

Fatty acid composition and conjugated linoleic acid content of cheeses produced with goat milk

Keçi sütünden üretilen peynirlerin yağ asidi bileşimi ve konjuge linoleik asit içerikleri

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Abstract

In this study, approximate compositions, fatty acid (FA) composition and conjugated linoleic acid (CLA) content of commercial cheeses (n=13) produced predominantly with goat milk in Turkey were determined. FA compositions of cheeses were similar. Major short and medium chain FAs in cheese samples included butyric, caproic and caprylic acids, respectively, according to their relative presence rates. Palmitic, oleic, myristic, stearic, lauric, linoleic and palmitoleic acids were found as the major long chain FAs in all cheese samples while palmitic, myristic and stearic acids were the major saturated FAs in a decreasing order. Palmitic acid was the major FA in cheeses while oleic acid was the dominant unsaturated FA. The ratio of lauric to capric acid was lower than 0.78 in all cheese samples. The range for the total CLA contents of cheese samples was from 1.79 to 4.83 mg/g fat. The highest CLA content was determined in a white cheese sample produced by a mixture of goat (70%) and cow (30%) milk while the lowest value was detected in an Ezine cheese sample produced by a mixture of goat (50%), sheep (45%) and cow (5%) milk. Especially, two white cheeses with a high CLA content could significantly contribute to the daily CLA intake of consumers. Results indicated that commercial cheese samples produced in Turkey had a high variability in their CLA contents.

Keywords: Goat milk, Cheese, Conjugated linoleic acid, Health, Fatty acid composition.

Öz

Bu çalışmada, ülkemizde ağırlıklı olarak keçi sütü ile üretilen peynirlerin (n=13) genel kompozisyonu, yağ asidi bileşimi ile konjuge linoleik asit (KLA) içeriği belirlenmiştir. Sonuçlar, tüm peynirlerin yağ asidi bileşimlerinin benzer olduğunu göstermiştir. Farklı peynir örneklerindeki kısa ve orta zincirli yağ asitleri nispi bulunma oranlarına göre bütirik, kaproik ve kaprilik asit olarak sıralanmıştır. Tüm peynir örneklerinde oransal olarak en fazla bulunan uzun zincirli yağ asitleri sırasıyla palmitik, oleik, miristik, stearik, laurik, linoleik ve palmitoleik asit olmuştur. Peynirlerde en fazla bulunan doymuş yağ asitleri olarak palmitik, miristik ve stearik asit belirlenmiştir. Peynirlerde, en fazla bulunan yağ asidi ve doymamış yağ asidinin sırasıyla palmitik asit ve oleik asit olduğu tespit edilmiştir. Tüm peynir örneklerinde laurik asidin kaprik aside oranı 0.78'den düşük bulunmuştur. Peynir örneklerinde toplam KLA içeriğinin 1.79 ile 4.83 mg/g yağ arasında değiştiği tespit edilmiştir. En yüksek KLA içeriği %70 keçi sütü ve %30 inek sütü karışımından üretilen beyaz peynirde, en düşük KLA içeriği ise %50 keçi, %45 koyun ve %5 inek sütü karışımından üretilen Ezine peynirinde belirlenmiştir. Özellikle, iki beyaz peynir örneği, tüketicilerin günlük KLA alımına önemli katkı yapma potansiyeline sahiptir. Çalışma sonuçları, Türkiye'de üretilen ticari peynirlerin KLA içeriklerinde büyük bir değişkenlik olduğunu göstermiştir.

Anahtar kelimeler: Keçi sütü, Peynir, Konjuge linoleik asit, Sağlık, Yağ asidi bileşimi.

