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A View on Volatile Compounds of Kars Gruyere Cheese, a Traditional Cheese in Turkey

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Abstract The study aims to determine volatile compound profile of Kars Gruyere cheese, which was produced by the traditional method. The volatile components were extracted from samples obtained from 20 different sales points, by using the SPME (solid phase micro-extraction) technique and identified using Gas Chromatography/ Mass Spectrometer (GC/MS). In the samples, totally 40 compounds were identified including aldehydes, ketones, alcohols, acids, esters, terpenes, aliphatic hydrocarbons, aromatic hydrocarbons, nitrogenous compounds and furan group. The study determined that the compounds of acetaldehyde, nonanal, 2-pentanone, ethanol, acetic acid, propionic acid, butanoic acid, ethyl propionate, ethyl butyrate, n-buthyl acetate, toluene and 6-methylthio-(1)-benzothiazole compounds have a significant share in the volatile compound porfile of Gruyere cheese's.

Keywords: *cheese, Gruyere, volatile compounds, SPME, GC/MS*

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1. Introduction

Gruyere is a hard cheese which is produced widely in France, Austria, Finland and notably in Switzerland [1]. There is a wide range of cheese types in different provinces or regions in Turkey. Gruyere cheese is one of these types of cheese and is one of several European types of cheese produced and preferred by consumers in Turkey. Gruyere cheese which is one of the 18 types of cheese of economic importance looks like Swiss cheese in form and resembles the Emmental in taste [1,2,3]. Approximately %90 of Gruyere, predominantly produced in Eastern Anatolia Region of the Republic of Turkey, particularly in the province of Kars and its neighborhood (544 tones), is produced in the province of Kars [4]. Gruyere comes after kashar, tulum and white cheese in terms of production volumes in the province of Kars and its neighborhood [5,6]. Gruyere cheese is produced from raw cow' milk with the addition of rennet and thermophillic starter culture (propionic acid bacteria) [7]. The rind of Kars Gruyere cheese usually produced by the traditional method is hard and light dirty brown colored. Its weight varies between 20 Kg and 70 Kg. The diameter of cheese varies between 40 – 65 cm, and the diameter of holes in cheese is approximately 0.3 to 2 cm. Ripening of this cheese takes 3 – 6 months depending on the size of the cheese [6,8].

Kars Gruyere is produced only from cow's milk and only a small percentage of the cheese is produced in factories whereas larger portion is produced in dairy farms in villages and cities using traditional methods. Taste is one of the most important criteria to determine the quality of cheese. Cheese aroma is a complex mixture consisting of hundred of volatile compounds which individually do not have an effect on the taste of the cheese [9]. These compounds are formed as a result of decomposition of such compounds in cheese especially protein, fat, lactose etc. through different and complex biochemical ways, particularly due to the effect of microbial enzymes [10]. Although there are a number of studies on aroma compounds of various cheese types in Turkey, no study on Kars Gruyere cheese has been found in the literature. Therefore, this study aims to identify the flavor compound and active aroma compounds of Kars Gruyere cheese which is one of Turkey's traditional cheese types with no known former study on its aroma composition.

2. Material and Methods

2.1. Material

Twenty samples were taken from 20 different sales points in Kars Province. Samples were transported in cold chain to the Department of Food Engineering, Faculty of Agriculture, Atatürk University. The samples were frozen and stored at -20°C until the volatile compounds analysis was performed.

2.2. Metod

2.2.1. The Extraction and Identification of Volatile Compounds

The extraction of volatile compounds was done using a SPME device, using fibers of 75 µm, carboxen/polydimethylsiloxane (CAR/PDMS). Before the analysis, the fibers were preconditioned as indicated by the manufacturer.5 g of samples were minced and weighed

into a 40 ml vial (Supelco, Bellefonte, PA, USA) and sealed with a PTFE-faced silicone septum (Supelco, Bellefonte, PA, USA). The vial was left at 40°C in a thermo block (Supelco, Bellefonte, PA, USA) for half an hour to equilibrate its headspace. Then, the fibre was exposed to the headspace while maintaning the sample at 30°C during 30 min. The compounds adsorbed by the fiber were identified by gas chromatographic analysis using MS detector.

