

Microbiological Analysis, Textural Evaluation, and Cholesterol Content of Kandırif Cheese

Kandırif Peynirinin Mikrobiyolojik Analizi, Dokusal Değerlendirmesi ve Kolesterol İçeriği

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Abstract

Kandırif cheese represents a distinctive variety of local cheeses within Turkey. The physical, chemical, and sensory attributes of Kandırif cheese distinctively set it apart from other cheese varieties. Given the study's objective to enhance the quality standards of regional products, there exists the potential for broadening the consumption scope of this locally manufactured cheese variant across larger geographical areas. In this study, twenty Kandırif cheese samples were procured from Kekikli Village situated within the Olur district of Erzurum where this cheese variety is traditionally crafted. This investigation encompassed an examination of the cholesterol content, fatty acid composition, textural properties, and microbiological characteristics of the sampled cheeses. Notably, the Kandırif cheese samples revealed significant disparities in microbiological quality, cholesterol and fatty acid levels, and texture profiles. Particularly, it was ascertained that Kandırif cheese, when produced within family businesses, exhibited a heightened susceptibility to yeast and mold contamination. The TAMB number ranged from 7.21 log cfu/g to 7.46 log cfu/g, Lactobacillus counts varied between 3.65 log cfu/g and 5.49 log cfu/g, and Lactococci were found between 2.53 log cfu/g and 3.94 log cfu/g. Seven of the twenty samples (35%) exhibited a coliform group bacteria count < 1.00 log cfu/g. *S. aureus* was consistently < 1.00 log cfu/g. Proteolytic bacteria ranged from 3.77 log cfu/g to 4.63 log cfu/g, lipolytic bacteria from 3.53 log cfu/g to 3.75 log cfu/g, and psychrophilic bacteria from 2.20 log cfu/g to 2.80 log cfu/g. Yeast and mold counts were between 4.08 log cfu/g and 4.66 log cfu/g. The cholesterol content of Kandırif Cheese samples ranged from 66.13 mg/100 g to 3869.77 mg/100 g. Regarding short-chain fatty acids, butyric acid percentages ranged from 2.61% to 4.00%, caproic acid from 1.47% to 2.12%, caprylic acid from 0.72% to 1.12%, and capric acid from 1.18% to 2.32%. Long-chain saturated fatty acids varied, with palmitic acid between 7.97% and 31.43%, stearic acid between 1.42% and 12.38%, and arachidonic acid between 0.00% and 2.55%. Sample 14 exhibited weaker texture, while sample 19 demonstrated higher textural properties. The cholesterol amount of Kandırif Cheese samples was between 66.13 mg/100 g and 3869.77 mg/100 g. In order to establish a consistent and standardized composition and quality for Kandırif cheese, it is imperative that the production process transitions to controlled conditions. Consequently, the traditional production practices associated with Kandırif cheese may necessitate a transformation, potentially transitioning towards factory-scale operations and standardized procedures.

Keywords: Kandırif cheese, Composition, Microbiological properties, Fatty acids, Cholesterol, Texture profile

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Öz

Kandırif peyniri, Türkiye'deki yerel peynirlerin belirgin bir çeşidini temsil eder. Kandırif peynirinin fiziksel, kimyasal ve duysal özellikleri onu diğer peynir çeşitlerinden belirgin bir şekilde ayırır. Çalışmanın bölgesel ürünlerin kalite standartlarını geliştirme amacı göz önüne alındığında, bu yerel olarak üretilen peynir çeşidinin tüketim kapsamını daha geniş coğrafi alanlara genişletme potansiyeli bulunmaktadır. Bu çalışmada, bu peynir çeşidinin geleneksel olarak üretildiği Erzurum'un Olur ilçesinde bulunan Kekikli Köyü'nden 20 Kandırif peyniri örneği temin edildi. Bu araştırma, örneklenen peynirlerin kolesterol içeriği, yağ asidi bileşimi, dokusal özellikleri ve mikrobiyolojik özelliklerinin incelenmesini kapsamaktadır. Özellikle, Kandırif peyniri örneklerinin mikrobiyolojik kalite, kolesterol ve yağ asidi seviyeleri ile tekstürel profillerinde önemli farklılıklar saptanmıştır. Özellikle, aile işletmelerinde üretildiğinde Kandırif peynirinin maya ve küf kontaminasyonuna karşı daha yüksek bir duyarlılık sergilediği tespit edilmiştir. TAMB sayısı 7,21 log kob/g ile 7,46 log kob/g arasında, *Lactobacillus* sayıları 3,65 log kob/g ile 5,49 log kob/g arasında değiştiği ve *Lactococci* sayısının 2,53 log kob/g ile 3,94 log kob/g arasında olduğu bulundu. 20 numunenin 7'sinde (%35) koliform grubu bakteri sayısı < 1,00 log kob/g düzeyinde bulundu. *S. aureus* sürekli olarak < 1,00 log kob/g, proteolitik bakteriler 3,77 log kob/g ile 4,63 log kob/g arasında, lipolitik bakteriler 3,53 log kob/g ile 3,75 log kob/g arasında ve psikrofilik bakteriler 2,20 log kob/g ile 2,80 log kob/g arasında bir değişim göstermiştir. Maya ve küf sayıları 4,08 log kob/g ile 4,66 log kob/g arasında bulunmuştur. Kandırif peyniri örneklerinin kolesterol içeriği 66,13 mg/100 g ile 3869,77 mg/100 g arasında değişmiştir. Kısa zincirli yağ asitleri açısından, bütirik asit yüzdeleri %2,61 ile %4,00 arasında, kaproik asit %1,47 ile %2,12 arasında, kaprilik asit %0,72 ile %1,12 arasında ve kaprik asit %1,18 ile %2,32 arasında değişmiştir. Uzun zincirli doymuş yağ asitleri ise palmitik asit %7,97 ile %31,43 arasında, stearik asit %1,42 ile %12,38 arasında ve araşidonik asit %0,00 ile %2,55 arasında olduğu tespit edilmiştir. 14 nolu örnek daha zayıf doku sergilerken, 19 nolu örnek daha yüksek dokusal özellikler gösterdiği gözlemlenmiştir. Kandırif peyniri örneklerinin kolesterol miktarı 66,13 mg/100 g ile 3869,77 mg/100 g arasında bulunmuştur. Kandırif peyniri için tutarlı ve standart bir bileşim ve kalite oluşturmak için, üretim sürecinin kontrollü koşullara geçiş yapması zorunludur. Sonuç olarak, Kandırif peyniriyle ilişkili geleneksel üretim uygulamaları, potansiyel olarak fabrika ölçөгindeki operasyonlara ve standart prosedürlere doğru geçiş yaparak bir dönüşümü gerektirebilir.

