

## Article

# Descriptive Characteristics and Cheesemaking Technology of Greek Cheeses Not Listed in the EU Geographical Indications Registers

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**Abstract:** Greece has a variety of cheeses that are registered as protected designation of origin and protected geographical indications, and many others that are produced in a traditional way, without such registration. This article aims to describe the characteristics of these cheeses, which do not bear a certification of geographical indication, in order to increase their significance. Therefore, in this work, the scientific data published about the history, production, composition, and other specific properties of some milk cheeses (Kariki, hard Xinotyri, soft Xinotyri, Kefalotyri, Kashkaval Pindos, Graviera, Manoura Sifnos, Teleme, Tsalafouti, Tyraki Tinou, Ladotyri Zakynthou, Touloumotyri, and Melichloro) and whey cheeses (Anthotyros, Myzithra, and Urda) are presented. This information may contribute to their better promotion and recognition, protecting their heritage, and supporting the local economy.

**Keywords:** traditional; cheese; Greece; composition; technology; characteristics



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## 1. Introduction

There is a long cheese making experience and tradition in Greece. Most of the epic writings of the ancient Greeks contain references to cheese. Cheese was included in the offerings to the gods by the ancient Greeks, and cheesemaking was established at Homer's time, with the Odyssey reporting the cyclops Polyphemus and his cheeses [1]. In Greece, eighty percent of its area consists of mountains, making the country one of the most mountainous in Europe. Greece also features a high number of islands. This geography can display different environments and microclimates, resulting in the development of different customs and traditions and, as a consequence, the existence of various cheesemaking procedures that led to a large variety of cheeses. Greece produces mainly ovine and caprine cheeses, as 139,488 tons of sheep, 40,795 tons of goat, and 25,336 tons of cow cheeses were produced in Greece in the year 2017 [2].

Cheeses linked to their place of production and traditional know-how can, after a specific procedure of approval, be listed in databases, such as E-Ambrosia and granted a geographical indication. This recognition can promote their unique characteristics, help producers better market their products, and enable consumers to trust quality products. The geographical indication system includes protected designation of origin (PDO) and protected geographical indication (PGI) schemes [3]. In Greece, twenty-two cheeses are registered as protected designation of origin (PDO) and one as a protected geographical indication (PGI). Their characteristics have recently been studied [4–6], and their quantities [7] are presented in Table 1.

However, Greece has many other cheeses produced traditionally with none of the above labels. Specifically, 41,769 tons of soft, 23,891 tons of whey, and 23,473 tons of hard and semihard cheeses were produced in Greece without having a PDO/PGI certification in the year 2021 [7]. These cheeses are greatly appreciated for their taste and flavor [8–12].

Their characteristics may vary due to many factors, such as environmental and specific production conditions, a lack of a standardized production process, etc. [13]. Some of these cheeses are manufactured on a large scale and sold in many different regions of Greece, while others are produced and consumed locally or even at the household level. Many of them are manufactured seasonally due to the seasonal fertility of the animal breeds and mainly sold on local markets, therefore, it is very difficult to quantify with precision their current production. Although, they have a high reputation in local areas, their commercial production is necessary due to their increasing demand. Traditional cheeses are linked to the historical and cultural places of origin and are influenced by the natural environment, the climate, the diet traditions, the customs, and the specific manufacturing conditions used [14]. The production of these cheeses is of great importance as they maintain local employment and influence the rural economy. There is a growing interest among consumers in local products, who are willing to pay higher prices, taking into account their quality, taste, and nutritional value, as well as their culture and history [15]. Additionally, gastronomic tourism is gaining popularity nowadays, and travelers are interested in local products as well as their ways of production [16]. Therefore, in order to maintain their existence and encourage their production, which has a close link to the territorial identity and cultural heritage is necessary to valorize these cheeses.

**Table 1.** Production quantities of protected designation of origin and protected geographical indication cheeses (year 2021).

Status	Cheese	Quantities (tons)
PDO	Feta	120,147
PDO	organic Feta	13,878
PDO	Formaella Arachovas	4
PDO	Parnassou	4
PDO	Ladotyri Mytilinis	342
PDO	organic Ladotyri Mytilinis	4
PDO	Pichtogalo Chanion	72
PDO	Sfela	94
PDO	Manouri	1801
PDO	organic Manouri	18
PDO	Kefalograviera	2575
PDO	Batzos	21
PDO	Anevato	17
PDO	organic Anevato	1
PDO	Kopanisti	19
PDO	Xinomizithra Kritis	278
PDO	Kasseri	2839
PDO	organic Kasseri	5
PDO	Katiki Domokou	870
PDO	Xigalo Siteias	50
PDO	Kalathaki Limnou	413
PDO	San Mihali	58
PDO	Graviera Agrafon	1
PDO	Arseniko Naxou	53
PDO	Graviera Kritis	3602
PDO	Galotyri	326
PDO	Graviera Naxou	1203
PGI	Krasotyri Ko (Tiri tis Possias)	1

In this context, the purpose of the present work is to present the literature data regarding the manufacture and characteristics of non-PDO and non-PGI cheeses produced in Greece.

## 2. Materials and Methods

This study focused on the collection and presentation of data for non-PDO and non-PGI Greek cheeses. The inclusion criteria were the cheeses without a granted geographical indication in order to inform and familiarize consumers with their specific characteristics and enhance their production, which in some cases is very limited. The first objective was to identify the cheeses, which belong to a non-PDO, non-PGI category, while the second objective was to present their description, composition, and other characteristics (such as microbiological, textural, particular trials to increase the acceptability, safety and self-life of cheese, etc.) from several published studies (books/book chapters, journal articles, and proceedings). The sources used were databases, such as Web of Science, Scopus, Google Scholar, and Science Direct, and the keywords used were 'Greek cheeses', 'traditional' as well as the specific name of each cheese. Each study was first evaluated to ensure that the abstract content was relevant to the objectives of the present work, and then data regarding the above objectives were presented.

In the present study, cheeses are grouped into the following categories according to their moisture content: hard (moisture < 38%), semihard (moisture < 46%), soft/brined (moisture < 58%), spread (moisture < 75%), and whey. In each category, cheeses are presented in alphabetical order, and their manufacturing technology details and compositional data are listed in tables.

## 3. Results and Discussion

### 3.1. Descriptive Characteristics of Hard Cheeses

Graviera (other than PDO), Kariki, Kefalotyri, Ladotyri Zakynthou, Manoura Sifnou, Melichloro, and hard Xinotyri cheese belong to this category. Their cheesemaking technology and composition are presented in Tables 2–4.

#### 3.1.1. Graviera (Other Than PDO)

Graviera is a very famous cheese that holds the second share, after Feta, in the Greek marketplace [17,18]. It was produced for the first time in 1914, but its cheesemaking technology was standardized in the Dairy Vocational School of Ioannina in 1917 [19]. Graviera Kritis, Graviera Naxou, and Graviera Agrafon are registered as protected designation of origin [20], while most of the others are traded under the name of the region where they are produced. Graviera is a hard cheese with a yellowish color, a firm texture with small, irregular eyes, a fairly sweet, slightly salty, piquant taste, and a pleasant aroma. Initially, only ovine milk was used for its manufacture [21], but nowadays Graviera cheeses from pure ovine, caprine, or bovine milk or mixtures of them can be found [17,18,22,23].

The manufacture of Graviera has been studied [19,21,24–26] and its composition [18,22,23,25–32] is presented in Table 4.

The ripening index (water soluble nitrogen/total nitrogen) of raw-pasteurized experimental Graviera cheeses at the 90th day of ripening is quite low ranging 6.10–5.09%, and possibly an increase in the ripening temperature may increase the proteolytic activity of rennet, plasmin, and bacteria, which may result in an increase in the WSN/TN content, while palmitic, oleic, and myristic fatty acids are in abundance in both cheeses. Raw cheeses contain 0.52% conjugated linoleic acid (CLA) and pasteurized 0.56% CLA. Lipid oxidation seems to be lower in pasteurized cheese than in raw cheese; however, statistically significant differences were measured at 120 days of ripening [26].

