Some quality properties and volatile compound profile of Ardahan Tel cheese, a traditional cheese in Turkey

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Abstract

Introduction. The aim of the research was to determine the pyhsico-chemical and microbiological properties and the volatile compound profile of Ardahan Tel cheese.

Material and Methods. After the cheese samples were dry matter, fat (Gerber method using Van Gulik butyrometer) salt content ($AgNO_3$ titration method) and pH analysis were made. Acidity was made according to the alkali titration method, and the results were expressed in terms of lactic acid %. Cheese samples were analyzed in terms of total aerobic mesophilic bacteria count and coliform group bacteria count, yeast and mold and lactobacilli and lactococcus count. Mass spectrometry was used for the analysis of volatile compounds of cheese samples.

Results and Conclusion. Dry matter, fat, salt, pH and acidity values of the samples varied between 46.57–59.75%, 3.69–5.12%, 9.07–10.05%, 5.13–5.62% and 0.40–0.55%, respectively. Cheese samples are included in the group of fat-free cheeses according to the classification specified in the Turkish Food Codex Cheese Communiqué.

The total aerobic mesophilic bacteria (TAMB) count of the samples ranged between 5.38–6.72 log CFU/g, lactobacilli count between 4.55–6.12 log CFU/g, lactococci count between 5.33–6.85 log CFU/g, and yeast-mold count between 2.52–3.45 log CFU/g. The number of coliform group bacteria is below the detectable limit.

A total of 38 compounds belonging to 8 chemical groups were identified: aldehydes, ketones, alcohols, acids, esters, terpenes, aliphatic hydrocarbons and aromatic hydrocarbons. Significant changes were determined in the aroma profile of Ardahan Tel cheese, depending on the manufacturer. Ethanol gave the highest level of alcohol in the samples. among the esters detected in the samples, ethyl acetate and butyl acetate gave higher levels and were determined in all samples. 9 compounds were determined in the ketone group, and the highest rate was found in 2-heptanone.

Acetic acid, butanoic acid, hexanoic acid, ethanol, 1-propanol, 1-hexanol, hexane and toluene generally gave higher values than all samples.

Conclusion. The volatile compound profile of this cheese is composed of aldehydes, ketones, alcohols, acids, esters, terpenes, aliphatic hydrocarbons and aromatic hydrocarbons. In addition to ethyl acetate also contributes significantly to the volatile compound profile.

Introduction

The abundance of the traditional product diversity of the countries is one of the indicators of their cultural wealth. Preserving this variety of products and bringing them to the industry is important both culturally and economically [1]. One of the most diverse areas in the dairy industry is cheese production. Today, there are approximately 4000 types of cheese with different flavor and texture characteristics in the world [2]. Depending on the local conditions, especially on cultural habits, and on the diversity of animal species and breeds, a variety of local cheeses are produced customarily in Turkey [3]. Local cheeses are known only in the region where they are produced, but not much in other regions. Some of these cheeses have faded into oblivion, and some of them have survived by being produced within the family and sold in local markets [4]. It has become an inevitable necessity to develop traditional products that are limited to family businesses and are about to disappear, and their characteristics to be determined and adapted to the industry [1]. Ardahan Tel cheese is one of the local cheese varieties. The nutritional value of this cheese varies depending on the fat content of the milk. Cheese contains more fat if it is made from the remaining milk by removing the fat collected on the surface after being rested before passing through a separator. In some cases, Tel cheese can be made from whole fat milk optionally [5].

In the production of Tel cheese, cow's milk is strained and kept for a certain period of time in large containers. After the fat on the surface is collected, it is left to rancid for 5-6 hours or more. Optionally, some fresh milk can be mixed into the skimmed milk. According to the amount of milk, the amount of yeast is calculated and added to the milk. It is then heated by mixing. This process continues until the curd sticks on the ladle. The cauldron where we have the curd is taken from the fire, the curd is removed and wrapped on a pole which is nailed to the wall. The cheese dough is stretched and folded on the pole and continued until the cheese assumes a string structure. The cheese, which is in the form of a string, is salted into a tin, a cube or a bagel, and then offered for consumption after the maturation period of 3–4 months. Sometimes, while the curd is hot, it is passed through the sieves to become string, and then salted, wrapped in cloths and sold. It can be consumed in fresh form or, if desired, it can be placed in cans or overalls with brine. It is matured in this way. Cheese is also known by names such as "Saçak", "Çivil", "Çeçil" or "Çekme Cheese" peculiar to the region. Yield in Tel cheese varies between 8–10% on average [5, 6].

The most important factors affecting cheese quality are characteristics such as the taste and aroma, texture and appearance of the cheese [7]. The unique characteristics of cheese are formed as a result of biochemical reactions such as glycolysis, proteolysis and lipolysis that occur during maturing. Free fatty acids released as a result of lipolysis reaction affect the taste and aroma of the cheese. It is also reported that most of the free fatty acids are precursors to many compounds, such as alcohols, esters, aldehydes, ketones, and lactones, which contribute significantly to the flavor of the cheese [8]. Free fatty acid content of cheese is affected by factors such as maturation time, microbiological activity, lipase activity, pH, temperature and salt amount [9]. The presence of short, medium and long chain fatty acids is accepted as the most important indicator after the compounds formed as a result of glycolytic and proteolytic reactions in the maturing of cheese [10, 11].

There are limited studies that investigated the physical, chemical and microbiological properties of Ardahan Tel cheese [12]. However, there is no study in the literature to determine the aroma profile of this cheese. In this research, it was aimed to determine the aroma profile and quality characteristics of Ardahan Tel cheese.

