Cholesterol Content and Fatty Acid Composition of Most Consumed Turkish Hard and Soft Cheeses

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Abstract

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Cholesterol content and fatty acid composition of 29 different most popular hard (Tulum, Teneke Tulum, aged Kashar, and fresh Kashar cheeses) and soft cheese (White Pickled cheeses) samples from the markets of Izmir in Turkey were determined by gas chromatography. Cholesterol content of hard and soft cheeses ranged from 46.47 to 138.99 mg/100 g fat. Relative to the mean cholesterol values, the highest cholesterol content was found in fresh Kashar cheese. The fatty acid composition is quite similar in all samples. As concerns the saturated fatty acids, the most abundant in the cheeses investigated were palmitic (C16:0), stearic (C18:0), and myristic acids (C14:0). Palmitic acid levels were found to be the highest of the saturated fatty acid in all samples. Oleic acid content (5.93–29.38 mg/100 g fatty acids) in all cheeses was considerable higher than those of other unsaturated fatty acids. No specific trend or correlation between cholesterol and individual fatty acids was observed.

Keywords: fatty acid composition; cholesterol content; cheese; health; nutrition

Although several articles pertaining to the chemical composition of different Turkish dairy products have been published, the data referring to the fatty acid composition and cholesterol content of most popular Turkish hard and soft cheeses including Tulum cheese, Teneke Tulum cheese, aged and fresh Kashar cheeses, and White Pickled cheese are rather scarce in the literature. Therefore, the objective of this study was to determine by capillary gas chromatography the fatty acid composition and cholesterol content of most popular cheeses in Turkey, because of their importance in human health and nutrition.

MATERIAL AND METHODS

Cheeses. Major cheese types produced in Turkey are white pickled cheese, Tulum cheese, and Kashar cheese (fresh and aged). White Pickled cheese is the most popular, and economically the most important variety of traditional cheese in Turkey. It is produced in almost all parts of Turkey from raw and heat-treated cows' milk. It is a soft variety, according to its total solids content and the ripening period, which may last from 7 to 90 days.

Tulum cheese is one of the most important types of Turkish traditionally cheeses. Its name appears to derive from the word "tulum" which means animal-skin-bag. The cheese is matured for 90–100 days in these skin bags. In recent years, some producers used tinplate boxes for the maturation process of this cheese. In this situation, the cheese is called "Teneke Tulum" (canned Tulum). These two types of Tulum cheeses have been classified as a hard cheese according to their total solids content.

Kashar cheese is another popular traditional cheese in Turkey with an annual production of approximately 41 000 tons. It is classified as a hard cheese. It requires a ripening period of 1–2 weeks at 12–16°C and 3–10 month at 2–3°C to reach its characteristic structure and flavour.

Sampling. Ten white pickled cheeses, 3 Tulum cheeses, 6 Teneke Tulum cheeses, 5 aged Kashar cheeses and 5 fresh Kashar cheeses were purchased from markets in Izmir province, Turkey. The sampling of Turkish cheeses was based on the volume of their production and consumption.

Lipid extraction. Lipids were extracted using purified kieselguhr (Fluka Chemie GmbH, Buchs, Switzerland) and diethyl ether (Riedel-de Haën, Germany) as described by Renner (1993). Approximately 20 g of sample was ground with 6–8 g of kieselguhr, and then mixed with 200 ml diethyl ether. The mixture was blended for 1 min. The mixture was filtered. The filtered solution (diethyl ether-lipid extracts) was concentrated using a rotary evaporator (Heidolph, Germany) at 45°C to a final volume of approximately 1–3 ml for analyses, and flushed with nitrogen until dry, and stored at –75°C for further analysis.

Preparation of fatty acid methyl esters. Fatty acid methyl esters were prepared according to AOCS Official Method Ce 2-66 (AOCS 1997).