The compounds adsorbed by the fiber were desorbed from injection port of the GC(Agilent Technologies 6890N) for 6 min at 250°C with splitless mode. Mass spectrometry (MS, Agilent Technologies 5973) was used as the detector in the system. DB-624 (J &W Scientific, 60 m, 0.25mm i.d., 1.4µm film) was used as the column in the system. Helium was used as the carrier gas in the system at a 1 ml/min flow rate.

Gas chromatography oven temperature was set at 40°C for 6 min, then the temperature was gradually increased at a 3°C/min rate up to 110°C, at a rate of 4°C/min to 150°C and at a rate of 10°C/min to 210°C and then held at this temperature for 15 min. (total processing time 56.33 min). Mass spectra were obtained by electron impact at 70ev. The compounds were determined by comparing the results with mass spectra form a database developed by NIST, WILEY and FLAVOR, in addition, the standard substances were also utilized in the identification. The results were expressed as means of three replicates for each firm.

2.2.2. Statistical Analysis

In the evaluation of results, the SPSS package software was used to determine cheese samples' average value and standard error [11].

Table 1. The aroma components of Kars Gruyere cheese sample (mean ± standard deviation)

		Gruyere Cheese Samples									
Volatile Compounds	**KI**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Aldehydes											
Acetaldehyde	<500	20.01±25.43	48.44±1.50	53.84±1.89	24.22±34.26	49.81±4.33	25.98±36.74	40.70±1.05	nd	23.95±30.81	29.28±38.39
Benzaldehyde	1029	0.58±0.82	1.30±0.00	3.66±3.57	0.66±0.93	1.09±0.03	1.25±0.07	1.03±0.09	1.35±0.26	0.87±0.20	1.80±0.53
Nonanal	1143	4.42±2.50	2.29±0.65	4.20±1.99	0.58±0.82	0.89±0.32	1.59±1.64	0.70±0.19	0.82±0.27	0.77±0.15	0.64±0.28
Ketones											
2-propanone	532	2.99±4.23	11.63±0.63	2.77±3.93	2.41±3.41	4.27±0.43	6.03±8.53	14.43±1.45	0.60±0.85	nd	17.74±1.55
2-butanone	645	72.32±9.97	60.30±0.40	20.08±6.00	41.57±39.00	32.05±45.33	65.41±92.51	33.25±41.25	21.42±0.52	77.70±23.69	150.74±10.67
2-pentanone	746	3.06±0.47	15.22±0.92	7.63±2.17	5.72±8.09	2.16±3.05	11.01±6.91	23.42±0.26	12.17±3.23	18.19±5.71	38.34±3.64
2-heptanone	946	3.40±4.81	11.60±1.00	50.86±18.01	6.20±5.95	9.55±1.55	9.97±3.35	24.11±0.77	11.76±2.14	22.88±3.73	36.01±2.40
2-octane	977	1.11±0.04	0.35±0.49	4.22±3.46	0.34±0.49	nd	1.44±1.04	0.69±0.04	0.85±1.20	2.76±0.80	1.29±0.09
2-nonanone	1130	3.20±0.77	2.67±0.20	nd	1.30±1.84	2.09±0.05	2.27±0.77	3.61±0.42	3.01±0.37	4.17±0.37	nd
Alcohols											
Ethanol	505	14.63±9.19	18.51±1.33	21.37±3.54	12.44±17.59	15.69±2.47	27.01±10.72	19.60±1.17	24.68±3.66	27.67±8.98	36.99±3.22
1-Propanol	611	nd	7.89±6.05	6.47±0.09	3.49±3.53	nd	9.87±4.07	8.85±1.19	11.05±0.85	5.71±0.44	1.73±0.05
2-Butanol	652	nd	8.95±0.19	23.39±5.40	nd	nd	68.96±85.14	3.65±0.01	3.70±1.12	5.71±8.07	nd
1-Butanol	741	3.58±0.30	7.57±0.22	2.59±0.49	nd	0.72±1.02	3.86±5.46	23.42±1.05	1.70±2.41	nd	nd
Pentanol	765	0.73±1.04	1.20±1.70	16.37±1.29	2.63±2.30	nd	4.71±3.24	3.57±0.01	3.87±0.21	12.01±4.98	7.37±0.59
