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Research Article

Determination of the Physicochemical Properties and Fatty Acid Composition of Some Cheese Types with Geographical Indication in Thrace Region

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Abstract: The purpose of the present investigation was to assess the differences in the quality characteristics of the famous cheese types produced in Thrace region and labeled with a geographical indication or not. The different physicochemical properties, mineral content, and fatty acid composition of Ezine Cheese and Edirne Feta Cheese, and Malkara Aged Kaşar Cheese with geographical indication were determined. The obtained data were compared with some of the physicochemical specifications stated in the geographical indication registration documents and also with the cheese types of the same category but without the geographical indication. For this purpose, 90 cheese samples from 23 different local producers in Edirne, Tekirdağ, Çanakkale, and Kırklareli were supplied in sealed packages. Dry matter (%), ash (%), salt (%), protein (%), titratable acidity (% lactic acid), acid count (mg KOH/g fat), color (L, a, b) values were determined. Additionally, fatty acid compositions and some mineral contents of the cheese were analyzed by using gas-chromatography and inductively coupled plasma-optic emission spectrometry (ICP-OES). This study aims to contribute to registration documents of geographical indication, which cover the characteristic specifications, including fatty acid composition, protein amount, acid count (free fat acidity), and color (L*, a*, b*) values. It is advised to revise the registration documents of the mentioned cheese types by including aroma-active components to the aroma characterization and texture specifications to the characteristic features through a broader study.

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1. Introduction

Due to its geographical location, Turkey is a country where not only agricultural and animal product range is wide but also a rich cuisine culture is developed as a result of multi-cultural communities coming together. Cultural richness has a significant effect on traditional food products throughout the country (Kantaroglu and Demirbas, 2018). In order to protect this rich local heritage, registration procedures and application of geographical indications are currently handled by the Turkish Patent and Trademark Office. The purpose of the geographical indication and traditional specialty is to

protect both the product and its production method. Consumers may prefer products associated with a regional identity compared to any other product relying on their trust in the related region. Therefore, geographical indication or traditional specialty both have a major contribution in protecting the regional identifications that have become a symbol of a certain level of quality. , The geographical indication concept is being used to name products that owe their quality and fame to a certain geographical region (Saygin Alparslan and Demirbas, 2019). Types of geographical indications are "protected designation of origin" (PDO) and "geographical indication" (GI). In our country, local food products protected under geographical indication display the existence of a production potential which is very important for the national economy (Kantaroglu and Demirbas, 2018).

There are 688 registered (geographically indicated) products in Turkey. Additionally, there are 716 more products that are still under process. As far as the geographical indication is concerned, 62.3% of them have GI, and 37.2% of PDO. Furthermore, a traditional specialty is used for 0.5% of the products. In this respect, there were 427 products with GI, 255 with PDO, and 6 with a traditional specialty by the end of 2020. When the proportional distribution of geographical indication over product groups is considered, cheese occupies 3.1% with a quantity of 21. On the other hand, dairy products other than cheese and butter have a rate of 0.9% with a quantity of 6 (Turk patent, 2021). Definition of cheese with GI are listed in the definitions section of the Turkish Food Codex Cheese declaration (Anonymous, 2015). Accordingly, it is defined as the cheese which is registered after their production region, method, and characteristic specifications are certified by relevant national or international institutions.

Although there is a huge capacity of cheese production by industrial and classical methods, registered Ezine cheese (PDO), Edirne Feta Cheese (GI), and Malkara Aged Kaşar Cheese (PDO) are also produced in Thrace region, which carries significant potential in terms of dairy products. Determination of some distinguishing physicochemical specifications of the mentioned products with a further display of nutrition specifications like mineral content and fatty acid composition, determination of whether they have been produced according to the technical specifications covered in the registration, and comparison of specifications with the unregistered cheese types of the same group, all show the importance of the study. Some physicochemical properties of the mentioned cheese types with GI were studied through this study, thus displaying their characteristic value and contributing to the geographical indication protection by means of scientific data.