1 Introduction

Goat cheese has been produced and consumed traditionally in Mediterranean countries like Turkey although its relative amount is usually lower than cow or sheep milk cheeses [1]. Interest in goat milk and its products have scientifically and commercially increased over the last three decades steadily because of their potential health benefits [2]. Significant nutritional and beneficial health effects of the consumption of goat milk and its products have been shown in a number of studies along with some epidemiological ones. Prominent nutritional and health benefits of goat milk consumption in comparison to cow milk include;

- Less allergenic effect [3],[4],
- Better digestibility of milk fat because of low globule size and high short- and medium-chain FA contents [4],

- Higher contents in mono-and polyunsaturated FAs [4],
- Higher contents of essential amino acids including threonine, isoleucine, lysine, cysteine, tyrosine and valine [6],
- Reduced total and LDL cholesterol levels with goat milk consumption [7], [8],
- Improvement of mineral bioavailability [9],[10] and,
- Positive effects on human immune system [11].

One of the most significant parameters determining the technological (i.e. texture, color and flavor), nutritional or dietetic quality of milk is its fatty acid composition. Triglycerides are the major constituents of goat milk fat, which corresponds to about 98% of total lipids [12]. The triglyceride composition of ruminant milk fat is very complicating and can contain up to 1300 different triglycerides [13]. For the fat

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content and FA composition of ruminant milks, the main environmental factor is animal nutrition [5].

Dietary milk fats are associated with some health problems particularly cardiovascular diseases because their saturated FA (SFA) content is high [14]. However, ruminant milk fats have some bioactive components like CLAs [15] and sphingolipids [16]. CLAs are naturally occurring positional and geometric isomers of octadecadienoic (linoleic) acid with conjugated double bounds [17] at various positions (i.e. 9 and 11, 10 and 12, 11 and 13) in the carbon chain of FA. Each of the bonds can be in cis or trans configuration [18], [19]. Cis-9, trans-11 (called rumenic acid) and trans-10, cis-12 C18:2 isomers are the most physiologically important isomers and constitute 80-90% and 3-5% of total CLAs, respectively. Rumenic acid and trans-10, cis-12 C18:2 isomer are attributed to several beneficial physiological effects such as anticarcinogenic [18], [20], antidiabetic [21], antiatherogenic [22] and antiobesity [23] effects. Dairy products are the major sources for dietary CLAs [17], and they account for about 70% of total CLA intake [24].

Goat milk has been mainly used for production of white, kashar and Tulum cheeses in Turkish dairy industry. In Turkey, the most produced and consumed cheese is white cheese [25], and it can be a soft (when produced freshly) or semihard (after maturation in brine for 3 months) cheese ripened and stored in brine [26]. Ezine cheese, a white cheese variety, is produced by a mixture of sheep's, goats' and cows' milks in Ezine, a county of the Canakkale city of Turkey. Ezine cheese is produced similarly to white cheese, but the geographical origin of milk used in production contributes a unique characteristic to this cheese [27]. The "Protected Geographical Indication" trademark was assigned to Ezine cheese by the Turkish Patent Institute in 2007. Kashar cheese, a pasta filata type cheese, is the second most important Turkish cheese variety after white cheese [28] and is similar to Kashkaval (Balkans), Caciocavallo (Italy) and Kasseri (Greece) [29]. Kashar cheese, is usually produced with cow and/or sheep milk. However, in recent years, goat milk has been also used in its production. This cheese is either sold fresh or ripened for 3 to 6 months. The production method and some properties of Kashar cheese has been reviewed previously by Kamber [29] in the literature.

Studies on the FA composition and CLA content of goat milk cheeses are limited while most studies are directed towards the FA composition and CLA content of cow milk cheeses. The objective of this study is to determine the approximate and FA composition, and CLA content of different cheeses produced (partially or solely) with goat milk.

2 Materials and methods

2.1 Goat cheese samples

Goat cheeses were purchased from either local or regional/national markets. Products with a statement of "goat milk" and/or "goat cheese" on their labels were specifically selected. Immediately after cheese samples were purchased, they were transferred into a laboratory refrigerator at 4°C prior to analyses. The procedure of the International Dairy Federation (IDF) Standard 50A was followed for sampling from cheeses [30]. The properties of cheese samples and the raw milk type used in their production (according to statements on their labels) are given in Table 1 and label information of cheeses was considered as accurate in interpreting the data. In this study, a total of 13 cheese samples [4 white cheeses, a Süzme/Feta type cheese produced with ultrafiltration (UF), 5 Ezine cheeses, a processed (eritime) cheese and 2 Kashar cheeses] were analyzed.