In 92 commercially prepacked Graviera cheeses (76 have a non-PDO label, and 16 are PDO), the content of Ca is 371–910 mg/100 g and the energy content is 302–492 Kcal/100 g [18]. The Graviera cheese of the Greek market is a nutritional source of macro and trace elements (especially for Ca, P, Zn, Cr, Fe, and Mo) and contains low levels of toxic elements, such as Cd, Pb, Sn, and Sb [17]. Graviera cheeses produced in various Greek places were characterized by Vatavali et al. [22,23], who found that the most abundant minerals are Na, Ca, P, Mg, Zn, Sr, and Fe, while palmitic, oleic, stearic, myristic, capric, and butyric are the major free fatty acids, and the most abundant group of volatile compounds is the

carboxylic acid group [22,23]. The total mineral content ranges from 13,621.79 mg/kg (Graviera from Lesvos) to 6754.21 mg/kg (Graviera from Chania). Additionally, Graviera from Chania has the highest volatile content, and that from Tinos has the lowest [22]. The highest levels [23] of oleic fatty acid were determined in Graviera from Messinia (26.97%). Myristic acid is found between 10.12% (cheeses from Messinia) and 12.23% (cheeses from Etoloakarnania), while the highest values of capric acid are determined in Graviera from Etoloakarnania (8.32%). The highest concentration of palmitic acid is determined in Graviera from Tinos [22]. The average content of conjugated linoleic acid in commercial Graviera cheeses is 0.75 g/100 g fatty acids, of saturated fatty acids is 69.95 g/100 g and that of monounsaturated fatty acids is 22.57 g/100 g [30].

Commercial samples of Graviera Paros contain 24.3% saturated fatty acids, 3.1% polyunsaturated fatty acids, 107 mg cholesterol/100 g cheese, 976 mg Ca/100 g, 40 mg Mg/100 g, 118 mg K/100 g and 705 mg Na/100 g [27].

Temperature-based sequential ventilation, when compared to continuous full-time air ventilation, reduces the energy consumption and the ventilation time of an industrial ripening room for Graviera cheese without significantly affecting the quality of the cheese [33]. Citric and acetic acids are the organic acids found in abundance in 35-day-old Graviera cheeses manufactured in a local plant (plant ripened) or in a controlled pilot ripening room (pilot ripened cheeses), which have constantly monitored conditions (18 °C, 90% relative humidity) under continuous or sequential (60% of the ripening time) air ventilation of 1.5 m/s [32].

Lalos and Roussis [34] reported that the use of refrigerated milk resulted in Graviera-type cheeses with lower organoleptic properties than those from raw milk.

Graviera cheese samples were discriminated according to their geographical origin and their types of milk using linear discriminant analysis and multivariate analysis of variance [17,22,23].

The microbial ecology of Graviera cheese was studied, and isolates of different microbiological groups were identified [28,32,35]. Studies regarding the behavior of *Listeria monocytogenes* in Graviera by adding specific strains of micro-organisms were conducted [36–41], and the results suggest that strains of *Enterococcus faecium* and *Lactococcus lactis* subsp. *cremoris* may contribute to *Listeria* inhibition during the ripening of this cheese. Strains of *Lactococcus lactis* subsp. *cremoris* were also evaluated for their antistaphylococcal properties in Graviera cheese by Samelis et al. [42].

Arvanitoyannis et al. [43] studied the effect of packaging on the shelf life of Graviera cheeses and found that the total viable counts and *Escherichia coli* increased in cheeses that were air packaged but were inhibited in the modified atmosphere packaging (mixture of 40% CO<sub>2</sub>/55% N<sub>2</sub>/5% O<sub>2</sub>, mixture of 60% CO<sub>2</sub>/40% N<sub>2</sub>, and mixture of 50% CO<sub>2</sub>/50% N<sub>2</sub>). The shelf life of grated Graviera cheese stored at 4 and 12 °C can be extended by both active (oxygen absorber combined with an ethanol emitter) and modified atmosphere (100% nitrogen) packaging in combination with a high barrier experimental polyethylene terephthalate-silicon oxides/low density polyethylene film [29]. In industrial applications, the shelf life of Graviera cheeses can be extended when modified atmosphere packaging (50% N<sub>2</sub>/50% CO<sub>2</sub> or 100% N<sub>2</sub>) is combined with an impermeable-to-light container [31].

### 3.1.2. Kariki Cheese

Kariki cheese is yellow, soft inside, and hard on the outside surface, with a salty and spicy flavor. Its maturation is held in an empty gourd (calabash), which is a type of pumpkin, for 40 days to seven months. Before eating, Kariki cheese must be removed from the calabash. The calabash, or *Lagenaria siceraria* (*Lagenaria vulgaris* Ser.) is one of the oldest cultivated plants. In the island of Tinos, this plant was initially known as Kariki and therefore the name of the cheese. The calabash is initially grown for at least three months in the field, and after harvesting it is sun-dried for one year so as to lose most of its moisture. After drying, it is cut around, the inside is cleaned with boiling water, and at this point it could be used as a container for Kariki cheese [44,45]. Kariki is also

named trachillas or Tinian blue cheese and it has been manufactured in the island Tinos, Aegean Sea since 1880s. Its production has not been widespread to the whole island but particularly in specific villages situated on the mountains of Tsiknias. Kariki cheese was usually offered to guests after a wedding ceremony. Its appearance did not encourage its dissemination; therefore, its production was only for household use. For the above reasons, this cheese has remained relatively unknown. Additionally, Kariki cheese could have accidentally originated from another cheese called “petroma”. Nowadays, Kariki cheese is produced only in a small, family-owned creamery. Its moisture content (Table 3) is very low (16.4%), probably because of the maturation process in the calabash, which absorbs the cheese moisture and diffuses it to the environment [44].

The saturated, monounsaturated, and polyunsaturated fatty acids of Kariki cheese are 75.07%, 14.59%, and 2.04% of the total fatty acids. Palmitic, oleic, and linoleic acid are the predominant saturated, monounsaturated and total polyunsaturated fatty acids, respectively. The  $\omega$ -3 fatty acids are 0.85% and the  $\omega$ -6 are 1.14% [44].

### 3.1.3. Kefalotyri Cheese

Kefalotyri is a hard cheese, probably the precursor of many hard cheeses in Greece [46]. There are several explanations regarding the origin of the name Kefalotyri. It may come from the word “Kefali” (which means head in Greek) and the word “tyri” (which means cheese in Greek) or from the word “Kefalo” (which means big), or because cheeses look like a Greek hat that is named “Kefalo” [1,24]. Its shape is flat and cylindrical, its texture is compact and firm, its taste is salty and piquant, and its size ranges from 5 kg to 10 kg. It is a table cheese, and it can be pan-fried, grilled or grated [47,48]. It is manufactured mainly from ovine, or caprine milk, or mixtures of them; however bovine milk can be used, too.

The cheesemaking technology may vary in different places in Greece where Kefalotyri is produced [19,47]. Raw milk is used for its artisanal manufacture; however, nowadays, pasteurized milk is used for its production [24,47–53].

The moisture content (Table 3) of artisanal cheese (40.4%) studied by Pappa et al. [48] was above the maximum limit (38%) [51] as not enough pressing was applied to assist drainage. The physicochemical characteristics of ovine grated Kefalotyri cheese after 3 months of storage, produced in December and in April, generally do not differ significantly except for fat, which is higher in December than in April [53,54].

The cholesterol concentration of commercial samples ranges from 87.9 to 101.4 mg/100 g [55], and the anti-atherogenic properties of Kefalotyri cheese were evaluated by Tsorotioti et al. [56], who found that it contained platelet-activating factor inhibitors, displaying its cardio-protected properties.

