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Original article

Investigation of Aroma and Chemical Properties of Matured Kashar Cheese Produced without Using Starter Culture

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Abstract

This study aimed to investigate the aroma profile, fatty acid composition, and general chemical characteristics of matured Kashar cheese (MKC) produced without starter cultures using mixed raw milk. A specific blend of cow (30%), goat (25%), and sheep (45%) milk was used in the production. Both milk samples and matured cheese were analyzed to determine changes during the ripening process. Texture profile analysis was also performed on cheese samples to evaluate the effects of compositional and processing variables.

A total of 65 volatile compounds were identified in MKC, whereas 47, 57, and 58 compounds were found in cow, sheep, and goat milk, respectively. Among these, 19 aroma compounds—particularly 2-pentanol, hexanoic acid ethyl ester, and 2,3-butanediol—were common to both milk and cheese samples, indicating their persistence or transformation during ripening. Notably, 22 fatty acids were detected exclusively in MKC, highlighting microbial and enzymatic activity during maturation.

Furthermore, variations in the chemical composition of milk, salt content, and the absence of starter cultures were found to influence the textural characteristics of the cheese. These findings provide insight into the complexity and uniqueness of traditional starter-free cheese production and contribute to the valorization of artisanal dairy practices.

Keywords: Aroma, Cheese, Fatty Acid, Matured Kashar, Milk.

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INTRODUCTION

Matured Kashar cheese (MKC) produced without starter cultures exhibits distinctive properties that set it apart from other types of cheese. These characteristics arise not only from the specific nature of the milk used but more importantly from the fundamental differences in traditional production techniques. One notable factor is the milk sourced from Kırklareli, which is recognized for its favorable hygienic conditions and low microbial load originating from its natural flora. These microbiological properties significantly influence the final quality of MKC. Furthermore, pasteurization conditions play a vital role in preserving these native characteristics, thereby contributing to the distinctiveness of the cheese (Askin, 2020).

Another key element contributing to uniqueness of MKC is the use of traditional rennet, which is derived from the abomasum (fourth stomach) of young animals that have not yet begun grazing. The standard procedure involves cutting the abomasum into small pieces and soaking them in a salt solution (12–20%) to extract the enzyme. The resulting extract is then subjected to technical, hygienic, sensory, and physiological processes to prepare it for cheese production (Leksir et al., 2019; Qian and Reineccius, 2003a).

Despite the widespread production and cultural significance of MKC, there is a lack of scientific data specifically characterizing MKC produced without starter cultures using mixed milk sources. This study addresses this gap by investigating the chemical, aroma, and textural properties of traditionally produced MKC. The combination of raw material quality, artisanal rennet, and the absence of starter cultures may result in significant differences in MKC quality.

MATERIALS and METHODS

Experimental Area and Sampling

The study was conducted on the pastures district of Kirklareli. As research area, the study was conducted in 13 different pastures named as Hacifakli, Pazarli, Kuzulu Kadiköy, Armağan, Geçitagzi, Elmacik, Koruköy, Kofçaz, Akalar, Çukurpinar, Kaynarca and Karakoç (Kirklareli, Turkey) located within the borders of Kirklareli province. The milk samples of sheep, goat and cow were obtained from local farms belong to each chosen pasture. Besides, MKC samples were collected from 3 different dairy plants, which processing MKC with traditional production method by the same procedure, in the location of these pastures.

Traditional Matured Kashar Cheese Production Method

The production followed a traditional method applied for decades.

Step 1: Milk Preparation

Raw material consisted of a mixture of sheep, goat, and cow milk at 30%, 25%, and 45%, respectively.

Step 2: Pasteurization and Cooling

Milk was pasteurized at approximately 62–64 °C and cooled to 32 °C (renneting temperature).

Step 3: Curd Formation

Stainless steel cheese boats were used for renneting. Rennet was added to milk at 32 °C. Once curd was formed, it was cut into pieces and pressed, then divided into four parts.