Anahtar Kelimeler: Kandırif peyniri, Bileşim, Mikrobiyolojik özellikler, Yağ asitleri, Kolesterol, Doku profili

1. Introduction

In the realm of cheese production, the conventional method involves the coagulation of milk, followed by the separation of whey from the curd, and subsequent processing of the curd through various techniques. Globally, cheese stands as the foremost food item in terms of consumption and international trade. Within the geographical boundaries of Türkiye, there exists a remarkable abundance of cheese varieties, surpassing 150 in number. While the majority of these varieties adequately cater to local demands, select types have gained popularity across the nation (Kamber and Terzi, 2008). According to the report published by the National Dairy Council, an impressive total of 22,960.379 tons of raw milk and 756.646 tons of cheese were manufactured nationwide in 2019 (Anonymous, 2021).

Kandırif cheese represents a distinctive variety of local cheeses within Türkiye. Notably some of the techniques used in the production of Erzurum Civil cheese, Kashar cheese, and Halloumi cheese are also employed in the production stages of Kandırif cheese. Erzurum Civil cheese, for instance, is derived from sourced skim milk, resembling the utilization of sour full-fat milk in the creation of Kandırif cheese. Furthermore, the manufacturing process for Kashar cheese involves a heat treatment of the clot at 72-75°C in 8% salt water. On the other hand, Kandırif cheese is subjected to a heating process within its hot whey at a maximum of 60°C, that mirrors the clot-heating phase akin to that of Kashar cheese. In the context of Halloumi cheese production in the Turkish Republic of Northern Cyprus, an alternate approach is taken a higher temperature of above 80°C is applied for clot heating in hot whey for 10 minutes, allowing the cheese to be later consumed by frying in a pan without oil (Ozdemir et al. 2022).

Distinctively, Kandırif cheese diverges in production through the employment of a smoking process by direct cooking in wood flame, in contrast to the frying method used for Halloumi cheese clot. Notably, a recent study by Ozdemir et al. (2022) engaged in the collection and analysis of 20 samples of Kandırif cheese from Kekikli village. This investigation yielded noteworthy findings, indicating that Kandırif cheese boasts a substantial dry matter, fat, and protein ratio, thus highlighting its notable nutritional value. Moreover, the low salt content associated with Kandırif cheese not only aligns with safety and compliance standards but also underlines its health benefits.

Furthermore, it was discerned that the ripeness of the examined cheese samples was relatively low, classifying them as fresh cheese. Consequently, the physical, chemical, and sensory attributes of Kandırif cheese distinctively set it apart from other cheese varieties (Ozdemir et al., 2022).

Investigations into the chemical and textural properties of Halloumi cheese have been carried out in Türkiye, as detailed in a study by Ergonul et al. (2011). Additionally, a separate study by Elgaml et al. (2017) delved into the production of Halloumi cheese utilizing various types of milk—such as cow's milk, goat's milk, and combinations of both. This comprehensive study encompassed an analysis of the physicochemical, microbiological, and rheological attributes. The rheological examination revealed that Halloumi cheese crafted exclusively from cow's milk exhibited less uniform characteristics but possessed a superior taste in comparison to the other treatment variations.

These findings underscore the significant impact of milk sources on the rheological properties and taste profile of Halloumi cheese, shedding light on the crucial role of milk composition in shaping the sensory attributes and textural consistency of this particular cheese variety. In a study made by Ergonul et al. (2011), the adhesiveness of Halloumi cheese samples displayed an average value of 17.86 kg·s and exhibited a broad variation, ranging from 0 kg·s to 67.37 kg·s. Conversely, the springiness values of these samples fell within a narrow range, specifically between 9.95 s and 9.99 s. Notably, no statistically significant disparities were observed among the springiness values of Halloumi cheeses marketed under different trademarks ($P > 0.05$). Furthermore, the gumminess scores for Halloumi cheese samples show a notable diversity, spanning from the lowest value of 2.33 kg to the highest value of 15.55 kg, with an average gumminess score of 6.88 kg. As for chewiness, the scores exhibited a wide-ranging spectrum, ranging from 23.24 kg·s to 155.11 kg·s, while the average chewiness score was determined at 68.52 kg·s.

