cheese, Mihaliç Lor cheese, Ayvalık Sepet cheese, Kirlihanım cheese and İvrindi Kelle cheese were investigated. For instance, the production of Manyas Kelle cheese from sheep and cow milk draws attention due to its salty and hard structure. Mihaliç Lor cheese, which has a unique flavor, is also produced from the whey left over from the production of mihaliç cheese. Ayvalık Sepet cheese is a porous cheese that is shaped and matured in strainer baskets. The research examined how the methods used in cheese production and the geographical and cultural conditions in the region affected cheese production. Additionally, some physicochemical properties and ripening processes of the cheeses were evaluated. These cheeses play an important role in preserving local gastronomy and passing it on to future generations. As a result, the promotion of Balıkesir local cheeses is considered an important step for the sustainable production of these products and their registration with a geographical indication. Thus, the promotion not only preserves the region's gastronomic heritage but also aims to create economic value.

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Introduction

The origins of cheese production trace back to ancient Mesopotamian civilizations, with archaeological evidence suggesting that cheese-making practices existed between 7.000 and 10.000 years ago [7]. Although definitive historical records are limited, it is widely believed that cheese was first produced by shepherds in Mesopotamia or the Indus Valley around 8.000 years ago [7, 14]. It is believed that cheese originated around 8.000 years ago in Mesopotamia, specifically in the “Fertile Crescent” region between the Tigris and Euphrates rivers. Some sources suggest that cheese was first discovered by shepherds, while others attribute its origin to the accidental souring of milk. One popular account describes a traveler carrying milk in a sheep’s stomach during a journey to Canada, where the milk curdled naturally, leading to the formation of cheese. Another hypothesis claims that the Scythian Turks, after domesticating mares, fermented mare milk and thereby produced an early form of cheese. Although no definitive evidence exists, it is widely accepted that the earliest cheese-making practices emerged in ancient Mesopotamia. The word “peynir” (cheese) entered the Turkish language following the migration of Turkish peoples into Anatolia [13].

In the Southern Marmara region, which includes Balıkesir, archaeological findings suggest that cheese production dates back approximately 8.500 years. Excavations conducted in 2015 revealed residues in ancient pottery and ceramic vessels, indicating early cheese-making activities. Similarly, lipid analyses of pottery fragments unearthed in Northwestern, Central, and Southern Anatolia between 2007 and 2008 revealed

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significant evidence of dairy processing, particularly in Northwestern Anatolia, where the densest cheese residues were found. The lipid traces discovered on ceramics from settlements around the Sea of Marmara, dating to approximately 7.000 BCE, indicate that milk had already become a commonly processed secondary product. Moreover, analyses of ceramic samples from the Barcın Höyük excavations in 2007 confirmed and reinforced these earlier findings [6].

Cheese remains an essential component of the human diet due to its rich nutritional content, including proteins, bioactive peptides, amino acids, fats, fatty acids, calcium, and vitamins—particularly A and B₂—as well as its high digestibility [13]. It can be broadly defined as a group of fermented dairy products characterized by diverse flavors, textures, appearances, and aromas, which vary based on regional production techniques [12]. Worldwide, there are over 1.000 different types of cheese, while in Turkey, more than 50 regional and local varieties exist. These cheeses differ significantly in their chemical, microbiological, and sensory properties depending on the type of milk used, the geographical region, and traditional methods of production [8, 16, 18, 19]. Around the world, traditional cheeses are distinguished by their unique flavor and texture profiles, which arise from the interaction of specific geographical conditions, artisanal production methods, and the composition of local microflora. For instance, in the production of Italian mozzarella cheese, indigenous milk microorganisms have been shown to play a crucial role in flavor development [31]. A metagenomic analysis of traditional Cypriot Halloumi cheese revealed that bacterial diversity is significantly higher in artisanal production compared to industrial manufacturing, and this microbial richness contributes to the cheese's characteristic properties [30]. In the Mediterranean region, the systematic documentation of traditional cheese making practices has been emphasized as essential for preserving cultural heritage, as these cheeses not only possess sensory value but also generate economic benefits for rural communities [28]. Furthermore, analytical approaches such as chemical isotope analysis, trace element profiling, and DNA-based techniques are increasingly employed to authenticate the geographical origin of cheeses, playing a critical role in safeguarding the authenticity and heritage of traditional varieties [29].

The agriculture and food industry is continuously evolving through ongoing research and technological innovation. Changing consumer preferences, cultural heritage, habits, and sustainability considerations play key roles in shaping these innovations. In today's context, consumers with an increasing awareness of health and food safety place greater emphasis on the nutritional and functional value of products, driving producers toward the development of functional foods. Consequently, the success of novel food products depends not only on their quality but also on their value-added functional attributes. Functional foods are defined as natural or processed products enriched with biologically active compounds [38]. These foods are characterized by their proven beneficial effects on human health, either by enhancing physiological functions or by reducing the risk of disease [39, 40]. Among functional foods, probiotic foods—produced by incorporating microorganisms with proven or potential probiotic properties, such as those found in fermented dairy products—represent one of the most significant and widely studied categories [39].

Probiotics are defined by the Food and Agriculture Organization (FAO) and the World Health Organization (WHO) as “live microorganisms which, when administered in adequate amounts, confer health benefits on the host” [39]. These microorganisms exert a wide range of beneficial effects, including antibacterial activity, prevention of cancer and cardiovascular diseases, anti-obesity and anti-diabetic effects, enhancement of the immune system, and protection against various infections [40]. Although numerous bacterial strains and yeast species have been identified as potential probiotics, members of the *Lactobacillus* and *Bifidobacterium* genera remain the most extensively studied and widely applied. Both genera have a long history of safe use in food products and are classified as “Generally Recognized as Safe” (GRAS), while also being dominant constituents of the human gut microbiota. Additionally, other genera such as *Lactococcus*, *Enterococcus*, *Propionibacterium*, and *Saccharomyces* (e.g., *S. cerevisiae* and *S. boulardii*) have been recognized for their probiotic potential due to their well-documented health-promoting properties [38].