Step 4: Fermentation

The curds were filtered and left to ferment on stainless benches.

Step 5: Heating and Kneading

Fermented material was sliced and placed in baskets with 76 °C water. Once paste consistency was achieved, it was kneaded, and marine salt was added.

Step 6: Surface Treatment and Aging

The curd fermented naturally via lactic acid bacteria from milk flora. Pasteurization during dough boiling improved sensory quality. The cheese was kept for 24 h, then placed on wooden benches in dim rooms with one-sided air flow (to avoid cracks).

Step 7: Drying and Maturation

After surface salting, scabs were formed, polished, and maintained daily. Salt dried the cheese by absorbing moisture; fungi were removed using hot water and brush.

Finally, the cheeses were vertically dried in pergolas and then packaged. All samples were stored at 80–85% humidity for at least 60 days and matured for 6 months in total.

Compositional Analyses of Milk and MKC Samples

Milk samples were analyzed in duplicate to determine °Brix, acidity (AOCS 942.15, 2016), and pH (AOCS 981.12, 2016). Similarly, MKC samples were analyzed in duplicate for their compositional properties. Protein content was determined using the Kjeldahl method (AOCS 960.52, 2011). Moisture content was measured by oven drying at 105 °C until a constant weight was achieved (AOCS 925.10, 1990). Ash content was assessed by placing 3 g of cheese into porcelain crucibles and incinerating them at 550 °C for 12 hours until a white residue remained (AOCS 986.25, 1990).

Volatile Composition

The volatile compounds in MKC samples were analyzed using the solid-phase microextraction gas chromatography-mass spectrometry (SPME-GC-MS) method described by Qian and Reineccius

(2003a) at the TÜBİTAK Marmara Research Centre Food Institute Laboratory. Each sample was analyzed in triplicate. For analysis, 10 mL of sample was transferred into screw-top vials sealed with silicon/Teflon membranes. These vials were incubated at 40 °C for 10 minutes with constant agitation at 250 rpm. The headspace of each vial was sampled using an SPME fiber (DVB/Car/PDMS 50/30 mm, Supelco, USA), which was exposed for 30 minutes. The separation and identification of volatile compounds were carried out using GC-FID/MS, following the method of Qian and Reineccius (2003b).

Fatty Acid Composition (FAC)

The fatty acid composition of the cheese samples was determined according to the method of Paquot (1979) at the Marmara Research Centre Food Institute Laboratory. Free fatty acids were analyzed using a Perkin Elmer Auto System XL gas chromatograph (UK) equipped with an SP2330 column. Methyl esters of fatty acids were separated using a fused silica capillary column (30 m × 0.25 mm × 0.20 µm film thickness). The oven temperature was programmed from 120 °C to 220 °C, while the injector and detector temperatures were set at 240 °C and 250 °C, respectively. Helium was used as the carrier gas at 10 psi with a split ratio of 1:50. The results were expressed as the percentage of individual fatty acids relative to the total fatty acid content (Askin, 2020). All analyses were performed in duplicate.

Texture Profile Analysis

The texture profile of the MKC samples was evaluated using a TA.XT Plus texture analyzer (Stable Micro Systems) following the method described by Gunasekaran and Ak (2003). Cubes of cheese measuring 1 cm^3 were compressed using a 50 kg load cell at a speed of 1 mm/s. The parameters measured included hardness, springiness, adhesiveness, and cohesiveness. Each analysis was carried out in triplicate.

Statistical Analysis

All experimental data were statistically evaluated using SPSS 16.0 software. The standard deviation was calculated for each dataset. Depending on the specific methodology used, all tests were performed in either duplicate or triplicate.