These findings delineate the diverse textural attributes characterizing Halloumi cheese, shedding light on the considerable variability in adhesiveness, springiness, gumminess, and chewiness within this cheese variety, as evidenced by the comprehensive study conducted by Ergonul et al. (2011). In a study by Eroglu et al. (2016), the

texture profile analysis (TPA) parameters of Kasher cheese samples were assessed across different ripening periods, specifically the 0th, 30th, 60th, and 90th days. Notably, the analysis included several essential parameters, such as hardness, chewiness, cohesiveness, resilience, springiness, adhesiveness, and gumminess. At the first stage of the maturing period, the hardness of the cheese samples demonstrated a range of 7223–8679 g. This substantial variance in hardness values among the samples was suggested to potentially correlate with the chemical composition, particularly factors such as fat, protein, or dry matter content of the samples (Eroglu et al. 2016).

This study encompassed the collection of 20 Kandırif cheese samples originating from producers in Kekikli village. A comprehensive range of analyzes was then conducted, covering physical, chemical, and microbiological assessments alongside a scrutiny of the fatty acid profile, cholesterol content analysis, and texture profile analysis (TPA).

2. Material and Methods

2.1. Material

The 20 Kandırif cheese samples, crafted by producers in Kekikli village, were carefully collected and preserved in sterilized packets. Subsequently, these samples underwent analysis within the laboratories of the Food Engineering Department at Atatürk University.

2.2. Methods

2.1.1. Microbiological analyzes of cheese samples

2.1.1.1. Preparation of samples

A total of 10 grams of cheese samples were measured under sterile conditions and placed in a sterile Stomacher bag. Subsequently, 90 milliliters of sterile physiological saline (0.85% NaCl) were introduced into the bag. The sample was then homogenized. Thus, 10^{-1} dilutions were prepared. Other dilutions were then prepared (Harrigan, 1998).

2.1.1.2. Enumeration of Total aerobic mesophilic bacteria (TAMB)

Plate count agar (PCA) was utilized to quantify the total aerobic mesophilic bacterial population. The dilutions were inoculated into the medium and incubated for 48 hours at $30 \pm 1^\circ\text{C}$. At the end of incubation colonies formed were counted (Messer et al. 1985).

2.1.1.3. Lactic acid bacteria count growing on MRS agar

MRS agar with pH adjusted to 5.7 was used for counting LAB growing on MRS agar. With MRS agar, 0.1 ml of appropriate dilutions were cultivated using the pour-smear plate method. Petri dishes incubated for 48 hours at $30 \pm 1^\circ\text{C}$ were counted (Speck 1976).

2.1.1.4. Counting of Lactococci grown on M-17 agar

For the enumeration of *Lactococci* in Kandırif cheese samples, sterile M-17 agar was obtained from suitable dilutions. Petri dishes were incubated for 48 hours at $30 \pm 2^\circ\text{C}$ in an aerobic environment by sowing with the cast plate method. Petri dishes containing colonies were counted (Diliello, 1982).

2.1.1.5. Coliform Group Bacteria Count

Violet Red Bile Agar will be cultivated from the appropriate dilutions of the cheese samples (Speck 1976). After incubation of petri dishes at $35 \pm 1^\circ\text{C}$, colonies with a red color around a pink halo was counted.

2.1.1.6. Counting of psychrophilic bacteria

1 ml of sample taken from appropriate dilutions was inoculated into PCA medium, the plates were incubated at 4°C for 10 days, and counts were made (Diliello, 1982).

2.1.1.7. Proteolytic bacteria counting

1 ml of appropriate dilution samples were taken and inoculated into gelatinous medium. Bacterial colonies formed after the plates were incubated for 72 hours at 22±2°C were counted (Diliello,1982).

2.1.1.8. Staphylococcus aureus count

Superficial cultivation was performed on Baird Parker Agar (BPA) from 0.1 ml sample taken from appropriate dilution. The Petri dishes were left to incubate for a period of 48 at 37°C, and colonies with black glossy 1.0-1.5 mm diameter narrow white margins 2.5 mm wide with clear zones were counted as *S. aureus* (Diliello,1982).

2.1.1.9. Enumeration of lipolytic bacteria

Enumeration of lipolytic bacteria was done by smear plate method using Tributyrin Agar (Merck). After the plates were incubated for 72 hours at 22±2°C, the colonies formed were counted and calculated (Diliello,1982).

2.1.1.10. Yeast and mold counting

Sowing according to the smear plate method using PDA (Potato Dextrose Agar) agar for yeast and mold counting in cheese samples has been made. Following a 5-day incubation of the inoculated Petri dishes at 25°C, the colonies of yeast and mold were enumerated (Speck, 1976).