2-heptanol	954	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
1-hexanol	1070	1.42±1.05	nd	9.53±13.47	0.22±0.31	nd	0.22±0.31	nd	nd	nd	nd
Acids											
Aceticacid	710	45.79±14.51	50.86±8.08	17.64±2.68	19.25±27.23	38.48±11.63	3.36±4.75	22.73±0.37	33.85±4.76	14.94±0.86	12.60±2.08
Propionicacid	794	10.50±4.95	65.00±15.55	39.50±3.53	34.50±30.40	88.00±124.45	30.00±33.94	36.00±2.82	59.00±2.82	25.50±3.53	2.50±2.12
Butanoicacid	882	38.15±9.04	111.41±12.84	31.33±0.14	17.75±16.62	61.71±9.86	86.81±22.36	69.33±7.69	42.65±4.38	13.20±4.21	24.42±6.56
Hexanoicacid	1023	14.150±15.60	8.03±1.64	22.23±22.01	2.07±1.51	1.96±1.51	5.55±5.14	6.26±3.09	3.86±1.54	2.25±0.36	3.88±2.42
Octanoicacid	1228	1.62±2.30	1.55±0.31	2.79±3.94	1.59±2.25	0.43±0.12	1.59±0.34	0.60±0.85	1.06±0.18	1.30±0.40	3.28±0.97
Esters											
Ethylpropionate	753	nd	1.81±0.48	3.19±0.57	1.44±2.04	2.49±1.08	1.80±0.49	nd	3.69±0.30	4.54±1.35	0.75±1.06
Propylacetate	758	nd	nd	1.09±1.55	0.63±0.90	nd	1.45±2.04	nd	2.90±0.15	2.94±0.95	nd
Ethylbutyrate	833	7.67±1.91	8.52±0.86	10.90±2.68	3.53±4.99	7.10±4.01	11.12±2.74	8.62±0.31	7.49±0.07	14.18±5.64	30.92±1.48
Butylacetate	852	2.35±3.33	3.65±5.16	1.53±2.17	1.17±1.66	0.58±0.82	4.24±4.49	5.20±0.16	3.33±0.45	1.79±0.67	1.27±1.79
Hexylbutyrate	935	2.26±3.19	5.62±7.94	6.57±0.31	2.39±3.38	1.58±0.70	7.85±4.86	8.77±0.59	7.38±0.57	5.50±2.06	4.56±0.09
Isopropylhexanoate	1148	3.28±1.50	1.22±0.52	nd	0.57±0.81	nd	1.59±0.00	0.83±0.29	0.79±0.30	0.99±0.12	0.82±0.01
Butylcapronate	1223	17.81±12.59	3.58±0.82	15.90±15.78	0.00±0.00	1.37±0.84	1.89±1.64	2.84±1.77	1.31±0.86	0.30±0.43	nd
Propyloctanoate	1333	1.07±1.51	0.53±0.75	nd	0.43±0.60	nd	nd	0.44±0.45	0.28±0.39	nd	nd
Terpenes											
3,7-Dimethyl-1,6-Octadiene	960	5.36±1.820	nd	1.83±2.59	nd	nd	7.63±10.82	5.77±3.55	nd	25.15±6.02	6.71±0.81
D-Limonene	1046	0.88±1.25	nd	1.34±1.89	nd	6.31±0.02	nd	2.35	1.06±1.50	1.01±1.42	nd
Aliphatic Hydrocarbons											
Hexane	600	1.54±2.19	nd	1.82±2.57	nd	nd	nd	nd	nd	nd	nd
Octane	800	nd	2.07±0.16	6.45±2.96	nd	1.79±2.53	6.11±5.87	2.82±0.20	nd	nd	7.45±1.01
Decane	1000	3.02±0.51	7.77±1.09	26.40±24.23	1.58±0.82	4.54±2.32	34.32±26.57	17.13±0.40	4.61±0.25	3.68±2.06	8.55±0.37
Undecane	1100	3.460±2.71	0.95±1.34	5.63±3.43	nd	nd	2.77±1.24	nd	nd	0.64±0.90	1.32±0.48
Dodecane	1200	4.38±4.42	1.71±0.46	3.01±2.80	0.52±0.73	1.02±0.24	2.05±0.02	1.52±0.56	1.02±0.21	0.91±0.28	1.18±0.38
Aromatic Hydrocarbons											
Toluene	795	13.72±3.72	5.15±7.28	28.64±2.36	5.53±7.83	8.25±11.67	12.35±2.89	10.98±0.19	16.62±1.76	30.85±9.05	15.74±0.48
Nitrogen Compounds											
N-hydroxy-N-phenyl-amino	1321	3.66±1.82	3.83±2.58	6.23±3.57	nd	2.04±0.14	3.51±2.38	2.39±1.12	1.70±0.30	1.59±0.28	2.33±1.07
Sulphurous Compounds											
6-methylthio(1) benzothienol	>1400	1.45±0.36	3.73±1.59	2.87±2.10	0.67±0.94	1.53±0.20	2.58±1.63	1.44±0.09	1.28±0.14	1.16±0.14	5.17±5.78
Furans											
Furan	969	nd	nd	1.65±2.34	nd	nd	2.47±3.50	nd	2.59±3.66	4.61±0.84	6.18±0.45