RESULTS and DISCUSSION

Compositional Analyses of Milk and MKC Samples

The compositional analyses were performed for milk and MKC samples. The chemical compositions of the milk samples are shown in Supplementary Table 1. Brix is one of the essential criteria, which is related to fat and protein content, for milk and milk products. According to literature data, the dry matter and protein values of the MKC samples were close to the upper limit, while ash values were comparatively lower. This may be attributed to variations in technological processes such as curd scalding temperature, duration, and the quantity and timing of salt and water addition. Moreover, the method and timing of salting significantly influenced ash levels. These variations help explain why ash content serves as a distinguishing parameter for MKC.

Table 1. Some chemical properties of milk samples with average values with standard deviations

Sample	Milk Cow	Sheep	Goat
Soluble Solid Content (%)	9.56 ± 0.22	13.17 ± 0.75	10.57 ± 0.11
Titration Acidity (%)	0.16 ± 0.003	0.21 ± 0.002	0.14 ± 0.001
pH	6.29 ± 0.41	6.55 ± 0.38	6.62 ± 0.26

Volatile Compounds

Volatile compounds of milk and MKC samples were determined. The full compound list is provided in Supplementary Tables 2 and 3, while a summary of compound classes is visualized in Figure 1. Alcohols, such as 2-butanol and 3-methyl-1-butanol, were among the most abundant compounds. 2-Butanol, which is derived from bacterial enzymatic reduction of diacetyl to acetoin and subsequently to 2-butanone, was particularly significant (Bontinis et al., 2008). Primary alcohols like 1-hexanol were shown to be sensitive to thermal treatments during processing.

Carboxylic acids—formed mainly via proteolysis, lipolysis, and lactose fermentation—exerted strong sensory effects due to their low odor thresholds (McSweeney and Sousa, 2000; Pinho and Pérès, 2003). Their role as flavor precursors, particularly in the formation of methyl ketones, esters, and aldehydes, was previously highlighted by Curioni and Bosset (2002).

Each group of volatile compounds contributed uniquely to MKC's sensory profile. For instance, acetic acid was associated with a vinegar-like sourness, butanoic acid with a rancid cheese odor, and hexanoic acid with the characteristic smell of goat cheese. Ketones such as 2-heptanone added herbaceous notes, while acetoin and 2-butanone were responsible for buttery and butterscotch aromas. Esters imparted fruity and floral notes, softening the sharpness of acids and balancing bitterness from amines.

Table 2. Volatile Compounds with average values of milks and matured kashar cheese samples

