



DETERMINATION OF SOME QUALITY PROPERTIES OF TRADITIONAL HÖŞMERİM CHEESE PRESERVED WITH DIFFERENT PACKAGING METHODS

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Keywords

Traditional cheese, Höşmerim, Packaging material, Shelf Life.

Abstract

In this study, the production of Höşmerim cheese, one of the traditional cheeses of Burdur province, and some of its quality characteristics during 90 days of storage in different packages were investigated. The cheeses were packaged in vacuum, non-vacuum polyethylene packaging, and modified atmosphere packaging (MAP) environments, and the chemical, biochemical, microbiological, taste profile, and sensory aspects of the product were examined over the shelf life. There were no significant differences in pH, dry matter, fat, fat in dry matter, salt, salt in dry matter, or protein contents across the experimental groups. However, total aerobic mesophilic bacteria and yeast- mould counts were greater in samples maintained in polyethylene packaging without vacuum than in samples stored with vacuum and MAP ($p < 0.05$). The hydroxy methyl furfural level of the brownish-yellow cheese was determined to be between 163.34-186.2 mol/L, and all sample values decreased during storage. According to the CIE colour system, the L^* value varied from 47.44 to 48.82, the a^* value from 9.65 to 10.34, and the b^* value from 9.6 to 11.26. The samples preserved with MAP showed a shift towards a white look on the surface after the 60th day. Höşmerim cheese remains microbiologically stable for 60 days under refrigerator conditions as long as the packaging remains unopened, but mold growth has been observed thereafter. As a result, it was established that samples packaged using the vacuuming or MAP process may be preserved for a longer period of time.

FARKLI AMBALAJ METOTLARI İLE MUHAFAZA EDİLEN GELENEKSEL HÖŞMERİM PEYNİRLERİNİN BAZI KALİTE ÖZELLİKLERİNİN BELİRLENMESİ

Anahtar Kelimeler Öz

Ambalaj materyali, Geleneksel peynir, Raf ömrü, Höşmerim.

Bu çalışmada, Burdur ili geleneksel peynirlerinden biri olan Höşmerim peynirinin üretimi ile farklı ambalajlarda 90 günlük depolama süresince bazı kalite özellikleri incelenmiştir. Elde edilen peynirler vakumlu, vakumsuz polietilen ambalaj ile modifiye atmosfer paketleme (MAP) ortamında paketlenerek raf ömrü süresince kimyasal, biyokimyasal, mikrobiyolojik, aroma profili yanı sıra ürünün duyu özellikleri değerlendirilmiştir. Deneme grupları arasında pH, kurumadde, yağ, kurumadde de yağ, tuz, kurumadde de tuz, protein içeriklerinde istatistiksel olarak önemli bir değişiklik gözlenmemiştir. Ancak polietilen ambalajda vakumlanmadan muhafaza edilen örneklerin toplam aerobik mezofilik bakteri ve maya küf sayısı, vakumlu ve MAP kullanılarak depolanan örneklerden daha yüksek bulunmuştur ($p < 0.05$). Kahverengimsi sarı tonlarında olan peynirin hidroksi metil furfural içeriği 163,34-186,2 $\mu\text{mol/L}$ arasında belirlenmiş, depolama süresince tüm örnek değerlerinde azalma görülmüştür. CIE renk sistemine göre, L^* değeri 47,44-48,82; a^* değeri 9,65-10,34; b^* değeri ise 9,6-11,26 arasında değişmiştir. MAP'la depolanan örneklerin 60. günden sonra yüzeyinde beyaz bir görünüme doğru değişim gösterdiği gözlenmiştir. Höşmerim peynirinin buzdolabı koşullarında ambalaj açılmadığı sürece 60 gün boyunca mikrobiyolojik olarak stabil kalabildiği, ancak daha sonra küf gelişimi olduğu belirlenmiştir. Bu nedenle vakumlama veya MAP tekniği ile paketlenen örneklerin daha uzun süre muhafaza edilebileceği tespit edilmiştir.

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Highlights

- Changes in pH, lactic acid, dry matter, and fat content in the different packaging are similar.
- Surface drying and color oxidation were observed in the product packaged MAP.
- Palmitic, oleic, and stearic acid levels were found to be high.
- HMF content varied between 163.4-186.2 µmol/L.
- Microbial quality was found to be better in vacuum and MAP packaging.

Graphical Abstract

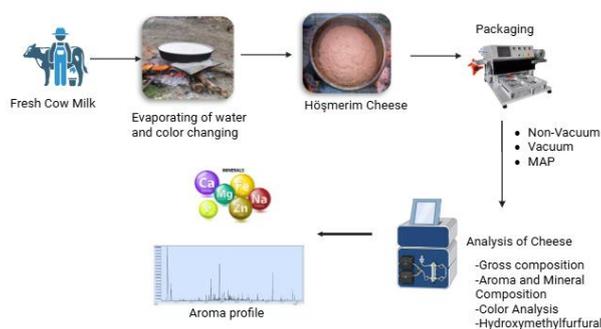


Figure. Production of Höşmerim cheese and its properties

Purpose and Scope

This study aims to test various packing materials for extending the shelf life of traditional cheese Höşmerim and to analyze product changes throughout a 90-day storage period.

Design/methodology/approach

The general component analyses of cheese produced using traditional methods were performed according to standard methods. Mineral content was analyzed using an ICP-OES device, while free fatty acid and aroma component analysis was performed using GC-MS.

Findings

Höşmerim cheese is a cheese produced by the Nomad people living in the provinces of Burdur and Isparta, typically consumed as fresh cheese, and has a short shelf life. For this reason, many producers store it in deep freezers. The study found that the pH, dry matter, fat, salt, ash, protein, water-soluble nitrogen, and ripening index of Höşmerim cheese stored in different packaging materials did not change during the 90-day storage period. Although microbial quality was preserved in packaging methods using vacuum PE and MAP, it was determined that the microbial content of samples stored in non-vacuum PE packaging increased. Due to prolonged heat treatment during production, the original brown color was obtained as a result of the Maillard reaction, and the color values were observed to vary between L* values of 47.44-53.29, a* values of 9.65-10.43, and b* values of 9.96-12.55. In samples stored in MAP packaging, drying and color oxidation on the upper surface were observed. High levels of P, K, Ca, Mg, and Na were detected in the samples.