2.2. Determination of fatty acid composition

The analysis of the fatty acid composition in Kandirif cheese samples was conducted using the fatty acid methyl ester technique, as outlined in AOAC 996.01 (Satchithanandam et al., 2001). A total of 0.1 g of oil, extracted from the cheese samples by an ether extraction method, was combined with n-hexane (10 mL) and subjected to shaking. Subsequently, a 0.5 mL portion of a 2 N potassium hydroxide solution in methanol was introduced, and the mixture was stirred for a duration of 1 to 2 hours. After allowing the mixture to stand in darkness, a volume of 1 µL from the upper phase was taken and injected directly into a gas chromatograph. The analysis utilized a Restek RTX-2330 capillary column, measuring 60 meters in length, with an internal diameter of 0.25 mm and a film thickness of 0.1 µm, on a Shimadzu gas chromatograph, specifically the QP2010 Plus model. The flame ionization detector (FID) was employed for detection. The column temperature was first maintained at 100°C for a duration of 3 minutes, before being raised to 240°C at a rate of 4°C per minute, maintaining this final temperature for an additional 18 minutes. The injection temperature was held constant at 250°C, and the detector temperature was adjusted to 255°C. Helium was used as the carrier gas, flowing at a rate of 0.64 mL/min, utilizing an injection split ratio of 1:80. The Lab Solution software was employed for the control of the GC/FID system, and a standard mix of fatty acid methyl esters (FAME) containing 37 components (Supelco) was used for comparison. The retention times and chain lengths of the FAME peaks were recognized through a comparative analysis of them to the established FAME standards, and the results were reported as percentages.

2.3. Cholesterol analysis

To assess the cholesterol content, a sample preparation was conducted involving the addition of 1 mL of stigmaterol (wit at a concentration of 0.5 mg/mL) and 0.5 mL of 2 N alcoholic potassium hydroxide to 5 g of the sample. This mixture was thoroughly mixed and subsequently incubated in an 80 °C water bath for a duration of 15 minutes. Following incubation, the mixture was allowed to cool to room temperature, after which 1 mL of distilled water and 5 mL of n-hexane were introduced and agitated for one minute. The resulting solution was then centrifuged at 2000 g for one minute, allowing for phase separation. From this, 1 mL of the upper phase was extracted into a vial for gas chromatography (GC) analysis. The GC analysis was conducted using a Restek Rtx-65TG column measuring 30 m in length and 0.32 mm in internal diameter, featuring a film thickness of 0.1 µm and a silica column comprising 65% diphenyl and 35% dimethyl-polysiloxane. The analysis was performed on a Shimadzu gas chromatography system (model QP2010 Plus) equipped with a flame ionization detector (FID). The column temperature was programmed to increase at a rate of 30 °C/min until reaching 150 °C, followed by a further increase to 360 °C at a rate of 15 °C/min, with this final temperature being maintained for an additional three minutes. The injection temperature was set at 300 °C, while the detector temperature was maintained at 370 °C. Helium served as the carrier gas throughout the analysis (Fletouris et al., 1998).

2.4. Texture Profile Analysis (TPA)

To measure the textural properties of Kandirif cheese, a TA.XTplus texture analyzer (Micro Systems Ltd, Godalming, UK) equipped with a 30 kg load cell was used. Cylindrical cheese samples of 10 mm height and 25 mm diameter were used at 20°C. A compression test using a two-bite P-50 probe and texture profile analysis (TPA) were performed on the samples. The cheese samples were compressed to 20% of their original height with a trigger force of 20 g and a speed of 1 mm/s. The speeds for both the pre-test and post-test measurements were conducted at 2 mm/s. (Everard et al., 2006). This study examined various texture characteristics, including hardness, stickiness, tackiness, springiness, gumminess, and chewiness, which were derived from the TPA curve. In instrumental analysis, hardness is quantitatively defined as the maximum force recorded during the initial compression cycle. Adhesiveness is characterized by the negative area under the curve corresponding to the first bite, indicating the work required to detach the compression plunger from the sample. Cohesiveness is determined as the ratio of the area observed after the second compression cycle to that of the first cycle. Springiness is calculated as the ratio of displacement (in mm) during the downward stroke of the second compression cycle relative to that of the first. Gumminess is defined as the product of hardness and cohesiveness, while chewiness is expressed as the product of gumminess and springiness (Lobato-Calleros et al., 1997).

3. Results and Discussion

3.1. The results of Microbiological Analysis

The results of microbiological analysis of Kandirif cheese samples are given in *Table 1*.

Table 1. The results (log cfu/g) of microbiological analysis of Kandirif cheese samples (log cfu/g)

SAMPLE NO	TAMB (Ad/g)	Lactobacil	Lactococcus	Coliform	S.aureus	Proteolitic	Lipolitic	Psicrophyli	Yealds and Moulds
1	7.46	4.63	3.46	1.18	<1.00	4.40	3.59	2.23	4.46
2	7.36	5.38	3.15	1.32	<1.00	3.91	3.61	2.34	4.49
3	7.21	4.54	2.83	1.08	<1.00	4.48	3.72	2.20	4.40
4	7.26	4.75	3.59	<1.00	<1.00	4.57	3.61	2.34	4.11
5	7.40	5.43	3.32	1.23	<1.00	3.77	3.73	2.40	4.34
6	7.41	4.64	3.48	1.28	<1.00	4.41	3.57	2.49	4.38
7	7.28	4.72	2.92	<1.00	<1.00	4.51	3.62	2.38	4.66
8	7.30	4.60	3.11	<1.00	<1.00	3.89	3.53	2.80	4.53
9	7.26	3.69	3.38	1.15	<1.00	4.34	3.75	2.34	4.48
10	7.34	5.41	3.08	1.20	<1.00	3.91	3.64	2.30	4.36
11	7.23	4.70	3.45	1.11	<1.00	3.87	3.58	2.41	4.08
12	7.36	4.56	2.53	<1.00	<1.00	4.40	3.54	2.26	4.48
13	7.34	3.76	3.61	<1.00	<1.00	4.48	3.70	2.51	4.41
14	7.30	4.66	3.94	1.11	<1.00	4.63	3.66	2.46	4.56
15	7.34	5.49	3.52	<1.00	<1.00	4.41	3.66	2.36	4.46
16	7.30	4.73	2.90	<1.00	<1.00	4.26	3.60	2.28	4.60
17	7.26	4.58	3.23	1.15	<1.00	3.96	3.72	2.43	4.57
18	7.34	4.52	3.28	<1.00	<1.00	4.61	3.69	2.30	4.61
19	7.23	4.63	3.51	1,20	<1.00	3.95	3.71	2.48	4.63
20	7.28	3.65	2.84	1,26	<1.00	3.92	3.66	2.45	4.41
Max.	7.46	5.49	3.94	1.32	<1.00	4.63	3.75	2.80	4.66
Min.	7.21	3.65	2.53	<1.00	<1.00	3.77	3.53	2.20	4.08