Retention Time (RT) *	Component	Area (%) **			
		Cow Milk	Sheep Milk	Goat Milk	Matured Kashar Cheese
6.00	Ethanol	**3.53±0.02**	**5.49±0.02**	**8.71±0.04**	**0.10±0.001**
2.39	2,3 Butanedione	5.47±0.14	1.71±0.03	2.51±0.11	-
2.41	2-Pentanone	-	0.45±0.03	-	4.53±0.22
2.42	N-Ethyl-1,3-dithioisoindoline	0.12±0.01	-	0.75±0.01	-
2.76	α-Pinene	-	-	1.01±0.01	0.95±0.01
2.77	p-Terin-6-carboxylic acid	-	0.11±0.01	-	-
2.79	2-Butanole	0.36±0.01	-	-	9.90±0.20
2.96	Butanoic acid ethyl ester	-	-	0.14±0.01	0.02±0.00
3.03	Benzene-methyl	0.30±0.01	0.13±0.01	0.21±0.01	-
3.04	9-Octadecenoic acid (Z)-, phenylmethyl ester	-	0.14±0.01	-	-
3.22	2,3-Pentanedion	1.40±0.01	0.48±0.01	-	-
3.24	Camphene	-	-	0.25±0.01	0.18±0.01
3.26	4,5, Dihydro-10-methyl-8-phenyl-7-thieno(2,3-a) quinolizin-7-one	-	0.35±0.04	-	-
3.31	4-Benzoyl-3-hydroxy-5-(N-phenylimino)-2(5H)-furanone	-	-	0.52±0.02	-
3.80	Iso-butyl alcohol	**0.41±0.01**	**0.79±0.01**	**0.11±0.01**	**0.16±0.01**
3.81	1-propanol-2-methyl	-	0.72±0.03	-	-
3.97	Sabinene	-	-	0.25±0.01	-
4.05	1-Butanol-3-methyl-acetate	0.09±0.00	-	-	-
4.25	12,15-Octadecadiynoic acid, methyl ester	0.05±0.00	-	-	-
4.28	9-Octadecanoic acid, phenylmethyl ester	-	0.10±0.01	-	-
4.33	Silane, triethyl(2-phenylethoxy)-	-	-	0.21±0.01	-
4.33	Benzene-1-2 dimethyl	0.11±0.01	-	-	-
4.70	Hexane 2,2,4 trimethyl	-	0.16±0.02	0.27±0.02	-
4.74	d-Mannitol,1-decylsulfonyl	0.13±0.01	-	-	-
5.30	Cyclopentolate	0.03±0.00	0.10±0.00	0.13±0.01	-
5.36	2-Heptanone	-	0.37±0.01	0.54±0.01	1.24±0.03
5.97	1-Butanol,3-methyl	**13.75±1.07**	**6.58±0.89**	**1.00±0.06**	**5.08±0.97**
6.07	Iso-amyl alcohol	-	**14.18±1.23**	0.52±0.01	-
7.14	1-Pentanol	**0.42±0.02**	**1.76±0.14**	**0.46±0.07**	**0.13±0.01**
7.50	Benzene, 1-methyl-3-(1-methylethyl)-	-	-	0.12	-
8.30	2-Butanone,3-hydroxy	**7.48±1.19**	**0.95±0.13**	**0.99±0.08**	**1.00±0.06**
9.99	3-Pentanol	0.14±0.01	-	-	-
10.27	Methyl ester of hexane sulfonic acid	-	-	0.26±0.01	-
10.27	Hexanol	-	0.23±0.01	-	0.14±0.01
10.27	1-Nonanol	0.03±0.00	-	-	0.02±0.00
10.54	2-Hydroxy-3-pentanone	0.21±0.01	-	-	0.02±0.00
11.32	2-Nonanone	-	-	0.28±0.04	0.25±0.01