Materials and methods

Material

Cheese samples were obtained from 11 different small family businesses from Ardahan province and its villages in Turkey and brought to the laboratory under cold conditions.

Method

Preparation of samples. Sampling was made for physical, chemical and microbiological analysis from samples belonging to each manufacturer. Samples were taken for volatile compound analysis and kept at -20ºC until analyzed.

Microbiological analysis. 25 g of cheese samples taken into sterile jars for microbiological analysis were weighed under sterile conditions, and 225 ml of Ringer's solution was added and homogenized for 3 minutes. In the preparation of other dilution liquids, 1 ml was taken from the first dilution tube using sterile pipettes and transferred to sterile tubes containing 9 ml of dilution liquid.

Total aerobic mesophilic bacteria count in cheese samples (TAMB) was counted on Plate Count Agar (PCA, Merck) for 48 hours at 30-32°C, coliform group bacteria count on Violet Red Bile Agar (VRBA, Merck) for 24 hours at 35-37°C, yeast and mold count Potato Dextrose Agar (PDA, Merck) for 3-5 days at 25°C. Man Rogosa Sharpe Agar for lactobacilli count (MRS, Oxoid) in anaerobic medium at 37°C for 72 hours and M17 Agar (Merck) for lactococci count at 37 ± 1°C for 48 hours were used [13, 14] .

Physical and chemical analysis. After the cheese samples were homogenized, dry matter, fat (Gerber method using Van Gulik butyrometer) salt content ($AgNO_3$ titration method) and pH analysis were made according to the methods specified by Kurt et al [15] Acidity was made according to the alkali titration method, and the results were expressed in terms of lactic acid % [16].

Volatile compound analysis. 5 grams of sample was weighed into a 40 ml vial (Supelco, Bellefonte PA, USA), and the vial was placed in a thermal block (Supelco, Bellefonte PA, USA) and kept at 40°C for half an hour to collect volatile compounds in the headspace. For adsorption of the compounds, CAR / PDMS fiber (Supelco 75 µm, USA) was placed in a vial and kept at the same temperature for 30 min. The fiber was then injected into gas chromatography (GC, Agilent Technologies 6890N). Mass spectrometry (MS, Agilent Technologies 5973) was used as a detector in the system. DB-624 (J&W Scientific, 60 m, 0.25 mm id, 1.4 µm film) was used as column in the system. The oven temperature of GC/MS was initially kept at 40°C for 6 min, then gradually increased to 110°C at 3°C / min speed, 150°C at 4°C / min speed, 210°C at 10°C / min speed and kept at this temperature for 12 min (total processing time 56.33 min). Helium was used as carrier gas in the system with a flow rate of 1ml / min. The results were evaluated by comparing from the library of mass spectrometry (NIST, WILEY, FLAVOR), and standard materials were also used for identification. Each sample was analysed in two parallels. The results were averaged and their standard deviations were calculated.

Statistical analyses

The manufacturer was taken as a factor in the study. The results obtained were subjected to analysis of variance and the main sources of variation found important were compared with Duncan multiple comparison test [17].

Results and discussion

Physico-chemical and microbiological analysis and aroma compounds results of the Ardahan Tel cheese samples are given in Table 1, Table 2 and Table 3.

Table 1

Physico-chemical properties of Ardahan Tel cheese

Manu-facturer	Dry Matter (%)	pH	Acidity (LA%)	Salt (%)	Fat (%)
A	48.85±0.21g	5.48±0.03bc	0.45±0.01de	10.05±0.28a	5.12±0.18a
B	56.28±0.03d	5.52±002bc	0.55±0.01b	10.24±0.13bc	3.49±0.02d
C	46.55±0.01f	5.45±0.07c	0.48±0.02b	11.14±0.06bc	4.05±0.07b
D	59.75±035a	5.13±0.14e	0.40±0.01cd	10.05±0.10d	3.02±0.02c
E	45.57±0.04i	5.52±0.03bc	0.45±0.02f	9.04±0.14a	3.38±0.04d
F	56.95±0.07b	5.59±0.02bc	0.44±0.01de	9.12±0.08b	5.02±0.03a
G	50.68±0.03e	5.77±0.04a	0.42±0.02def	10.03±0.05d	4.99±0.01a
Ğ	49.83±0.01f	5.28±0.02d	0.53±0.01ef	10.13±0.09c	3.78±0.13d
H	46.89±0.01h	5.23±0.02de	0.54±0.02b	10.05±0.12a	3.01±0.01c
I	59.75±0.02a	5.56±0.01bc	0.52±0.01a	10.07±0.07bc	4.97±0.02a
İ	56.65±0.01c	5.62±0.04b	0.51±0.02bc	10.02±0.22d	4.01±0.02b
Mean	52.42±1.13	5.44±0.18	0.50±0.10	10.18±0.12	3.78±0.23

The letters a, b, c, d, e and f indicate means that significantly differ at $p<0.001$ and $p<0.01$

Table 2

Microbiological properties of Ardahan Tel cheese (log CFU/g)