Cheese represents a valuable alternative to fermented milk and yogurt as a carrier of probiotics to the gastrointestinal tract due to its unique functional advantages. Cheese is the best dairy matrix for keeping probiotics alive because it has a high pH and fat content, low oxygen levels, good ripening conditions, and a long shelf life [39, 40]. Moreover, cheese can buffer gastric acidity, thereby protecting probiotic bacteria during gastrointestinal transit [39]. These characteristics position cheese as one of the most effective fermented products for delivering a high number of live probiotics to the intestines [39, 40]. To be classified as a functional food, probiotic cheese must maintain probiotic viability at levels of 10⁶–10⁷ CFU/g or mL throughout storage while preserving the product's compositional integrity and sensory properties [39].

Both fresh and ripened cheeses have been reported to contain numerous bioactive peptides, which exhibit a wide range of potential biological activities. Most of the bioactive peptides identified in cheese act as

angiotensin-converting enzyme (ACE) inhibitors and antihypertensive agents; however, other peptides with antimicrobial, antidiabetic, immunomodulatory, opioid, mineral-binding, and antioxidant activities have also been detected [41]. Helal and Tagliazucchi's [41] study looked at the peptidomic profiles and bioactive properties of six types of cheese: Karish, Domiati, Ras, Feta-type, Gouda, and Edam. The analysis identified 809 peptides, of which 82 were confirmed as bioactive. Gouda cheese showed the most ACE inhibitory, DPP-IV inhibitory, and antioxidant effects. Additionally, the antihypertensive tripeptides VPP and IPP were most abundant in Gouda, whereas APFPE was predominantly found in Edam. The study suggested that the consumption of Gouda, Edam, and Domiati cheeses could potentially exert antihypertensive effects in individuals with elevated blood pressure [41].

Traditional cheese production serves not only as a means of food provision but also plays a strategic role in preserving biocultural heritage and promoting local development. Worldwide, it is often examined in relation to the concept of “terroir,” which emphasizes the influence of geographical origin on agricultural cheese production. Factors such as local microflora, climate, pasture characteristics, and artisanal production practices are critical in shaping the distinctive characteristics of cheese [33]. Moreover, studies have indicated that traditional production methods support a richer diversity of indigenous microorganisms, whereas industrial-scale production may reduce this microbial diversity, potentially diminishing the unique flavor profiles of the cheese [30]. In Turkey, traditional cheeses offer considerable diversity due to the country's varied geography and climate, with approximately 75 distinct cheese varieties produced across its seven geographical regions [13]. In regions such as Eastern Anatolia, traditional cheeses, including *tulum*, *civil*, and herb-infused varieties, are still produced using methods passed down through generations within households [34]. These cheeses can serve as alternative income sources for rural families, command premium prices in the market, and present opportunities for regional branding [34]. However, traditional production also faces challenges, including issues related to hygiene, standardization, scale, and marketing. Consequently, it is crucial to support the protection of traditional cheeses through mechanisms such as geographical indications to safeguard both their authenticity and economic potential [32].

Geographical indications (GIs) are generally classified into two main categories: “designation of origin” and “geographical indication” [20, 52]. A designation of origin indicates that all the characteristics of a product are entirely attributable to the natural and human factors of a specific geographical region, with every stage of production and processing closely linked to that area. In contrast, a geographical indication requires that a product is associated with a particular region, but only one or more stages of production, processing, or preparation need to occur within that region. In other words, a geographical indication reflects that only certain aspects of the production process, rather than the entire product, are connected to the specified area [20]. Food, agriculture, mining, handicrafts, and industrial goods may all be eligible for geographical indication registration [52]. In the European Union, regulations 2081/92 and 2082/92, enacted in 1992, established systems to protect and promote local food products. These include PDO (Protected Designation of Origin), which safeguards products with characteristics entirely attributable to a specific origin; PGI (Protected Geographical Indication), which protects products linked to a region through at least one stage of production or processing; and TSG (Traditional Speciality Guaranteed), which guarantees traditional composition or production methods [48].

Food tourism has increasingly become integrated with traditional tourism in many countries and, in some destinations, serves as the primary motivation for travel. This sector, which encompasses subfields such as wine, beer, chocolate, and cheese tourism, has been successfully marketed in countries like France, Switzerland, Italy, and the Netherlands. Turkey, positioned at the crossroads of both Asian and European cultures, endowed with rich agricultural resources, and historically hosting numerous civilizations, holds substantial potential for gastronomic tourism. Turkish regional cuisines, shaped by the legacy of Ottoman culinary traditions, have gained international recognition through cities such as Gaziantep, Hatay, and Afyonkarahisar, which are included in the UNESCO Creative Cities Network, while other cities including Şanlıurfa, Adana, Edirne, Konya, Muğla, Kayseri, Diyarbakır, and Rize contribute to gastronomic tourism through their unique culinary heritage [50]. Kars province is Turkey's first registered cheese route, which is quite rich in terms of cheese variety. Kars cheese was registered by the Turkish Patent and Trademark Office in the category of protected designation of origin in 2015, following an application by Kafkas University. Another cheese produced in the village of Boğatepe, which belongs to Kars, is Kars Gruyère cheese [43]. The studies to create Turkey's first cheese route were conducted in 2020 by the Department of Gastronomy and Culinary Arts at Atatürk University Faculty of Tourism, and it was planned to establish a 'Kars Cheese Route Experience Workshop' by utilizing the good practice example of the Schleswig-Holstein Cheese Route to create a well-structured, mapped, and registered regional route passing through Kars' local dairies and natural

and cultural heritage sites and to organize tour programs to selected dairies on the cheese route [53]. There are six stops along the Kars Cheese Route. On the Kars cheese route, participants visit 4 dairies and 2 museums. At the other 4 stops on the Kars Cheese Route, participants visit 4 dairies: Sarıkamış Öztürk Süt, Koçulu Peynircilik, Bozyiğit Göksu Mandıra, and Osmanoğlu Süt Ürünleri [43].