Volatile Compounds	Gruyere Cheese Samples										
	KI	11	12	13	14	15	16	17	18	19	20
Aldehydes											
Acetaldehyde	<500	57.05±8.78	29.63±41.10	29.50±41.75	20.84±29.47	1.07±1.52	56.98±0.49	31.48±44.52	26.81±37.92	34.27±48.46	nd
Benzaldehyde	1029	0.86±0.24	0.98±0.19	0.43±0.61	1.44±0.26	0.61±0.86	0.29±0.41	3.63±3.52	4.18±4.64	1.37±0.39	0.82±0.42
Nonanal	1143	1.89±2.06	1.21±0.15	1.26±0.18	1.91±2.12	1.42±2.00	0.59±0.84	1.61±0.69	0.12±0.17	0.33±0.47	nd
Ketons											
2-propanone	532	32.61±9.51	nd	0.66±0.93	6.64±9.36	16.96±23.98	2.22±3.14	18.59±0.11	4.24±6.00	12.27±0.63	10.91±15.43
2-butanone	645	114.09±10.50	120.86±0.14	104.44±94.76	142.23±2.39	155.41±10.21	80.50±11.82	48.91±0.29	18.98±1.33	109.35±7.74	31.54±4.20
2-pentanone	746	30.58±15.33	3.66±0.97	14.38±1.49	23.46±19.67	36.25±8.97	4.66±2.19	71.21±0.93	3.63±1.00	12.70±3.37	37.07±13.25
2-heptanone	946	34.91±13.37	4.82±0.44	14.25±0.52	22.41±16.21	51.50±12.24	6.73±0.09	91.92±3.87	14.54±8.54	9.94±3.56	21.61±0.01
2-octane	977	3.41±1.25	nd	1.43±0.26	121±0.07	1.75±0.82	nd	4.70±4.62	3.93±4.02	0.82±1.16	2.64±0.45
2-nonanone	1130	4.80±0.13	1.26±1.78	2.90±0.84	3.70±1.79	5.86±0.58	0.45±0.64	9.91±0.25	4.18±2.25	4.52±2.95	3.67±1.03
Alcohols											
Ethanol	505	23.50±7.60	49.48±1.97	36.73±13.03	34.32±0.39	40.38±7.11	34.94±12.83	35.71±3.74	61.81±10.44	42.59±8.92	51.21±14.71
1-Propanol	611	3.38±0.07	16.38±0.09	10.62±0.85	13.06±1.82	11.89±2.34	5.08±4.51	7.07±0.01	21.95±0.36	12.90±0.86	6.48±0.10
2-Butanol	652	nd	94.27±0.36	47.16±66.69	38.33±30.18	nd	9.96±14.08	nd	13.90±4.72	13.22±13.98	nd
1-Butanol	741	2.20±0.36	2.06±0.06	38.61±40.98	22.25±21.38	nd	0.94±1.33	nd	93.79±13.08	2.34±0.35	0.95±1.35
Pentanol	765	4.18±1.50	1.45±2.05	9.44±7.02	3.82±5.41	nd	nd	8.40±0.17	5.58±2.28	9.60±3.79	10.87±5.21
2-Heptanol	954	nd	3.50±0.70	4.65±2.67	3.00±4.24	1.50±2.12	0.47±0.67	9.50±3.53	5.10±4.38	9.26±1.78	5.00±4.34
1-Hexanol	1070	16.50±1.82	12.94±1.41	10.77±3.29	11.47±5.87	8.94±0.59	7.40±10.46	14.20±2.38	10.93±5.26	10.88±0.85	6.21±1.09
Acids											
Acetic acid	710	14.18±0.62	30.39±0.39	5.63±4.52	12.71±1.82	27.36±5.74	38.05±12.97	7.15±0.47	10.71±1.48	11.88±2.26	28.11±7.81
Propionic acid	794	20.50±3.53	19.00±0.08	5.00±4.24	4.00±1.41	47.50±3.53	127.50±6.36	4.50±0.70	22.50±4.95	27.00±1.41	99.50±4.95
Butanoic acid	882	15.24±4.43	22.69±4.84	4.61±0.56	26.10±3.49	28.70±4.48	27.29±0.52	21.58±5.67	nd	34.89±6.68	31.01±9.19