Research limitations/implications

When manufactured under standardized industrial production standards, it may attain national recognition and be classified as a traditional cheese.

Practical implications

By controlling the temperature and time of heat treatment applied in production and storing it in suitable packaging, it is possible to transform it into industrial production and obtain an economic input.

Social Implications

Production is currently limited to a specific region. By identifying the characteristics of this traditional cheese and organizing its labeling information, it has the potential to be introduced to other regions, providing additional income for the local population.

Originality

Research on Höşmerim cheese is quite limited. Determining the quality characteristics of this product is important both for providing data that will contribute to its classification as a type of cheese and for its suitability for industrial production.

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1. Introduction

Countries' cultural values have changed over time, shaped by the communities that have resided on their territory. Each village displays its cultural characteristics and contributes significantly to the region. Traditional cuisines are at the forefront of these ideals (Köten et al., 2014). During the stages of raw material supply, food production, storage, transportation, distribution, and presentation, the essential precautions must be taken to eliminate risk factors in order to guarantee the safety of the food that is produced using traditional methods. It has been observed that it is difficult to achieve certain criteria and that high productivity is not obtained when it comes to the production of these products, which are mostly produced by small firms that are owned and operated by families (Demirbaş et al., 2006; Kusat, 2012). In conventional food manufacturing, changing the composition of the product is unfeasible; nevertheless, technological advancements can be employed to enhance food safety, quality, and convenience. Minor modifications implemented at any stage of the production process may be seen as innovative in the development of traditional foods, without undermining the product's conventional attributes. Moreover, advancements can be achieved in aspects such as altering the shape or dimensions of the food product or enhancing packaging for improved preservation (Belc et al., 2016; Ötleş et al., 2016). Consequently, the present state of knowledge in food science, methodologies, and breakthroughs can be enhanced, maintained, and improved to increase the market presence of traditional foods (Guerrero et al., 2016). Approximately 193 varieties of cheese have been recognized in Türkiye. Although the manufacturing procedures for these cheeses are comparable across areas, the structure, taste, and textural qualities of the cheese are strongly influenced by the production technique, the vegetation of the region, the climate conditions, and certain additives and characteristics (Durlu-Özkaya and Gün, 2007).

In the Mediterranean region, within the borders of the provinces of Burdur, Isparta, Antalya, and Denizli, there are various types of cheese known by different names, ranging in color from light brown to dark brown, obtained by heating milk for a long time. The caramelized product produced by concentrating milk through evaporation without the addition of acid or rennet, which thickens as the water evaporates, is called as Höşmerim cheese by local producers. The product is occasionally produced using milk with high acidity, which can also lead to the formation of acid curds. However, in the product derived from fresh milk, the primary alterations can be attributed to the denaturation of serum proteins, enhanced water holding capacity, and the Maillard reaction caused by lactose-protein interactions. It is stated that Dolaz cheese is produced by the Karakoyunlu, Hayta, Honamlı, and Sarıkeçili nomads living in Isparta province (especially in the Yalvaç district), while Höşmerim cheese is produced by the Sarıkeçili nomads in Burdur province (especially in the Çavdır, Tefenni and Gölhisar districts) (Okur and Güzel-Seydim, 2011; Yıldız Geren, 2023). Dolaz and Höşmerim cheeses are the most well-known varieties in the region and are products with different raw material characteristics. Höşmerim cheese is obtained by heating fresh and whole-fat milk with developed acidity for a long time (Yıldız Geren, 2023), while whey is used in the production of Dolaz cheese (Şimşek and Sağdıç, 2006; Okur and Güzel-Seydim, 2011). Höşmerim cheese, which is not produced industrially and is produced only in a limited region, is just one of the many cheese varieties that are on the verge of extinction. Local people consume this cheese for breakfast, over pasta, and as an ingredient in many dishes. Therefore, the primary objective of this study is to identify product characteristics to establish product standards and to examine the chemical, biochemical, microbiological, and sensory properties of the product, sold unpackaged, packaged using vacuum and Modified Atmosphere Packaging techniques throughout its shelf life.

2. Material and Method

2.1. Material

In this study, raw Holstein cow milk was used provided from Evciler Village in May and June (Gölhisar-Burdur-Türkiye, located at latitude 37.058282 and longitude 29.500306) and cheese production were made by nomadic people who live this region. The cheeses were packaged at Duranlar Dairy Plant using vacuum and non-vacuum Polyethylene (PET) and modified atmosphere packaging (MAP) packaging materials. After the cheeses are divided into 500 g portions, they are packaged using MAP and vacuum and non-vacuum PET packaging materials. In the MAP machine, 70% nitrogen, 30% CO₂, and 0.5% oxygen were utilized. The product is sealed with a 65-micron thick PET Polypropylene EVOH Anti-Fog (PET/PPEVOHPP AF) film.

2.2. Method

2.2.1. Cheese Production

Fresh raw milk, used in the production of Höşmerim cheese, is placed in a cauldron and subjected to heat treatment over a wood fire for approximately 16-18 hours. This process allows the water to evaporate and, in particular, the

protein and fat portions to precipitate. According to the producer's experience, the boiling process is stopped when the desired firm consistency and brown color change are achieved. The resulting products are packaged and stored at 4 °C for 90 days. Höşmerim cheese production was carried out three times.