Studies have identified bacteria from the genera *Lactobacillus*, *Leuconostoc*, *Lactococcus* and *Enterococcus* as the dominant microflora in traditional Turkish cheeses such as Tulum cheese; for example, a study on Izmir Tulum cheese indicated that the genera *Lactobacillus*, *Lactococcus* and *Enterococcus* were present [44]. In addition, it has been suggested that these bacteria have the potential to suppress the proliferation of pathogens through lactic acid production, thus having probiotic-like effects (for example, studies have reported that *Enterococcus* spp. isolates exhibit antimicrobial effects against pathogens) [45]. When examining the types of cheese flavored with herbs, such as Herbal Cheese, it was determined that plants commonly used in cheese production include *Allium* spp., *Thymus* spp. and *Mentha longifolia*, and that these plants contain antimicrobial and antioxidant components, thus contributing to the safety of the cheese [46]. However, it has been emphasized in the literature that factors such as the use of raw milk in cheese production, short ripening time, and uncontrolled storage temperatures may increase the risk of survival of pathogens (e.g. *Listeria monocytogenes*) [47].

Despite advancements in modern dairy technologies, regional cheese varieties continue to be influenced by cultural traditions and consumer preferences. Several factors contribute to the diversity of cheese, including the type of milk (cow, sheep, goat), coagulation method (acid or rennet), milk processing (raw or pasteurized), fat content (full-fat to fat-free), cheese texture (soft to hard), and salt [13]. Consumer habits reveal that each country produces and consumes specific types of cheese based on cultural practices and socio-economic factors. In Turkey, white cheese, Kashar cheese, and Tulum cheese are the most commonly produced and consumed. However, regional varieties such as mold-ripened cheese, curd, Lor cheese, Dil cheese, Circassian cheese, and herb cheese are also widely appreciated and produced [7].

While production techniques vary across Turkey, the fundamental process remains consistent: milk casein is coagulated using enzymes or acids, the whey is separated, and the remaining curd is pressed into solid cheese. The defining characteristics of regional cheeses are shaped by factors such as the use of starter cultures, milk composition, animal feed, and the type of raw milk used (cow, sheep, goat, or buffalo) [8, 13]. The aim of the research is to provide information on the production methods and some characteristic features of local cheeses produced in Balıkesir province and its districts, which are not widely included in the literature, most of which have geographical indications, are produced commercially in local dairies or homemade, and add economic value to the local people.

Province of Balıkesir and Regional cheese varieties of Balıkesir

Geographically located in the Marmara Region, Balıkesir is a vast city with a coastline stretching from the Aegean Sea in the west to the Marmara Sea in the North [49, 51] and covering an area of 14.272 km². Much of the city's advertising focuses on the motto "The Province That Feeds Turkey." Furthermore, considering its potential in marine, nature, thermal, cultural tourism, agriculture, and animal husbandry, the city also has significant potential for gastronomy tourism [51].

Manyas Kelle cheese (Mihaliç cheese)

Mihaliç cheese is widely produced in the central regions of Bursa, Balıkesir, and Çanakkale, particularly in the districts of Karacabey, Mustafakemalpaşa, Gönen, Manyas, Erdek, and Bandırma [14]. These cities are shown that in map of Türkiye (Fig. 1).

Table 1 Average values belong to some physicochemical properties of Mihaliç cheese

Samples	pH	Lactic acid (%)	Dry mater (%)	Salt (%)	Fat (%)	Ash (%)	Protein (%)	Referances
Minimum	5.09	0.37	56.7	3.27	25.3	4.93	18.6	[1]
Maximum	5.92	1.04	64.1	8.18	33.1	10.09	24.6	
Average	5.51	0.56	60.4	5.92	27.5	7.54	22.0	
Minimum	5.40	0.13	63.70	5.29	20.50	9.15	20.43	[25]
Maximum	6.24	0.49	72.75	8.92	34.00	14.28	31.60	
Average	5.82	0.31	68.24	6.75	26.08	11.77	25.49	

It is believed to have originated from Greek cheese-making traditions [14]. This traditional cheese was officially registered with geographical indication (Registration No. 628) on December 16, 2020 [27]. Average values are for some physicochemical properties of Mihaliç cheese are given in Table 1.



Fig 1 The provinces where local cheeses are produced in Balıkesir and some neighboring provinces are shown on the map of Türkiye [57]

Previously produced only during the months of April to July, the use of mixed milk and the adoption of year-round production practices in small-scale dairies have enabled the continuous availability of this cheese [14]. Mihaliç cheese is a hard, densely structured cheese with a color ranging from cream to pale yellow. It has a slightly glossy appearance, is typically fat-free, and is characterized by a sharp, distinctive flavor and aroma. The cheese features small holes (3–4 mm in diameter) that become less frequent from the center toward the outer edges. It is notably salty and possesses a white rind approximately 3–4 mm thick. Manyas Kelle cheese is a regional hard cheese with a firm rind measuring 2–3 mm in thickness. It has a yellowish-white color, a non-cracked, porous structure, and a unique flavor profile described as slightly acidic and salty. This cheese is traditionally produced using sheep's milk, cow's milk, or a combination of both, sourced from animals grazing on the natural pastures and drinking water of the Manyas district in Balıkesir. It is aged in brine and is available in both full-fat and semi-fat forms [12, 14]. Fig. 2 shows the production stages of traditional Mihaliç cheese.