Hexanoic acid	1023	14.25±20.16	5.49±0.89	2.15±0.47	2.37±1.76	6.55±0.72	1.02±0.30	6.25±2.54	6.98±4.26	8.52±0.26	2.34±1.39
Octanoic acid	1228	nd	3.32±0.03	nd	2.01±0.12	3.17±0.28	0.72±0.13	0.60±0.85	nd	2.82±0.04	0.51±0.12
Esters											
Ethyl propionate	753	2.24±0.41	2.45±0.66	0.72±1.01	3.49±4.94	5.23±1.37	3.25±1.00	1.73±0.08	2.07±0.73	2.92±0.74	8.99±3.19
Propyl acetate	758	nd	6.24±0.05	nd	nd	5.48±1.42	nd	nd	2.02±0.46	4.59±1.01	nd
Ethyl butyrate	833	7.19±1.79	10.32±0.78	14.17±9.99	20.62±12.39	11.31±3.89	7.55±3.22	15.60±2.09	42.46±15.19	13.37±4.69	15.68±4.43
Butyl acetate	852	1.63±2.30	2.47±0.92	6.20±0.81	3.26±1.08	1.32±0.08	1.45±2.06	3.86±2.03	33.60±13.00	3.54±1.37	1.95±0.02
Hexyl butyrate	935	2.78±2.00	7.94±1.16	8.02±8.27	5.85±3.89	8.20±2.85	1.05±0.11	9.87±4.75	30.37±15.35	15.60±4.50	13.07±2.82
Isopropyl hexanoate	1148	nd	1.88±0.22	nd	0.32±0.46	1.18±1.67	nd	nd	0.81±1.15	2.83±0.71	nd
Butyl capronate	1223	8.89±11.30	nd	1.18±0.44	nd	nd	0.24±0.34	1.22±1.73	3.22±4.55	nd	1.53±1.48
Propyl octanoate	1333	nd	nd	nd	nd	0.26±0.37	nd	nd	0.32±0.46	0.76±0.21	nd
Terpenes											
3.7-Dimethyl-1,6-Octadiene	960	6.07±2.01	4.09±0.30	4.68±2.62	2.44±3.45	6.66±0.72	0.73±1.03	5.06±2.41	6.01±8.50	nd	3.63±5.13
D-Limonene	1046	nd	2.61±3.69	4.47±2.23	4.18±3.47	nd	2.72±3.85	4.70±4.42	nd	nd	nd
Aliphatic Hydrocarbons											
Hexane	600	3.01±0.82	nd	2.47±3.17	0.87±1.24	nd	nd	5.59±3.32	1.11±1.58	1.18±1.67	1.94±2.75
Octane	800	8.70±4.99	9.47±6.10	3.27±1.91	nd	6.20±2.35	9.91±5.71	8.08±0.61	2.06±2.90	1.69±2.39	8.08±3.06
Decane	1000	5.68±0.83	2.85±0.17	2.32±1.93	5.26±3.96	105.40±33.95	21.55±9.32	17.40±2.03	8.96±5.58	8.43±10.05	5.94±1.29
Undecane	1100	3.01±4.26	3.08±1.94	1.53±2.16	2.39±2.51	4.78±3.22	0.29±0.42	4.47±3.94	5.46±6.04	9.53±1.28	1.59±0.67
Dodecane	1200	1.97±1.09	1.78±0.06	0.82±0.28	0.90±0.36	1.28±0.15	0.67±0.06	1.46±0.63	2.37±0.82	3.53±0.16	0.82±0.27
Aromatic Hydrocarbons											
Toluene	795	20.27±0.82	15.01±3.38	17.56±1.06	13.73±1.92	24.62±7.06	nd	18.72±2.64	12.20±4.12	15.13±3.65	nd
Nitrogen Compounds											
N-hydroxy-N-phenyl-amino	1321	1.21±0.01	0.86±0.02	0.88±0.06	1.11±0.59	0.85±0.30	1.11±0.42	4.53±4.98	0.85±0.23	0.77±0.07	0.98±0.005
Sulphurous Compounds											
6-methylthio(1) benzothienol	>1400	1.49±0.07	0.83±0.08	0.99±0.33	1.11±0.10	0.86±0.46	1.17±0.03	3.03±2.99	1.71±1.49	0.75±0.03	0.89±0.12
Furans											
Furan	969	nd	1.22±1.73	nd	1.60±2.26	nd	nd	nd	1.01±1.42	nd	nd