Determination of fatty acid composition by gas chromatography. Instrumentation used for the analyses was as follows: a Hewlett-Packard GC (model 5890 series II) equipped with Supelcowax-2560 fused silica capillary column (100 m × 0.5 mm i.d., 0.2 μm film thickness; Supelco Inc., Bellefonte, PA, USA), and a flame ionisation detector. The injection volume was 1 μl. The temperature of GC oven was programmed from 100°C to 220°C at the rate of 4°C/min. The injector and detector temperatures were 300°C. Nitrogen was used as the carrier gas and the flow rate was 1 ml/min. The split ratio was set at 1:100.

The identification of our chromatographic peaks was carried out by comparison of their retention times using appropriate standards of fatty acid methyl esters (Sigma Chemical Company, St. Louis, MO, USA).

Determination of cholesterol contents. Cholesterol was determined by the procedure described by Fletouris *et al.* (1998). For the preparation of cholesterol standards, the stock solution (2 mg/ml) was prepared by dissolving 20 mg of the reference standard (Sigma Chemical Company, St. Louis, MO, USA) in hexane in a 10 ml volumetric flask. The working solutions were prepared by appropriate dilutions of aliquots from the stock solution with hexane to obtain solutions in the range of 10 to 80 μg/ml.

GC conditions used for analyses was as follows: Ultra 1 fused silica capillary column (25 m × 0.32 mm i.d., 0.52 μm film thickness; Hewlett-Packard, USA). Oven temperature was set at 285°C, injection port temperature at 300°C, and flame ionisation detector temperature at 300°C. The flow rates were 2 ml/min for nitrogen, 30 ml/min for hydrogen, and 300 ml/min for air. The injection volume was 2 μl with a split ratio of 20:1.

The concentration of cholesterol (C) in the analysed samples was calculated according to the equation $C = M \times V \times 2.5$, where M = computed mass (nanograms) of the analyte in the injected extract (1 μl), V = dilution factor, if any, that was applied.

Recovery. Percentage recovery was determined by adding a known concentration of the cholesterol standard to the selected samples during extraction. The amounts added were roughly 50% of the actual concentration of the samples. The concentration of the cholesterol standard in the mixture was then determined in a way similar to the sample analysis. Without exception, the recovery rates of > 91% were achieved for the compounds analysed.

Statistical analysis. Multiple linear regression analysis was conducted to determine the relation between the cholesterol content and fatty acid percentages of the dairy products. Microsoft Excel software (Washington, USA) and SPSS 9.05 statistic software package (Chicago, USA) was used to perform all the statistical analyses (SPSS 1999). All experiments and analyses were completed in duplicates.

RESULTS AND DISCUSSION

Cholesterol is found almost exclusively in foods of animal origin, especially in meat and dairy products. The cholesterol contents of Turkish hard and soft cheeses are presented in Table 1. As presented, the cholesterol content of Turkish most popular hard (Tulum, Teneke Tulum, fresh Kashar, and aged Kashar cheeses) and soft cheeses (white pickled cheeses) in fat bases ranged from 46.47 to 110.49 mg/100 g (mean 86.23 mg/100 g), 76.59 to 110.58 mg/100 g (mean 90.30 mg/100 g), 88.85 to 127.15 mg/100 g (mean 109.08 mg/100 g), 87.51 to

Table 1. Cholesterol content of Turkish hard and soft cheeses

Sample	Cholesterol content (mg/100 g fat)	Sample	Cholesterol content (mg/100 g fat)
T1	46.47 ± 4.12	FK1	96.29 ± 7.84
T2	110.49 ± 8.11	FK2	120.81 ± 11.37
T3	101.73 ± 12.26	FK3	112.30 ± 6.85
TT1	85.80 ± 3.09	FK4	127.15 ± 13.88
TT2	85.19 ± 14.34	FK5	88.85 ± 3.72
TT3	88.60 ± 5.61	WPC1	79.18 ± 7.68
TT4	110.58 ± 6.55	WPC2	82.00 ± 15.84
TT5	76.59 ± 2.75	WPC3	99.42 ± 4.96
TT6	95.03 ± 7.87	WPC4	85.00 ± 4.23
AK1	96.39 ± 4.99	WPC5	138.99 ± 9.12
AK2	103.14 ± 10.59	WPC6	82.07 ± 13.58
AK3	87.51 ± 4.88	WPC7	95.01 ± 6.91
AK4	113.35 ± 13.93	WPC8	79.06 ± 7.36
AK5	97.30 ± 5.67	WPC9	81.23 ± 14.89
		WPC10	74.97 ± 8.44