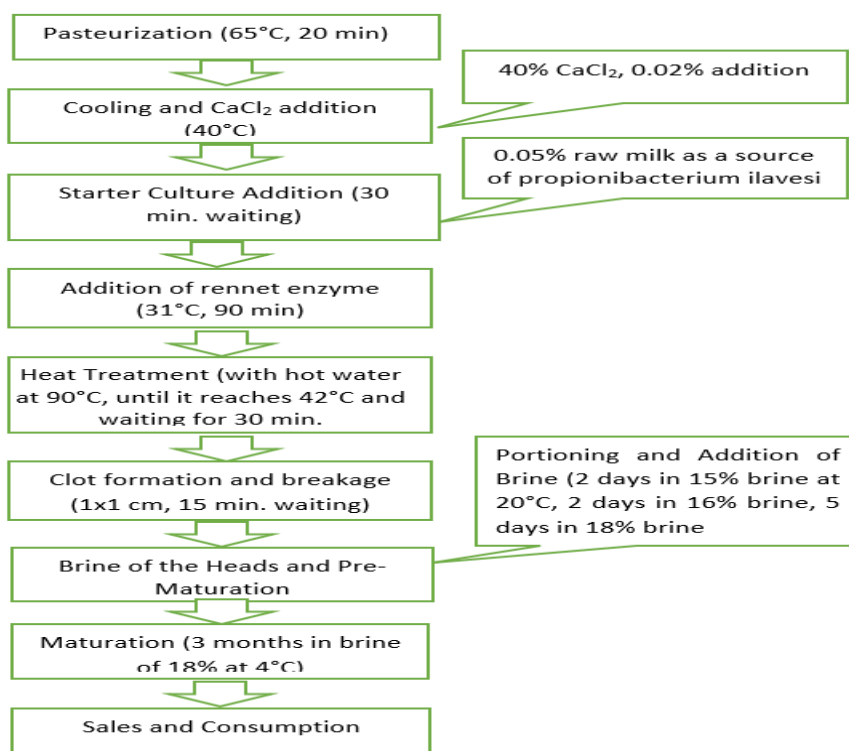


Fig 2 Manyas Kelle cheese production flow chart [6]

In the traditional production process of Manyas Kelle cheese, filtered raw milk is first heat-treated at 50–55°C for 30 minutes and then cooled. Rennet is added to initiate coagulation at 27–35°C, which takes 60–90 minutes. Once coagulated, the curd is cut into rice grain-sized pieces, stirred continuously, and allowed to rest for 10–15 minutes. It is then cooked by adding hot water (82–88°C) to reach a final curd temperature of 38–45°C. This step, which plays a crucial role in developing the cheese's texture and quality, requires significant expertise. After pressing for 12–16 hours and removing the whey, the curd is cut into blocks weighing 3–5 kg and placed in a 22% NaCl brine solution for 10–21 days. The cheese is then ripened at 10–20°C for a minimum of three months. Its characteristic porous structure and flavor fully develop during this brine aging period [12, 14]. The appearance of Mihaliç cheese is shown in Fig. 3.



Fig 3 Photograph of Mihaliç cheese [1]

Sirvatka Lor (curd) cheese

Sirvatka lor cheese is a traditional type of curd cheese unique to the Marmara Region, particularly produced in the districts of Mustafakemalpaşa, Manyas, and Savaştepe, located in the provinces of Bursa and Balıkesir. The term *sirvatka*, used by local Balkan immigrant communities, refers both to the whey obtained during Mihaliç cheese production and to the curd cheese made from this whey. This cheese is derived from the whey produced during the making of Mihaliç cheese, specifically from the residual boiled whey left in the vat after curd boiling. Commonly known among locals as Kelle or Mihaliç lor, this curd cheese is considered to be of higher quality in terms of taste and nutritional properties when compared to other types of curd cheese [14, 26].

Production method

The production process begins by heating the whey obtained during Mihaliç cheese production in large cauldrons until coagulation occurs. The contents of the cauldron are then left to curdle for about 45 minutes, during which time the curds rise to the surface. These curds are carefully collected using ladles and transferred onto cheesecloth to drain for approximately one day. After whey drainage, approximately 0.5 kg of fine salt is incorporated per 1.5 cans of curd. The salted curd is then tightly packed into small wooden barrels, covered with white wax paper, and sealed securely. The barrels are weighted and left to rest for two days, after which the cheese is ready for consumption. Sirvatka Lor cheese can be consumed in various forms. It is commonly eaten fresh at breakfast or further processed by salting, mixing with green peppers and spices, and placing it in jars to mature. In the winter months, it is typically stored in 18% brine and kept in cool conditions for extended consumption [14].

Basket Lor (Curd) cheese

Basket curd cheese is a regional specialty primarily produced in the Ayvalık district, as well as other parts of the Southern Marmara and Northern Aegean Regions of Turkey. This variety is traditionally consumed fresh and also serves as a base for another cheese type known as Kirlihanım. The cheese is produced using traditional curdling techniques similar to those used in making cottage cheese. Once the curd is obtained, it is processed and placed into baskets, using the same method as in traditional basket cheese production. The curd is then left to drain within the baskets, resulting in a fresh cheese with a soft and moist texture that is ready for immediate consumption [14]. The appearance of Basket Lor (Curd) cheese is shown in Fig 4.