The concentration of Se ranges from 48.2 to 85.8 ng/g [57] and of nitrate from 1.3 ppm to 9.5 ppm [58]. In Kefalotyri samples from the Greek market, acetic, oleic, palmitic free fatty acids [59] and propionic, butyric organic acids are found in higher levels than orotic, citric, piruvic, and acetic acid [60].

In artisanal Kefalotyri cheese, the volatile compounds butanoic acid and 3 methyl butanoic acid are found in abundance, and a rather satisfactory hygienic and sanitary condition is observed [48].

The levels of fatty acids in the 60–90 days old Kefalotyri cheese manufactured in December and in April are similar [49]. Protein oxidation of grated Kefalotyri cheeses produced in December is higher than that of cheeses produced in April at 90 days of storage and cheeses stored under modified atmosphere exhibit higher organoleptic properties than cheeses stored under vacuum. Lipid oxidation is lower in December than in April cheeses during modified atmosphere or vacuum storage [54]. The lipid and protein oxidation of grated Kefalotyri cheese stored under fluorescent light for 40 days at 4 °C are higher, but the organoleptic and color properties are lower than the samples kept in the dark [53].

Migration of low-density polyethylene food packaging material and of di-(2-ethylhexylexyl) adipate plasticizer was detected in Kefalotyri cheese by Katsara et al. [61] and Goulas et al. [62], respectively.

Changes in lactic acid bacteria of Kefalotyri cheese during ripening were studied by Litopoulou-Tzanetaki [63] who proposed that it is better to use for the manufacture of Kefalotyri cheese, a starter culture that consists of lactic acid bacteria which are present in the cheese in the beginning and then disappear (such as *Streptococcus lactis*, *S. lactis* subsp. *diacetylactis*, *S. thermophilus*) as well as of lactic acid bacteria that survive during ripening (such as *L. casei*).

A Kefalotyri-like cheese from goat milk with probiotic lactobacilli was manufactured by Kalavrouzioti et al. [64].

Orinotyri is a hard cheese manufactured with a technology that is very similar to that of Kefalotyri cheese, in a mountainous village in Epirus, Greece, and is sold in the neighboring market [19,65]. The name Orinotyri comes from the Greek word “Orino” which means mountainous.

#### 3.1.4. Ladotyri Zakynthou

Ladotyri, cheese is ripened and stored in oil, usually olive oil [19,27]. Ladotyri Zakynthou is a hard cheese that is produced on the island of Zakynthos, Ionian Sea. Ladotyri Zakynthou contains 69% saturated fatty acids, 27.5% monounsaturated fatty acids, 3.5% polyunsaturated fatty acids, 747 mg Ca/100 g, 551 mg P/100 g, 42 mg Mg/100 g and 68 mg K/100 g cheese, its ripening index (i.e., percentage of soluble nitrogen on total nitrogen) is 22.2% [27].

#### 3.1.5. Manoura Sifnou

Manura is a very hard cheese manufactured in the island of Sifnos, in the Aegean Sea, as a farmhouse product. Raw 100% sheep milk or a mixture 50% sheep milk –50% goat milk from local animals is used for its production (Table 2). The cheese is covered by reddish wine sediment, and it is sold in the form of small wheels with a reddish surface and a mean weight of approximately 650 g, 12 cm diameter, and 8 cm height [27,66–68]. The treatment with red wine appears to have an inhibitory effect on the growth of the cheese microflora. Lactic acid bacteria are the main group found in the cheese during ripening [67,68]. The pH of the cheese (Table 3) is 4.88 initially, 4.39 after drying on straw lattices, and 4.79 after the removal of the wine sediment [68]. As this cheese is produced in an artisanal way without heat treatment and inoculation with starter culture, the decrease in the pH values could be due to the adventitious microflora (from the milk, the manufacturing procedure, the microenvironment, etc.) while the treatment with red wine, which has an inhibitory effect on the growth of cheese microflora, possibly results in an increase in the pH values.

#### 3.1.6. Melichloro (Melipasto) Cheese

Melichloro cheese is produced in the island of Lemnos (Aegean Sea) at the end of the lactation period, using raw ovine milk without the addition of starter cultures and its manufacturing technology has been studied previously [27,66,67,69,70]. Lactobacilli compose the non-starter lactic acid bacteria of mature Melichloro cheese [66,70]. The majority of the lactic acid bacteria isolated are from the genus *Enterococcus* (66%), while the rest belongs to *Pediococcus* (15%), *Leuconostoc* (8%), *Lactobacillus* (6%) and *Lactococcus* (5%) in Melichloro cheese. Two isolates (*Lactobacillus brevis* ACA-DC 1705, *Leuconostoc mesenteroides* ACA-DC 1738) show the most promising probiotic properties and can be used as adjuncts cultures [69].

**Table 2.** Manufacturing technology of nonprotected designation of origin and nonprotected geographical indication hard cheeses.

Step	Graviera <sup>1</sup>	Kariki <sup>2</sup>	Kefalotyri <sup>3</sup>	Ladotyri Zakynthou <sup>4</sup>	Manoura Sifnou <sup>5</sup>	Melichloro <sup>6</sup>	Hard Xinotyri <sup>7</sup>
Milk (warm/refrigerated, full fat/partly skimmed)	ovine, caprine, bovine standardized (casein/fat:0.7–0.8)	Fresh, cow milk (full fat)	ovine, caprine, bovine usually standardized to fat 5.6% for the ovine milk and 3% for the bovine	80% ovine-20% caprine	Warm (within an hour of milking) Ovine, 50% ovine-50% caprine	Warm (within an hour of milking) Ovine	Goat (full fat)
Pasteurized or raw milk	pasteurized	Pasteurized (63–65 °C, 30 min)	pasteurized	Raw, thermized (62–63 °C) milk	Raw	Raw	Raw or Pasteurized (63 °C, 30 min)
Starter culture	<sup>8</sup> yes, also propionic bacteria can be added		<sup>9</sup> yes		no	no	No, sometimes a small amount of whey from the previous day is added
Rennet, temperature, Duration	yes, 32–35 °C, 30–40 min	2 g/100 L milk at 32 °C, 12 h	yes, 32–36 °C, 30–60 min	yes	rennet of animal origin	yes, from the stomach of small ruminants	3–4 mL/100 L milk, 24 h
Cutting	in small pieces, size of corn	cut with a hand-held cube cutting tool	in small pieces		Size of nut	In very small pieces	
cooking of the curd	yes, at ~52 °C for approx. 30 min		yes, at 43–45 °C for approx. 20 min		no		
Drainage-molding	into molds (usually diameter 45–50 cm, height 12 cm)	Hung in sacks, for 24 h, at ambient temperature	into molds (usually diameter 30 cm, height 10–11 cm)	Into rectangular molds (20 × 20 × 15 cm)	Initially with stirring of the curd, then placed into clean baskets (tyrovolia)	Into baskets for several hours	In pierced plastic molds for 2–3 h
Pressing	yes, 1–2 h (1–2 times their weight)	For 24 h	yes for 3–4 h				
salting	dry salted/immersion in brine (18–20 Be) when pH of cheeses = 5.2–5.4	1% NaCl	immersion in brine (18–20 Be for 1–2 days, when pH of cheeses = 4.8) and/or dry salting for several days	Dry salted with coarse salt and left for drainage 10–12 h in wooden shelves.	with coarse salt for 2–3 days, on a different side every day	Dry salted in every side many times	1.5% dry salt

Table 2. Cont.