T – Tulum cheese, TT – Teneke Tulum cheese, AK – Aged Kashar cheese, FK – Fresh Kashar cheese, W – White pickled cheese

113.35 mg/100 g (mean 99.54 mg/100 g) and 74.97 to 138.99 mg/100 g (mean 89.69 mg/100 g), respectively. The differences in the cholesterol content of Turkish cheeses may be explained by the differences in the fat content of cheeses, origin, and production technologies. Generally, these cholesterol contents were found to be higher than those of Fletorius *et al.* (1998) in Greek Teleme, Feta, and Teleme imitation cheeses. Also, Fletorius *et al.* (1998) reported that the cholesterol concentration in some Greek, Italian, Danish, and French cheeses such as Kaseri, Romano, Blue, and Camembert varied from 71.40 to 143.30 mg/100 g. The cholesterol contents of Turkish cheeses are in the range reported by Piironen *et al.* (2002) and Andrikopoulos *et al.* (2003).

According to the mean cholesterol values, the highest cholesterol content was found in the fresh Kashar cheese. Except for Tulum cheese 1, the cholesterol contents of Tulum cheeses were the highest among all cheese types. As seen from our results, the highest cholesterol content among all cheeses analysed was found in hard cheeses due to their high fat content (Inal 1990; Renner 1993). In the same way, the cholesterol contents of milk and milk products correlated with their fat contents, and a positive correlation was found in previous studies (Piironen 2002). The high cholesterol content is derived from the milk properties used in the production and during the processing conditions of dairy products. Our data also make it possible to obtain a more reliable estimation of the dietary cholesterol intakes and the comparisons of the contributions of various dairy products to the dietary cholesterol intake in Turkey.

Ruminant milk fats contain a wide range of fatty acids and 437 distinct acids have been identified in bovine milk fats (Collins *et al.* 2003). This situation is reflected in the dairy products. The results of fatty acid compositions (percentage of fatty acids) of Turkish cheeses are presented in Tables 2 and 3. The fatty acid composition of all samples is quite similar. Among the saturated fatty acids, the most abundant in the cheeses investigated were palmitic acid, stearic acid and myristic acid. Palmitic acid is one of the major saturated fatty acids; it raises serum cholesterol level while stearic acid does not (Grundy 1997). Palmitic acid was found to have the highest level of saturated fatty acid in all samples. As seen in Table 3, the oleic acid

Table 2. Fatty acid composition of Turkish cheeses (percentage of fatty acids) (Saturated fatty acids)