14.05	Acetic acid	**16.82±1.07**	**19.08±1.44**	**10.20±1.21**	**5.62±0.23**
15.13	1-Hexanol-2-ethyle	**1.31±0.02**	**0.82±0.01**	**1.26±0.03**	**0.12±0.01**
16.24	S*-S*-2-hydroxy(4-methoxy-2-trimethylsilphenyl)methyl-1-cycloheptanone	**0.39±0.01**	**0.36±0.01**	**0.95±0.01**	**0.08±0.00**
16.32	2-Methyl-3-thiolannone	0.14±0.01	-	-	-
17.16	2-(2-Pyridyl)-3-(trimethylsilyl)-5,6,7,8-tetrahydroquinoline	-	-	0.53±0.01	-
17.19	1,3-Butenadiol	-	2.18±0.12	0.75±0.01	-
17.43	Propanoic acid	0.09±0.01	0.56±0.01	-	0.17±0.00
17.64	1-Octanol	-	-	0.15±0.01	-
18.01	Methane, sulfinylbis	-	-	0.21±0.01	-
18.05	Dimethyl sulfoxide	0.41±0.01	-	-	-
18.64	2,3-Butanediol	**3.95±1.14**	**0.79±0.05**	**0.45±0.02**	**0.56±0.03**
18.83	1-[2-Methyl-3-(methylthio) allyl] cyclohex-2-enol	-	-	0.44±0.01	-
19.16	7,8-Bis(trimethylsilyl)benzo(5,6-g)-1H,3H-quinazoline-2,4-dione	-	-	0.17±0.01	-
20.66	Butanoic acid	**5.29±1.01**	**4.6±1.77**	**4.52±0.01**	**16.01±1.98**
21.00	3-(3,3-dideutero-n-butyl) thiophene	-	-	0.17±0.01	-
21.49	Sulphurous acid, cyclo hexyl methyl hexyl ester	0.07±0.00	1.04±0.01	0.72±0.01	-
22.16	Pentanoic acid	**1.56±0.31**	**0.45±0.01**	**3.86±0.13**	**1.21±0.07**
22.27	Cyclohexane,1-(cyclo hexyl methyl)-4-(1-methyl)	0.20±0.04	-	-	-
22.30	Decane,5,6, bis (2,2-dimethyl propylidene)	-	2.44±0.17	-	2.34±0.22
23.51	Hexadeca methyl cyclo octa siloxane	-	0.32±0.01	-	0.01±0.00
25.87	1-Cyclohexene-1-acetaldehyde, 2,6,6-trimethyl	-	-	0.30±0.00	-
25.91	Methoxy phenyl oxime	**0.51±0.02**	**0.32±0.02**	**0.25±0.07**	**0.01±0.00**
27.02	6-Tridecene, 2,2,4,10,12,12-hexamethyl-7-(3,5,5-trimethylhexyl	-	-	0.53	-
27.65	1,4-Diphenyl, but-3-ene-2-0l	0.07±0.00	-	-	-
28.37	Hexanoic acid	**6.10±0.11**	**8.17±0.23**	**11.34±0.31**	**25.89±1.01**
29.12	(1-Fenilpropane 1,2-diol) or benzyl alcohol	-	0.07±0.00	-	0.07±0.00
29.98	Methane, sulphonylbis	-	-	0.93±0.01	-
29.99	Dimethyl sulfone	0.46±0.01	0.32±0.01	-	-
30.19	Benzene ethanol	0.11±0.01	0.28±0.01	-	0.26±0.01
31.64	4-Butoxy-2,4-dimethyl-2-pentene	-	0.16±0.01	-	-
31.81	3-(3,3-dideutero-n-butyl) thiophene	-	0.82±0.01	4.04±0.61	-
31.96	Heptanoic acid	-	-	0.06±0.00	0.24±0.00
32.45	Ethanol, 2,2'-oxybis-	-	1.10±0.04	-	0.01±0.00
32.47	Citronellal or (2,2,4,5-tetramthyl-4-hexene-3-one)	0.24±0.02	-	-	0.14±0.00
33.04	Sulphurous acid, cyclo hexyl methyl hexyl ester	1.64±0.03	5.12±0.43	1.37±0.04	-
34.22	Cyclopentanone, 3-(3-hydroxy-1-propenyl)	-	-	0.10±0.01	-

34.51	2,4,4,6,6,8,8-Heptamethyl-1-nonene	0.09±0.01	1.05±0.02	0.53±0.01	-
35.23	Mebutamate	-	1.80±0.05	2.99±0.51	-
35.39	Octanoic acid	**2.19±0.11**	**4.05±0.33**	**16.53±0.46**	**9.27±0.92**
36.03	Cyclohexane, carboxylic acid	0.11±0.01	-	-	0.03±0.00
36.06	p-Cresol or (Phenol, 4-methyl-)	-	0.10±0.01	-	-
36.30	m-Cresol or (Phenol-3-methyl)	-	0.31±0.01	-	-
38.08	Methyl benzoate	0.31±0.01	-	-	0.19±0.01
38.67	Nonanoic acid	**0.18**±0.03	**0.29**±0.02	**0.25**±0.02	**0.16**±0.02
38.89	Phenol-4-ethyl	-	0.11±0.01	0.17±0.01	-
39.48	1-Ethyldioxyindol	-	0.81±0.01	-	-
40.66	Phenol,2-(1,1-dimethyl)-4-methyl	0.17±0.01	0.16±0.01	0.38±0.01	-
41.58	4-Butoxy-2,4-dimethyl-2-pentene	-	0.11±0.01	-	-
41.83	Decanoic acid	**1.03±0.07**	**1.59±0.04**	**10.07±0.09**	**2.10±0.03**
43.15	Trithiane glycol	-	0.06±0.00	-	0.03±0.00
44.31	1,3,5-Trimethyladamantane	-	0.06±0.00	0.19±0.01	-
45.31	Hexadecanoic asit	-	-	0.28±0.01	0.14±0.01
45.59	2-Dodecen-1-yl (-) succinic anhydride	-	0.17	-	-
46.27	Benzoic acid	**2.72**±0.33	**3.03**±0.11	**2.15**±0.20	**0.32**±0.01
50.73	Octyl phenol isomer	-	-	0.08±0.00	-
53.64	Phenol, 2,2ı-methylenebis(6-(1,1-di-methylethyl)-4-methyl	18.76±1.01	1.65±0.06	3.16±0.06	-
56.11	Hexanedioic acid, diocyl ester	**0.17±0.01**	**0.44±0.01**	**0.10±0.01**	**0.03±0.00**
58.38	Hexadeconoic acid	**0.86±0.04**	**0.54±0.01**	**0.55±0.01**	**0.28±0.01**