Fig 4 Photograph of Basket Lor (Curd) cheese [11]

Ayvalık Tulum cheese

Ayvalık tulum cheese is traditionally made using raw milk sourced from goats, cows, sheep, or a mixture of these. The production process begins with filtering the raw milk through a fine cheesecloth folded into 5–6 layers. The milk is then heated to 58–60°C and immediately cooled to the appropriate fermentation temperature. To initiate coagulation, 15 mL of rennet is added per 100 liters of milk, and the mixture is left undisturbed for approximately 2 hours [14, 16].

At the end of the coagulation period, the milk is checked for curd formation. Once clotting is confirmed, the curd is cut into small pieces using a perforated ladle. To aid whey separation, hot water is poured over the curd, increasing its temperature to around 36–38°C. As the curd settles at the bottom of the container, the whey is separated and removed. The curd is then gathered by hand, shaped into a ball, and placed into reed baskets known locally as *bucket* or *guva*, which come in sizes of 1, 3, or 5 kilograms. The top surface of the curd is smoothed out to match the basket shape. No weight is applied during this draining process. Instead, the curd naturally takes the shape of the basket as it drains. After some time, the cheese is turned upside down to ensure that the top also adopts the basket's characteristic pattern. About 15 minutes after whey drainage begins, the cheese is removed from the basket, and both the top and bottom surfaces are salted using fine-grained salt. The cheese is then returned to the basket to continue draining. After approximately 18 hours, once the curd has developed a firm texture, it is removed from the basket and placed on a wooden surface in a shaded area. The cheese is dry-salted by applying salt every two days over a 15-day maturation period. At the end of this maturation stage, the cheese is packaged and made ready for sale [14, 16]. The appearance of Ayvalık Tulum cheese is shown in Fig 5.



Fig. 5 Photograph of Ayvalık Tulum cheese [11]

Ayvalık Kiri Hanım cheese

Kiri Hanım cheese is a traditional, mold-ripened cheese produced in the districts of Ayvalık, Foça, and Karaburun. It is a regional specialty of Anatolia, considered the dried form of lor (curd cheese) unique to the Ayvalık area. The cheese is made using the whey left over from the production of basket cheese, which is typically made from whole sheep's or goat's milk [16]. In its production, the whey is heated to 90°C to induce coagulation. Once curdled, the whey is transferred into perforated molds and left to drain for 7–8 hours. After

this initial drainage, a thin layer of fine salt is sprinkled over the surface of the cheese, which is then left to rest for 3–4 days [4, 16].

Following this resting period, the cheeses are placed on wooden shelves in a well-ventilated room and turned regularly over the course of approximately one month to ensure even drying. During this time, a thin layer of gray-white mold develops on the surface, with the edges gradually turning a brownish color—signaling that the cheese is ready for consumption [16].

At this stage, the mold-ripened cheese develops a soft, spreadable consistency. It can be consumed after washing or further baked to achieve a firmer texture and a lightly caramelized flavor. When baked, the outer edges darken and harden, allowing the cheese to be stored for extended periods. Initially pure white in color, the cheese develops mold over 20–30 days, which gives it the name Kirlihanım, meaning “Dirty Lady” cheese, referring to its spotted and aged appearance [4, 16]. The appearance of Ayvalık Kirlihanım cheese is shown in Fig 6.



Fig 6 Photograph of Ayvalık Kirlihanım cheese [4]

Ayvalık Sepet (Basket) cheese

Ayvalık Sepet cheese, also known as Ayvalık Kelle cheese, originated from the culinary practices of populations who settled in Ayvalık and its surrounding areas during the population exchange period. This traditional cheese was officially registered with a geographical indication (source mark no. 1664) on November 22, 2024 [22]. Ayvalık Sepet cheese is produced using sheep's, goat's, cow's milk, or their mixtures, depending on local practices. The cheese is matured in brine containing 10–12% salt and is characterized by its round shape, firm rind, perforated texture, and lack of surface cracks. Its color ranges from white to yellow, and its texture may vary from semi-hard to hard depending on the length of the ripening period [22].

After the production process, Ayvalık Sepet cheese is aged for a minimum of 120 days. During this time, pores develop uniformly throughout the cheese, and the diameter of these pores increases as the aging period extends [22]. By the end of the ripening stage, the cheese develops a thick, hard rind and a dry matter moisture content of no more than 60%. It also contains a low amount of dissolved salt (maximum 6%) and takes on the characteristic basket shape due to being drained in traditional baskets[22]. The fat content in the dry matter of the cheese is at least 40%. When produced using mixed milk, the proportion of sheep's and/or goat's milk typically ranges between 10% and 30%, depending on the producer. Importantly, the milk used in the production of Ayvalık Sepet cheese is not subjected to fat removal, dilution with water, or the addition of any external ingredients or preservatives [22]. The appearance of Ayvalık Sepet cheese is shown in Fig 7.



Fig 7 Photograph of Ayvalık Sepet cheese [22]

Ünsal [23] reported that the flavor of Ayvalık Sepet cheese closely resembles that of Mihaliç cheese. According to Karakaş and Korukluoğlu [15], this cheese is typically produced from raw milk in the region; however, in certain areas, the milk is heat-treated at 65–70°C. Kınık et al. [17] noted that cheeses made from raw milk are either fermented at their existing temperature or after being gently heated to 30–40°C following filtration through 5–6 layers of fine cheesecloth. The production stages of Ayvalık Sepet cheese are shown in Fig. 8.

Kepsut Bükdere Moldy (Leather) Katık cheese

Among the unique regional cheeses of Balıkesir is Kepsut Bükdere Moldy Leather Katık Cheese—locally referred to as *katık*—which was submitted for geographical indication registration in 2021. This traditional cheese is produced in the Kepsut district from yogurt made using a mixture of goat's, sheep's, and cow's milk. The yogurt is seasoned and then matured by salting it inside goat or sheep skins. A distinguishing feature of this cheese is its production process, which involves the use of mixed milk and boiling the pressed animal skin with oak bark sourced from the local area.