The total aerobic mesophilic bacteria (TAMB) counts of the samples ranged from 7.21 log cfu/g to 7.46 log cfu/g, while the *Lactobacillus* count fell within the range of 3.65 log cfu/g to 5.49 log cfu/g. Çinici and

Ozdemir(2024) found that in fried and unfried Kandirif cheese samples TAMB numbers ranged from 3.09 log cfu/g to 7.22 log cfu/g. Sengul et al. (2010) reported TAMB counts of Kashar cheese samples to be between 7.70 and 8.20 log cfu/g, which is consistent with our findings. Atasever et al. (1999) conducted a study on Hallomi cheese samples and determined that the TAMB count of fresh samples ranged from 6.16 log cfu/g to 6.69 log cfu/g, indicating lower counts compared to our results. Sıçramaz and Ayar (2023) found that Circassian cheese exhibited an increased dry matter content and a firmer texture, which can be attributed to the coagulation process conducted at 90°C and a smoking duration of six hours. Additionally, the extended smoking time (six hours) contributed to a reduction in microbial growth. Çinici and Ozdemir(2024) found that in unfried and fried Kandirif cheese samples, *Lactobacillus* counts ranged from 3.09 log cfu/g to 7.26 log cfu/g and *Lactococcus* count ranged from 3,06 to 7.26 as parallel to our founds. Sengul et al. (2010) also found that the average *Lactobacillus* counts of Kashar cheese samples were 7.36 log cfu/g. In contrast, the *Lactobacillus* counts of Kandirif cheese samples were lower than those reported by Sengul et al. (2010). The *Lactococcus* counts of Kandirif cheese were found to range from 2.53 log cfu/g to 3.94 log cfu/g. Ozdemir and Demirci (2006) reported an average *Lactococcus* count of Kashar cheese at 3.5×10 cfu/g, which was lower than our findings. Karpuz and Palabıyık (2024) found that the LAB (MRS) counts of the cheddar cheese sample stored in propolis-treated vacuum packaging decreased by 0.60 log cfu g⁻¹ (p<0.05) compared to the control.

Additionally, the count of coliform group bacteria was determined to be less than 1.00 colony-forming units per gram (cfu/g) in seven samples (35%) out of the twenty samples, with the highest coliform group bacteria count in Kandirif cheese samples detected as 1.32 log cfu/g. In the investigation by Atasever et al. (1999), the coliform group bacteria count within samples of Halloumi cheese ranged between 4.25 log cfu/g and 4.35 log cfu/g.

While the maximum concentration of coliform bacteria measured as 4.99 log cfu/g, was observed in unfried Kandirif cheese, the coliform counts of fried Kandirif cheese samples was below the detectable limit (Çinici and Özdemir, 2024). Conversely, Sengul et al. (2010) did not detect coliform bacteria in the Kashar cheese samples under scrutiny. Similarly, Sarı et al. (2018) ascertained the average coliform bacteria count to be 6.09 log cfu/g, along with the count of *E. coli* at 3.79 log cfu/g in the case of Mengen cheese samples. Furthermore, Ozdemir and Demirci (2006) documented the average count of coliform group bacteria as 3.5×10 cfu/g within Kashar cheese samples.

The observed disparities in coliform bacterial counts across these studies are postulated to arise from variations in the heating temperatures applied during curd processing and potential differences in hygiene conditions during the storage of cheese samples. Notably, the curd heating temperatures for Kashar cheese (72°C-75°C) and Hallomi cheese (80°C-90°C) notably exceeded those employed during the production of Kandirif cheese (approximately 56-60°C).

The yeast and mould counts of cheese samples were between 4.08 and 4.66 log cfu/g. Çinici and Ozdemir (2024) found that the number of yeasts and molds of fried and unfried Kandirif cheese samples were between 1.91 log cfu/g and 5.83 log cfu/g, respectively. The findings of Çinici and Ozdemir (2024) revealed higher levels in unfried samples compared to our own findings. Conversely, the yeast and mold counts in the present study exceeded those reported by Elgaml et al. (2017) for Halloumi cheese samples. The *Staphylococcus aureus* count in all Kandirif cheese samples was found to be less than 1.00 log cfu/g. As parallel with our findings, Sengul et al. (2010) reported that the number of *Staph. aureus* in Kashar cheese samples was below 10 cfu/g. In a study by Ozdemir and Demirci (2006), the average count of *Staph. aureus* in Kashar cheese samples was determined to be 1.6x10cfu/g. Conversely, Elgaml et al. (2017) observed no presence of *Staph. aureus* in Halloumi cheese samples, consistent with our results. The count of proteolytic bacteria in the samples ranged from 3.77 log cfu/g to 4.63 log cfu/g, while the count of lipolytic bacteria was observed to be between 3.53 log cfu/g and 3.75 log cfu/g. Additionally, the count of psychrophilic bacteria varied from 2.20 log cfu/g to 2.80 log cfu/g. The findings of Ozdemir and Demirci (2006) regarding the mean counts of proteolytic microorganisms, lipolytic bacteria, and psychrotrophic bacteria in Kashar cheese samples were consistent with our results.