* It is an area under the peak for each component is considered as a measure of component concentration.
** Retention time is time interval between sample injection and the maximum of the peak.

Table 3. Volatile Compounds which were determined only for matured kashar cheese samples

Retention Time (RT) *	Component	Concentration (%)			
		Cow Milk	**Sheep Milk**	**Goat Milk**	**Matured Kashar Cheese**
2.17	Heptane, 2,2,4,6,6-pentamethyl	-	-	-	0.55±0.04
2.18	Heptane, 5-ethyl-2,2,3-trimethyl-	-	-	-	0.01±0.00
2.61	Nonane, 2,2,4,4,6,8,8-heptamethyl	-	-	-	0.03±0.00
3.49	Undecane	-	-	-	0.14±0.03
4.14	2-Pentanol	-	-	-	4.92±0.55
4.63	1-Butanol	-	-	-	0.44±0.03
7.08	Hexanoic acid ethyl ester	-	-	-	2.07±0.38
9.15	2-Heptanol	-	-	-	0.42±0.08
10.03	Propionic acid 2 hydroxy ethyl ester	-	-	-	0.27±0.11
12.95	Octanoic acid ethyl ester	-	-	-	0.25±0.01
13.54	Pentanoic acid, 2,2-dimethyl-, 1,2,3-propanetriyl ester	-	-	-	0.02±0.00
14.45	4-Heptanol, 2,6-dimethyl	-	-	-	0.05±0.00
16.19	Benzaldehyde	-	-	-	0.24±0.02
17.22	2,3-Butanediol	-	-	-	1.11±0.27
19.23	Propylene glycol	-	-	-	0.03±0.00
21.74	Furan methanol	-	-	-	0.06±0.01
26.16	1,3-Propanediol	-	-	-	0.13±0.01
29.38	Hexadecamethyl hepta siloxane	-	-	-	0.02±0.00
29.52	Butanoic acid, butyl ester	-	-	-	0.05±0.01
43.63	9-Decanoic acid	-	-	-	0.07±0.01
47.77	Dodecanoic acid	-	-	-	0.09±0.03
53.27	Tetra decanoic acid	-	-	-	0.02±0.00

Fatty Acid Compositions (FAC)

The fatty acid composition of milk and MKC samples is summarized in Table 4. Overall, sheep and goat milks showed higher concentrations of short- and medium-chain fatty acids (C4:0–C12:0), while cow milk had higher unsaturated fatty acid content. MKC samples exhibited an intermediate profile, with noticeable concentrations of butyric and caproic acids, known for their contribution to cheese aroma and digestibility. The presence of C18:3 (α-linolenic acid), a plant-derived fatty acid, indicates the contribution of pasture-based feeding. The slightly lower concentration of polyunsaturated fatty acids (PUFAs) in MKC compared to raw milks may be due to losses during processing or differences in microbial conversion. Some inconsistencies, such as higher stearic acid in MKC than goat milk, may arise from processing-induced lipid rearrangement or fat hydrolysis during ripening (Elgersma et al., 2006).