2.2 Methods

2.2.1 Physicochemical analyses

Total solids content, acidity and salt content of cheese samples were determined by TS 591 [31] while the fat contents of goat milk cheeses were determined by the Gerber method [32]. A digital pH meter (Jenco 6173, Jenco, San Diego, CA, USA) was used to determine the pH values of cheeses. The crude protein content of cheese samples was assessed by the nitrogen analyzing system DUMATHERM® (Gerhardt, Königswinter, Germany) using the Dumas method [33]. A conversion factor of 6.38 was used to calculate the crude protein contents of cheese samples. The fat and salt contents of cheese samples were also expressed on total solids basis.

2.2.2 Lipid extraction and preparation of fatty acid methyl esters (FAMES)

Lipid extraction from cheeses was performed according to a method proposed by Renner [32]. Grated cheese sample (ca. 20 g) was crushed with kieselguhr (Fluka Chemie GmbH, Buchs, Switzerland) (6-8 g) in a beaker. Diethylether (Fluka Chemie GmbH, Buchs, Switzerland) (200 mL) was then added to the mixture and mixed vigorously for a minute. The mixture was filtered and then the solvent was removed from filtered solution (solvent-lipid extracts) at 40°C under vacuum by using a rotary evaporator (Scilogex, Rocky Hill, CT, USA). Lipid extract was nitrogen-flushed until dry, and it was stored in a glass vial at -20°C prior to further analyses.

Table 1. Cheese samples used in this present study and their composition of raw milk stated on their labels.

Sample No	Cheese Type	Raw Milk Ratios Stated on Label (%)		
		Goat milk	Cow Milk	Sheep milk
1	White	60	40	-
2	Ezine	50	N**	N
3	Ezine	80	10	10
4	White	60	40	-
5	Processed (Eritme)	60	40	-
6	White	95	5	-
7	Ezine	80	10	10
8	Ezine	80	10	10
9	Süzme/Feta Type*	100	-	-
10	White	70	30	-
11	Ezine	50	5	45
12	Kashar, Fresh	90	10	-
13	Kashar, Ripened	90	10	-

*: Produced by ultrafiltration (UF). N: Not stated.

The method of Yilmazer and Secilmis [34] was used to prepare FAMES. Briefly, methanolic HCl (1 mL, 1.5 M) was mixed with lipid extract (200µL) and waited for 2 hours at 80°C. After cooling, 0.5 mL of water was added, and then 1 mL of hexane was used to extract FAMES.

2.2.3 Gas chromatographic analysis

The system containing an Agilent 78890A gas chromatography unit (Agilent Technologies, Wilmington, DE, USA) equipped with an Agilent 5975C quadrupole mass spectrometer detector (MS) was used to analyze fatty acids and CLA in cheese samples. An electron impact ionization mode for MS detector was at 70 eV, and mass range was 30-500 m/z in a scan mode for fragment ions. A CP-SIL 88 fused silica capillary column (100 m x 0.25 mm i.d., 0.2 µm film thickness; Chrompack, Middleburg, The Netherlands) was used in FAME analyses. The temperature was set to 240°C for the injector and detector, and injection volume was 1 µL. Carrier gas was helium with a flow rate of 1mL/min. The temperature program of a column oven was 60°C for 4 min, 60 to 175°C at 13°C/min for 27 min, 175 to 215°C at 4°C/min for 5min, and 215 to 240°C at 4°C/min for 15min while the split ratio was set at 1:20. MSDCHEM software was used for data handling. CLA methyl ester (mixture of the cis- and trans- isomers of 9,11- and 10,12-octadecadienoic acid methyl esters, Prod. No. 05632) and Supelco® 37 Component FAME Mix (Sigma-Aldrich, Cat. No. 47885 U) was purchased from Interlab Inc. (Istanbul, Turkey).

2.2.4 Statistical analysis

Triplicates of analyses were expressed as mean ± standard deviation. Microsoft Excel® software (Washington, USA) was used to perform all calculations.