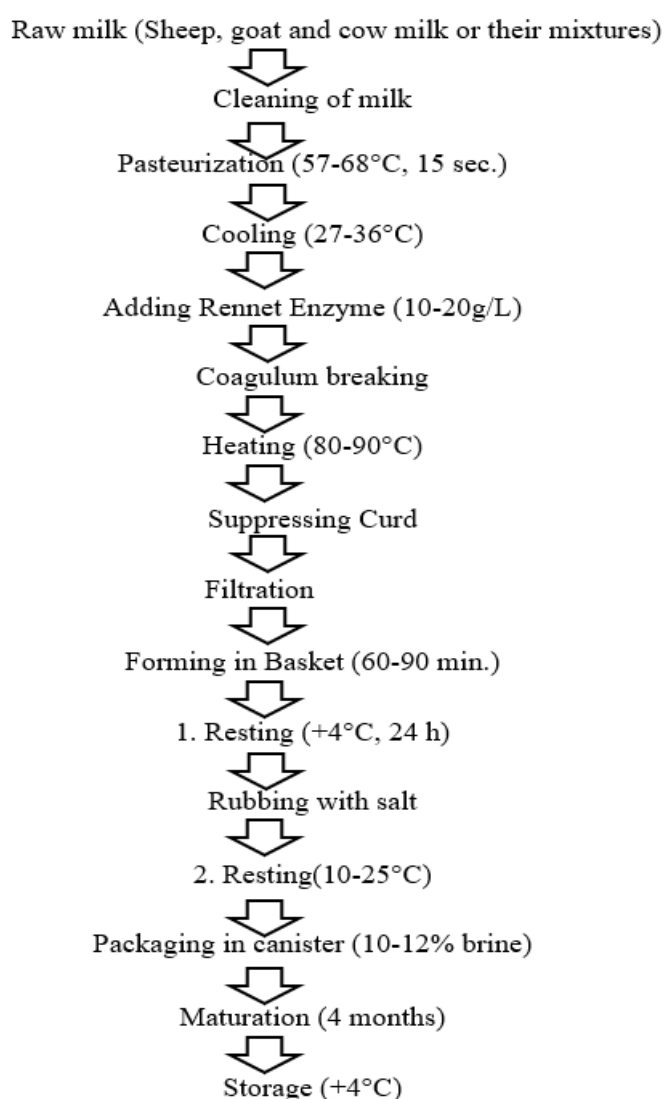


Fig 8 Production stages of Ayvalık Basket cheese [22]

The resulting product has a yellowish cream-white color, a dry and moldy outer layer, a distinct flavor profile, and a crumbly texture that breaks apart easily under pressure. Notably, Kepsut Bükdere Katık cheese has been recognized and included in the *Ark of Taste*—a global catalog established by the Slow Food Biodiversity Foundation in 1996 to document and protect endangered, traditional, and artisan food products [20]. The appearance of Kepsut Bükdere Moldy (Lather) Katık cheese is shown in Fig 9.



Fig. 9 Photograph of Kepsut Bükdere Moldy (Lather) Katık cheese [4]

Sındırgı Eğridere Woolly Tulum Cheese

Sındırgı Eğri Dere Woolly Tulum cheese is a traditional Turkish cheese produced from raw milk obtained from sheep grazing between April and July or from cows that graze year-round [55]. The milk is used without skimming and coagulated at milking temperature using rennet derived from animal sources. Following coagulation, which takes approximately one hour, the curd is cut and stirred with a ladle before being transferred to cheesecloth for whey drainage. To further remove whey, a stone is pressed over the curd, which is then left on a wire rack for one hour. The drained curd is cut into slices and salted with dry salt. After salting, the cheese is stored in containers for 15 days in a cool, shaded environment. For the preparation of the leather casing, sheep or lamb skins are salted, folded, and dried. Once dried, the skins are rehydrated in a suitable container to soften them for cheese filling. The softened skins are inflated using an air pump, and their wool is sheared with scissors and washed three to five times. The skin is then sewn into a bag using thread, and cheese is filled into the woolly side of the casing. The tulum is stored in a non-humid environment and turned every three to five days to allow air circulation without opening the top. After ripening for 2.5–3 months under the combined influence of the mixed microbiota from raw milk and the tulum casing, the cheese develops its characteristic flavor, aroma, and texture imparted by the sheep's skin [54]. This cheese has been recognized on the 'World Heritage List' by Art of Taste [55]. The appearance of Sındırgı Eğridere Woolly Tulum cheese is shown in Fig 10.



Fig 10 Photograph of Sındırgı Eğridere Woolly Tulum cheese [54]

Circassian cheese

Circassian cheese is traditionally produced by Circassian families residing in regions of Anatolia with dense Circassian populations, including Sinop, Düzce, Bolu, Sakarya, Balıkesir, Bursa, Çanakkale, Biga, Hendek, and Gönen. Typically, the cheese is shaped into round, pressed molds weighing approximately 0.5 kilograms. The dried form of Circassian cheese ranges in color from white to cream and is known for its characteristic aroma, slightly salty or unsalted taste, soft texture, and smooth, poreless appearance. In contrast, the smoked variety features a light brown outer surface, a pale yellow to cream-colored interior, a subtle saltiness, a thin rind, and lower fat content. Fresh versions tend to have a light yellow color [10, 14].