Manu-facturer	TAMB	Lactobacilli	Lactococci	Yeast-Mold	Coliform
A	6.71±0.03b	5.80±0.01c	6.64±0.02b	2.65±0.02c	< 2
B	6.68±0.03b	4.62±002ı	5.54±0.01h	3.04±0.02b	< 2
C	5.76±0.02e	4.80±0.01g	5.73±0.02a	3.14±0.01f	< 2
D	6.50±0.01c	4.94±0.07f	6.85±0.02a	3.12±0.01a	< 2
E	6.39±0.02d	4.55±0.01i	6.42±0.02c	2.74±0.01g	< 2
F	5.48±0.03f	6.12±0.02a	5.33±0.01ı	2.52±0.03d	< 2
G	5.39±0.02g	5.43±0.04d	6.18±0.03d	2.81±0.03b	< 2
Ğ	6.54±0.04c	5.75±0.01c	6.05±0.03e	2.94±0.03e	< 2
H	5.38±0.01e	4.69±0.01h	5.19±0.01i	2.72±0.02h	< 2
I	7.03±0.01a	5.19±0.01e	6.60±0.01b	3.27±0.01de	< 2

The letters a, b, c, d, e, f, g, h and i indicate means that significantly differ at $p<0.001$ and $p<0.01$.

The pH value in cheese samples varied between 5.13 and 5.62 (Table 1). Similar results were obtained from the studies made on civil [18], which is in the same group with Tel cheese, Erzurum Civil (Cambaztepe et al [19] and Ardahan Çeçil [12]. However, lower pH values

(3.82-4.45) were determined in another cheese type called Çeçil cheese [20], In Bayburt Civil [21] cheese, higher pH values such as 6.07 were detected. These differences are thought to arise from the production method and production conditions.

It was determined that the acidity values (% LA) varied between 0.40-0.55% in Ardahan Tel cheese samples. Similar to the findings obtained in this study, Yangılar and Kızılkaya [12] found that Ardahan Çeçil cheese samples varied in the range of 0.43%. However, higher acidity values were determined in these types of cheese [20-22]. The amount of dry matter in cheese is an important quality parameter, and it varies depending on the raw material, production method and maturation / storage conditions [1]. As can be seen in Table 1, the amount of dry matter in Ardahan Tel cheese was determined as minimum 46.57% and maximum 59.75%. Similar results were found in Ardahan Çeçil [12] and Bayburt Civil [21] cheeses. However, lower amounts of dry matter were determined in Erzurum Civil cheese [23]. An important factor in dry matter is the fat content. In terms of fat ratio, it was found higher than other samples belonging to producers with codes A, F, G and I (Table 1). Cheese samples are included in the group of fat-free cheeses according to the classification specified in the Turkish Food Codex Cheese Communiqué (10> milk fat) [24].

Fat rates were determined by Tekinşen et al. [20] as ranging between 0.50-4.50%, by Bakırcı and Andiç [22] as between 0.10-9%, and by Yangılar and Kızılkaya [12] as between 3.66-6.25% and Arslaner and Salık [21] as between 0.50-2.60%.

Salt, which is added later in order to give flavor to the cheese and to increase its durability and to direct maturation, has an effect on the consistency and yield. It is reported that the pickling or dry salting process affects the dry matter and ash content of the cheese [23, 25]. The salt content of the samples ranged from 9.07 to 10.05% (Table 1). In other studies, on the subject, it was determined that the salt ratio showed a wide variation [12, 21, 22]. The wide variation in salt ratio is thought to be due to the water ratio of cheese and non-standard production conditions. In addition, some cheese varieties can be sold without salting after production.

Microbiological properties of the samples are given in Table 2. The total aerobic mesophilic bacteria count was determined as 5.39-7.02 log CFU/g. Similar numbers were obtained in similar cheese types [1, 12, 22, 26]. In the present study, the numbers of lactobacilli and lactococci varied between 4.55-6.12 log CFU/g and 5.33-6.85 log CFU/g respectively. As can be understood from these results, lactococci constitute an important part of the microbiota. The number of lactobacilli is also very close to the total number of bacteria in some samples. It is estimated that the differences between samples varied depending on the degree of heat treatment applied in the production as well as the maturation conditions and the amount of salt used. Generally, this cheese, which is matured and put on the market, can also be offered fresh for consumption. The results obtained show that lactic acid bacteria develop during maturation and form the dominant microbiota. Lactic acid bacteria are important microorganisms in the production and maturation of many dairy products, especially cheese. Lactic acid bacteria count was determined by Yangılar and Kızılkaya [12] as 6.96 log kob/g, by Sarı et al. [1] as 7.19 log kob/g and by Şengül et al. [26] as 5.75 log kob/g .

The yeast-mold number of the samples was found to be 2.52-3.27 log CFU/g. However, in this type of cheese, similar [12, 26] or higher [21, 22] yeast-mold numbers were also determined. The number of coliform group bacteria was found below the detectable limit in all samples. This result is thought to be due to the heat treatment applied in the production of Ardahan Tel cheese and the sensitivity of this group of microorganisms to salt [25].\

Table 3

Aroma compounds detected in Ardahan Tel cheese samples produced from cow's milk (n=11)