Step	Graviera <sup>1</sup>	Kariki <sup>2</sup>	Kefalotyri <sup>3</sup>	Ladotyri Zakynthou <sup>4</sup>	Manoura Sifnou <sup>5</sup>	Melichloro <sup>6</sup>	Hard Xinotyri <sup>7</sup>
Ripening	at approximately 12 °C (relative humidity 85–90%) initially, transferred to 18 °C until the age of 45 days, then to 12 °C until the age of 90 days and then stored to cool room	placed in calabash for 90 days	for 90 days	Into tanks with olive paste, at room temperature for at least 90 days	Initially on beds of straw to dry for 3–4 months, then into barrels with red wine to ‘soften’ for 5–10 days, then into barrels and covered with wine sediment for 1 day and finally to empty barrels until sold	Cheeses in the baskets are put in a wooden cage and hug in a tree under the sun for 4–5 days drainage. Then cheeses are removed from the baskets and are left for 2–3 months ripening. Finally cheeses are washed with sea salt, dried with a cloth and are ready for consumption	in an uncontrolled atmosphere (22–28 °C, relative humidity 70–80% for 45 days)

When no information is available, the manufacturing step is left empty. <sup>1</sup> References [19,21,24–26]. <sup>2</sup> Reference [44]. <sup>3</sup> References [19,24,47–50,52,53]. <sup>4</sup> Reference [27]. <sup>5</sup> References [27,68]. <sup>6</sup> References [27,66,67,69,70]. <sup>7</sup> References [10,71]. <sup>8</sup> starters can be lactic acid bacteria consisting of strains of *Lactococcus lactis*, *Leuconostoc mesenteroides*, *Streptococcus thermophilus*, *Lactobacillus helveticus*. <sup>9</sup> starters can be lactic acid bacteria consisting of strains of *Lactococcus lactis*, *Lactococcus cremoris*, *Lb. delbrueckii ssp. bulgaricus*, *Streptococcus thermophilus*.

Table 3. Composition of nonprotected designation of origin and nonprotected geographical indication hard cheeses.

Parameter	Kariki	Kefalotyri	Ladotyri Zakynthou	Manoura Sifnou	Melichloro	Hard Xinotyri
pH	4.2 (90 days old [44])	4.95–5.3 (90-days old depending on the season and starters used [49,52] 5.2 (artisanal, 90 days old [48]) 40.4%(artisanal, 90 days old [48])		4.88 (fresh cheese) 4.79 (after the removal of wine sediment, ~100 day old) [68]	4.49–6.14 [66,69]	4.57–4.77 (pasteurized-raw 90 days old [10]) 4.29 (artisanal 90 days old [71])
Moisture	16.4% (90 days old [44])	36.12–35.80% (90-days old, experimental samples, depending on the season and starters used [49,52] 33.1–37.2% (commercial samples [55])	37.02% [27]	49.66% (fresh cheese) 30% (after the removal of wine sediment, ~100 days old) [68]	31.40% [66]	28.97–35.49% (pasteurized-raw 90 days old [10]) 16.43% (artisanal 90 days old [71])

Table 3. Cont.

Parameter	Kariki	Kefalotyri	Ladotyri Zakynthou	Manoura Sifnou	Melichloro	Hard Xinotyri
Fat	44.8% (90 days old [44])	29.87–31.88% (90-days old, experimental samples, depending on the season and starters used [49,52] 28.9–35.7% (commercial samples [55]) 28.8% (artisanal, 90 days old [48])	30.7% [27]			58.62% (artisanal 90 days old [71]) 42.20–34.50% (pasteurized-raw 90 days old [10])
Fat-in-dry matter		47.06–47.66% (90-days old cheese produced with different starters [52]) 26.31–25.93% (90 days old cheese produced in December-April [49])	48.8% [27]			
Proteins	34.9% (90 days old [44])	23.9–28.5% (commercial samples [55]) 23.3% (artisanal, 90 days old [48]) 4.1% (artisanal, 90 days old [48])	26.7% [27]			30.70% (artisanal 90 days old [71])
Salt	2.1% (90 days old [44])	3.60–4.09% (90-days old, experimental samples, depending on the season and starters used [49,52])	2.84% [27]			2.87–2.68% (pasteurized-raw 90 days old [10]) 2.57% (artisanal 90 days old [71])
Salt-in-moisture				3.78% (fresh cheese) 9.20% (after the removal of wine sediment, ~100 days old) [68]	5.8 [66]	
ash		4.5–5.9% (commercial samples [55]) 3.9% (artisanal, 90 days old [48])	5.23% [27]			3.28–2.47% (pasteurized-raw 90 days old) [48] 2.75% (artisanal 90 days old [71])

Values are expressed on a wet basis unless otherwise reported. When no information is available, the value of parameter is left empty. Numbers in brackets refer to the references.

**Table 4.** Composition of Graviera cheeses.

Graviera	Moisture	Fat	Proteins	Salt	pH	Ash	Fat-in-Dry-Matter	References
Graviera Paros (commercial cheeses)	38%	32.5%	28.44%	2%		4.56%	45%	[27]
Cheeses (0 days old-63 days old)	37.5–36.1%	30.2–31.8%	26.6%	3.5%	5.9–6.29 (0 days old-10 weeks old)			[29,31]
Raw-pasteurized cheeses (90 days)	36.36–34.84%	29.33–32.92%	26.50–27.52%	1.80–1.86%	5.35–5.49		45.99–50.46%	[26]
Cheeses (sampling every month for one year)	34.33 g/100 g	29.86 g/100 g						[30]
Market cheeses (PDO and non PDO, from label)		18–42 g/100 g	22–34 g/100 g	0.5–3 g/100 g				[18]
Cheeses produced with natural-commercial cultures (90 days old)	35.4–34.0%			1.8–1.9%	5.7–5.6			[28]
Plant ripened-control pilot ripened cheeses (35 days old)	35.2–34.9%			1.6–1.4%	5.6			[32]
Cheeses 90 days old	35.08%			1.31%	5.76		54.57%	[25]
Cheeses (from different geographical origin)	29.25 (from Messinia)–37.25% (from Rethymno)		25.15 (from Arta)–30.56% (from Chania)	1.82 g/L (from Chania)–3.80 g/L (from Ioannina)	5.58 (from Trikala)–5.93 (from Thessaloniki)	3.86% (from Lesvos)–6.29% (from Ioannina)	45.97% (from Tinos)–53.99% (from Thessaloniki)	[22,23]

Values are expressed in wet basis unless otherwise reported. When no information is available, the value of parameter is left empty. Numbers in brackets refer to the references.

### 3.1.7. Hard Xinotyri Cheese

Hard Xinotyri is a farmhouse cheese, produced from raw goat milk, which is often mixed with a small proportion (~5%) of sheep milk. This cheese is manufactured in the island of Naxos (Aegean Sea, Cyclades complex). It has a wrinkled rind with yellow-grey color and a firm, compact texture with white-yellow color. Hard Xinotyri cheese has the shape of truncated cone and weights approximately 500 g. It has a smell of yeast, and its taste is slightly acidic and salty [71]. As this cheese is mainly produced from raw milk in an artisanal way, its moisture content is found (Table 3) to vary from 16.43% [71] to 37.19% at 90 days of storage [10]. This is probably due to the lack of standardization of its manufacture. A common practice [10] in the island is to produce it from pasteurized milk but without adding starter cultures. However, a starter culture is necessary because the acid production at an appropriate rate and time is a key step in the manufacture of a good quality cheese. In the study of Pappa et al. [10] pasteurized and raw cheeses are categorized as having an excellent quality, that is 47% minimum fat-in-dry matter content and 35% maximum moisture content, according to the Greek legislation.

Lipolysis increases, proteolysis is very limited, and variations in the mineral content (Ca, P, Mg, and Zn) content of artisanal cheeses are observed during ripening and storage. The most abundant volatile compounds of artisanal cheeses are ethanol, acetic acid, and hexanoic acid ethyl ester, while oleic, palmitic, myristic, stearic, and capric free fatty acids are found at high levels [71,72].

### 3.2. Descriptive Characteristics of Semihard Cheeses

Two semihard cheeses are included in the present study, Kashkaval of Pindos and Tyraki Tinou cheese. Their manufacturing steps and compositional data are presented in Tables 5 and 6, respectively.