It is important to note that while the counts of coliform group bacteria and *S. aureus* were low in our samples, the high level of yeast and mold contamination in the cheese samples is a cause for concern based on our microbiological analysis. Apaydın and Gümüş (2018) found that the *S. aureus* counts were between 0.93–1.71 log cfu/g in instant soups samples as parallel to our findings.

3.2. The results of cholesterol (mg/g) and fatty acids analysis (%)

The results of cholesterol and fatty acids of Kandirif cheese samples are given in Table 2.

Table 2. The results of cholesterol (mg/g) and fatty acids analysis (%)

Sample No	Cholesterol Amount (mg/g)	Butyric acid (C4:0)	Caproic acid (C6:0)	Caprylic acid (C8:0)	Capric acid (C10:0)	Lauric acid (C12:0)	Myristic acid (C14:0)
1	19.37	2.96	1.85	1.02	2.29	2.82	11.45
2	7.23	3.82	2.00	0.94	1.98	2.29	10.02
3	16.66	3.34	1.81	0.93	1.91	2.15	9.77
4	4.00	3.32	1.74	0.96	2.04	2.45	10.43
5	7.34	2.91	1.78	0.78	1.89	2.26	9.89
6	7.40	2.73	1.47	0.76	1.43	1.68	7.48
7	13.41	2.84	1.47	0.78	1.48	1.75	8.51
8	2.42	3.21	1.92	0.97	1.95	2.27	10.01
9	13.66	3.23	1.93	0.85	1.87	2.22	10.21
10	1.29	3.50	1.98	0.93	2.12	2.35	10.44
11	7.52	3.67	2.00	1.05	2.32	2.69	11.28
12	12.23	3.58	1.95	1.09	2.17	2.49	10.81
13	13.90	3.58	2.09	1.04	2.06	2.30	10.21
14	7.39	3.58	1.90	0.86	1.88	2.22	10.55
15	0.66	3.34	1.87	1.12	2.10	2.39	10.65
16	11.61	2.61	1.74	0.84	1.84	2.16	9.53
17	4.43	2.84	1.68	0.95	2.35	2.35	10.27
18	35.90	3.26	1.90	0.91	1.85	2.30	10.34
19	11.67	2.84	1.38	0.73	1.32	1.60	6.93
20	38.70	3.16	1.92	0.85	1.95	2.36	10.86

The cholesterol content of Kandirif cheese samples in our study fell within a wide range, from 0.66 mg/g to 38.69 mg/g. Çetinkaya and Öz (2018) reported that the cholesterol level of Kars Gravyer cheese ranged from 45.70 to 55.80 mg/100g. However, it is important to note that the cholesterol levels in Kandirif cheese were notably lower than those reported for Kars Gravyer cheese.

In comparison, the cholesterol content of Halloumi cheese samples marketed in Türkiye, as reported by Ergonul et al. (2011), ranged between 7.54-14.79 mg/100g. Regarding the butyric acid ratio, our findings for Kandirif cheese samples showed a variation between 2.61% and 3.82%. In contrast, El-Matweely et al. (2023) found that the average butyric acid ratio in Gouda cheese was 1.39%, indicating that the butyric acid content in Kandirif cheese was higher than that of Gouda cheese.

The caproic acid ratios within the Kandirif cheese samples exhibited a range from 1.38% to 2.08%. Notably, Çetinkaya and Öz (2018) reported that the caproic acid ratios during a 90-day ripening period of Kars Gravyer cheese samples fell within the range of 1.72–2.04 mg/100g, aligning with our own study findings. In the case of caprylic acid, the ratios observed in the Kandirif cheese samples spanned from 0.73% to 1.12%. Furthermore, it is worth noting that the average caprylic acid ratio in Gouda cheese samples was determined to be 1.25% (El-Matweely et al., 2023), surpassing the levels observed in our caprylic acid findings. Conversely, the capric acid ratios within the Kandirif cheese samples, ranging from 1.32% to 2.35%, were comparatively lower than those documented in ripened Gouda cheese, which stood at 2.82% (El-Matweely et al., 2023).

Additionally, the lauric acid (C12:0) ratios within the samples fluctuated between 0.99% and 2.82%. The lauric acid ratio in Gouda cheese, as identified by El-Matweely et al. (2023), stood at 3.14%, marking a higher proportion compared to our present study. Additionally, the myristic acid ratios within our samples demonstrated a range from 6.93% to 11.45%, where the myristic acid level at 10.85% reported by El-Matweely et al. (2023) aligned with

our findings. Moreover, the palmitic acid values observed in Kandırif cheese samples ranged from 19.76% to 31.43%, with El-Matveely et al. (2023) noting an average palmitic acid ratio of 30.56% in ripened Gouda cheese, which closely resembles our highest palmitic acid ratio. Gün and Şimşek(2011) in Halloumi cheese samples and found that the stearic acid content of the samples was determined to be 7.80–12.72% from TRNC and 6.90–11.05% from Türkiye, and the myristic acid level was 9.98–12.67% from TRNC and 2.95–11.89% from Türkiye. The findings of Gün and Şimşek (2011) were parallel with our findings.