2. Material and Methods

In this study, samples were supplied in sealed packages from 23 different producers. Among these, Ezine Cheese, Edirne Feta Cheese, and Malkara Aged Kaşar Cheese samples with GI carrying diverse maturity time and milk type as declared on their label, were supplied from the authorized producers in their own region, whereas aged kaşar samples without GI and cheese stated as Ezine Cheese and Edirne Feta Cheese on their label were supplied from producers in Edirne, Tekirdağ, Çanakkale, and Kırklareli. The contact information of the companies authorized with GI registration was provided by Edirne Chamber of Commerce and Industry, Çanakkale Commodity Exchange, Ezine Cheese, and Dairy Farmer Protection, Development and Promotion Association, Malkara Chamber of Commerce and Industry, and related institutions of Ministry of Agriculture and Forestry. Special attention was paid during sampling to make sure that labels had logos and certification numbers on them. The related cheese samples were then divided into 6 groups as such: 6 samples with geographical indication named as ÇC1-6 (PDO), 6 without geographical indication but carrying Ezine cheese statement on the label named Ç1-6; 5 samples with geographical indication named as EC1-5 (GI), 7 without geographical indication named E1-7 but carrying Edirne feta cheese statement on the label; 2 samples of Malkara Aged Kaşar Cheese samples with geographical indication shoved as MC1-2 (PDO), 4 aged kaşar cheese without geographical indication showed as M1-4. Sampling was performed on a triplicate basis. 1 kg samples of each cheese type were provided during the study, using 90 samples in total. Cheese samples have been supplied during the April 2020 – October 2020 time interval. Cheese samples were provided in their original packages.

Physicochemical analysis and fatty acid composition determination methods applied to the samples are referred to below. Dry matter content (AOAC, 1990), ash content (AOAC, 1990), titratable acidity (lactic acid %) (AOAC, 1990), pH (AOAC, 1990), color analysis (Bhale et al., 2003), salt content

(Bradley et al., 1992), fat content with Gerber method (Anonymous, 2008), acid count (Renner, 1993), protein content with Kjeldahl method (AOAC, 1990) were performed. Mineral content analysis (Bakircioglu et al., 2011) and fat extraction method (Folch et al., 1956) were done according to described methods.

First, fat extraction was performed in order to do the fatty acid composition analysis for the cheese samples. Later, the obtained fat samples were transformed into methyl ester forms and processed for composition analysis with GC-FID. Fatty acids were determined by comparing the retention time of 37 FAME standard solution (Nu-Check-Prep, Inc., Elysian, MN, USA; Supelco, Inc., Bellefonte, PA, USA). The esterification of extracted fat samples for chromatographic analysis was done by acid-base methylation method. 2 mL sodium methoxy was added to 100 µL of the sample. The sample was then mixed with vortex for 2 minutes, followed by a 50°C hot water bath for 10 minutes. Later, 1 mL 14% boron trifluoride was added to the sample, which was once again mixed with vortex for 2 minutes and followed by 50°C hot water bath for 10 minutes. The sample was then vortexed again after adding 5 mL distilled water and vortexed once more after adding 5 mL hexane. A phase separation in the tube was observed. The obtained upper phase was transferred to an amber-colored vial filtered by a 0,45 µm syringe and kept at 20°C until the analysis (Özer et al., 2016).

All the obtained data are displayed as average ± standard deviation. The data was assessed by using one-way analyses of variance method (One-way ANOVA) through JMP statistical software (version 5.0.1.a SAS Institute. Inc. Cary, NC, USA). In cases where a statistically significant difference was observed between the sample means, multiple comparison was done by using Tukey test. Significance level (α value) was determined as 0.05 in all statistical assessments. The significance level between the mean data was given as a letter system in the tables. In order to obtain accurate results, every analysis and sampling was performed on a triplicate basis.

3. Results and Discussion

The results of proximate analysis for cheese samples were shown in Table 1. Dry matter content (%) of Malkara Aged Kaşar Cheese, Ezine Cheese, and Edirne Feta Cheese products with geographical indication complied with the values given in the related registration documents and were higher than the other cheese types without the geographical indication in the same type of cheese. Ash content (%) of Malkara Aged Kaşar Cheese, Ezine Cheese, and Edirne Feta Cheese products were higher than the other cheese types without the geographical indication in the same product group. However, this difference was statistically significant ($p<0.05$) only for Edirne Feta Cheese with geographical indication. There were no defined criteria for ash content % in registration documents and related notifications.