3 Results and discussion

3.1 Composition of cheese samples

The composition, pH and acidity value of cheese samples are shown in Table 2. The total solids contents of cheese samples were between 41.09 (UF white cheese) and 60.98% (ripened Kashar cheese). Total solids contents of cheese samples studied were higher than a minimum value in cheese groups specified in the Turkish Food Codex (TFC) Cheese Notification (2015/6) [35]. The crude fat content of samples ranged from 22.00 to 29.00% while the total solids-based fat content (data not shown) varied from 45.92% (ripened Kashar cheese) to 55.98% (white cheese). According to the TFC Cheese

Notification, all cheese samples were within a category of full-fat cheeses. This result was also consistent with statements on the label of cheeses. The salt contents of cheese samples were between 2.68 (fresh Kashar cheese) and 5.56% (Ezine cheese). In general, pH and acidity values of all cheese samples were in good agreement with literature values [36], [37].

3.2 Fatty acid composition of goat milk cheeses

Fatty acid compositions of cheese samples are presented in Table 3. In general, the FA compositions of all cheese types were found similar. Five fatty acids (C16:0, C18:1, C18:0, C14:0, C10:00) were quantitatively accounted for >78% of total FAs in all cheeses (Table 3). This result was similar to the value reported (>75%) by Alonso et al. [38] for the same FAs in various goat milk samples.

Lipolysis in cheese increases the content of free FAs, and particularly short- and medium-chain FAs contribute to cheese flavor directly [39]. The FAs caproic (C6:0), caprylic (C8:0) and capric acids (C10:0) are usually responsible for the distinctive aroma of goat milk cheeses [1]. Short- and medium-chain FAs in cheese samples were capric, caprylic, caproic and butyric (C4:0) acids. Interestingly, butyric acid content was higher than caproic acid in some cheese samples. Higher ratios of caprylic and capric acids were detected in lipid extracts of Ezine, Süzme/Feta type and white cheese samples (sample numbers of 3, 9 and 10) produced with 80, 100 and 70% goat milk, respectively. Results were in good agreement with Alonso et al. [38], who assumed that dairy products made of goat's milk had a high content of these two FAs (C8:0 and C10:0).

Results indicated that the capric and caproic acid contents of cheeses did not increase linearly with an increase in the ratio of goat milk used in production for different cheese types. This was also noticeable for the same cheese types, which contained the same proportion of goat milk, due to the different production practices in each enterprise. This result might be related with compositional differences of milk used and processing technology in cheese production. Long chain FAs in cheese samples in a decreasing order included palmitic (C16:0), oleic (C18:1 n-9), myristic (C14:0), stearic (C18:0), lauric (C12:0), linoleic (C18:2 n-6) and palmitoleic (C16:1 n-7) acids. In some cheese samples, e.g. white (sample numbers 1 and 10), Süzme/Feta type (sample number 9), Ezine (sample numbers 2, 3, 8 and 11), processed (sample number 5), stearic acid was found more abundant than myristic acid.

Table 2. Chemical properties of cheese samples used in this study (mean ± standard deviation).

Sample	Total Solids (%)	Fat (%)	Protein (%)	Salt (%)	pH	Acidity (%)
1	51.81±0.13	29.00±0.00	19.65±0.51	3.02±0.08	4.78±0.01	2.47±0.01
2	46.76±0.14	23.25±0.35	18.68±0.21	3.82±0.09	4.94±0.02	1.79±0.02
3	49.28±0.27	26.50±0.71	17.73±0.13	4.05±0.09	4.88±0.01	1.91±0.01
4	50.05±0.10	25.00±0.00	20.25±0.28	4.03±0.00	5.14±0.01	1.89±0.08
5	50.03±0.28	25.00±0.71	16.64±0.20	3.16±0.01	5.02±0.01	2.11±0.12
6	51.02±0.30	25.75±0.35	19.29±0.13	4.92±0.02	5.16±0.01	1.66±0.00
7	48.17±0.19	24.00±0.71	18.24±0.17	5.56±0.04	4.74±0.00	1.92±0.06
8	48.09±0.08	23.00±0.00	17.80±0.24	4.80±0.02	4.98±0.01	1.97±0.00
9	41.09±0.07	22.00±1.41	12.70±0.12	2.71±0.09	4.57±0.01	2.12±0.00
10	48.56±0.26	26.25±0.35	17.64±0.14	4.74±0.09	4.90±0.00	1.84±0.11
11	49.01±0.01	26.75±0.35	18.65±0.09	3.98±0.06	5.02±0.01	1.93±0.06
12	55.05±0.06	27.50±0.71	23.77±0.46	2.68±0.10	5.24±0.01	1.52±0.09
13	60.98±0.14	28.00±0.00	26.94±0.13	4.44±0.05	5.80±0.01	1.36±0.41