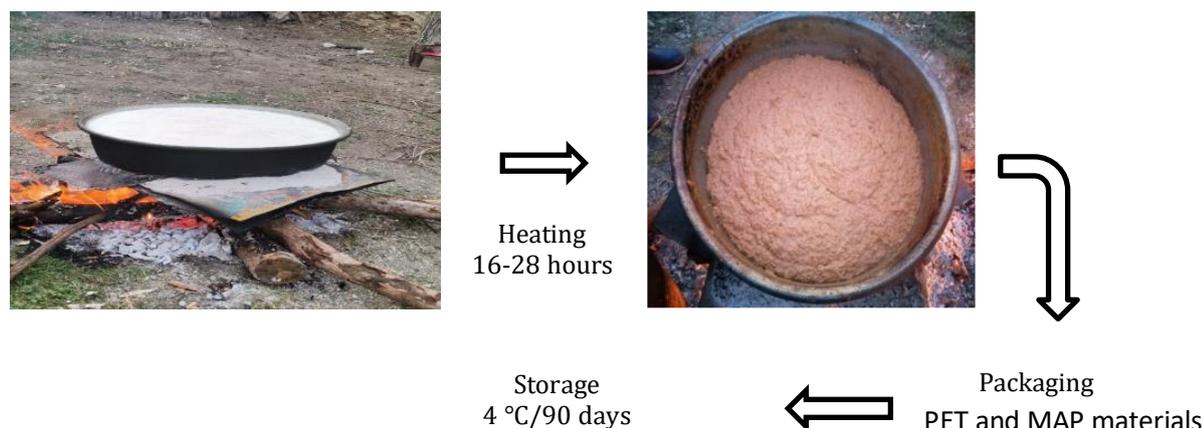


Figure 1. Höşmerim cheese production

2.2.2. Gross Composition: The dry matter, the fat, the ash, salt, and titratable acidity was determined by AOAC (Anonymous, 2000a; 2000b). The pH value was measured using a Mettler Toledo digital pH meter (Greifensee, Switzerland). Total nitrogen, protein, water soluble nitrogen and ripening index were analysed by Kjeldhal method (Anonymous, 1993). The EPA 6010 method was used to analyze certain mineral content using ICP-OES (Nobrega et al., 2012). The total HMF content was measured using a spectrophotometer. Ten grams of the samples were weighed into a beaker, then 5 mL of 0.3N oxalic acid was added and stirred. The samples were placed in a water bath at 40 °C for one hour, then cooled before 5 mL of a 40% trichloroacetic acid (TCA) solution was added. After filtering the samples using Whatman No. 42 filter paper, 4 mL of the filtrate was obtained and 1 mL of 0.05 M thiobarbituric acid (TBA) solution was added. The samples were again placed in a 40 °C water bath for 30 minutes before being examined at 443 nm with a spectrophotometer (Optizen Pop UV-Visible Spectrophotometer, KLAB, South Korea). HMF values were determined using the equation as follows; $\text{HMF content } (\mu\text{mol/L}) = (A_{443} - 0.055) \times 87.5$ (Keeney and Bassette, 1959).

2.2.3. Analysis of Free Fatty Acids: The analysis of fatty acid methyl esters was described by Bardakçı and Seçilmiş (2006). The device configuration is as follows: Operating Temperature: The initial oven temperature is 80 °C. After waiting for 4 minutes at 60 °C, the temperature was increased to 175°C at a rate of 13 °C per minute. The oven was left at this temperature for 27 minutes. Then, it is increased to 215°C at a rate of 4 °C per minute. It is held at this temperature for 5 minutes. Then, it is increased to 240 °C at a rate of 4 °C per minute. It is held at this temperature for 15 minutes. Detector and injector temperature: 240 °C. Injection volume: 1 µL, detector and injector temperature: 240 °C, derivatization agent: 1.5 M methanolic HCl, derivatization temperature: 80 °C, and derivatization time: 2 hours. Flow rate was 1 mL/min, split ratio: 20:1.

2.2.4. Analysis of Volatile Aroma Compounds: Volatile component analysis was performed using the SPME-GC-MS method. After weighing 5 g of samples, 10 µL standard solution (prepared in a total of 1 mL of diethyl ether solution; contains 0.1 µL 2-methyl, 3-heptanone and 6 µL 2-methyl valeric acid) and 1 g of NaCl were added. The samples were then kept in a fiber-free environment at 40 °C for 30 minutes, and then in a fiber-containing environment at 40 °C for 30 minutes. Afterwards, the samples were transferred to the GC-MS scanner with fiber, and the peaks obtained from the samples were calculated using the software program. The GC-MS column temperature was set at 40 °C for 5 minutes, then increased to 230 °C at a rate of 10 °C per minute, resulting in a total processing time of 90 minutes. Helium was used as the carrier gas, and the flow rate was applied at 1.2 mL/min (Guneser and Karagül-Yüceer, 2011).

2.2.5. Color measurement: CIE L*a*b* color values were measured with a Minolta CR-400 colorimeter (MinoltaCorp, Ramsey, NJ, USA).

2.2.6. Microbiological Analysis: Total mesophilic aerobic bacteria, yeast-mold, and coliform bacteria analyses were performed (Halkman, 2007). Plate Count Agar (Merck) medium was used for total mesophilic aerobic bacteria and were cultured for 48 hours at 37°C. Potato Dextrose Agar (Merck) medium was used for yeast and molds and petri dishes were incubated for 5 days at 25°C.

2.2.7. Statistical Analysis: The statistical analysis of the samples was determined by using the SPSS 22.0 program and by examining the significance level of the differences between the groups. After applying one-way analysis of variance (ANOVA) to evaluate the data, differences between groups and storage days were determined, and $p \leq 0.05$ were considered statistically significant. The research was carried out in three replications, using two parallel analyses.