Volatile Compounds	KI	Manufacturer				
		A	B	C	D	E
Aldehydes						
Nonanal	1143	17.41±6.40	1.50±0.50	5.69±5.69	10.63±9.63	14.69±4.47
Ketones						
Acetone	530	2.00±0.90cd	nd	1.76±1.76cd	6.80±2.48bcd	1.80±1.80cd
2-propanone	532	0.95±0.95	8.27±6.74	nd	nd	nd
2-butanone, 3-hydroxy	645	0.53±0.53	8.80±3.77	17.32±8.11	6.29±2.63	4.13±1.88
2-pentanone	746	0.60±0.60	0.96±0.96	1.55±1.17	1.13±1.13	2.92±1.56
2-heptanone	946	0.50±0.50	22.44±6.87	47.91±12.83	1.69±0.01	7.91±4.58
Nonanone, 2-methyl	962	nd	0.50±0.50	1.31±0.31	nd	2.08±1.50
Nonanone, 3-methyl	970	2.00±1.00	9.93±8.92	7.82±7.82	1.12±0.13	1.98±0.98
Nonanone, 2,5-dimethyl	1032	nd	9.84±8.84a	8.18±7.17ab	1.38±0.14	1.50±0.50bc
2-nonanone	1130	nd	2.54±0.45b	9.77±4.59a	0.50±0.50d	1.09±0.05c
Alcohols						
Ethanol	505	40.65±0.90	15.21±2.18	35.22±2.42	62.08±1.12	39.27±3.41
1-Propanol	611	42.20±16.46	61.83±22.46	42.67±23.77	14.09±2.67	17.86±9.11
1-Butanol, 3 methyl	741	0.30±0.30b	3.70±2.03b	11.47±6.45a	2.46±1.15b	0.54±0.54b
Pentanol	765	0.73±1.04	1.20±1.70	16.35±1.29	2.63±2.20	nd
2-heptanol	954	1.05±1.05	1.20±0.19	1.26±0.16	1.96±0.74	nd
1-hexanol	1070	45.92±7.20	39.54±1.87	28.80±4.66	31.70±10.01	23.44±18.94
Phenethyl alcohol	1204	0.50±0.50	2.14±1.11	3.12±1.93	0.30±0.30	2.14±0.43
Acids						
Acetic acid	710	10.81±0.21bcd	11.04±1.19bc	4.07±0.19de	4.97±0.29cde	26.32±4.31a
Propionic acid	794	23.52±8.84a	0.50±0.50b	15.99±5.53a	nd	2.44±0.82ab
Butanoic acid	882	19.08±5.53	28.87±6.95	74.05±16.58	4.63±0.26	73.25±73.24
Hexanoic acid	1023	34.90±10.46a	10.12±0.64c	5.06±5.06d	25.03±11.93b	1.96±1.51d
Octanoic acid	1228	6.56±1.13b	4.67±1.71b	0.94±0.23b	1.59±0.36b	0.43±0.12b
Esters						
Ethyl acetat	639	15.75 ±6.63	21.77±13.11	16.61±9.29	29.09±14.33	21.73±13.58
Butyl acetate	852	2.33±3.30	3.67±5.16	1.51±2.12	1.19±1.68	0.60±0.80
Isopentyl hexanoate	1294	0.48±0.48	2.15±1.27	0.67±0.26	0.72±0.30	2.66±0.52
Terpenes						
α-Pinene	949	11.92±11.92	8.59±8.59	6.79±6.79	1.18±0.17	0.57±0.57
3-Carene	1033	20.24±20.24	12.32±12.32	6.17±6.17	1.36±1.36	nd
D-Limonene	1046	34.24±13.21a	3.50±0.50c	32.30±2.31a	2.96±0.35c	5.57±1.74c
Aliphatic Hydrocarbons						
Hexane	600	15.75±4.62	85.56±7.92	11.53±1.33	41.57±11.33	42.79±6.99
Octane	800	24.22±24.22	12.76±12.76	30.72±9.96	1.44±1.44	14.09±14.09
Decane	1000	8.53±2.53	10.54±0.72	9.45±0.45	11.06±3.38	16.38±7.69
Undecane	1100	2.82±2.00	36.95±16.34	17.65±5.80	25.09±13.44	23.05±18.01
Dodecane	1200	2.61±0.39	4.37±2.93	1.51±0.62	1.94±0.97	4.28±1.79
Aromatic Hydrocarbons						
Toluene	795	12.90±1.39ab	31.64±4.58a	29.17±3.46a	5.90±0.85b	5.92±1.18
p-Xylene	895	7.50±0.50	0.65±0.65	1.07±0.07	1.33±0.33	1.80±0.14
Benzene, 1-ethyl-3-methyl	989	1.32±1.32	1.00±0.00	1.00±0.00	1.01±0.01	1.43±0.43
Benzene, 1-ethyl-2-methyl	1063	nd	nd	nd	1.73±0.73	2.65±1.34
Benzene, 1,3,5, trimethyl	1087	16.08±5.01	5.71±5.71	45.93±28.31	32.40±3.48	15.61±11.35