Circassian cheese is traditionally produced by first straining the milk immediately after milking and then boiling it in containers known as *suwan*, which hold 5–6 liters of milk. Once the milk reaches the appropriate fermentation temperature, 3% of a homemade cheese culture is added to the side of the container and thoroughly mixed in. Alternatively, sour whey or sour yogurt may be used as a starter culture. In some

households, diluted citric acid is added to promote curd formation, while in others, rennet is introduced during boiling and the milk is heated a little longer.

When the whey turns clear and small, round curds begin to form, the milk is removed from the heat. A portion of the whey is ladled out, and the curds are carefully transferred to round baskets made from willow branches, typically around 30 cm in diameter and 5–10 cm in height. The curds are allowed to drain and take the shape of the basket. Salt is applied to the upper surface of the cheese, which is then flipped and salted on the opposite side. On the third day, the cheese is rinsed with water and consumed fresh. When stored under proper conditions, fresh Circassian cheese can be consumed within two weeks. To produce a dried version, the cheese is hung in a sunny area, such as a rooftop or garden, to dry naturally. While traditional versions carry the imprint of the basket mold, commercially sold Circassian cheeses today often appear smooth and uniform, indicating a shift by dairies to the use of plastic molds instead of traditional baskets [10, 14]. The appearance of Circassian cheese and Smoked Circassian cheese is shown in Fig 11.



Fig 11 Photograph of Circassian cheese and Smoked Circassian cheese [56]

İvrindi Kelle (Head) cheese

İvrindi Kelle (Head) Cheese has been produced for approximately 22–23 years in the Balıkesir province, particularly in the village of Sarıalan, which is affiliated with the İvrindi district, as well as in other local factories. The cheese is typically produced during the months of April, May, and June, when the milk yield of *Kıvırcık* and *Kıvırcık-Merino* sheep is at its peak. During this period, only sheep's milk is used for curd cheese production due to its abundance and richness.

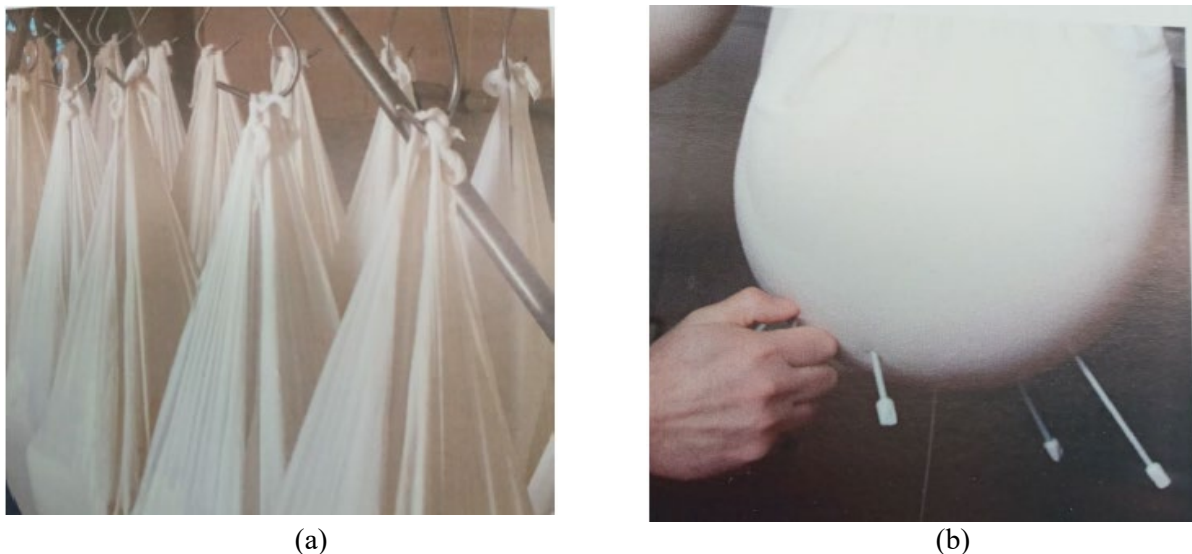


Fig 12 Curd is put into cotton cloth bags and hung on hangers and curd is shaped like a head (a), thin and long metal rods are inserted into curd and taken out (b) [24]

In the remaining months of the year, as the availability of sheep's milk declines, producers adapt by mixing sheep's milk with cow's milk, goat's milk, or a combination of these, according to specific proportions, to continue producing this cheese [2, 24]. The traditional method of drained and shaping in the production of İvrindi Kelle cheese is shown in Figure 12.

Production of İvrindi Kelle (Head) cheese

The production of İvrindi Kelle cheese begins with milking sheep grazing on native vegetation typical to the İvrindi region, including wheat, rye, oats, couch grass, and sainfoin. Initially, the raw sheep milk undergoes thermization at 50–55°C, followed by pasteurization at 65°C in jacketed open boilers. After pasteurization, the milk is cooled to approximately 35°C for fermentation, and 10–12 mL of rennet is added per 100 liters of milk. The coagulated milk is then subjected to a scalding process, essential for developing the characteristic porous structure of the curd cheese [2, 24].

Following coagulation, whey is drained using one of two methods. In the first, curds are wrapped in cotton cloths, hung to drain, and pierced with long, thin metal rods to facilitate whey separation. This process simultaneously shapes the curds into the traditional “head” form. The second method involves placing curds in perforated molds where whey is expelled under pressure for 12–16 hours. The cheeses then undergo a 20-day pre-ripening phase [2, 24]. To preserve the cheese, it is immersed in saltwater at room temperature for 4 to 7 days before being matured in cold storage for 3 to 5 months. Due to its firm, porous rind and texture, İvrindi Kelle is classified within Turkey's “hard porous cheese” category. The cheese has been granted Geographical Indication status (registration no. 1025) as of February 9, 2022 [2]. The appearance of İvrindi Kelle cheese is shown in Fig 13.