3. Experimental Results and Discussion

3.1 Gross Composition

Changes in pH during cheese production and storage significantly affect the chemical, biochemical, and microbiological quality of the product. In addition to rennet coagulation, changes in the pH of acid curd cheeses affect the stability of casein and the structure of the cheese. Depending on the type of cheese, pH is reported to affect salt absorption and diffusion, enzyme activity, microflora development, and calcium distribution in the micelle and serum phases. Studies indicate that a 0.1 unit change in pH affects hydrogen ion (H^+) concentration by a factor of 1 (Bansal and Veena, 2024). The effect of using different packaging materials in the test groups and the 90-day storage period on the product's pH was found to be insignificant. During this period, it can be said that the H^+ concentration was 1.3 times higher in cheeses with a pH ranging from 5.52 to 5.65. Similarly, it was determined that the titration acidity values did not change during storage (Table 1). Cheeses produced under prolonged exposure to high temperatures exhibit low levels of mesophilic aerobic bacteria and yeast-mold counts at the initial stage. Due to their packaging without contamination, microbial growth during storage is minimal. This significantly affects pH and titration acidity values, demonstrating that the products complete their shelf life without souring. Acidity levels were found to be lower in Dolaz cheese, which is the most similar variety to Höşmerim cheese. The pH values of Dolaz cheese made from sheep, goat, and cow milk were found to be 4.51, 4.77, and 4.49, respectively, while the lactic acid (%) values were 1.84, 1.33, and 1.61. The use of milk from different types of animals and the addition of whey during production are important factors in the low acidity (Şimşek and Sağdıç, 2006). The dry matter content may vary depending on the temperature and time applied by the manufacturer. Höşmerim cheese is considered a semi-hard cheese due to its high solid content. The moisture content of the samples was observed not to be affected by the packaging material during storage, and the water in the product composition did not evaporate, meaning there was no drying of the product. This is important in traditional product preservation, and it has been observed that product quality changes and product yield decrease, especially in products with water vapor permeability such as skin bag (Okur, 2010). Şimşek and Sağdıç (2006) have determined that the dry matter content in Dolaz cheese is 51,61-54,27%, 42,23-56,27%, and 41,18-57,52% in sheep, goat, and cow milk, respectively. Gün et al. (2012) determined the dry matter in 20 Höşmerim cheese samples collected Burdur province to be 52,99%. Milk fat affects not only the structure of cheese but also its flavor and fatty acid composition. Since whole milk is used in production and the moisture content is also reduced, it has been found to contain more fat than other cheeses, which significantly affects its nutritional value. When evaluated as the fat content in the dry matter of all samples, it was observed to have a fat content between 30.89-32.40% and no statistically significant change was observed during storage. Cheeses to which dry salt is added as part of the production technique are not excessively salty, although the amount used depends on consumer preference. The salt content of the cheese samples was between 1.39% and 1.46% and during storage, there were no discernible changes in the salt content. In the study conducted by Gün et al. (2012), the average salt content of Höşmerim cheese was found to be 4.17%, which is approximately twice as high as the values found in the research findings.

Findings regarding protein content indicate that Höşmerim cheese is a good source of protein. Depending on the animal species, production technique, and the hardness or softness of the cheese, variations in protein content may occur. Therefore, the protein content may vary in different types of cheese. For example, the protein content determined as 16.74% and 18.06% in ewe and goat's milk cheese (Kawęcka et al., 2022), while the protein content of Edirne White Cheese produced in Turkey was determined to be 17.16%, Erzincan Tulum cheese 19.59%, Ezine Cheese 18.22%, and fresh Kashar cheese 26.99% (Sekban, 2024). In a study conducted on Höşmerim cheese, the protein content was determined to be 14.29% (total nitrogen 2.24%). In the study, the ripening index calculated based on water-soluble nitrogen (0.55%) was determined to be 24.73% (Gün et al., 2012). When evaluated according to the study data, a ripening index between 20.88% and 21.45% was calculated for different packaging materials. The findings obtained are similar to those for Höşmerim cheeses produced in small family businesses.

The fact that the total nitrogen, water-soluble nitrogen, and ripening index values did not change during storage indicates that the proteolysis level in the product, which was produced without cheese rennet and had a low microbial load, remained at the same level as the initial level. The protein content of traditionally produced Dolaz cheese from the same region was determined to be 21.49%, total nitrogen content 3.37%, water-soluble nitrogen 0.67%, and ripening index 20.19%. In Dolaz cheese adapted to industrial production, the values were determined to be 18.92%, 2.97%, 0.83%, and 28.25%, respectively (Okur, 2010).

The most important feature of Höşmerim cheese is not only the evaporation of its water during prolonged heat treatment, but also the Maillard reaction that occurs during this process as a result of the reaction between the carbonyl group in the reducing sugar and the nitrogen in the α -amino group of the proteins. In the final stage of this reaction, hydroxymethylfurfural is formed as a result of the dehydration of sugars (Burdurlu and Karadeniz, 2002). Thus, the color of the product varies from light brown to dark brown, depending on the duration of the heat treatment applied and the level of formation of brown pigments. In a study examining the relationship between the fat content of pasteurized and UHT milk and HMF formation, the total HMF content ranged from 0.95-2.14 $\mu\text{mol/L}$ and 5.18-6.47 $\mu\text{mol/L}$, respectively, and that the total HMF content of 21.38 $\mu\text{mol/L}$ in the case of a fat content of 3 g/kg was 15.52 $\mu\text{mol/L}$ in the sample with 35 g/kg (Morales and Jiménez-Pérez, 1999). According to the research findings, the HMF content in Höşmerim cheese was determined to vary between 163.4 and 186.2 $\mu\text{mol/L}$. In samples collected from the Gölhisar-Tefenni district market in Burdur province, the HMF content determined by HPLC was found to vary between 10.10 and 898.50 mg/kg (Gün et al., 2012). The color values indicate that the cheese has a matte appearance and is quite distant from a creamy yellow color. When compared to the L^* (98.04), a^* (2.41), and b^* (4.76) values detected in fresh white cheese (Şevik et al., 2024), the effect of brown color formation is more clearly seen. The effect of packaging material on color is significant; in particular, the cheese group packaged with MAP oxidized and turned white on day 90, resulting in a b^* value that differed from the other samples (Figure 1).

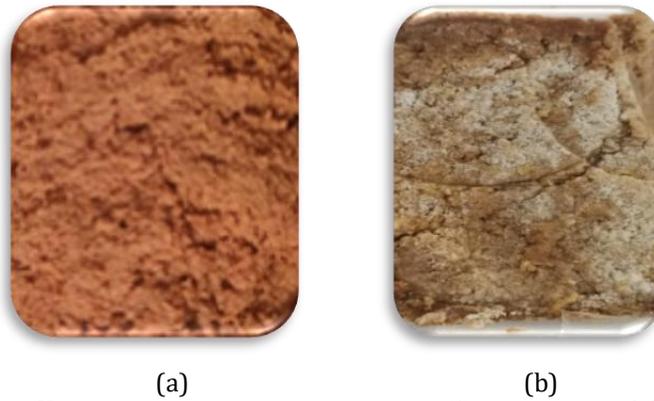


Figure 2. Color changing in Höşmerim cheese packaging under modified atmosphere (a) 1th day and b) 90th days)