Continue of Table 3

Volatile Compounds	KI	Manufacturer F	G	Ğ	H	I	İ
Aldehydes							
Nonanal	1143	14.23±8.41	0.52±0.19	1.10±0.10	0.50±0.50	nd	6.16±2.15
Ketones							
Acetone	530	nd	9.51±1.45	1.39±1.39cd	18.09±1.38a	8.56±1.26bc	13.04±0.43ab
2-propanone	532	12.01±1.60	5.74±5.74	nd	nd	5.64±5.63	nd
2-butanone, 3-hydroxy	645	9.06±3.85	15.00±14.09	nd	0.80±0.69	14.10±1.62	4.61±0.40
2-pentanone	746	4.30±2.38	nd	nd	7.32±3.37	2.04±0.00	0.70±0.70
2-heptanone	946	16.37±10.35	nd	0.50±0.50	5.54±0.63	nd	9.42±3.31
Nonanone, 2-methyl	962	nd	nd	nd	nd	nd	0.80±0.18
Nonanone, 3-methyl	970	2.41±0.71	0.90±0.92	1.08±0.08	7.02±5.02	nd	2.56±1.03
Nonanone, 2,5-dimethyl	1032	nd	0.50±0.50c	nd	nd	0.50±0.50c	1.97±1.05b
2-nonanone	1130	nd	1.00±1.00	0.50±0.50d	nd	2.54±0.45b	1.40±0.68c
Alcohols							
Ethanol	505	14.14±2.03	46.36±5.56	23.86±1.99	nd	68.69±2.07	29.98±4.38
1-Propanol	611	28.27±2.17	nd	1.07±0.47	0.93±0.93	1.00±0.00	1.00±1.00
1-Butanol, 3 methyl	741	2.75±2.71b	1.69±1.69b	nd	0.80±0.80b	14.10±1.62b	8.01±0.98b
Pentanol	765	4.74±3.24	3.59±0.01	3.97±0.21	12.05±4.98	7.37±0.59	nd
2-heptanol	954	4.45±2.81	3.63±3.63	nd	1.65±1.65	3.44±0.15	2.32±0.43
1-hexanol	1070	0.22±0.31	1.00±0.00	1.29±1.29	nd	0.77±0.77	1.63±0.86
Phenethyl alcohol	1204	1.04±1.04	nd	0.99±0.19	4.90±3.07	1.42±0.42	5.19±3.46
Acids							
Acetic acid	710	9.73±1.97bcd	4.22±4.21cde	12.58±0.79b	1.72±0.42e	5.20±0.84cde	4.70±0.31cde
Propionic acid	794	nd	nd	1.22±0.00ab	nd	nd	1.49±0.11ab
Butanoic acid	882	4.67±4.67	15.62±0.60	7.37±0.54	1.36±1.36	9.22±093	62.98±42.97
Hexanoic acid	1023	12.58±5.93	34.92±3.09a	34.76±9.64a	18.48±8.48c	25.03±11.93b	12.58±9.93c
Octanoic acid	1228	15.31±2.34a	13.01±3.02a	2.03±0.40b	7.98±0.36b	0.12±0.12b	4.71±1.14b
Esters							
Ethyl acetate	639	26.88±16.25	5.91±0.61	4.86±0.40	4.89±0.55	36.56±1.97	12.41±0.41
Butyl acetate	852	4.24±4.50	5.22±0.17	3.35±0.44	1.79±0.69	1.29±1.77	1.61±0.69
Isopentyl hexanoate	1294	0.75±0.75	nd	0.24±0.24	0.43±0.43	0.38±0.38	0.76±0.21
Terpenes							
α-Pinene	949	nd	nd	nd	nd	nd	3.09±1.37
3-Carene	1033	10.28±7.40	3.95±3.95	nd	1.30±0.30	1.43±0.43	5.28-2.18
D-Limonene	1046	15.97±3.77b	2.74±2.74c	1.60±0.09c	2.78±0.49c	2.04±0.04c	0.58±0.04c
Aliphatic Hydrocarbons							
Hexane	600	36.38±9.88	27.38±2.07	82.64±16.10	70.07±10.93	47.99±37.69	74.50±5.30
Octane	800	1.09±1.09	0.91±0.91	3.90±1.88	nd	1.63±1.63	nd
Decane	1000	6.88±3.50	5.06±5.06	3.59±1.14	7.10±0.62	nd	8.08±1.04
Undecane	1100	2.40±0.23	0.50±0.50	1.59±0.41	1.48±0.20	1.56±0.41	1.00±0.00
Dodecane	1200	4.71±0.40	0.70±0.70	1.80±0.38	1.44±0.44	1.18±0.38	2.26±0.40

Continue of Table 3

Volatile Compounds		Manufacturer					
	KI	F	G	Ğ	H	I	İ
Aromatic Hydrocarbons							
Toluene	795	11.80±1.67ab	2.48±0.19b	1.69±0.05b	1.98±0.78b	3.50±0.06b	1.97±0.22b
p-Xylene	895	1.92±0.92	2.50±2.50	nd	1.32±0.22	0.55±0.55	1.06±0.25
Benzene, 1-ethyl-3-methyl	989	5.11±1.01	0.50±0.50	nd	nd	1.00±0.00	1.13±0.32
Benzene, 1-ethyl-2-methyl	1063	3.50±3.50	0.79±0.79	1.00±0.00	0.50±0.50	1.30±0.30	1.04±0.36
Benzene, 1,3,5, trimethyl	1087	nd	0.52±0.52	nd	0.50±0.50	2.05±1.05	1.67±1.67

The letters a,b,c,d and e indicate means that significantly differ *at* $p<0.01$ and $p<0.05$;
nd: not detected

A total of 38 compounds were detected, including one compound in the aldehydes group, 9 in the ketone group, 7 in the alcohol group, 5 in the acid group, 3 in the ester group, 3 in the terpene group, 5 in the aliphatic hydrocarbon group, and 5 in the aromatic hydrocarbon group (Table 3).

Cheese flavor is one of the most important criteria determining the choice and acceptance of consumers, and it is a complex mixture of hundreds of volatile compounds that do not affect the taste of cheese alone [27].

The aroma of a cheese variety can be thought of as a result of a certain balance between volatile compounds produced during cheese making [28]. It is stated that the basic flavor of cheese consists of the complex balance of non-volatile and volatile substances that are formed as a result of microbiological and biochemical reactions arising from the raw material of the milk, processing stages and maturation [29].