The average salt content % of the dry material of all the studied cheese types were within the value range given in the registration documents of the cheese with geographical indication except Malkara Aged Kaşar Cheese with PDO. Furthermore, it was observed that all cheese types, except Malkara Aged Kaşar Cheese with PDO, displayed variability within their product group in terms of salt % and salt in dry matter content % ($p<0.05$) (Turk patent, 2007,2017,2020).

Table 1. Physicochemical analysis of all cheese samples

Sample	Code	% Dry matter	% Ash	% Salt	% Salt in dry matter	% Fatty	% Fatty in dry matter	% Protein	Titratable acidity (lactic acid %)	pH	Acid number
Malkara aged Kaşar Cheese with PDO	MC1	65.99±0.05 b	3.84±0.13 a	3.84±0.13 a	5.91±0.08 a	29.8±0.35 b	48.2± 0.28 b	31.82±0.22 b	0.8±0.05 b	4.91±0.00 b	2.38±0.02 b
	MC2	71.85±0.49 a	3.91±0.10 a	3.91±0.10 a	6.15±0.07 a	33.8±0.49 a	54.07± 0.24 a	33.20±0.02 a	0.93±0.03 a	5.77±0.00 a	2.83±0.02 a
Malkara aged Kaşar Cheese	M1	61.18±0.11 d	2.79±0.16 c	2.79±0.16 c	4.21±0.15 d	25.6±0.70 a,b	42.30± 0.28 c	31.46±0.00 a	0.72±0.07 c	5.10±0.01 c	2.45±0.06 c
	M2	62.90±0.07 b	3.46±0.32 a,b	3.46±0.32 a,b	6.10±0.14 b	26.2±0.56 a,b	47.50± 0.42 b	32.11±0.36 a	0.7±0.06 c	5.49±0.01 a	2.39±0.06 c
	M3	61.48±0.04 c	3.10±0.04 b,c	3.10±0.04 b,c	5.12±0.02 c	24.8±0.42 b	40.45± 0.05 d	32.29±0.56 a	0.92±0.02 b	5.39±0.01 b	2.75±0.06 b
	M4	65.63±0.04 a	3.68±0.16 a	3.68±0.16 a	6.73±0.04 a	28.1±0.77 a	52.05± 0.42 a	31.92±0.24 a	1.15±0.07a	4.86±0.00 d	3.46±0.02 a
Ezine Cheese with PDO	ÇC1	56.95±0.07 c	5.62±0.24 a	4.69±0.03 a	6.69±0.01 a	28.4±0.21 c	51.2±0.07 c,d	22.87±0.06 b,c	1.29± 0.07 a	4.4±0.00 f	2.92±0.03 a,b
	ÇC2	63.81±0.08 a	5.36±0.02 a,b	4.45±0.05 a,b	6.30±0.07 b	33.7±0.28 a,b	54.75±0.16 b,c	24.03±0.17 a,b	1.17±0.07 a	4.62±0.00 d	2.2±0.01 b,c
	ÇC3	59.15±0.21 b	4.84±0.02 b,c	4.27±0.2 b,c	6.11±0.02 b	28.5±0.56 c	48.3±0.12 d,e	25.18±0.34 a	0.97±0.03 b	4.82±0.01 b	2.9±0.04 b
	ÇC4	55.37±0.09 d	4.69±0.26 c,d	3.77±0.05 d	5.32±0.02 d	28.1±0.28 c	44.2±0.05 e	22.29±0.61 c	0.99±0.07 b	4.54±0.00 e	2.28±0.05 b,c