Code	C4:0	C6:0	C8:0	C10:0	C11:0	C12:0	C13:0	C14:0	C15:0	C16:0	C17:0	C18:0	C20:0
T1	1.12	1.34	1.46	5.26	0.07	3.70	0.10	13.75	0.50	35.09	0.99	10.98	0.06
T2	2.52	1.90	1.23	2.80	0.05	3.33	0.10	11.68	1.27	33.69	0.08	11.30	0.20
T3	2.62	1.97	1.58	4.05	0.03	2.86	0.07	9.48	0.90	30.08	0.72	16.60	0.32
TT1	2.67	1.91	1.20	2.68	0.04	3.12	0.10	11.20	1.13	33.14	0.75	13.32	0.25
TT2	2.26	1.63	1.09	2.67	0.04	2.91	0.09	10.53	1.10	31.03	0.76	14.34	0.27
TT3	2.67	2.04	1.60	4.13	0.04	3.43	0.09	10.90	1.18	30.01	0.06	12.60	0.30
TT4	2.48	1.86	1.47	4.30	0.04	3.26	0.09	11.68	1.35	34.07	0.99	11.27	ND
TT5	2.80	2.30	1.93	5.44	0.06	3.50	0.09	11.82	1.39	33.65	0.07	12.06	0.04
TT6	1.90	1.52	1.22	3.60	0.03	2.84	0.08	10.90	1.35	33.38	0.97	11.64	0.01
AK1	2.23	1.94	1.63	4.84	0.04	3.34	0.09	10.61	1.21	29.81	0.84	13.09	0.01
AK2	9.47	3.98	2.82	6.44	0.56	4.80	0.16	11.31	0.95	22.05	0.67	9.23	ND
AK3	5.33	2.06	2.00	6.08	0.05	3.60	0.10	10.31	1.26	25.94	1.02	12.64	0.44
AK4	2.51	1.95	1.40	3.47	0.04	3.20	0.09	11.23	1.32	30.35	0.80	11.30	0.26
AK5	1.84	1.50	1.19	2.90	0.04	3.44	0.09	12.04	1.54	28.14	0.15	12.36	0.02
FK1	12.90	8.73	4.49	6.70	0.58	4.50	ND	9.94	0.90	23.28	0.45	8.40	ND
FK2	2.85	2.34	1.74	4.68	0.10	4.32	0.13	12.50	1.23	32.01	0.70	11.22	0.27
FK3	2.64	1.90	1.21	2.73	0.04	3.19	0.10	11.46	1.16	33.18	0.71	11.63	0.24
FK4	3.67	1.98	1.28	2.97	0.05	3.52	0.11	11.79	1.20	32.34	0.70	10.58	0.20
FK5	2.29	1.58	1.17	3.04	0.05	3.54	0.10	12.03	1.19	32.28	0.73	12.96	0.24
W1	1.93	1.31	0.85	2.04	0.03	2.41	0.08	9.76	1.08	31.05	0.74	14.18	0.30
W2	45.65	9.96	3.84	4.57	0.54	3.26	ND	7.31	0.74	11.68	0.29	2.50	ND
W3	6.56	5.73	5.06	13.11	0.42	5.18	ND	13.03	1.53	25.15	0.72	6.50	0.31
W4	7.86	2.27	1.41	3.04	0.03	3.24	0.09	11.04	1.13	28.95	0.75	10.99	ND
W5	1.57	1.88	2.16	7.47	0.08	4.60	0.10	12.00	1.25	29.67	0.99	11.70	0.31
W6	2.06	1.66	1.03	2.28	0.03	2.79	0.11	11.47	1.71	37.22	1.03	9.30	0.01
W7	2.54	2.53	2.66	8.45	0.05	3.95	0.07	10.25	1.03	28.49	0.85	13.02	0.38
W8	3.11	2.14	1.33	2.95	0.28	3.38	0.08	11.34	1.25	30.85	0.84	13.17	0.23
W9	2.70	1.90	1.19	2.64	0.04	3.13	0.09	11.38	0.01	33.90	0.76	12.06	0.24
W10	2.23	1.73	1.15	2.60	0.04	3.05	0.09	11.08	1.12	32.72	0.73	13.40	0.25

T – Tulum cheese, TT – Teneke Tulum cheese, AK – Aged Kashar cheese, FK – Fresh Kashar cheese, W – White pickled cheese, ND – no detectable amount

content (5.93–29.38%) in all Turkish hard and soft cheeses was considerable higher than that of other cis-monounsaturated fatty acids. In Table 4, the results for the fatty acid ratios of cheeses (percentage of methyl esters) are categorised as saturated (SFA), monoansatutated (MUFA), polyunsatutared (PUFA), and total unsaturated (TUFA). The differences between the fatty acid ratios of cheeses were found to be insignificant ($P > 0.05$) with all cheeses (Table 4). These results are not much different from those found in the literature with several cheese varieties of different origin (Andrikopoulos *et al.* 2003). Also, the results are in agreement with our previous findings obtained with some Turkish dairy

Table 3. Fatty acid composition of Turkish cheeses[a] (percentage of fatty acids) (unsaturated fatty acids)