Milk fat is very important for the characteristic cheese flavor because it undergoes various reactions such as hydrolysis, oxidation and esterification and produces FFA, lactones, esters, and ketones that contribute to the flavor of the cheese. Free fatty acids (FFAs), saturated and unsaturated aldehydes, and ethyl esters are fat-derived flavor volatiles that play an important role in the overall flavor of cheese [30].

FFAs are formed by the oxidation and decarboxylation of fatty acids [31, 32].

In this study, only nonanal was determined as the aldehyde. The amount of nonanal was higher than the values determined by Nogueira et al. [33], Karagül-Yüceer et al.[34] and Çetinkaya and Kaban [35]. The threshold value of aldehydes is very low, and they are compounds formed as a result of amino acid catabolism and lipid oxidation. These compounds turn into alcohols and acids during maturation [1].

Acids are compounds that can be formed through lipolysis, proteolysis, and fermentation of lactose [36, 37]. Free fatty acids have strong sensory properties and are important compounds in the formation of flavor and aroma of many dairy products, especially cheese and fermented milk products [38]. Hexanoic Acid, butanoic acid and acetic acid have a larger share among the acids determined in Ardahan Tel cheese. Studies on the aroma components of different cheese types have also reported that these three acids have an important role in the volatile compound profile [33, 35, 37, 39]. The acetic acid and butanoic acid levels of the samples were higher than the values determined by Hayaloglu and Karabulut [37] in Civil cheese samples and lower than the values determined by Çetinkaya and Kaban [35] in Kars Gravyer cheese. The hexanoic acid levels of the samples were higher than the values determined by Çetinkaya and Kaban [35] and Gün et al [40].

Alcohols are formed by lactose metabolism, reduction of methyl ketones, amino acid metabolism, and the breakdown of unsaturated fatty acid [36]. Ethanol gave the highest level of alcohol in the samples. Similarly, studies on different cheese types have reported higher ethanol ratio among alcohols [33, 35]. Ethanol, 1-Butanol, 3-methyl, 2-heptanol and 1-hexanol values determined in Ardahan Tel cheeses were higher than the values determined in Minas cheese by Nogueira et al. [33] and in Civil cheese samples by Hayaloglu and Karabulut [37] and in Kars Gravyer cheese by Çetinkaya and Kaban [35]. The amount of 2-heptanol was lower than the value determined by Karagül-Yüceer et al [34] in Çanakkale Ezine cheese, and the amount of pentanol was similar to the value determined by Çetinkaya and Kaban [35] in Kars Gravyer cheese.

Esters are formed by esterification of alcohols with short chain carboxylic acids [35]. As can be seen from Table 3, among the esters detected in the samples, ethyl acetate and butyl acetate gave higher levels and were determined in all samples. Aroma active esters are compounds formed as a result of the reaction (esterification) of short or medium chain fatty acids and alcohols [27]. It is reported that most esters detected in cheeses give a fruity or floral taste sensation and their sensory perception thresholds are low [41].

The amount of ethyl acetate determined in the Tel cheese samples was higher than the values determined in Civil cheese by Hayaloglu and Karabulut [37] in Akçakatık cheese by Şimşek and Tuncer [42] and in Coalho cheese by Bezzara et al [39] and butyl acetate amounts were close to the values determined by Çetinkaya and Kaban [35] in Kars Gravyer cheese.

Ketones are mainly formed by the action of fungal or bacterial enzymes as a result of the conversion of triglycerides into free fatty acids by lipase. Ketones can be reduced to alcohols and give a sharp taste to cheeses [36]. The change in the amount of free fatty acids in cheese is also reflected in the methyl ketone composition that occurs [35]. Free fatty acids serve as substrates, especially in the formation of methyl ketones, lactones and esters [35]. 9 compounds were determined in the ketone group, and the highest rate was found in 2-heptanone. 2-heptanone ratios were found to be higher than the ratios determined by Hayaloglu and Karabulut [37] in Civil cheese and by Bezzara et al. [39] in Coalho cheese, but lower than the values determined by Çetinkaya and Kaban [35] and Kavaz et al. [43] .

Hydrocarbons are mostly secondary products formed as a result of the autoxidation of oil [44]. Although these compounds do not directly affect the aroma of cheese, they can act as a precursor compound in the formation of other aroma components and are compounds found in trace amounts in cheeses [44]. The aliphatic hydrocarbons determined in the study are hexane, undecene, octane, decane and dodecene, and aromatic hydrocarbons are toluene, p-xylene, benzene,1-ethyl-3-methyl, benzene,1-ethyl-2-methyl and benzene,1,3,5 trimethyl. The amount of toluene determined in Tel cheeses was higher than the value determined by Kesenkeş and Akbulut [44] in white cheese and by Hayaloglu and Karabulu [37] in Civil cheese. Hexane gave the highest rates in all samples. Hexane levels were higher than the values determined by Hayaloglu and Karabulut [37], Kavaz et al. [43] and Çetinkaya and Kaban [35] in different types of cheese. The amount of octane determined in cheese samples was higher than the values determined by Çetinkaya and Kaban [35] in Kars Gravyer cheese. The difference in hydrocarbon amounts can be affected by the type of cheese types, production method, ripening conditions and period.

Terpenes are volatile compounds of vegetable origin that do not form during the ripening of cheeses and pass into the product through milk as a result of grazing the animal on the pasture [1]. In the research, α-pinene, D-limonene and 3-carene were determined as terpenes. D-limonene showed the highest proportions in 11 samples. D-limonene value in cheese samples were determined to be higher than the values determined by Akpınar et al.