Table 1. Cross composition of Höşmerim Cheese

Properties	1. Day			30. Days			60. Days			90. Days			
	A	B	C	A	B	C	A	B	C	A	B	C	
pH	5.53±0.10 ^{aA}	5.62±0.11 ^{aA}	5.52±0.11 ^{aA}	5.64±0.09 ^{aA}	5.61±0.08 ^{aA}	5.65±0.08 ^{aA}	5.59±0.10 ^{aA}	5.61±0.08 ^{aA}	5.60±0.09 ^{aA}	5.64±0.09 ^{aA}	5.63±0.10 ^{aA}	5.62±0.10 ^{aA}	
Titrateable Acidity (%L.A.)	0.73±0.01 ^{bC}	0.71±0.02 ^{bC}	0.76±0.03 ^{aC}	1.16±0.011 ^{aA}	1.04±0.11 ^{aA}	1.11±0.04 ^{aA}	0.85±0.10 ^{aB}	0.88±0.06 ^{aB}	0.86±0.07 ^{aB}	0.83±0.10 ^{aBC}	0.80±0.01 ^{abB}	0.76±0.01 ^{bC}	
Dry Matter (%)	61.30±2.09 ^{aA}	62.00±2.13 ^{aA}	62.11±1.60 ^{aA}	62.25±1.26 ^{aA}	62.26±1.62 ^{aA}	62.71±2.15 ^{aA}	61.44±2.01 ^{aA}	61.55±2.15 ^{aA}	61.75±2.31 ^{aA}	60.12±1.91 ^{aA}	60.32±2.33 ^{aA}	60.61±1.55 ^{aA}	
Fat (%)	19.38±1.11 ^{aA}	19.63±1.28 ^{aA}	19.75±1.02 ^{aA}	19.52±1.32 ^{aA}	19.58±1.20 ^{aA}	19.47±1.02 ^{aA}	19.85±1.92 ^{aA}	19.67±1.64 ^{aA}	19.71±1.82 ^{aA}	19.48±1.62 ^{aA}	19.86±2.12 ^{aA}	19.84±1.25 ^{aA}	
Salt (%)	1.40±0.09 ^{aA}	1.39±0.15 ^{aA}	1.41±0.11 ^{aA}	1.43±0.11 ^{aA}	1.44±0.05 ^{aA}	1.46±0.12 ^{aA}	1.39±0.12 ^{aA}	1.42±0.05 ^{aA}	1.43±0.08 ^{aA}	1.43±0.04 ^{aA}	1.45±0.03 ^{aA}	1.42±0.06 ^{aA}	
Ash (%)	3.73±0.14 ^{aA}	3.69±0.45 ^{aA}	3.69±0.36 ^{aA}	3.69±0.25 ^{aA}	3.72±0.11 ^{aA}	3.74±0.13 ^{aA}	3.69±0.23 ^{aA}	3.74±0.11 ^{aA}	3.78±0.20 ^{aA}	3.75±0.16 ^{aA}	3.71±0.18 ^{aA}	3.76±0.21 ^{aA}	
Protein (%)	20.35±0.02 ^{aA}	20.29±0.03 ^{aC}	20.40±0.04 ^{aA}	20.46±0.06 ^{aA}	20.51±0.02 ^{aA}	20.45±0.03 ^{aA}	20.34±0.01 ^{aA}	20.47±0.05 ^{aB}	20.36±0.02 ^{aA}	20.37±0.07 ^{aA}	20.51±0.03 ^{aA}	20.40±0.02 ^{aA}	
Total Nitrogen (%)	3.19±0.01 ^{aA}	3.18±0.03 ^{aC}	3.20±0.01 ^{aA}	3.21±0.06 ^{aA}	3.22±0.02 ^{aA}	3.21±0.01 ^{aA}	3.19±0.02 ^{aA}	3.21±0.03 ^{aAB}	3.19±0.06 ^{aA}	3.19±0.01 ^{aA}	3.22±0.02 ^{aA}	3.20±0.02 ^{aA}	
Water Soluble Nitrogen (%)	0.67±0.01 ^{aB}	0.67±0.02 ^{aA}	0.68±0.03 ^{aA}	0.67±0.02 ^{aB}	0.68±0.01 ^{aA}	0.67±0.04 ^{aA}	0.67±0.03 ^{aB}	0.68±0.01 ^{aA}	0.67±0.04 ^{aA}	0.69±0.03 ^{aA}	0.68±0.01 ^{aA}	0.67±0.03 ^{aA}	
Ripening Index	20.88±0.02 ^{bC}	21.13±0.03 ^{aA}	21.11±0.02 ^{aA}	21.02±0.01 ^{aB}	21.06±0.03 ^{aA}	20.97±0.04 ^{aA}	21.08±0.02 ^{aB}	21.10±0.02 ^{aA}	20.97±0.05 ^{aA}	21.45±0.03 ^{aA}	21.11±0.02 ^{aA}	21.08±0.03 ^{bA}	
HMF (µmol/L)	186.2±1.2 ^{bA}	171.4±1.4 ^{bA}	181.3±0.8 ^{aA}	165.1±1.4 ^{cB}	171.2±0.3 ^{bA}	181.0±0.9 ^{aA}	166.5±0.6 ^{bB}	169.2±0.7 ^{aAB}	178.2±0.5 ^{aA}	163.4±1.3 ^{bB}	167.2±0.6 ^{aB}	173.1±0.3 ^{aB}	
Color	L*	47.44±0.21 ^{aB}	48.82±0.15 ^{aB}	48.71±0.14 ^{aB}	50.95±0.09 ^{abAB}	49.89±0.15 ^{bB}	53.29±0.22 ^{aA}	51.32±0.12 ^{abA}	50.64±0.14 ^{bAB}	52.59±0.18 ^{aA}	51.32±0.12 ^{bA}	51.15±0.17 ^{bA}	52.59±0.21 ^{aA}
	a*	9.87±0.08 ^{aB}	9.65±0.03 ^{bB}	9.82±0.02 ^{aB}	10.02±0.07 ^{bA}	10.04±0.04 ^{bA}	10.43±0.03 ^{aA}	10.18±0.02 ^{aA}	9.80±0.05 ^{abA}	9.86±0.06 ^{bA}	10.34±0.02 ^{aA}	10.22±0.05 ^{abA}	10.13±0.04 ^{bA}
	b*	10.68±0.02 ^{aB}	10.56±0.06 ^{aA}	10.65±0.03 ^{aC}	10.50±0.05 ^{bA}	10.45±0.01 ^{bA}	11.26±0.04 ^{aB}	10.25±0.04 ^{bB}	9.60±0.12 ^{bB}	11.22±0.06 ^{aA}	10.28±0.03 ^{bB}	10.71±0.07 ^{bA}	12.55±0.04 ^{aA}