Results are expressed in Arbitrary Area Units ($\times 10^{-6}$) as means of 2 replicates of each samples; KI – Kovats index calculated for DB-624 capillary column (60 m x 0.25 mm x1.4µm) installed on a gas chroma to graph equipped with a mass selective detector.

3. Results

The mean values for the volatile components of Gruyere cheese are shown in Table 1. In the samples, a total of 40 compounds were identified in aldehydes, ketones, alcohols, acids, esters, terpenes, aliphatic hydrocarbons, aromatic hydrocarbons, nitrogen compounds, sulfur compounds and furan group.

4. Discussion

A total of 40 compounds were identified in the study; these were 3 compounds in the aldehydes group, 6 in the ketones group, 8 in the alcohol group, 5 in the acid groups, 8 in the ester group, 2 in the terpenes group, 5 in the aliphatic hydrocarbon group, 5 in the aromatic hydrocarbon group, 1 in the nitrogenous compounds group, 1 in the sulfurous compound group and 1 in the furan group. The dynamic headspace technique was used to identif the volatile components of eight different hard cheeses (Cheddar, Edam, Gouda, Gouda 20+, Proosdij, Maasdam, Gruyere and Parmesan), the identified volatile components were in aldehydes, alcohols, ketones and sulfur compounds groups [12]. The study conducted to determine the changes in aroma during short ripening period of Goude type cheese made from raw and

pasteurized milk found significant differences in volatile compounds of raw milk cheese and pasteurized milk cheese and identifed 65 volatile compounds in Gouda cheese (aldehydes, ketones, free fatty acids, ethyl esters, lactons, branched chain and aromatic aldehydes, alcohols, sulfur compounds, indoles, branched chaid volatile acids [13].