#### 3.2.1. Kashkaval (Pindos) Cheese

Kashkaval is a pasta filata cheese produced in Greece; its cheesemaking technology has been recorded since 1900, but only recently this cheese has been studied. Artisanal Kashkaval cheese is produced in the mountains of Pindos (>1000 m height) with raw or pasteurized sheep milk [73,74]. A semi-industrial production of Kaskaval of Pindos cheese, based on the traditional protocol, was conducted by Pappa et al. [11], who reported that Kaskaval of Pindos cheese can be successfully manufactured using only sheep milk or by adding a small quantity of goat milk (10%). The type of salting (dry-salting or immersion in brine) does not have any effect on its physicochemical and sensory properties [75]. Butyric, palmitic, myristic, oleic, and stearic are the major free fatty acids. Esters are the volatile group found in abundance in raw cheeses and ketones in pasteurized foods [74]. Mesophilic non-starter lactobacilli and enterococci are the most predominant groups in raw cheeses, and *Lactococcus lactis* starter in pasteurized cheeses [74]. During manufacture, the pasta filata process (i.e., thin slicing of the curd and immersion of the slices in hot water of approximately 80 °C) improves the hygienic condition of raw cheese [75]. Kaskaval of Pindos cheese has, now, been applied for registration in the public database eAmbrosia as a Protected Geographical Indication (PGI) product for Greece [76].

#### 3.2.2. Tyraki Tinou

It is a semihard cheese made from cow milk in the island Tinos of Cyclades. It is manufactured without the addition of starter cultures. Milk coagulation takes place with the addition of small quantities of rennet and acid development (from the metabolism of lactose by the microorganisms). Tyraki Tinou has a content of P 131 mg/100 g cheese, of Mg 8.8 mg/100 g cheese and of K 63 mg/100 g cheese. Its ripening index, i.e., percentage of soluble nitrogen on total nitrogen is 4.57% [27].

**Table 5.** Manufacturing technology of nonprotected designation of origin and nonprotected geographical indication semihard cheeses.

Step	Kashkaval of Pindos <sup>1</sup>	Tyraki Tinou <sup>2</sup>
Milk (warm/refrigerated, full fat/partly skimmed)	Sheep or 90% sheep-10% goat	
Pasteurized or raw milk	Raw or pasteurized	Pasteurized with the addition of 10% raw bovine milk
Starter culture	Yes in pasteurized milk	no
Rennet, temperature, Duration	Rennet (1:10.000 strength) at 33–35 °C, for 40 min	yes, at 25 °C, the curdling lasts until the next day at approximately 22 °C
Cutting cooking of the curd	In small pieces to 42 °C in 30 min	yes
Drainage-molding	In molds filled with a cheese cloth	The curd is collected in sacks and left for drainage for another two days
Pressing	Yes	
Ripening	For 20 h to 17 °C until pH = 5.0–5.2	
Pasta filata process	yes i.e., the curd is cut in slices put in hot water, manipulated until having a homogenous and compact texture, kneaded and put in molds for one day	
Salting	dry salted or immersion in brine	3%
Ripening	at 12 °C for 90 days then stored at 2–4 °C	put in small cylindrical molds filled with cheese cloth for one day, then packed in plastic bags under vacuum and stored in cold places

When no information is available, the manufacturing step is left empty. <sup>1</sup> References [11,73]. <sup>2</sup> Reference [27].

**Table 6.** Composition of nonprotected designation of origin and nonprotected geographical indication semihard cheeses.

Parameter	Kashkaval of Pindos	Tyraki Tinou
pH	5.2–5.50 (90-days old, depending on type of milk and heat treatment [11,73])	4.38 (2-days old [27])
Moisture	38.7–41.83% (90-days old, depending on type of milk and heat treatment [11,73])	40.0% (2-days old [27])
Fat	27.58–30.9% (90-days old, depending on type of milk and heat treatment [11,73])	33.38% (2-days old [27])
Fat-in-dry matter		57.15% (2-days old [27])
Proteins	22.94–24.6% (90-days old, depending on type of milk and heat treatment [11,73])	21.86% (2-days old [27])
Salt	2–2.7% (90-days old, depending on type of milk and heat treatment [11,73])	2.23% (2-days old [27])
Ash	4.24–5.1% (90-days old, depending on type of milk and heat treatment [11,73])	2.56% (2-days old [27])

Values are expressed on a wet basis unless otherwise reported. Numbers in brackets refer to the references. When no information is available, the value of the parameter is left empty.

### 3.3. Descriptive Characteristics of Soft Cheeses

The manufacturing steps and compositional data of Teleme and Touloumotyri (Touloumisio) soft cheeses are presented in Tables 7 and 8, respectively.

#### 3.3.1. Teleme Cheese

Teleme is a white-brined cheese with acid and a salty taste. Its origin is from Romania, but Greek refugees from East Romylia introduced it at the beginning of the previous century [19,77]. Sheep, goat, or cow milk, or a mixture of them, can be used for its production. It has many similarities with Feta PDO cheese. The type of milk used and some details in the manufacture procedure (Teleme is drained under pressure and salted in brine solution) result in differences in the flavor (Teleme has a more acidic flavor) and texture (Teleme is crumblier and harder) between these two cheeses [24,78].

Its manufacture is summarized in Table 7 [79–81]. Milk is usually standardized to obtain a fat content of over 43% on dry matter for first-quality cheese (i.e.,  $\leq 56\%$  moisture and  $\geq 43\%$  fat in dry matter). Phenylalanine, valine, and lysine are the free amino acids [82] found in abundance. The type of milk, culture, and ripening time affect the volatile compounds [83] and the rheological characteristics [84] of Teleme cheeses.

**Table 7.** Manufacturing technology of nonprotected designation of origin and nonprotected geographical indication soft cheeses.

Step	Teleme <sup>1</sup>	Touloumotyri <sup>2</sup>
Milk (warm/refrigerated, full fat/partly skimmed)	Sheep, goat, cow standardized to 6.1%, 4.4%, 3.4%, respectively,	The same as for Feta.
Pasteurized or raw milk	pasteurized (63–65 °C for 30 min)	The same as for Feta.
Starter culture	yes 0.5% (thermophilic, mixed thermophilic-mesophilic, mesophilic)	The same as for Feta.
Rennet, temperature, Duration	3 g/100 kg milk, at 35 °C for 55 min	The same as for Feta.
Cutting,	in cubes of 1.5 cm	The same as for Feta.
Drainage-moulding	in moulds	The same as for Feta.
Pressing	until no whey is expelled	
Salting	Cut in blocks and salted by immersion in brine (14%) for 16 h, then put in metal containers and dry salted (1.5%). After 48 h in 19 °C, brine (5%) is added until it covers the cheese.	The same as for Feta. Then, cheeses are cut in small pieces and put tightly in skin bags. Brine (10% salt) or previously boiled salted milk (5%) is added in the skin bag and the opening is closed.
Ripening	Ripened at 19 °C until pH < 4.6 and moisture < 56%, then stored for minimum 60 days.	Left to ripen in the skin bags for 60 days.

When no information is available, the manufacturing step is left empty. <sup>1</sup> References [79–81]. <sup>2</sup> References [19,67].

**Table 8.** Composition of nonprotected designation of origin and nonprotected geographical indication soft cheeses.

Parameter	Teleme	Touloumotyri
pH	4.20–4.52 (60-day old experimental, depending on type of milk and culture used [80,81])	5.17 [19]
Moisture	54.69–57.76% (60-day old experimental, depending on type of milk and culture used [80,81])	54.1% [19]
Fat	20.4–24.6% (60-day old experimental, depending on type of milk and culture used [80,81])	
Proteins	14.43–16.6% (60-day old experimental, depending on type of milk and culture used [80,81])	
Salt	2.59–3.43% (60-day old experimental, depending on type of milk and culture used [80,81])	3.8% [19]
K	53.50–77.35 mg (60-day old experimental, depending on type of milk [80])	
Mg	6.25–20.30 mg (60-day old experimental, depending on type of milk [80])	
Zn	0.84–1.87 mg (60-day old experimental, depending on type of milk [80])	
Mn	2.50–18.15 µg ((60-day old experimental, depending on type of milk [80])	
Cu	57.40–72.50 µg (60-day old experimental, depending on type of milk [80])	
Fe	175–334 µg (60-day old experimental, depending on type of milk [80])	
Cholesterol	51.3–68.9 mg/100 g (commercial samples [55]) 59.20–67.53 mg/100 g (60-day old experimental, depending on type of milk [80])	

Values are expressed on a wet basis unless otherwise reported. Numbers in brackets refer to the references. When no information is available, the value of the parameter is left empty.