Table 4. Fatty acid composition of milks and matured kashar cheese samples

Fatty Acids	**Milk Samples** **Sheep**	**Goat**	**Cow**	**Matured Kashar Cheese**
Butyric Acid (C4:0)	2.37±0.33	2.02±0.24	1.83±0.06	2.39±0.12
Caproic Acid (C6:0)	1.70±0.09	1.95±0.85	1.89±0.13	2.03±0.44
Caprylic Acid (C8:0)	1.34±0.07	1.90±0.04	2.19±0.24	1.84±0.50
Capric Acid (C10:0)	3.87±0.35	6.38±0.76	7.82±0.44	5.50±0.23
Undecanoic Acid (C11:0)	0.26±0.08	0.38±0.03	0.36±0.03	-
Lauric Acid (C12:0)	2.70±0.34	4.20±0.50	4.95±0.22	3.60±0.60
Tridecanoic Acid (C13:0)	0.07±0.01	0.09±0.01	0.11±0.01	0.07±0.02
Miristic Acid (C14:0)	9.89±0.41	12.41±0.30	11.82±0.45	11.02±0.40
Myristoleic Acid (C14:1)	0.62±0.02	0.71±0.15	0.36±0.04	0.62±0.04
Pentadecanoic Acid (C15:0)	1.03±0.05	1.06±0.05	0.91±0.02	1.23±0.05
Palmitic Acid (C16:0)	30.06±1.22	33.87±1.28	27.64±1.10	30.66±1.90
Palmitoleic Acid (C16:1)	1.10±0.090	1.11±0.08	1.07±0.09	1.09±0.09
Heptadecanoic Acid (C17:0)	0.82±0.02	0.68±0.02	0.63±0.01	0.83±0.01
Stearic Acid (C18:0)	13.60±1.15	9.95±1.00	9.80±1.56	12.81±1.27
Oleic Acid (C18:1n9c)	**26.77±2.07**	**20.06±1.93**	**24.12±1.90**	**21.51±1.20**
Linoleic Acid (C18:2n6c)	**2.09±0.09**	**1.90±0.08**	**2.80±0.06**	**2.27±0.08**
α- Linolenic Acid (C18:3n3)	0.97±0.02	0.64±0.02	0.80±0.03	0.69±0.03
ϒ- Linolenic Acid (C18:3n6)	-	-	-	0.02±0.00
Arachidic Acid (C20:0)	0.25±0.01	0.24±0.01	0.27±0.01	0.24±0.01
Cis-11- Eicosenoic Acid (C20:1)	0.06±0.01	0.05±0.01	0.05±0.01	0.03±0.00
Cis-11,14- Eicosenoic Acid (C20:2)	0.03±0.00	0.03±0.00	0.02±0.00	-
Cis-8,11,14- Eicosenoic Acid (C20:3n6)	-	-	-	0.05±0.01
Cis-11,14,17- Eicosatrienoic Acid (C20:3n3)	0.06±0.01	0.04±0.01	0.08±0.01	-
Arachidonic Acid (C20:4n6)	0.15±0.01	0.14±0.01	0.23±0.01	0.16±0.01
cis-5,8,11,14,17- Eicosapentaenoic Acid (C20:5n3)	0.03±0.00	0.04±0.01	0.09±0.01	0.04±0.00
Heneicosenoic Acid (C21:0)	0.06±0.01	0.03±0.00	0.02±0.00	1.09±0.01
Behenic Acid (C22:0)	0.11±0.01	0.11±0.01	0.13±0.01	0.12±0.01
Cis-13,16- Eicosapentaenoic (C22:2)	-	-	-	0.03±0.00
Tricosanoic Acid (23:0)	-	-	-	0.05±0.01
Lignoceric Acid (C24:0)	-	-	-	0.06±0.01
C14:1/C14:0	0.07±0.01	0.06±0.01	0.03±0.00	0.06±0.00
ΣMUFA	28.55±1.29	21.93±0.47	25.24±0.78	23.25±1.10
ΣPUFA	3.15±0.64	2.62±0.52	3.77±0.69	3.46±0.04
ΣSFA	68.12±1.56	75.26±1.90	70.38±1.98	73.60±1.76