HMF: Hydroxy Methyl Furfural

3.2. Microbiological Properties

On the first day of storage, the total mesophilic aerobic bacteria count specified was not detected in samples B and C, while it was detected at 1 log cfu/g in sample A. Bacterial growth was observed after the 30th day in samples matured in vacuum and non-vacuum polyethylene packaging, and after the 60th day in samples packaged in modified packaging. The total mesophilic aerobic bacteria count determined as 2.2 log cfu/g on the 30th day in sample A decreased to 1.5 log cfu/g on the 90th day. In sample B, this number varied between 0.7 and 1.3 log cfu/g during the storage period, it remained at a maximum level of 1 log cfu/g in the vacuum packaging and MAP samples. The yeast and mold count increased from 1.2 log cfu/g to 2.6 log cfu/g in sample A, while it remained at a maximum level of 1 log cfu/g in the vacuum packaging and MAP samples. Overall, it can be said that vacuum packaging and modified atmosphere packaging techniques provide a longer shelf life compared to non-vacuum packaging techniques. In a study conducted on 10 pieces Dolaz cheese collected Isparta region, total aerobic bacteria, yeast and mould, psychrophilic bacteria and Enterobacteriaceae counts were determined as 5.41 log cfu/g, 4.13 log cfu/g, 3.24 log cfu/g and 1.50 log cfu/g, respectively (Şimşek ve Sağdıç, 2006).

3.3. Mineral Content

Determining the ash content in cheese and other dairy products provides important information in terms of nutritional value. Ash content, which is particularly related to mineral content, is associated with the type of milk (cow, sheep, goat milk, etc.), the type of feeding, and especially the ratio of dry matter components in the product composition. In the manufacturing of Höşmerim cheese, the moisture content changed due to high-temperature processing, and an increase in ash content was noticed as a result of a related increase in dry matter. This increase also allows consumers to get more minerals from a single serving of cheese, which helps them achieve their daily requirements. The alterations in the macro (phosphorus, calcium, potassium, magnesium, and sodium) and micro-elements (iron, manganese, and zinc) of Höşmerim cheese samples during storage are presented in Table 2. Ca, which is essential for cellular function and the control of nerve and muscle activity, has a 400-500 mg daily dietary limit in Türkiye. Therefore, it is possible to say that consuming 100 g of Höşmerim cheese meets half of the daily requirement. The amount of P and Ca in the cheeses was found to be significantly higher than that of all other elements. The phosphorus and calcium in the cheese mass are related to the casein structure and can undergo significant changes during stages such as milk coagulation and whey separation (González-Martín et al., 2011). Since no enzymes are used in Höşmerim cheese, there is no whey separation. Therefore, it can be assumed that the minerals do not leave with the whey, remain more in the cheese curd due to the evaporation of water, and their proportions in the dry matter increase compared to other cheeses. However, when compared to other regional cheeses, the samples had a high P content, but low Ca and Na levels. For example, in Kargı tulum cheese, P levels were determined to be 171.5-215.2 mg/kg, Na 1153.0-1850.3 mg/kg, and Ca 17784.4-2555.2 mg/kg (Kırdar et al. 2015). The mineral composition of Kargı tulum cheese revealed Fe levels of 0.20-0.58 mg/kg, Mn 0.11-0.19 mg/kg, and Zn 0.28-0.34 mg/kg. These values are around 11 times higher for Fe and Mn, and 7.5 times higher for Zn, than those obtained from Höşmerim cheese. In a study conducted on traditional Oştiepok cheese, Ca (4411-9842 mg/kg), Na (5708-13907 mg/kg), K (221-950 mg/kg), Mg (250-552 mg/kg), Fe (4.90-26.2 mg/kg), Mn (0.26-1.21 mg/kg), and Zn (14.6-32.4 mg/kg) were found to be higher than the values obtained from Höşmerim cheese (Şnirc, et al., 2020). This alteration is assumed to be caused by the additives added to animal feed.

3.4. Free fatty Acid Composition

Unsaturated fatty acids include oleic acid, linoleic acid, and linolenic acid. A reduction in oleic acid content was detected from the 1st day to the 60th day of storage, whereas a significant rise was observed across all samples on the 90th day (Table 4.19). The maximum oleic acid content was observed in MAP on day 1, reaching 30.484%. The linoleic acid content was observed to reach its maximum levels during vacuum packaging on days 30 and 60, ranging from 5.093% to 5.292%. The linolenic acid content in MAP samples declined from 0.9% on day 1 to 0.267% on day 90 of storage. The maximum linolenic acid content was observed on day 30 of storage, reaching 0.907%. The group of saturated fatty acids include butanoic acid, caproic acid, caprylic acid, capric acid, lauric acid, myristic acid, palmitic acid, and stearic acid. An increase in butanoic acid level occurred during storage in vacuum and non-vacuum packaging, whereas a decrease was observed in modified atmosphere packaging (MAP). The caproic acid concentration was consistent across all samples and exhibited minor increases during storage. The caprylic acid concentration increased in all samples until the 60th day of storage, followed by a decline in all samples on the 90th day of storage. The examination of capric acid content revealed the highest concentration in vacuum packaging, measured at 3.074% on the 60th day of storage. The minimum value was determined in the MAP sample at 2.049% on the 90th day of storage. The lauric acid concentration of the samples revealed a decline in vacuum-packed samples from 3.87% to 3.247% during storage. The MAP samples exhibited a rise from 3.677% to 3.851%. During storage, the myristic acid concentration elevated in non-vacuum and MAP samples, whereas it reduced in vacuum-packed samples. The maximum palmitic acid concentration was determined in non-vacuum packaging at