Pappa et al. [85] reported that cheeses produced using thermophilic and mesophilic cultures showed the highest and the lowest levels of proteolysis, respectively. Teleme goat cheese showed a slower rate of  $\alpha_s$ -casein hydrolysis than sheep or mixed sheep-goat cheeses while all cheeses had the same level of phosphotungstic acid soluble nitrogen during ripening and storage [86]. Proteomics can successfully characterize the proteins and peptide profile of Teleme cheese [87].

Ultrafiltration was applied in the manufacture of Teleme cheese [88–90]. Teleme cheese was also manufactured from refrigerated stored milk [91] and from deep frozen curd [92].

Regarding the microbiological data, *Lactobacillus plantarum* predominates during ripening; lactococci are found in high counts in the curd and in 15-days-old Teleme cheese, but lactobacilli predominate until the end of ripening, suggesting that nonstarter lactic acid bacteria can have an important role in its ripening [66,93]. Teleme cheese manufactured with the addition of *Pediococcus pentosaceus* along with the starter culture has higher counts of lactic acid bacteria, better organoleptic properties, and accelerated proteolysis than control cheeses [94].

### 3.3.2. Touloumotyri (Touloumisio) Cheese

Touloumotyri is a white brined cheese that is ripened and preserved in skin bags, the Touloumia. Touloumotyri is considered as the precursor of Feta cheese [19]. It has a slightly acidic taste and pleasant organoleptic properties. Nowadays, this cheese is produced in small quantities, and it can be found locally in Greece. It is manufactured from raw sheep or goat milk or mixtures of them. The production of this cheese has been dramatically reduced nowadays, mainly due to its preservation in the skin bags. The preparation of skins preferable from goats (as these skin bags last longer) is a laborious procedure. The skins are salted with a lot of grainy salt, folded, pressed, and kept for 10–15 days. Then they are shaved, cleaned with brine, and reversed so as the part with the hair is inside the

bag [19,27,66,67]. This cheese is left to ripen in the skin bag for up to 60 days in cool stores. In the beginning of the ripening, it is important to overturn daily the skin bags which are filled with cheese pieces, to prevent the growth of moulds. Usually, it is necessary to add brine or milk frequently [19,67]. The addition of milk was a common practice some decades ago in order to regulate saltiness and improve the organoleptic properties (flavor-aroma) of the cheese due to milk fermentation. Additionally, skin bags are opened from time to time to allow the gas formed to escape [46].

Lactobacilli are the predominant micro-organisms in Touloumotyri cheese, while enterococci and yeasts are found at high levels. *E. faecium* and *Lactobacillus plantarum* are the most frequent species detected. The non-starter lactic acid bacteria are found to contribute to the cheese's ripening and flavor [95].

### 3.4. Descriptive Characteristics of Spread Cheeses

Tsalafouti and soft Xinotyri are spreadable cheeses, and the main steps of their production and composition are shown in Tables 9 and 10, respectively.

**Table 9.** Manufacturing technology of nonprotected designation of origin and nonprotected geographical indication spread cheeses.

Step	Tsalafouti <sup>1</sup>	Soft Xinotyri <sup>2</sup>
Milk (warm / refrigerated, full fat/partly skimmed)	Full fat, ovine	Full fat, goat
Heating of milk	Raw with salt 0.2% is heated to approx. 90 °C under stirring	No (Raw) or yes (pasteurized at 63 °C for 30 min)
Starter culture	No	no
Rennet, temperature, Duration	No	Curdling at room temperature (18–20 °C) for 20 h
Cutting	No	In cubes
Drainage-moulding	No	In plastic pierced containers with cheese clothes in it, for 10 h at 16 °C
Salting	No additional salting	Edible sea salt (approx. 1.5 g per 100 kg fresh cheese) is distributed uniformly in the cheese mass
Ripening-storage	For 20 days in caves under running water (10 °C) and it is stirred two times per day, then at 4 °C	In tins (approx. 1.5 kg) at 4 °C

<sup>1</sup> References [96,97]. <sup>2</sup> Reference [9].

#### 3.4.1. Tsalafouti Cheese

Artisanal Tsalafouti cheese is an acid-curd cheese manufactured in the mountains using ovine milk during the summer, at the end of the lactation period. It has a white color and a soft, consistent, spreadable texture without gas openings, and its taste is mildly acidic, sour, and refreshing. During its manufacture, the heating of milk over an open fire slightly increases the solid content and yields a viscous coagulum. As no starter culture or rennet is added, the manufacture of artisanal Tsalafouti relies mainly on the spontaneous acid fermentation of the milk by indigenous micro-organisms. The addition of fresh product to the same vessel (i.e., a procedure that is performed up to three times) can ensure the buildup of a specific indigenous microflora that sours the milk during ripening. Artisanal Tsalafouti is left to acidify for several days in caves under running water, and its compact texture is normally induced through isoelectric precipitation of casein micelles by lowering the pH, which is initialized by the native microorganisms of the milk and the microclimate of the environment of maturation [96,97]. A semi-industrial manufacturing procedure based on the artisanal cheesemaking technology was applied by Pappa et al. [98]. The industrial

manufacture of it includes the addition of a small quantity of rennet [99]. Mesophilic lactic acid bacteria compose mainly the microflora of artisanal Tsalafouti, proteolysis increases during ripening, and the volatile compounds 3-methyl-1-butanol, ethanol, heptanal, and hexanal are found in abundance [96].

In industrial Tsalafouti cheese, mesophilic lactic acid bacteria predominate during ripening and storage, and acetoin, acetone, ethanol, and 3-methyl butanol are the principal volatile compounds. Sensory evaluation showed that Tsalafouti cheese keeps its organoleptic properties for 45 days [99].

Tsalafouti cheese has, now, been submitted for registration as a PDO cheese [100].

### 3.4.2. Soft Xinotyri Cheese

Soft Xinotyri is an artisanal spread cheese produced from goat milk on the island of Naxos (Aegean Sea). It can be consumed fresh (immediately as an unsalted curd) or after ripening and cold storage [9]. The pH of raw cheese is 4.44, while that of pasteurized cheese is 4.38, and they did not differ significantly on day 1 (Table 10). Their total viable counts, reflecting the total lactic acid bacteria populations, did not differ significantly as well. Probably the post-thermal contamination of the milk with adventitious micro-organisms under the artisanal cheesemaking conditions was high enough to reduce the fresh curd pH of pasteurized cheese compared to that of the raw milk cheese. Oleic, palmitic, capric, and caprylic acids are the principal free fatty acids; threonine, alanine, and lysine are the predominant free amino acids and ethyl hexonate, ethyl octanoate, ethyl decanoate, ethanol, 3-methyl butanol, phenyl ethyl alcohol, and acetone are the volatile compounds found in abundance. Pasteurization with the addition of an appropriate starter culture is recommended for the standardization and safety of this type of cheese [9].