Avşar et al. [14] identified 54 volatile compounds in Ezine cheese, 133 in Kars kashar cheese, 102 in Erzincan Tulum cheese and88 in Izmir Tulum cheese. Another study on Swiss cheese reported that there are more than 600 volatile compounds in Swiss cheese and these compounds are a result of lactose, lactate and citrate metabolisms of microorganisms in their ripening process. At the same time, many compounds such as hydrocarbons, alcohols, compounds containing sulfur, furan, ester, ketones and aldehydes are important for the aroma profile of Swiss cheese [15]. In this study, acetaldehyde, benzaldehyde, and nonanal were identified as the aldehydes. In 18 samples, excluding two samples, the highest ratios were obtained in acetaldehyde. Aldehydes are formed upon the disintegration of amino acids through microbial enzymes. The final products of amino acids and proteolysis may degrade into many flavor components such as ammoniac, aldehydes, phenols, indoles and alcohols. The amount of degradation products depends on the combination of active enzyme in the cheese. Firstly, the transformation of compounds and certain amino acids, which emerge in the second stage of amino acid catabolism, into aldehydes due to effect of deaminase on the amines occurs. At the final stage, aldehydes are reduced and oxidized into alcohols [16]. Many studies reported that the aldehydes were transient aroma compounds in cheese due to their rapid reduction into relevant alcohols or oxidation to acids [9,17]. Acetaldehyde amount in Gruyere cheese was found to be 119 in the study conducted by [12]. to identify volatile compound of various cheese types. This value is higher than the value we found in our samples. Methyl ketones are formed by the enzymic oxidative decarboxylation of fatty acids [12]. Free fatty acids serve as substrate in the formation of particularly methyl ketones, lactones and esters [18]. The values of 2-pentanone, 2-heptanone, 2-Nonanone were lower than the values of 2-pentanone (243), 2-Heptanone (219) and 2-Nonanoe (115) found in the study which identifed water soluble volatile compounds of eight different hard cheese types [12]. The variance in the amount of free fatty acids in cheese also affects the methyl ketones composition formed [19]. The differences in the values obtained in the study might have originated from the differences in the amounts of free fatty acids in cheese types. In the study, ketone was identified as 2-propanone, 2-butanone, 2-pentanone, 2-heptanone, 2-Nonanone and 2-Octane. 2-butanone represents the highest percentage in all samples. The highest 2-butanone value was found in the sample no 10 (150.74±10.67). In the study, alcohol was identified as ethanol, 2-butanol, 1-butanol, penthanol, 2-heptanol, 1-hexanol, 1-propanol, and butanol. Ethanol represents the highest concentration in all samples. The highest ethanol concentration (61.81 ±10.44) was found in sample no.18 and the lowest (12.44 ±17.59) in sample no.14. While ethanol was found as the highest alcohol percentage in Gruyere cheese in a study on aroma ingredients of different cheese types [12]. This percentage is higher than the percentage found in this study. Alcohols in cheese may be formed through different ways such as lactose metabolism, reduction of methyl ketones, decomposition of amino acid metabolism and linoleic or linolenic acid. 2,3-butanediol, which can exist in lower concentrations in the fermented dairy products, is one of the significant aroma compounds formed as a result of citrate metabolism [20]. In this study, ester was identified as ethyl propionate, propyl acetate, ethyl butyrate, propyl octanoate, butyl caproate, butyl acetate, hexyl butyrate, isopropyl hexanoate and ethyl ester. Ethyl butyrate represents the highest concentration in all cheese samples. This compound was reported to be the most substantial compound in the ripening process of Gruyere cheese [21]. Esters are the compounds formed as a result of reaction (esterification) of alcohols with short or medium chain fatty acids [9]. Many esters identified in cheeses are reported to provide fruity or floral flavor to cheese and have low sensory perception thresholds [20].