Code	C14:1	C15:1	C16:1	C17:1	C18:1		C18:2		C18:3	C20:1
					trans-9	*cis*-9	*trans*-9, 12	*cis*-9, 12	*cis*-6, 9, 12	
T1	0.007	0.02	1.44	0.37	0.007	21.10	0.86	0.22	0.02	0.08
T2	1.06	0.014	0.62	0.01	0.005	25.01	0.18	1.70	0.04	0.06
T3	0.43	ND	0.47	0.02	0.009	26.66	0.11	0.10	0.02	0.04
TT1	0.81	0.006	0.61	ND	0.009	25.70	0.14	0.15	0.009	0.06
TT2	0.72	0.02	0.61	0.02	ND	28.27	0.31	0.11	0.04	0.07
TT3	0.70	0.01	0.66	0.007	ND	27.70	0.28	0.14	0.02	0.07
TT4	0.68	0.014	1.35	0.01	2.23	20.65	0.14	0.36	0.10	0.64
TT5	0.57	0.02	0.63	0.014	0.009	22.22	0.15	0.16	0.044	0.06
TT6	0.61	0.01	1.31	0.01	ND	25.27	0.32	1.87	0.017	0.06
AK1	0.62	ND	1.17	ND	0.002	25.75	0.15	1.68	0.03	0.06
AK2	0.92	ND	0.89	0.23	5.39	16.59	0.35	1.35	ND	ND
AK3	0.22	0.01	0.77	0.40	0.006	23.31	0.02	1.88	0.15	1.41
AK4	0.96	0.008	1.40	0.43	ND	26.00	0.11	1.80	0.04	0.50
AK5	1.06	0.02	0.64	0.01	ND	29.38	0.35	0.16	0.02	0.04
FK1	0.83	ND	0.97	ND	0.42	14.54	0.19	1.71	ND	ND
FK2	0.74	ND	1.22	0.28	0.05	19.83	0.12	2.88	0.07	0.09
FK3	1.05	0.006	0.67	0.03	ND	26.87	0.12	0.15	0.043	0.07
FK4	1.07	0.01	1.53	0.36	ND	23.51	0.10	2.07	0.017	0.26
FK5	0.91	0.02	0.64	0.34	ND	25.53	0.29	0.11	0.06	0.07
W1	0.73	0.01	0.64	0.003	ND	29.09	0.26	2.47	0.02	0.08
W2	0.51	ND	0.60	ND	1.386	5.93	0.35	0.40	ND	ND
W3	0.68	ND	0.81	0.32	0.62	12.05	ND	1.23	ND	0.47
W4	0.93	0.02	1.27	0.35	2.78	20.93	0.009	1.96	0.05	ND
W5	0.42	0.03	0.92	0.34	0.015	22.06	0.15	2.11	0.02	0.05
W6	1.25	0.004	2.02	0.007	ND	24.94	0.15	0.26	0.015	0.06
W7	0.31	0.01	0.72	0.30	ND	21.34	0.15	2.20	0.109	0.04
W8	0.05	0.04	0.62	0.37	ND	26.57	0.10	0.20	0.02	0.05
W9	1.02	0.002	0.71	0.41	ND	26.72	0.10	0.13	0.01	0.07
W10	0.91	0.01	0.62	0.01	ND	27.03	0.11	0.15	0.01	0.06

T – Tulum cheese, TT – Teneke Tulum cheese, AK – Aged Kashar cheese, FK – Fresh Kashar cheese, W – White pickled cheese, ND – no detectable amount

products including strained (Torba) yoghurt, cream (Kaymak), butter, and processed cheese samples (Seckin *et al.* in print). *Trans* isomers ranged from 0% (zero) to 5.32% with the mean value of 0.32%. The highest value (5.32%) for *trans* fatty acids was detected in an aged Kashar cheese. Independent of the serious factors such as the properties of raw milk, origin, feeding, and season, these values are lower than the findings of Aro *et al.* (1998) for 14 European countries cheeses.