[45] in İzmir Tulum cheese made from cow's milk and by Çetinkaya and Kaban [35] in Kars Gravyer cheese.

Conclusion

- Ardahan Tel cheese is a non-fat cheese variety with a pH value of 5–6. However, the salt content can be up to 10%.
- Lactococci and lactobacilli have an important share in the microbiota of this cheese variety. The number of coliform group bacteria is below the detectable limit. This result is a good indication of the high hygienic quality of this traditional product. It is understood that the salt ratio is an important factor in the inhibition of coliform group bacteria.
- Dry matter content of this cheese type is generally around 50%. The volatile compound profile of this cheese is composed of aldehydes, ketones, alcohols, acids, esters, terpenes, aliphatic hydrocarbons and aromatic hydrocarbons.
- The most Tel here is that aldehydes formed as a result of lipid oxidation are generally at a very low level in this product.
- Only nonanal was identified as aldehyde. Among alcohols, the ethanol level draws attention. In addition to acetic acid, butanoic acid and hexanoic acid are thought to contribute to the aroma of this cheese variety. According to the results obtained, ethyl acetate also contributes significantly to the volatile compound profile.

References

1. Sarı K., Yaman H., Coşkun H., Akoğlu A. (2018), Microbial quality, volatile compounds profile, textural and some chemical properties of traditional Mengen Cheese, *Gıda*, 43(2), pp. 185–196.
2. Üçüncü M.(2004), *A'dan Z'ye Peynir Teknolojisi*, Cilt II. Ege Üniversitesi, Mete Basım Matbaacılık, İzmir.
3. Elmalı G., Uylaşer V. (2012), Geleneksel gıdalardan çeçil peynirinin üretimi ve özellikleri, *Uludag Üniversitesi. Ziraat Fakültesi Dergisi,* 26, pp. 83–92.
4. Uysal H., Kavas G., Kınık Ö. (1999), Türkiye'de Üretilen Geleneksel Süt Ürünleri, *GAP I. Tarım Kongresi*, *26–28 Mayıs*, pp. 247–254, Şanlıurfa.
5. Çetinkaya A. (2005), *Yöresel peynirlerimiz*, 1. Baskı, Academic Book Production, Kars.
6. Tekinşen O.C., Tekinşen K.K. (2005), *Süt ve süt ürünleri*. Selçuk Üniversitesi Basımevi, Konya.
7. Şengül M., Erkaya T., Ceyhun A.E. (2011), Karın Kaymağı peynirinin yağ asidi kompozisyonu, *Atatürk Üniversitesi Ziraat Fakültesi Dergisi*, 42 (1), pp. 57–62.
8. Lightfield K.D., Baer R.J., Schmgoethe D.J., Kasperson K.M., Brouk, M.J. (1993), Composition and flavor of milk and Cheddar cheese higher in unsaturated fatty acids, *Journal of Dairy Science,* 76, pp. 1221–1232.
9. *Farkye N.Y., Fox P.F. (1990), Objective indices of cheese ripening, Trends in Food Science &Technology,* 1, pp. 37–40.
10. Woo A.H., Lindsay R.C. (1984), Concentration of major free fatty acids and flavor development in Italian cheese varieties, *Journal of Dairy Science*, 67(5), pp. 960–968.
11. Yangılar F., Kızılkaya P.Ç. (2015), Ardahan'ın aromatik Çeçil peynirlerinin mikrobiyolojik ve kimyasal özelliklerinin belirlenmesi, *Bitlis Eren Üniversitesi Fen Bilimleri Dergisi,* 4(2), pp. 122–130.