Table 2. continue The results of fatty acids (%) ratio of Kandırif cheese samples (continue)

Sample No	Palmitic acid (C16:0)	Stearic acid (C18:0)	Oleic acid (C18:1n9c)	Linoleic acid (C18:2n6c)	linolenic acid (C18:3n3)
1	31.16	12.35	19.11	1.50	0.98
2	28.34	11.89	23.11	2.07	1.15
3	27.78	11.40	20.90	3.60	0.95
4	30.12	11.78	23.07	1.54	1.15
5	28.87	12.01	20.44	4.32	0.76
6	22.31	9.29	20.69	9.52	0.77
7	26.58	10.93	23.01	5.86	0.98
8	28.80	11.65	24.05	2.19	1.28
9	30.58	11.66	24.71	1.33	1.41
10	30.83	11.70	23.47	0.85	1.29
11	31.36	12.25	21.55	1.04	1.08
12	30.41	11.57	24.10	0.80	1.32
13	28.64	11.06	21.86	3.42	1.05
14	31.43	11.72	24.03	1.12	1.12
15	30.93	11.92	25.32	0.47	0.55
16	26.92	11.67	22.31	4.32	1.47
17	27.49	11.36	21.90	5,86	1.28
18	29.73	12.38	22.74	4.12	0.97
19	19.76	7.34	17.08	4.18	0.47
20	29.91	12.31	25.12	0.77	1.28

Furthermore, our investigation unveiled that the stearic acid ratios within the samples fluctuated from 7.34% to 12.35%. Interestingly, the stearic acid content in Gravyer cheese samples, as identified by Çetinkaya and Öz (2018), ranged from 13.24 mg/100g to 15.16 mg/100g. Similarly, El-Matveely et al. (2023) reported an average stearic acid content of 12.32% in Gouda cheese samples, mirroring our highest observed value of 12.35%.

The oleic acid content in the examined samples exhibited a range from a minimum of 17.08% to a maximum of 25.32%. El-Matveely et al. (2023) found that the average oleic acid value of ripened Gouda cheese was 24.17%, falling within the spectrum of our observed values. Additionally, Çetinkaya and Öz (2018) reported the oleic acid levels in Gravyer cheese samples ranging from 20.19 mg/100g to 23.12 mg/100g.

Regarding linoleic acid ratios, samples exhibited a range from 0.47% to 9.52%, differing from El-Matveely et al.'s (2023) average linoleic acid ratio for Gouda cheese, which was 0.37%. Notably, their finding was lower than our observed minimum value. The linolenic acid content in Kandırif cheese samples varied from 0.47% to 1.47%, whereas El-Matveely et al.'s (2023) study reported a higher linolenic acid ratio of 2.18%, surpassing our observed values.

In a separate study by Gökçe et al. (2022), the saturated fatty acids (SFAs) content in Adıyaman cheeses ranged from 69.74 to 76.75g/100 g, monounsaturated fatty acids (MUFAs) ranged from 18.29 to 26.10 g/100 g, polyunsaturated fatty acids (PUFAs) ranged from 0.64 to 4.26 g/100 g, and conjugated linoleic acid (CLA) amounts in Adıyaman cheese were determined in the range of 0.735 to 10.318 mg/g fat.

3.3. The results of texture profile analysis (TPA)

Table 3, presents the texture profile of Kandırif cheese samples.

Table 3. The results of texture profile analysis of Kandırif cheese samples

Sample No	Hardness (N)	Adhesiveness (N.s)	Cohesiveness	Springiness	Chewiness (N)	Gumminess (N)
1	140.28	-0.005	0.81	0.92	108.19	113.90
2	130.64	-0.004	0.85	0.93	105.86	111.87
3	206.28	-0.006	0.82	0.89	150.74	169.11
4	234.81	-0.004	0.85	0.92	187.72	208.67
5	81.50	-0.004	0.80	0.90	154.44	173.69
6	96.47	-0.013	0.84	0.89	157.88	178.32
7	190.69	-0.008	0.83	0.89	141.31	171.85
8	214.31	-0.003	0.85	0.91	174.37	182.48
9	110.52	-0.006	0.76	0.83	72.74	83.58
10	143.36	-0.003	0.79	0.86	104.70	116.79
11	155.18	-0.005	0.84	0.93	131.29	143.12
12	170.70	-0.002	0.84	0.89	150.90	159.87
13	261.51	-0.006	0.88	0.94	123.04	229.96
14	35.95	-0.008	0.77	0.95	27.47	29.07
15	277.14	-0.002	0.89	0.94	226.18	247.62
16	214.86	-0.006	0.86	0.89	172.22	192.73
17	56.83	-0.004	0.77	0.86	42.77	45.26
18	178.76	-0.006	0.80	0.94	143.67	152.28
19	222.84	-0.008	0.86	0.93	178.61	196.02
20	180.97	-0.006	0.88	0.94	151.22	161.63

The hardness of cheeses is contingent upon fluctuations in moisture content, with hardness values exhibiting a correlation with the chemical composition, encompassing factors such as fat, protein, and dry matter content (Eroglu et al., 2016). Additionally, during the maturation period, the level of proteolysis, salt content, and moisture content play important roles in influencing the hardness of cheese (Awad, 2006). As the ripening periods of Malatya cheese increased, its hardness value decreased (Hayaloglu et al. (2014). The hardness of cheese is intricately tied to variations in fat content, where the distribution of fat globules within the casein matrix contributes to the characteristic smoothness of cheese. In cheeses with reduced fat content, the texture tends to be rigid and resilient, owing to the predominant influence of milk proteins (Mistry, 2001; Romeih et al., 2002).