**Table 10.** Composition of nonprotected designation of origin and nonprotected geographical indication spread cheeses.

Parameter	Tsalafouti	Raw-Pateurized Soft Xinotyri
pH	4.23–4.38 (artisanal [96])	4.44–4.38 (1-day-old [9])
	3.85–4.16 (industrial [99])	4.41–4.55 (60-days old [9])
Moisture	78.38–79.5% (artisanal [96,97])	73.4–71.0% (1-day-old [9])
	68.06–69.06% (industrial [99])	63.2–66.8% (60-days old [9])
fat	14.03–15.05% (industrial [99])	15.7–16.0% (1-day-old [9])
	9.75–10.25% (artisanal [96])	18.7–17.8% (60-days old [9])
Fat-in-dry matter	41.3–48.18% (artisanal [96,97])	59–55.1% (1-day-old [9])
	45.09–47.19% (industrial [99])	50.7–53.6% (60-days old [9])
proteins	10.63–11.08% (industrial [99])	9.34–9.79% (1-day-old [9])
	6.5–7.79 (artisanal [96,97])	15.0–11.2% (60-days old [9])
salt	1.33–1.81% (industrial [99])	0.28–0.22% (1-day-old [9])
	0.34–0.54% (artisanal [96])	1.0% (60-days old [9])
ash	2.38–2.43% (industrial [99])	0.84–0.75% (1-day-old [9])
		1.4–1.5% (60-days old [9])

Values are expressed on a wet basis unless otherwise reported. Numbers in brackets refer to the references.

### 3.5. Descriptive Characteristics of Whey Cheeses

Anthoryros, Myzithra, and Urda are the whey cheeses included in the present study. Table 11 presents their manufacturing technology, and Table 12 their composition.

**Table 11.** Manufacturing technology of nonprotected designation of origin and nonprotected geographical indication whey cheeses.

Step	Anthotyros <sup>1</sup>	Myzithra <sup>2</sup>	Urda <sup>3</sup>
Type of filtered whey	ovine or caprine,	ovine or caprine, cow	ovine or caprine
Heating under stirring, Addition of milk, Addition of NaCl	yes, 10% raw ovine or caprine milk, 0.5% salt at ~70 °C	yes, 3–5% milk at 65–70 °C, 1–1.5% salt at 73–75 °C	yes, 12 kg sheep milk in 55 kg sheep whey or 22 kg goat milk in 65 kg goat whey, at 55 °C, 1% salt at 70 °C
Appearing of small particles of whey proteins at ~80 °C stirring is stopped- Curd is held at ~90 °C for 20 min to be cooked	yes	yes	yes
Transferring of curd to pierced stainless steel molds with a cheese cloth inside them	yes	yes	yes
Draining of cheeses	3–4 h	3–4 h	overnight at room temperature, the following day cheeses are additionally salted (first washed with brine, then dry salted)
Transferring to ~5 °C	yes	yes	yes, after ripening at ambient temperature for approx. Twenty-five days

<sup>1</sup> References [19,27,47,101,102]. <sup>2</sup> References [27,46,102]. <sup>3</sup> Reference [8].

### 3.5.1. Anthotyros Cheese

Anthotyros is manufactured from the ovine or caprine whey of hard, semihard, or soft cheeses. Anthotyros was initially produced on the island of Crete, but today it is manufactured all over Greece [19,101]. It has a compact texture, a pleasant flavor, and it can be eaten either as a table cheese or it can be used for grating. The name ‘Anthotyros’ means ‘blossom cheese’ and it comes from the word ‘anthos’ which means ‘flower’ because of the way the small particles of denatured whey proteins look when they appear on the surface during cheesemaking [47]. In some cases, i.e., usually when bovine whey is used, an acidification reagent, such as an aqueous solution of citric acid, is added to help the precipitation of the whey proteins during its manufacturing procedure [102]. Cheeses can be consumed immediately or after additional salting and drainage [47,102].

Commercial samples have mean values of cholesterol 56.2 mg/100 g of cheese, saturated fatty acids 10.7 g/100 g, monounsaturated fatty acids 3.2 g/100 g, polyunsaturated fatty acids 0.63 g/100 g, and of energy 200 kcal/100 g [55].

Kalogridou-Vassiliadou et al. [101] found in 50 samples purchased from retail shops a 7.84 mean log of total counts, 7.18 mean log counts of lactic acid bacteria and 5.78 mean log counts of enterococci, 6.74 mean log counts of coliforms bacteria, 5.48 mean log counts of yeasts and 4.48 mean log counts of *Micrococcaceae*. The high counts of micro-organisms in the cheeses may suggest high contamination after production and the cheese environment did not adversely affect their growth or some of them may have survived heat treatment of the whey [101]. Anthotyros cheeses manufactured by Tsiotsas et al. [103] had 4.54 log cfu/g aerobic mesophilic bacteria, 3.80 log cfu/g yeasts, and 1.2 log cfu/g enterobacteriaceae.

New technologies or additives have been introduced to traditional products nowadays. These may have beneficial results, such as producing healthier products, or maintaining their authenticity. However, the unique characteristics of the cheeses should not be altered. The evolution of spoilage bacteria in fresh Anthotyros cheeses stored at 4 °C under vacuum for 40 days, manufactured with or without the addition of 5% (*v/w*) of an enterocin A-B-P crude extract, was studied by Sameli et al. [104], who found that the crude extract did not retard the growth of spoilage bacteria but it enhanced the growth of lactic acid bacteria as well as the declines of the gram-negative bacteria of later storage. However, more

work should be conducted regarding the effect of the addition of the crude extract on the sensory properties of the cheese. Commercially available nisin can have a promising role in controlling *L. monocytogenes* added post processing in Anthotyros cheeses stored at 4 °C under vacuum for 45 days [105]. Irradiation at doses up to 4 kGy may be used in ready-to-eat Anthotyros cheese for the control of *L. monocytogenes* [103]. The easy growth of *L. monocytogenes*, *Aeromonas hydrophila* and *Escherichia coli* O157:H7 in Anthotyros and Myzithra whey cheeses even during refrigerated storage is reported [106–108], and further recommendations are provided for the post packing pasteurization of the cheeses in addition to good hygienic practices during their handling and packing. Kapetanakou et al. [109] investigated the potential growth or survival of *L. monocytogenes* which inoculated commercial Anthotyros cheese and found that it survived at populations which were lower or similar to the level of inoculation during storage due to the high competition with other micro-organisms and/or low pH/aw during storage.

Tsiraki and Savvaides [110] showed that the combined use of vacuum packaging or modified atmosphere packaging (40% CO<sub>2</sub>/60% N<sub>2</sub>) with the addition of basil oil, compared to aerobic packaging, extended the shelf life of Anthotyros while the cheese maintained its good organoleptic characteristics. Arvanytogiannis et al. [111] found that a modified atmosphere packaging (40%CO<sub>2</sub>/55%N<sub>2</sub>/5%O<sub>2</sub>, or 60% CO<sub>2</sub>/40% N<sub>2</sub> or 50% CO<sub>2</sub>/50% N<sub>2</sub>) could prolong the shelf life of Anthotyros cheese better than air packaging. Additionally, the use of modified atmosphere packaging (30% CO<sub>2</sub>/70% N<sub>2</sub> or 70% CO<sub>2</sub>/30% N<sub>2</sub>) extends the shelf life of Anthotyros cheese without losing its good organoleptic characteristics compared to vacuum packaging [112].

### 3.5.2. Myzithra Cheese

Myzithra is a whey cheese widely produced in Greece. It is a table cheese with no rind, and it can be eaten freshly (often it is used for the preparation of pies and other dishes) or it can be consumed dried (usually for grating). Its texture is grainy but not spreadable. It can be said that Myzithra cheese is a mass of denatured whey proteins. Sometimes, this curd of proteins is consumed a little after its preparation, warm, with or without salt addition. Myzithra cheese is usually, produced from sheep and goat whey because it is richer in fat and protein; however, cow whey can also be used [24,27,46,113].

Alcohols and ketones are the volatile groups found in high levels in Myzithra cheese [114]. Commercial Myzithra has mean values of 0.13 mg /100 g conjugated linoleic acid [115] and 42.7 mg/100 g cholesterol content [55].