Table 3. Composition of fatty acids (%) in extracted lipids of goat cheese samples (mean ± standard deviation).

Fatty Acid	Cheese Samples						
	1	2	3	4	5	6	7
C4:0	1.05 ± 0.08	1.00 ± 0.01	1.04 ± 0.06	0.99 ± 0.01	0.98 ± 0.00	0.80 ± 0.02	0.92 ± 0.01
C6:0	1.22 ± 0.00	0.92 ± 0.01	1.17 ± 0.00	0.97 ± 0.01	1.25 ± 0.01	1.02 ± 0.01	1.08 ± 0.02
C7:0	0.02 ± 0.00	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.01	0.01 ± 0.01	0.01 ± 0.00
C8:0	1.95 ± 0.00	0.92 ± 0.01	1.98 ± 0.01	1.27 ± 0.02	1.93 ± 0.01	1.40 ± 0.02	1.82 ± 0.04
C9:0	0.04 ± 0.00	0.02 ± 0.00	0.01 ± 0.00	0.02 ± 0.00	0.04 ± 0.00	0.03 ± 0.00	0.04 ± 0.00
C10:0	6.69 ± 0.04	6.40 ± 0.04	7.15 ± 0.07	4.11 ± 0.03	6.46 ± 0.03	4.69 ± 0.04	6.05 ± 0.10
C11:0	0.20 ± 0.00	0.17 ± 0.09	0.21 ± 0.02	0.29 ± 0.01	0.25 ± 0.01	0.27 ± 0.00	0.25 ± 0.01
C12:0	3.64 ± 0.02	2.82 ± 0.00	3.26 ± 0.01	3.2 ± 0.02	3.61 ± 0.00	3.18 ± 0.05	3.43 ± 0.06
C14:0	9.92 ± 0.08	9.69 ± 0.26	9.20 ± 0.03	10.19 ± 0.07	9.42 ± 0.09	9.45 ± 0.13	10.21 ± 0.20
C14:1n-5	0.47 ± 0.01	0.86 ± 0.01	0.16 ± 0.00	1.00 ± 0.01	0.59 ± 0.15	0.86 ± 0.02	0.46 ± 0.02
C15:0	1.07 ± 0.00	0.95 ± 0.01	1.03 ± 0.03	1.04 ± 0.00	0.90 ± 0.00	0.95 ± 0.00	1.19 ± 0.02
C15:1n-5 (cis)	0.26 ± 0.02	0.25 ± 0.04	0.21 ± 0.02	0.07 ± 0.00	0.04 ± 0.00	0.14 ± 0.13	0.23 ± 0.04
C16:0	29.42 ± 0.17	29.08 ± 0.36	29.72 ± 0.19	29.22 ± 0.16	29.13 ± 0.19	29.23 ± 0.29	31.38 ± 0.42
C16:1n-7	1.26 ± 0.10	1.55 ± 0.13	1.31 ± 0.02	1.95 ± 0.03	1.34 ± 0.01	1.80 ± 0.13	1.68 ± 0.01
C17:0	0.42 ± 0.02	0.48 ± 0.01	0.54 ± 0.17	0.45 ± 0.02	0.60 ± 0.05	0.54 ± 0.01	0.61 ± 0.17
C17:1n-7	0.71 ± 0.00	0.51 ± 0.00	0.27 ± 0.03	0.45 ± 0.01	0.33 ± 0.09	0.29 ± 0.08	0.37 ± 0.09
C18:0	12.21 ± 0.04	11.83 ± 0.06	11.27 ± 0.03	8.50 ± 0.32	10.71 ± 0.19	9.20 ± 0.02	9.64 ± 0.09
C18:1n-9	23.64 ± 0.12	27.20 ± 0.54	24.59 ± 0.53	26.46 ± 0.55	24.53 ± 0.84	26.58 ± 0.19	23.80 ± 0.13
C18:2n-6	1.95 ± 0.05	3.30 ± 0.01	2.30 ± 0.03	3.09 ± 0.09	2.53 ± 0.43	3.36 ± 0.10	2.23 ± 0.17
C18:2n-6*	0.46 ± 0.01	0.79 ± 0.05	0.56 ± 0.01	0.88 ± 0.13	0.76 ± 0.20	0.95 ± 0.10	0.35 ± 0.04
C18:3n-3	0.77 ± 0.00	0.80 ± 0.03	0.73 ± 0.00	0.94 ± 0.02	0.74 ± 0.06	0.47 ± 0.09	0.68 ± 0.02
C18:3n-6	0.89 ± 0.01	0.26 ± 0.01	0.79 ± 0.01	0.53 ± 0.00	0.37 ± 0.07	0.89 ± 0.01	0.85 ± 0.02
C20:0	0.18 ± 0.00	0.19 ± 0.01	nd**	0.29 ± 0.02	0.16 ± 0.00	nd	0.27 ± 0.09
Others	1.56 ± 0.01	1.10 ± 0.04	2.49 ± 0.01	4.08 ± 0.01	3.32 ± 0.01	3.89 ± 0.01	2.45 ± 0.05