The acids identified in this study are the acetic, propionic, butanoic, octanoic and hexanoic acid. Butanoic acid represents the highest concentration in 19 samples, except for one sample. The highest butanoic acid concentration of 111.41 ± 12.84 was found in sample no.2. A study on the aromatic identification of Swiss cheese reported that the propionic and acetic acid are two important volatile compounds and these compounds are caused by the activity of Propionibacterium [22]. In a study on the formation and dispersion of acidic volatile fatty acids in the ripening process of Swiss Gruyere cheese, the concentration of butanoic acid in the inner and outer portions of cheese was found to be higher compared to other acids [23]. The above mentioned values are much higher than the values found in this study. A study performed using gas chromatography-mass spectrometry in order to determine the compounds providing typical specific flavor of Swiss Gruyere cheese reported that the typical flavor of Gruyere cheese samples was created by 2-/3-methylbutanal, methional, dimethyl trisulfide, phenyl acetaldehyde, 2-ethyl-3, 5-dimethyl pyrazine, 2,3-diethyl-5 methyl pyrazine, methanethiol, as well as butyric, 2- / 3- metal butyric and phenyl acetic acid [24].

D-limonene and 3.7-dimethyl-1.6-octadiene have been identified as terpenes in the study. Except for 5 samples, 3.7-dimethyl - 1.6-octadiene represent the highest concentrations in 15 samples. N-hydroxyl - N-phenyl-amino was identified as nitrogenous compounds in this study. N-hydroxy-N-phenyl-amino represents the highest concentration in nineteen out of twenty samples. 6-methylthio (1) benzothiazole was identified as the sulfurous compound in the study. 6-methylthio(1) benzothiazole, identified in all samples, was found to be the highest as 5.17 ±5.78 in sample no.10. Sulfurous compounds with low molecular weight in cheese were identified as methanethiol, hydrogen sulfide, dimethyl sulfide, carbonyl sulfide and dimethyl-trisulfide Sulfurous compounds form other volatile flavor ingredients through interaction with each other and with other compounds [25]. Various hydrocarbons were also identified in the study. The hydrocarbons are mostly secondary products produced as a result of autoxidation of fatty acids [10,20]. Although said molecules do not directly affect the aroma

of cheese, they are likely to play a lead compound role in the formation of other aromatic substances [20]. Aliphatic hydrocarbons, identified in the study, are hexane, undecane, octane, decane and dodecane. Decane represents the highest concentration in all samples. Toluene was identified as the aromatic hydrocarbon in the study. Toluene was found in 18 samples out of 20 and the highest concentration was obtained in toluene in the sample no. 9 (30.85±9.05). Furan was in 8 samples and no furan was found in 12 samples in the study. The highest furan concentration was found in the sample no 10 (6.18±0.45).

5. Conclusion

Aroma components, effective on the taste of consumer, include many complex and interrelated events that occur during the ripening of cheese. The diversity in these components is an expression of cheese quality. In addition, flavor formation in the cheese is affected by many factors such as ripening time and temperature, microbial flora, the enzyme and starter cultures employed, type and components of milk, process applied to milk and feeding patterns of animals from which milk is obtained. Depending on these parameters, each cheese produces specific flavor and structure. Detailed studies are required to identify aroma compounds in cheese types which are important dairy products and consumed frequently in Turkey. It can be concluded that flavors of all types of cheese can be identified with the accurate and full identification and control of interactions between advanced catabolisms and compounds in formation of flavor compounds of different types of cheese.

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