A new reduced-fat Myzithra cheese with high Ca and Mg content was successfully produced by Kaminarides et al. [116], while a modified Myzithra cheese was manufactured by substituting the whey with 65% dried whey protein concentrate [117]. The fermentation of ovine milk with the bacteriocinogenic strain *Streptococcus thermophilus* ACA-DC 0040 prior to its addition to the whey, contributes to the safety of produced Myzithra cheese and to the extension of its shelf life [114]. A functional Myzithra cheese with the adjunct encapsulated probiotic bacterial strain *Lactobacillus casei* ATCC 393 in *Pistacia terebinthus* resin (pissa Paphos) was manufactured by Schoina et al. [118] with high commercialization potential. Although the addition of acid is generally used in the bovine whey, as already reported, Pappas and Voutsinas [119] added various acids (i.e., citric, lactic, and acetic) to the ovine whey during the manufacture of Myzithra cheese. The addition of acids resulted in increased protein retention in the cheese and, therefore, increased yield, while Myzithra cheese did not lose its sensory properties.

**Table 12.** Composition of nonprotected designation of origin and nonprotected geographical indication whey cheeses.

Parameter	Anthotyros	Myzithra	Urda
pH	6.4–6.3 (experimental; day 0-day 42 [103]) 6.17 (mean values, commercial samples [101])	6.26–6.50 (experimental cheeses [114,116,117])	6.39–6.41 (experimental sheep-goat 1-day old samples [8]) 5.04–5.46 (experimental sheep-goat 90-day old samples [8])
moisture	65.24–67.7% (mean values, commercial samples [27,55,101]) 65–66.5% (experimental; day 0-day 42 [103]) maximum 40% (dried samples [19])	65.3–67.06% (experimental cheeses [114,116,117]) 65.3–74.62% (mean values, commercial samples [27,55]) 36.82–38.63% (mean values, commercial dried samples [27,113]) 20.83–20.92% mean values, commercial dried samples [27,113])	56.97–54.13% experimental sheep-goat 1-day old samples [8]) 30.76–27.52% (experimental sheep-goat 90-day old samples [8]) 43.5–45.7% (experimental sheep-goat 90-day old samples [8])
fat	16.6–16.5% (experimental; day 0-day 42 [103]) 13.88–16.3% (mean values, commercial samples [27,55])	9.24–17.3% (experimental cheeses [114,116,117]) 3–16.9% (mean values, commercial samples [27,55])	28.8–29.7% (experimental sheep-goat 1-day old samples [8])
fat-in-dry matter	42.75% (mean values, market samples [27]) minimum 65% (dried samples [19])		
proteins	11.5–12.42% (mean values, market samples [27,55]) 9.6–9.7% (experimental; day 0-day 42 [103])	24.42–25.44% mean values, commercial dried samples [27,113]) 13.1–14.63% (mean values, commercial samples [27,55]) 11.9–15.89% (experimental cheeses [114,116,117])	21.92–18.38% (experimental sheep-goat 90-day old samples [8]) 14.57–12.63% (experimental sheep-goat 1-day old samples [8]) 3.64–3.35% (experimental sheep-goat 90-day old samples [8])
salt	0.6–0.5% (experimental; day 0-day 42 [103]) 0.57–0.6% (mean values, commercial samples [27,55])	8.66–9.05% mean values, commercial dried samples [27,113]) 0.8–2.95% (mean values, commercial samples [27,55])	0.60–0.51% (experimental sheep-goat 1-day old samples [8])
ash	1.3–1.75% (mean values, market samples [27,55])	9.93–10.94% mean values, commercial dried samples [27,113]) 1.5–4.14% (mean values, commercial samples [27,55]) 0.81–1.75% (experimental cheeses [114,116,117])	
lactic acid (%)	0.5–1.75% (mean values, market samples [27,55])		
brine concentration	1.46% (mean values, commercial samples [101])		
lactose		3.51–3.90% (experimental cheeses [114,116,117])	

When no information is available, the value of the parameter is left empty. Values are expressed on a wet basis unless reported. Numbers in brackets refer to the references.

### 3.5.3. Urda Cheese

Urda is an artisanal cheese, manufactured mainly in farms in North Pindos (approximately 1500 m height) from sheep or goat whey, during the summer. It is ripened in the air for approximately 25 days, and then it is stored either in cool cellars or in the refrigerator for up to 360 days. Urda can be consumed fresh from the first day of its manufacture or as mature cheese. The mature cheese has a pleasant flavor, and it is very much appreciated by consumers. It can be grated or cooked in a frying pan and eaten with honey as a dessert [8].

The artisanal cheese is produced from sheep or goat whey (obtained after the manufacture of hard/semihard cheeses with a procedure that includes “beating” the cheese coagulum to fortify the whey with fat). The main group of micro-organisms in the artisanal Urda cheese is mesophilic lactic acid bacteria, while enterococci, aerobic gram-negative bacteria, and enterobacteriaceae are found in abundance. Proteolysis and lipolysis increase during ripening and storage. The two most predominant groups of volatile compounds are ketones and terpenes in fresh cheese, while free fatty acids and ketones are the most abundant compounds in mature cheese [8]. Urda cheese was semi-industrially manufactured by Pappa et al. [11] using a cheesemaking procedure based on the artisanal one.

### 3.6. Other Cheeses

Armiotyri cheese is produced using raw goat milk, in the islands of Greece, apart from the island of Crete, using the cheesemaking technology of Kefalotyri cheese. Chlorotyri cheese is produced in all of Greece using all kinds of milk. It is a fresh, semisoft, cooked cheese that is kept in brine until it is consumed. Kathoura Ikarias is produced on the island of Ikaria (Aegean Sea) from local goat milk. During manufacture, the curd is cooked gently, and the cheese can be eaten either after its drainage or it is cut into thick slices, salted, and put in brine until consumption [67]. Trima Kythnos is produced on the island of Kythnos (Aegean Sea). It resembles Kopanisti PDO cheese; however, the salting takes place during pressing as well as when the cheese is finally placed in clay jars [120].

Other cheeses produced in different regions of Greece are: Tyrozouli, Nivato, Niotiko, Skotyri, Dermatotyri Samou, Armexia Androu, Sitaka Kassou, Petroti, Manouli Karpathou, Elaiki Kassou, Viosyra, Klotsotyri, Tyroglia, Tyrovolia, Souroto, Thylikotyri, Victoria, Volaki, Manousos, Hmichloro, Axiali, Axialomyzithra, Komos, Souroma, cheese of lakos in the island of Serifos, Athotyra, Galomyzithra, Malathouni etc. [45,121,122]. For many of them, there is lack of scientific information, therefore, it is necessary to study them thoroughly by standardizing their technology, improving their quality, ensuring their safety, finding their typical characteristics, and establishing their identity in order to maintain their uniqueness. The use of pasteurized milk with the addition of a suitable starter culture could be recommended as an alternative to raw milk. Specific information during their manufacture, such as the quality of the milk, the amount and type of rennet used, the pH before salting and at the end of ripening, and the shelf-life is important in order to produce the best quality cheeses and enable consumers to make more informed purchasing choices.

## 4. Conclusions

Traditional cheeses in Greece are produced by our ancestors, and their manufacture is transmitted from one generation to another. Some of them are not well known and are associated with specific celebrations and seasons of the year. Cheeses manufactured in a traditional way have unique characteristics and organoleptic properties, and a standardization of their production can provide constant quality and safety, resulting in an increase in their added value as well as preserving territorial cultural traditions. They can become more familiar and can enter new markets, especially if commercialization strategies are applied, giving in that way an economic boost to the regions involved. Possibly these cheeses can, finally, be certified labeled, such as PDO, PGI, specificity of ‘mountainous cheeses’, ‘island cheeses’.

New technologies or additives could provide health improvements in line with consumers’ needs. They could improve the quality by identifying the best ripening time,

avoiding degradation of sensory attributes, and maintaining their authenticity. However, they should be used with respect for tradition, and it is necessary to comply with regulations allowing cheeses to keep their identity.

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