Table 4. Fatty acid ratios of some Turkish cheeses[a]

	n	SFA	MUFA	PUFA	TUFA
Tulum cheese	3	71.903 ± 1.21[a]	25.811 ± 2.45[a]	1.083 ± 1.03[a]	26.894 ± 3.48[a]
Teneke Tulum cheese	6	71.121 ± 2.54[a]	27.073 ± 2.29[a]	0.727 ± 0.75[a]	27.800 ± 3.04[a]
Aged Kashar cheese	5	69.324 ± 2.85[a]	27.639 ± 2.76[a]	1.535 ± 0.48[a]	29.174 ± 3.24[a]
Fresh Kashar cheese	5	73.327 ± 4.48[a]	24.383 ± 4.92[a]	1.586 ± 1.08[a]	25.969 ± 6.00[a]
White pickled cheese	10	73.902 ± 7.32[a]	24.146 ± 7.09[a]	1.275 ± 0.98[a]	25.421 ± 8.07[a]

[a]average ± standard deviation (SD) of percentage of fatty acids

SFA – saturated fatty acids, MUFA – monounsaturated fatty acids, PUFA – polyunsaturated fatty acids, TUFA – total unsaturated fatty acids

Several clinical studies have shown that a high *trans* fatty acid diet causes adverse changes in the plasma lipoprotein profile, with an increase in LDL and a decrease in HDL. Due to this reason, the Food and Agriculture Organisation (FAO) and the World Health Organisation (WHO) recommended in 1994 that fats for human consumption contain less than 4% of the total fat as *trans* (Tavella 2000). Except one cheese (AK2), our samples have considerably less *trans* fatty acids in total fatty acids. They ranged from trace amounts to 2.78%. Among *trans* fatty acids the detected, the C 18:1 *trans*-9 isomer comprised 69.53% of total *trans* fatty acids, followed by the C 18:2 *trans*-9, 12 isomer (30.47%). Among the fatty acids classes, the saturated ones were predominating, followed by *cis*-MUFA, and PUFA (Table 4). *Cis*-MUFAs which are found in cheeses, can lower serum LDL cholesterol and can play a protective role in many cardiovascular diseases. The abundance of fatty acids decreased, in average, in order: 16:0 > 18:1 > 18:0 > 14:0 > 4:0 > 10:0 > 12:0 > 6:0 > 8:0 > 15:0 > 18:2 *cis*-9, 12 > 16:1 > 14:1 > 17:0 > 18:2 *trans*-9, 12 > 20:0 > 17:1 > 20:1 > 11:0 > 13:0 > 18:3 *cis*-6, 9, 12 > 15:1 > 18:1 *trans*-9. No specific trend or correlation between cholesterol and individual fatty acids was observed. The results for fatty acids were generally within the ranges reported for Greek cheeses (Andrikopoulos *et al.* 2003).

CONCLUSIONS

In the present study, we looked at the cholesterol content and fatty acid profile of the most consumed 5 different Turkish cheeses. Using our chromatographic conditions, we obtained a satisfactory separation and identification of all compounds analysed. Cheeses showed rather similar fatty acid composition. The fatty acid profile showed that palmitic acid was predominant, whereas oleic was the major monounsaturated fatty acid. Recent recommendations suggest a polyunsaturated/saturated ratio to be about 1 for fatty foods. In our study, no sample meets this criteria due to the nature of milk fat. The cholesterol content of all cheeses ranged from 46.47–138.99 mg/100 g fat, and the highest cholesterol content in all cheeses analysed was found in hard cheeses.

A high dietary fat intake, coupled with low fat quality, can raise serum cholesterol and negatively affect several coronary heart diseases (Sandstorm 1993; Dashti *et al.* 2003). Because the dairy products have a low PUFA/SFA ratio and unbalanced ratios of SFA/MUFA/PUFA, there is a need of dietary changes for the populations who consume much cheese and other dairy products in their diet. These may include the modification of the fat composition towards higher PUFA/SFA by partial substitution of milk fat and other animal fats with vegetable fats. Another approach for balancing the quality of fat is a dietary manipulation in the animal feeding in Turkey.

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