*: (CLA, all isomers). nd: not detected

Table 3. Continued.

Fatty Acid	Cheese Samples					
	8	9	10	11	12	13
C4:0	1.09 ± 0.13	0.94 ± 0.06	0.88 ± 0.00	1.09 ± 0.16	0.85 ± 0.01	1.08 ± 0.14
C6:0	1.02 ± 0.00	1.45 ± 0.03	1.15 ± 0.00	1.13 ± 0.02	1.12 ± 0.00	0.93 ± 0.01
C7:0	0.01 ± 0.00	0.00 ± 0.00	0.02 ± 0.00	0.02 ± 0.00	0.02 ± 0.00	0.01 ± 0.00
C8:0	1.77 ± 0.00	2.53 ± 0.06	1.98 ± 0.01	1.69 ± 0.04	1.67 ± 0.03	1.31 ± 0.02
C9:0	0.03 ± 0.00	0.04 ± 0.00	0.04 ± 0.00	0.03 ± 0.01	0.01 ± 0.00	0.03 ± 0.01
C10:0	6.05 ± 0.05	8.80 ± 0.13	7.04 ± 0.19	6.25 ± 0.55	5.50 ± 0.05	4.50 ± 0.05
C11:0	0.19 ± 0.01	0.20 ± 0.00	0.06 ± 0.00	0.05 ± 0.00	0.07 ± 0.00	0.27 ± 0.01
C12:0	3.02 ± 0.01	3.81 ± 0.10	3.69 ± 0.03	3.53 ± 0.06	4.18 ± 0.05	3.20 ± 0.04
C14:0	9.23 ± 0.14	9.43 ± 0.19	9.83 ± 0.12	9.95 ± 0.15	10.99 ± 0.15	10.18 ± 0.08
C14:1n-5	0.33 ± 0.00	0.42 ± 0.01	0.42 ± 0.00	0.61 ± 0.04	0.72 ± 0.01	0.89 ± 0.06
C15:0	1.38 ± 0.35	1.12 ± 0.02	1.05 ± 0.01	1.16 ± 0.02	1.08 ± 0.01	1.05 ± 0.01
C15:1n-5 (cis)	0.09 ± 0.00	0.11 ± 0.00	0.08 ± 0.01	0.07 ± 0.02	0.24 ± 0.02	0.06 ± 0.00
C16:0	29.31 ± 0.04	30.46 ± 0.66	29.17 ± 0.41	28.37 ± 0.50	30.02 ± 0.82	36.26 ± 0.60
C16:1n-7	1.66 ± 0.04	1.29 ± 0.21	2.55 ± 0.01	1.58 ± 0.28	1.80 ± 0.00	2.26 ± 0.21
C17:0	0.83 ± 0.01	0.83 ± 0.01	0.64 ± 0.05	0.67 ± 0.02	0.49 ± 0.01	0.51 ± 0.05
C17:1n-7	0.35 ± 0.04	0.27 ± 0.02	0.35 ± 0.01	0.39 ± 0.01	0.53 ± 0.09	0.03 ± 0.08
C18:0	10.95 ± 0.24	11.43 ± 0.19	10.24 ± 0.01	11.68 ± 0.02	9.99 ± 0.02	8.54 ± 0.01
C18:1n-9	26.97 ± 0.17	21.06 ± 0.59	24.72 ± 0.74	23.52 ± 0.54	24.22 ± 0.46	21.80 ± 0.17
C18:2n-6	2.25 ± 0.28	1.43 ± 0.00	2.68 ± 0.04	3.02 ± 0.04	3.26 ± 0.42	1.51 ± 0.03
C18:2n-6*	0.11 ± 0.12	0.36 ± 0.01	0.23 ± 0.01	0.24 ± 0.04	0.53 ± 0.02	1.06 ± 0.17
C18:3n-3	0.77 ± 0.02	0.64 ± 0.02	0.72 ± 0.02	0.82 ± 0.01	0.26 ± 0.02	0.53 ± 0.00
C18:3n-6	1.07 ± 0.03	1.13 ± 0.03	0.95 ± 0.08	1.13 ± 0.12	0.74 ± 0.03	0.62 ± 0.01
C20:0	0.25 ± 0.03	0.13 ± 0.08	0.30 ± 0.11	0.35 ± 0.10	0.32 ± 0.10	0.33 ± 0.05
Others	1.27 ± 0.02	2.12 ± 0.80	1.21 ± 0.03	2.65 ± 0.14	1.39 ± 0.01	3.04 ± 0.03