35.789% on the 30th day, while the minimum was measured in non-vacuum packaging at 29.112% on the 90th day. The stearic acid concentration diminished in vacuum-packed samples (21.485% to 15.826%), whereas it increased in MAP samples (18.657% to 21.887%). Since there are no studies on the fatty acid composition of Höşmerim cheese, it is not possible to make a complete comparison. However, in studies conducted on other types of cheese, Kınık et al. (2005) found that palmitic acid was the most abundant fatty acid in 29 hard and soft cheese samples consumed in Türkiye, followed by stearic and myristic acids. Researchers found that the oleic acid levels in the samples ranged between 5.93% and 29.38%. In addition, Tulum cheese included 71.903% saturated fatty acids, 25.811% monounsaturated fatty acids, 1.083% polyunsaturated fatty acids, and 26.894% total unsaturated fatty acids. When compared to other varieties of cheese, höşmerim cheese had less butyric acid, caprylic acid, palmitic acid, and caproic acid, while capric acid, lauric acid, and myristic acid were similar. However, höşmerim cheese contains an enormous quantity of stearic acid.

3.5. Volatile Aroma Compounds

Höşmerim cheese samples exhibited substantial concentrations of ethanol, 2-heptenone, methoxyacetic acid, furfural, benzaldehyde, acetic acid, 2-furanmethanol, hexanoic acid, maltol, oxalic acid, and phenol. The ethanol concentration in Höşmerim cheese increased in all samples throughout storage; however, in MAP samples, it was elevated initially and decreased by the conclusion of the storage period. The analysis of 2-heptenone content revealed an important increase in the MAP sample ($P < 0.05$). The concentration of 2-heptenone increased on the 1st and 60th days of storage, however a reduction was noted on the 90th day. Furfural levels reduced after storage in vacuum-free samples, decreasing from 193.76 to 58.63 µg/kg. There was an increase at the beginning of storage in the vacuum sample, but no furfural was found after day 60. In the MAP sample, on the other hand, it varied from 0 to 139.0 µg/kg during storage, depending on the period that it was stored. The samples had 258.25 µg/kg of benzaldehyde on the first day of storage and 26.4 µg/kg on the 90th day of storage. The amount of benzaldehyde in the non-vacuum packaging decreased down depending how long it was stored. When looking at the acetic acid levels in the samples, there was an enormous increase in both the vacuum-packed and MAP samples, depending on how long they had been stored. Common volatile compounds that contribute to cheese aroma include aldehydes, ketones, acids, esters, alcohols, and lactones. These volatile compounds are produced during the processing and storage of milk and dairy products through microbiological and enzymatic processes, as well as thermal processing (McSweeney and Sousa, 2000). Melanoidins formed as a result of the Maillard reaction are responsible for the components of aldehydes and aldehyde derivatives found in the aroma profile (Bertrand et al., 2018).

4. Conclusion

Traditional dairy products, particularly cheese, are extremely valuable internationally. Recognizing the different types of cheese produced in various countries and regions and preserving their unique production processes has become an important trend in recent years. In order to protect these products by obtaining a geographical indication registration certificate, it is first necessary to understand their historical background, production technologies, and product characteristics. This study examined Höşmerim cheese, which is popular among the Nomadic people living in the Gölhisar and Tefenni districts of Burdur province, identified some of its quality characteristics, and investigated the possibility of using different packaging materials to extend its shelf life. According to the findings, vacuum packaging technology has a substantial influence on increasing product shelf life, whereas MAP technology has been shown to have a negative effect on product appearance due to causing color oxidation. While the effect of vacuum and non-vacuum PE packing material and MAP application on the product's overall chemical qualities was similar, some changes were identified in the aroma components. The difference in the mineral content of the products compared to other cheese types may be attributed to the feeding habits of the animals raised in the region. As a result, many quality parameters have been defined for this product, which is in danger of being forgotten in our country. More scientific research should be conducted on various cheese types, such as Höşmerim cheese produced by the Nomad culture in the Mediterranean region. More effort should be made to identify and classify products that are at risk of being forgotten or have a low market share outside their own region, as well as to reveal their basic characteristics that will serve as their fingerprint.

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Conflict of Interest

No conflict of interest was declared by the authors.

Table 2. The alterations of mineral content of Höşmerim cheese during storage ($\mu\text{g/g}$)

Mineral Content	1. Day			30. Days			60. Days			90. Days		
	A	B	C	A	B	C	A	B	C	A	B	C
P	5729.1	5214.10	5006.80	4473.40	5964.20	4959.30	4722.70	5161.20	5082.40	5050.80	5253.80	5095.20
Mg	46.90	41.80	40.70	35.10	46.20	36.10	39.10	45.60	40.40	40.10	42.60	38.70
Ca	169.00	160.80	152.60	137.30	180.20	139.40	166.60	169.20	152.90	152.90	170.30	156.90
Na	29.20	30.80	28.70	25.60	31.40	25.50	25.50	25.60	26.60	24.00	25.80	24.30
K	407.30	386.90	355.50	317.40	432.40	330.70	321.60	339.80	339.30	334.00	360.70	333.70
Zn	2.60	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.40	2.50
Mn	1.90	2.10	2.00	2.00	2.10	2.00	2.10	2.00	2.10	2.00	2.20	2.10
Fe	5.80	6.30	6.10	6.00	6.50	6.10	6.30	6.00	6.40	6.20	6.00	5.90