Fig 13 Photograph of İvrindi Kelle cheese [24]

Savaştepe Mihaliç Kelle cheese

Savaştepe Mihaliç Kelle cheese, produced in the Savaştepe district of Balıkesir, utilizes either a mixture of sheep and cow's milk or solely cow's milk. The cheese is characterized by a hard, crack-free rind with a porous structure ranging from yellow to white, situating it primarily within the hard cheese group, though it may also be semi-hard depending on maturation. The cheese matures in brine, with sheep's milk sourced mainly from Kıvrıcık and Kıvrıcık Merino hybrid breeds. Due to the seasonal milk production of these sheep, cheeses produced between April and June often contain sheep's milk, while production in other periods relies solely on cow's milk. When blended, sheep's milk must constitute at least 40% of the mixture [5, 24].

Traditional production involves collecting curds in straining cloths, hanging them on hooks, and piercing them with needles to expel whey and shape the curd into a “head.” Remaining whey is removed by pressing the curd in perforated molds for 12–16 hours. The dry resting phase allows for moisture reduction and rind color development. Immersing the cheese in saltwater encourages the formation of pores up to 10 mm in diameter [5, 24]. Livestock feeding practices within the region predominantly involve pasture grazing—80–90% for small ruminants and 70% roughage for cattle—with supplementary feeding of alfalfa, barley-oat pellets, pulp, and corn silage [5, 24]. Raw milk is filtered and thermally processed at 50°C and 65°C for up to 15 minutes before cooling to fermentation temperatures between 30–35°C, depending on the season. Rennet is added at 10–20 g per 100 liters of milk, with fermentation lasting 1 to 1.5 hours. Once curds reach the size of rice grains, they undergo scalding at 80–95°C to develop texture and flavor. Following traditional shaping and whey removal, cheeses are brined (14–16°Brix) at room temperature for 5–10 days, enabling eye formation, then matured at 4°C for at least 120 days. The final product is packaged according to food safety standards and

stored below 8°C during distribution [5, 24]. The appearance of Savaştepe Mihaliç Kelle cheese is shown in Fig 14.



Fig 14 Photograph of Savaştepe Mihaliç Kelle cheese [24]

Conclusion

Traditional cheese production worldwide embodies a unique interplay between geography, local microbial ecosystems, and cultural heritage. These products not only serve as a testament to regional biodiversity and artisanal expertise but also represent an essential part of rural socio-economic sustainability. Across Mediterranean and European contexts, studies have shown that traditional methods relying on raw milk and indigenous microbiota enhance both flavor complexity and microbial diversity, distinguishing artisanal cheeses from industrially produced counterparts. Similarly, Turkey's rich and diverse geography enables the production of numerous regional cheeses such as tulum, otlu, çeçil, and mihaliç, each reflecting centuries-old practices transmitted through generations. However, the use of unpasteurized milk, short ripening periods, and non-standardized hygiene conditions necessitates careful evaluation of microbial safety, particularly concerning pathogens like *Listeria monocytogenes* and *Staphylococcus aureus*. At the same time, the lactic acid bacteria naturally present in these cheeses—mainly *Lactobacillus*, *Lactococcus*, *Leuconostoc*, and *Enterococcus* spp. —contribute to fermentation, flavor, and potential probiotic benefits, while herbs used in otlu cheese (*Allium*, *Thymus*, and *Mentha longifolia*) further enhance its antimicrobial and antioxidant properties. Beyond microbiological and sensory aspects, traditional cheese production carries significant socio-economic and cultural value by promoting rural livelihoods, reducing migration, and supporting food and cheese tourism initiatives, as seen in regions like Kars, Erzincan, and Balıkesir. Therefore, strengthening geographical indication systems, ensuring hygiene and maturation standardization, and investing in producer education are vital to preserving the authenticity, safety, and sustainability of Turkey's traditional cheese heritage. Ultimately, artisanal cheeses serve not only as functional and probiotic foods but also as living symbols of biocultural identity and local economic resilience.

Research into the regional cheese varieties produced in Balıkesir Province highlights the remarkable richness and diversity of local cheeses, deeply intertwined with the area's cultural heritage, natural resources, and geographical characteristics. These cheeses—ranging from the distinctive flavors of Manyas Kelle and Mihaliç Lor cheeses to the carefully crafted Ayvalık Sepet and İvrindi Kelle cheeses—represent a longstanding cheese tradition consumed and cherished across generations. Registration with geographical indications is a critical measure for protecting these products, ensuring their authenticity, and preventing imitation. Such recognition enhances market value and provides regional producers with greater competitiveness both nationally and internationally. By raising awareness and appreciation of these traditional cheeses, the region can attract food enthusiasts, researchers, and tourists, thereby fostering gastronomic tourism and economic development. Beyond economic gains, preserving and promoting these cheeses supports biodiversity and sustainable agricultural practices. Utilizing milk from sheep, goats, and cows grazed on Balıkesir's natural pastures helps maintain traditional farming systems and the ecological balance of the region. In conclusion, the preservation and promotion of Balıkesir's local cheeses extend beyond mere culinary interest. They embody cultural identity, bolster local economies, and ensure environmental sustainability. These efforts guarantee that the rich cheese-making traditions of Balıkesir continue to enrich Turkey's culinary heritage and offer future generations a genuine taste of the past.

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The authors confirms that the data supporting this study are cited in the article.

Compliance with ethical standards

Conflict of interest

The authors declare no conflict of interest.

Ethical standards

The study is proper with ethical standards.

Authors' contributions

During the study, Ogün DEĞİRMENCİ and Büşra Nur ŞENGÜL conducted literature research, Musa YALMAN wrote the article.

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