12. Hagen M., Nervus A. (1999), Production of ice cream containing probiotic bacteria. *Milchwissenschaft*, Milk Science International, 54, pp. 265–268,
13. Halkman K. (2019), *Gıda mikrobiyolojisi*, Başak Matbaacılık, Ankara.
14. Kurt A., Çakmakçı S., Çağlar A. (2012), *Süt ve Mamulleri Muayene ve Analiz Metotları Rehberi* (10. Basım), Erzurum: Atatürk Üniversitesi Yayınları No:252/D, 254.
15. Turkish Standards Institution – TSE. (2006), TSE -TS 591 (White cheese Standarts). Ankara, Turkey: Turkish Standards Institution.
16. SPSS: (2019), SPSS for Windows Release 20. SPSS Pro. Inc.
17. Ayar A, Akın N., Sert D. (2006), Bazı Peynir Çeşitlerinin Mineral Kompozisyonu ve Beslenme Yönünden Önemi, Türkiye 9. Gıda Kongresi, 24–26 Mayıs 2006, Bolu, pp. 319–322.
18. Cambaztepe F., Çakmakçı S., Dağdemir E. (2009), Effect of some technological parameters on microbiological, chemical and sensory qualites of civil cheese during ripening, *International Journal of Dairy Technology*, 262 (4), pp. 541–548.
19. Tekinşen O.C., Atasever M., Keleş A. (1996), Civil peynirinin kimyasal ve organoleptik özellikleri, *Selçuk Üniversitesi Veteriner Bilimleri Dergisi*, 12(1), pp. 65–7l.
20. Arslaner A., Salık M.A. (2020), Bayburt Civil peynirinin bazı kimyasal, biyokimyasal ve mikrobiyolojik özellikleri ile mineral ve ağır metal içerikleri, *Gıda,* 45(3), pp. 433–447.
21. Bakırcı I., Andic S. (1999), Muş–Bulanık yöresinde üretilen cecil peyniri üzerinde bir araştırma, *Yüzüncü Yıl Üniversitesi Veteriner Fakültesi Dergisi*, 10, pp. 67–71.
22. Kurt A., Öztek L. (1976), Erzurum ilinde yapılan mahalli peynirlerden civil peynirinin bileşimi ve bunların diğer peynir çeşitleriyle karşılaştırılmaları, *Atatürk Üniversitesi Ziraat Fakültesi Dergisi,* 7 (4), pp. 103–119.
23. Anon. (2015), Türk Gıda Kodeksi Peynir Tebliği, Tebliğ No: 2015/6.
24. Guinee TP., Fox PF. (2017*), Salt in Cheese*: *Physical, chemical and biological aspects, Chapter 13*, In Cheese: Chemistry, Physics and Microbiology, pp. 317–375,
25. Şengül M., Değirmenci M., Erkaya T. (2009), Compositionel and microbiological characteristics during ripening of Çeçil cheese, A traditional Turkish cheese, *Asian Journal of Chemistry,* 21(4), pp. 3087–3093.
26. McSweeney PLH., Sousa N.I. (2000), Biochemical pathways for the production of flavour compounds in cheeses during ripening: A review. *Lait,* 80(3), pp. 293–324.
27. Çakmakçı S. (1996),Peynir lezzeti ve oluşumu–I, *Gıda*, 21(4), pp. 261–268.
28. Delgado FJ., González-Crespo J., Cava R., García-Parra J., Ramírez Ri. (2010), Characterisation by SPME-GC-MS of the volatile profile of a Spanish soft cheese P.D.O. Torta del Casar during ripening, *Food Chemistry*. 118, pp. 182–189.
29. Jo Y., Benoist D.M., Ameerally A., Drake M.A. (2018), Sensory and chemical properties of Gouda cheese, *Journal of Dairy Science*, 101(3), pp. 1967–1989.
30. Marilley L., Casey M.G. (2004), Flavours of cheese products: Metabolic pathways, analytical tools and identification of producing strains, *International Journal of Food Microbiology*, 90, 139–159
31. Leuven IV., Caelenberg TV., Dirinck P. (2008), Aroma characterisation of Gouda–type cheese*, International Dairy Journal*, 18(8), pp. 790–800.
32. Nogueira MCL., Luachevsky G., Rankin SA. (2005), Study of volatile composition of Minas cheese, *LWT- Food Science and Technology,* 38(5), pp. 555–563.
33. Karagül-Yüceer Y., Tuncel B., Guneser O., Engin B., İsleten M., Yaflar K., Mendes M. (2009), Characterization of aroma–active compounds, sensory properties, and proteolysis in ezine cheese, *Journal of Dairy Science*, 92, pp. 4146–4157.
34. Bontinis ThG., Mallatou H., Pappa E.C., Massouras Th., Alichanidis E.(2012), Study of proteolysis, lipolysis and volatile profile of a traditional Greek Goat cheese (Xinotyri) during ripening, *Small Ruminant Research*, 105(1–3), pp. 193–201.

35. Hayaloglu AA., Karabulut İ. (2013), SPME/GC–MS Characterization and comparison of volatiles of eleven varieties of Turkish Cheeses, *International Journal of Food Properties*, 16(7), pp. 1630–1653.
36. Manion D.T., Furey A., Kılcawley K. (2015), Free fatty acids quantification in dairy products, *International Dairy Journal Technology*, 69(1), pp.1–12.
37. Bezerra TKA., Araújd ARB., Arcanjd NMD., Sılva FLH., Queirdga RCRE., Madruga MS. (2016), Optimization of the HS–SPME–GC/MS technique for the analysis of volatile compounds in caprine Coalho cheese using response surface methodology. *Food Science and Technology*, 36(1), pp. 103–110.
38. Çetinkaya A., Kaban K. (2017), A View on volatile compounds of Kars Gruyere Cheese, a traditional cheese in Turkey, *American Journal of Food Science and Technology*, 5(1), pp. 6–10.
39. Gün İ., Güneşer O., Karagül-Yüceer Y., Güzel Seydim Z.B., Torun F., Çakıcı S. (2019), Aromatic and sensorial properties of çökelek cheese produced by different methods, *Süleyman Demirel Üniversitesi Fen Bilimleri Enstitüsü Dergisi,* 23, pp. 131–138.
40. Molimard P., Spinnler H.E. (1996), Review: Compounds involved in the flavor of surface mould–ripened cheeses: Origins and properties, *Journal of Dairy Science,* 79(2), pp. 169–184.
41. Şimşek B., Tuncer Y. (2018), Some properties of fresh and ripened traditional Akcakatik cheese, *Korean Journal for Food Science of Animal Resource*, 38 (1), pp. 110–122.
42. Kavaz A., Bakırcı İ., Kaban G. (2013), Changes of volatile compounds of Herby cheese during the storage period, *Kafkas Universitesi Veteriner Fakültesi Dergisi*, 19 (3), pp. 535–540.
43. Kesenkeş H., Akbulut N. (2006), Destek kültür olarak kullanılan bazı mayaların beyaz peynir aroması üzerine etkileri, *Ege Üniversitesi Ziraat Fakültesi Dergisi*, 43(2), pp. 73–84.
44. Akpınar A., Yerlikaya O., Kınık Ö., Korel F., Kahraman C., Uysal H.R. (2017), Some physicochemical characteristics and aroma compounds of Izmir Tulum cheese produced with different milk types, *Ege Üniversitesi Ziraat Fakültesi Dergisi*, 54(1), pp. 27–35.