Table 3. Fatty acid methyl ester composition of Höşmerim cheese

Fatty Acids	1. Day			30. Days			60. Days			90. Days		
	A	B	C	A	B	C	A	B	C	A	B	C
Butanoic acid	0.694	0.603	0.701	0.599	0.524	0.618	0.632	0.549	0.885	0.749	0.723	0.555
Caproic acid	0.931	1.082	1.053	1.007	1.087	1.028	1.102	1.119	1.257	1.068	1.055	1.008
Caprylic acid	0.788	1.023	0.970	0.934	0.996	0.956	1.045	0.975	1.077	0.877	0.883	0.988
Capric acid	2.206	2.988	2.821	2.747	2.903	2.820	3.074	2.824	2.989	2.466	2.488	2.049
6-Heptenoic acid	0.142	0.191	0.181	0.173	0.184	0.174	0.192	0.182	0.190	0.158	0.157	0.187
Undecanoic acid	0.056	0.073	0.070	0.069	0.072	0.071	0.074	0.069	0.073	0.059	0.061	0.072
Lauric acid	2.849	3.870	3.677	3.647	3.805	3.712	4.022	3.742	3.778	3.168	3.247	3.851
Tridecanoic acid	0.105	0.137	0.131	0.130	0.134	0.132	0.142	0.132	0.131	0.110	0.117	0.134
Myristic acid	9.928	13.062	12.494	12.634	12.622	12.635	13.728	12.810	12.603	10.661	11.303	13.061
Pentadecanoic	1.498	1.949	1.859	1.882	2.446	1.870	2.033	1.919	1.914	1.786	1.668	1.972
Tetradecanoic acid	0.646	0.856	0.802	0.811	0.400	0.807	0.876	0.827	0.828	0.214	0.728	0.850
Palmitic acid	29.163	34.085	34.208	34.509	33.704	33.075	35.789	33.127	34.245	29.112	30.599	33.810
Palmitoleic acid	1.580	0.156	1.838	1.655	1.621	1.799	1.906	1.685	1.708	1.611	1.738	1.618
Hexadecanoic acid	1.442	1.794	1.726	1.749	1.702	1.713	2.119	1.702	1.708	1.405	1.534	1.770
Heptadecanoic acid	0.784	0.981	0.924	0.940	0.931	0.925	0.900	0.951	0.944	0.750	0.842	0.975
Stearic acid	13.909	21.485	18.657	17.391	19.715	18.382	19.352	20.573	19.636	13.326	15.826	21.887
Oleic acid	26.992	13.273	15.351	17.192	9.230	11.380	10.057	8.723	7.881	30.484	24.356	12.089
Linoleic acid	4.620	0.259	0.104	0.107	5.093	5.088	0.269	5.292	5.346	0.234	0.095	0.086
Nonadecanoic acid	0.092	0.931	0.250	0.248	0.105	0.103	0.965	0.053	0.051	0.721	0.236	0.789
Linolenic acid	0.234	0.236	0.900	0.907	0.256	0.248	0.243	0.253	0.266	0.152	0.817	0.267
Eicosanoic acid	0.954	0.200	0.223	0.230	1.124	1.108	0.381	1.136	1.124	0.500	0.527	1.186
5,8,11,14-Eicosatetraenoic acid	0.306	0.367	0.363	0.361	0.357	0.357	0.300	0.357	0.366	0.288	0.300	0.376

Tablo 4. Volatile Aroma Compounds of Höşmerim Cheese

RT	Volatile Aroma Compounds	A				B				C			
		1	30	60	90	1	30	60	90	1	30	60	90
6.252	Ethanol	33.09	50.47	51.25	49.56	80.32	268.07	6.48	91.25	283.25	852.45	ND	147.23
6.641	Butanoic acid	17.53	ND	ND	ND	ND	ND	ND	ND	170.78	21.68	ND	ND
9.564	Disulfide, dimethyl	ND	ND	ND	8.37	5.03	ND	5.11	ND	10.26		5.78	6.41
12.149	2-Heptanone	36.99	14.35	ND	33.01	11.15	41.34	26.35	170.24	242.60	36.2	529.06	9.46
12.392	1-Botanol-3-Methyl	310.24	86.44	49.49	ND	ND	ND	ND	ND	520.24	76.35	ND	ND
13.079	Hexanoic acid, ethyl ester	18.08	157.38	ND	183.08	ND	ND	ND	ND	ND	95.30	ND	ND
13.904	Acetic acid	439.59	2446.4	854.32	715.26	148.64	1022.41	ND	467.19	51.00	75.07	ND	513.78
15.897	Metoxyacetic acid	374.99	298.25	ND	100.34	20.35	141.17	134.65	45.9	164.54	39.50	43.09	56.96
19.892	2-Nonanone	160.85	60.56	ND	ND	ND	82.76	105.56	272.28	151.99	73.65	529.92	95.49
22.300	1-Hexanol	35.43	26.32	19.24	10.82	9.71	32.33	27.3	ND	ND	ND	ND	ND
22.923	Furfural	193.76	96.39	46.95	58.63	85.24	127.91	ND	ND	ND	49.59	41.86	139.06
23.366	Benzaldehyde	258.25	125.31	66.52	26.40	ND	ND	ND	556.85	ND	75.9	65.75	ND
31.333	6-Methyl-1-Octanol	ND	58.36	ND	47.05	44.8	96.67	137.7	428.74	127.22	ND	63.23	48.39
32.791	2-Furanmethanol	3649.67	1585.21	1257.10	1960.02	1429.51	ND	1725.15	452.56	54.60	ND	1169.04	3304.70
38.843	Hexanoic acid	ND	ND	ND	183.09	ND	718.13	103.31	885.41	724.25	575.61	1442.62	182.66
39.832	Benzaldehyit	666.53	267.81	121.36	90.44	ND	84.17	28.03	556.85	ND	ND	18.96	41.41
53.034	Oktanoic acid	ND	ND	1489.02	1745.31	ND	24.43	64.01	198.64	644.05	201.00	451.28	182.13
57.811	Oxalic acid	1054.52	1303.71	764.31	174.58	71.52	33.38	66.47	ND	ND	393.33	19.81	678.06
57.962	Nonanoic acid	ND	3087.16	ND	358.12	301.23	46.08	181.52	91.90	ND	54.87	19.81	77.66
45.268	Maltol	1013.19	177.45	98.75	124.04	75.61	183.68	105.64	660.80	267.15	112.78	72.91	303.79
58.216	Phenol	245.32	42.58	56.32	78.41	75.67	164.87	77.19	881.35	ND	64.02	9.01	25.58
67.563	Benzoic acid	1620.73	3393.61	1880.20	ND	19.81	358.12	301.23	46.08	181.52	91.90	ND	59.86

RT : Retention Time,

ND: Not Dedected

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