*: (CLA, all isomers).

Palmitic, myristic and stearic acids were the major saturated FAs in goat cheeses, which was found similar to Pietrzak-Fiećko et al. [40]. The major FA was palmitic acid while the major unsaturated FA was oleic acid in cheeses studied. Similar FA compositions were also found in different cow's milk cheese types [41], and in fresh and semi-hard goat cheeses [5].

Alonso et al. [38] found that the five major FAs in goat's milk were palmitic, oleic, capric, myristic and stearic acids. They reported that the presence of capric and caprylic acids in goat milk was 2.7% and 9.9%, respectively, and the ratio of lauric (C12:0) to capric (C10:0) acid in goat cheeses was 0.56 while it

was 1.14 in cow cheeses. As a characteristic property, the ratio of lauric/capric acids in goat milk is <0.5 while it is >1 in cow and sheep milk. Thus, the ratio of lauric/capric acids can be used as a significant indicator for the detection of milk falsification [42]. In this present study, the ratio of lauric/capric acids was lower than 0.78 for all cheese samples (Table 4). Lower ratios of lauric/capric acids (≤0.78) could be related with a high goat milk ratio (≥50%) in the production of cheeses.

Table 4. Conjugated linoleic acid contents of cheeses and the ratio of lauric to capric acids (C12:0/C10:0) in fat samples extracted from cheeses.

Sample No	Cheese	Goat milk Ratio Stated on Label (%)	CLA content (mg/g fat)	CLA Content (mg/100 g of Sample)	C12:0/C10:0
1	White	60	2.67±0.07	77.43	0.54
2	Ezine	50	2.65±0.06	61.61	0.44
3	Ezine	80	2.28±0.02	60.42	0.46
4	White	60	4.70±0.09	117.50	0.78
5	Processed (Eritme)	60	1.91±0.11	47.75	0.56
6	White	95	2.17±0.05	55.88	0.68
7	Ezine	80	3.65±0.07	87.60	0.57
8	Ezine	80	4.27±0.17	98.21	0.50
9	Süzme/Feta type*	100	2.10±0.00	46.20	0.43
10	White	70	4.83±0.09	126.79	0.52
11	Ezine	50	1.79±0.27	47.88	0.56
12	Kashar, Fresh	90	3.10±0.11	85.25	0.76
13	Kashar, Ripened	90	2.25±0.00	63.00	0.71

*: Produced by ultrafiltration (UF).