The hardness of Kandırif cheese displayed a range from 35.95 N to 277.14 N. Deshwal et al. (2020) found that the hardness value of Heloumi cheese samples varied between 45.11N and 186.96N as parallel to Kandırif cheese samples. However, Kashar cheese samples which is similar as structure to Kandırif cheese exhibited parallel hardness values at the beginning of the ripening period, ranging from 70.83 N to 85.11 N (Koca and Metin,2004).

Adhesiveness is characterized as the negative force area associated with the initial bite, signifying the effort needed to counteract the appealing interactions between the surface of a food item and the surfaces of other materials it encounters (Pavia et al., 1999). The adhesiveness of Kandırif cheese varied from 0.013 N.s to 0.002 N.s. The adhesiveness founds (0.003 and 0.052) by Deshwal et al. (2020) were parallel with the research founds. The adhesiveness values (0.0002 g.s and 0.005 g.s) of Kashar cheese samples(Yıldırım Maviş et al., 2022) were lower than that of Kandırif cheese.

The fat content significantly influences the chewiness of cheeses. In fact, the chewiness is primarily determined by several factors, including the type of cheese, the production method, and the aging process. Specifically, full-fat cheeses exhibit lower chewiness values in comparison to low-fat cheeses or those produced from skim milk (Koca and Metin, 2004). Chewiness scores of Kandırif cheese samples ranged between 27.47 N and 226.18 N. Deshwal et al. (2020) found that chewiness scores of Heloumi cheese were 15.84Nmm and 63.61Nmm. Comparatively, Ergonul et al. (2011) noted that the chewiness scores of Halloumi cheese samples fluctuated between 23.24 kg.s and 155.11 kg.s, aligning with the chewiness scores of Kandırif cheese samples.

Cohesiveness serves as an indicator of the deformation experienced by cheese prior to its fracture (Karaman Akalın, 2013). This property is affected by the robustness of the internal bonds that constitute the cheese matrix (Awad et al., 2002). The cohesiveness values for Kandırif cheese samples ranged from 0.76 to 0.89. Deshwal et al. (2020) found that cohesiveness values of Heloumi cheese were 0.31 and 0.43. Sahan et al. (2008) reported a comparable pattern in Kashar cheese, which they ascribed to the elevated protein levels present in low-fat cheese.

Springiness is significant for determining the plastic/elastic properties. It serves as an indicator of a sample's capacity to regain its original form following deformation induced by initial compression (Bourne, 2002). Springiness values for Kandırif cheese samples fell within the range of 0.83 to 0.94. Deshwal et al. (2020) found that springiness values of Heloumi cheese were 0.88 and 0.97 as similar to our findings. Koca and Metin (2004) concluded that reduced-fat cheeses tend to exhibit higher cohesiveness and springiness values. Gumminess refers to the elastic and rubber-like properties of a sample, defined as the energy required to break down a semi-solid food until it reaches a state suitable for swallowing.

Gumminess is described as the energy needed to disintegrate a semisolid food until it becomes ready for swallowing (Nateghi et al., 2012). When the fat ratio decreased in Kashar cheese samples, the gumminess score of samples increased (Koca and Metin (2004)). The gumminess scores of Kandırif cheese samples varied between 29.07 N and 247.62. The gumminess scores of Haloumi cheese samples were between 22.53N and 58.73N. (Deshwal et al. 2020). The gummy scores for Halloumi cheese samples were found to be lower compared to those of Kandırif cheese samples. At Kashar cheese samples which is similar to Kandırif cheese as body, Koca and Metin (2004) found that gumminess values were between 2.41 and 11.15. The findings of Koca and Metin (2004) were lower than that of our findings.

4. Conclusion

In Türkiye, only a few cheeses are prepared for direct heating and immediate consumption post-production, with Kandırif cheese standing as one of these distinctive varieties. Notably, an examination of Kandırif cheese samples revealed significant disparities in microbiological quality, cholesterol and fatty acid levels, and texture profiles. Particularly, it was ascertained that Kandırif cheese, when produced within family businesses, exhibited a heightened susceptibility to yeast and mold contamination.

In order to establish a consistent and standardized composition and quality for Kandırif cheese, it is imperative that the production process transitions to controlled conditions. Consequently, the traditional production practices associated with Kandırif cheese may necessitate a transformation, potentially transitioning towards factory-scale operations and standardized procedures. However, further research endeavors focused on this particular cheese are deemed advantageous, offering valuable insights into cheese technology and paving the way for potential advancements and refinements within the realm of Kandırif cheese production.

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Ethical Statement

There is no need to obtain permission from the ethics committee for this study.

Conflict of Interest Statement

We declare that there is no conflict of interest between us as the article authors.

Authorship Contribution Statement

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