Texture Profile Analysis

The textural parameters of matured kashar cheese (MKC) samples are presented in Table 5. Firmness, cohesiveness, adhesiveness, and gumminess values were determined as 12977 ± 27 g, 0.33 ± 0.01, 3.96 ± 0.13 g·s, and 4016 ± 36 g, respectively. The firmness value was found to be considerably higher than previously reported for MKC (Salinaz-Valdés et al., 2015), indicating the influence of production variables such as moisture and salt content.

Moisture content is known to be inversely related to firmness; lower moisture levels generally result in a denser and more rigid protein network, thereby increasing firmness (Kaya, 2012). In the present study, the relatively low moisture of MKC samples supports this correlation. Similarly, high salt concentrations are reported to enhance protein aggregation and matrix rigidity by reducing electrostatic repulsion between casein micelles, thus contributing to higher gumminess values (Ma, 2013).

The adhesiveness value (3.96 g·s) found in this study was slightly higher than that of semi-hard cheeses like Tulum or Kashkaval, possibly due to the specific fermentation conditions and extended maturation. According to Hayaloğlu and Ozer (2011), milk fat also plays a crucial role in modulating texture by softening the protein network and serving as a precursor for volatile aroma compounds during ripening.

There remains some debate in the literature regarding the effect of the animal feeding system on cheese textural properties. While Gulati et al. (2018) and Combs et al. (2007) reported no statistically significant effect of feeding regimen on firmness and cohesiveness, O'Callaghan et al. (2016) found that chewiness and springiness could be influenced by diet. This discrepancy suggests that the impact of feed may be cheese-type dependent and influenced by variables such as milk composition and microbial activity.

The observed gumminess value (4016 g) also reflects a well-structured protein matrix, likely enhanced by a relatively high salt concentration and extended ripening. In cheeses with lower salt content, undesirable bitterness and poor structure may result from excessive proteolysis and elevated water activity (Ma, 2013). Therefore, the salt level used in MKC production appears to have provided favorable mechanical properties without compromising sensory quality.

These findings emphasize the importance of controlling both formulation (moisture, fat, salt) and process parameters (ripening time, microbial flora) in determining the final textural quality of matured kashar cheese.

Table 5. The average values for textural parameters of matured kashar cheese samples

Sample	Firmness (g)	Cohesiveness	Adhesiveness (g.sn)	Gumminess (g)
Matured Kashar Cheese	12977 ± 27	0.33 ± 0.01	3.96 ± 0.13	4016± 36

CONCLUSION

The findings confirm that matured kashar cheese (MKC), traditionally produced from a unique blend of sheep, goat, and cow milk sourced exclusively from the pastures of Kırklareli, carries distinctive compositional and sensory properties. The low microbial load of the region's raw milk and the use of natural starter cultures contribute significantly to the rich aroma profile and the diversity of volatile compounds found in MKC samples.

This study highlights the relevance of traditional production methods in shaping the chemical and textural characteristics of MKC. The presence of key aroma compounds originating from both milk and cheese stages, along with distinct fatty acid and texture profiles, underscores the role of local practices and raw material quality.

These insights support the development of strategies for regional branding, standardization of artisanal production, and promotion of geographically indicated products. Furthermore, the results contribute to the valorization of traditional cheese-making and provide a scientific basis for policies aimed at protecting and promoting high-value, region-specific dairy products.

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