3.3 CLA Contents of cheeses

The CLA contents of cheese samples ranged from 1.79 to 4.83 mg/g fat (Table 4). The highest CLA content was determined in a white cheese (sample number 10) containing a mixture of 70% goat milk and 30% cow milk while the lowest was detected in an Ezine cheese (sample number 11) with a mixture of goat (50%), sheep (45%) and cow milk (5%). An increase in goat milk ratio used in cheese production did not result in any increase in the CLA content of cheeses (Table 4).

Prandini et al. [43] reported that goat cheese samples (n=8) contain 4.29±1.78 mg/g fat (1.22±0.49 mg/g sample) cis-9, trans-11 CLA. Eleven cheese samples in this present study had a lower CLA content than those reported by Prandini et al. [43] (Table 4). Cossignani et al. [5] reported that mean CLA contents of fresh and semi-hard goat cheeses produced in Italy were 5.3±1.5 and 7.4±4.9 mg/g fat, respectively, which were higher than the values of this present study. In general, the CLA content of goat cheese samples in this study was lower than that of cow milk samples reported by Shantha et al. [44], Jiang et al. [45] and Ma et al. [46]. Jahreis et al. [47] reported that sheep and cow milk has higher CLA concentration than goat milk, which could explain the results of this present study.

Several factors such as origin of raw milk, seasonal variations, feeding differences, production and ripening conditions of dairy products may primarily influence the CLA contents of dairy products [48], [49]. Differences in the CLA contents among cheeses in this study could be explained by differences in raw materials used in the production (milk type and ratio, location, season, animal nutrition etc.) and processing and ripening conditions used in the production of different cheese types.

To evaluate the CLA contribution of cheese samples to human diet, the CLA contents were also expressed as mg per 100g of product (Table 4). Estimated required daily intake of potential health benefits of CLA was reported as 700-800 mg/day/70 kg body weight [50], and estimated CLA intake of different populations (except Australia) was stated between 95 (Canada) and 452 mg/day (Germany) [51]. Results indicated that white cheese samples (sample 4 and 10) with the highest CLA contents as mg/100 g of sample might have a significant potential for the contribution of CLA intake by consumers.

4 Conclusions

Results indicated that all cheese types had a similar FA profile. The major short- and medium-chain FAs in all cheese samples were butyric, caproic and caprylic acids. The long chain FAs in all cheese samples in a decreasing order included palmitic, oleic, myristic, stearic, lauric, linoleic and palmitoleic acids. The major saturated FAs in cheeses were palmitic, myristic and stearic acids. The major FA in cheeses was palmitic acid while the major unsaturated FA was oleic acid. The ratio of lauric to capric acids was lower than 0.78 in all cheese samples. The range of the total CLA contents was 1.79 to 4.83 mg/g fat in cheese samples. Especially two white cheese samples (60 and 70% goat milk used in the production, respectively) with the CLA contents of 117.50 and 126.79 mg/100 g of sample might significantly contribute to the daily CLA intake for regular consumers.

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6 Author contributions

Oğuz GÜRİSOY supervised the overall experimental design, carried out the literature search, and wrote the manuscript with Yusuf YILMAZ. Rabia FAKI, Kübra KOCATÜRK and Gamze ESGİN collaborated in the collection of cheese samples and performed all chemical analyses. Rabia FAKI, Kübra KOCATÜRK and Yusuf YILMAZ processed the data and performed the statistical analysis. Final manuscript was read and approved by all authors.

7 Ethics committee approval and conflict of interest

There is no need to obtain permission from the ethics committee for the article. We declare no conflict of interest.

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