	ÇC5	59.21±0.15 b	4.32±0.04 c,d	3.91±0.16 c,d	5.78±0.14 c	31.8±0.98 b	58.52±1.05 a,b	22.69±0.14 c	0.94±0.05 b	4.98±0.00 a	1.92±0.09 c
	ÇC6	59.15±021 b	4.23±0.02 d	3.92±0.19 c,d	5.79±0.02 c	34.1±0.14 a	62.77±1.41a	20.21±0.21 d	0.95±0.03 b	4.72±0.05 c	3.66±0.13 a
Ezine Cheese	Ç1	50.72±0.16 c	5.26±0.05 a	4.94±0.08 a	7.10±0.01 a	23.5±0.63 c	36.8±0.08 c	21.78±0.04 b	1.18±0.03 a	4.86±0.01 b	3.03±0.11 a,b
	Ç2	50.01±0.72 c	4.21±0.02 c	3.15±0.12 c	5.23±0.04 d	24.8±0.42 b,c	39.72±0.25 b,c	20.19±0.04 c	0.92±0.05 b,c	4.58±0.02 d	2.68±0.09 a,b
	Ç3	53.14±0.04 b	4.77±0.02 b	4.01±0.11 b	6.22±0.38 b	26.6±0.63 a,b	44.28±0.04 a,b	21.54±0.26 b	1.07±0.05 b	4.94±0.00 a	2.37±0.09 b
	Ç4	50.56±0.08 c	3.77±0.02 d	2.95±0.10 c	4.94±0.22 e	26.4±0.49 a,b	45.47±0.02 a,b	19.87±0.21 c	0.77±0.09 c,d	4.7±0.00 c	2.23±0.03 b
	Ç5	55.60±0.14 a	3.67±0.02 d	3.04±0.35 c	5.15±0.18 d	27.6±0.21 a	43.4±0.11 a,b	23.66±0.09 a	0.65±0.02 d	4.63±0.05 c,d	2.23±0.04 b
	Ç6	53.08±0.11 b	4.65±0.04 b	3.85±0.06 b	5.66±0.07 d	25.9±0.56 a,b	47.02±0.04 a	21.69±0.45 b	1±0.03 b	4.18±0.01 e	3.48±0.55 a
Edirne Feta Cheese with GI	EC1	60.23±0.04 c	5.23±0.04 a	4.78±0.24 a	6.95±0.04 a	31.4±1.27 a,b	52.25±0.47 a	23.21±0.16 a,b	1.23±0.05 a	4.46±0.01 c	3.65±0.03 a,b
	EC2	56.04±0.05 d	3.72±0.08 c	3.29±0.16 b	5.15±0.14 b	29.25±0.49 b	44.9±0.77 a	22.73±0.37 b	0.62±0.01 a	4.5±0.01 c	1.78±0.049 d
	EC3	60.91±0.15 b	4.51±0.09 b	4.12±0.18 a	7.05±0.77 a	32.4±0.21 a	57.2±3.28 a	23.66±0.55 a,b	1.1±0.05 a	4.63±0.00 b	3.8±0.07 a
	EC4	60.81±0.08 b	4.05±0.21 b,c	3.23±0.11 b	5.66±0.28 a,b	32±0.77 a,b	56.35±2.13 a	24.09±0.07 a	0.87±0.07 b	4.76±0.00 a	2.51±0.02 c
	EC5	63.21±0.15 a	5.18±0.11 a	4.40±0.50 a	6.26±0.05 a,b	33.7±0.14 a	54.2±1.30 a	24.24±0.12 a	1.25±0.05 c	4.63±0.05b	3.53±0.03 b
Edirne Feta Cheese	E1	51.09±0.11 d	3.76±0.02 b	3.08±0.21 c	5.42±0.02 d,e	24.7±0.21 b,c	43.24±1.12 b	22.41±0.14 b	0.68±0.06 a	4.54±0.01 e	2.14±0.04 c
	E2	51.91±0.14 c	3.94±0.05 b	3.46±0.21 b,c	5.83±0.04 b,c	25.9±0.21 b	48.1±0.4 a	21.73±0.14 b	0.95±0.05 a	4.51±0.01 e	3.32±0.11 a
	E3	51.02±0.02 d	3.76±0.01 b	3.19±0.13 b,c	5.55±0.05 c,d	23.9±0.35 c	43.11±0.85 b	22.81±0.07 b	0.73±0.07 a	4.74±0.00 c	1.69±0.10 d
	E4	52.90±0.07 b	3.85±0.00 b	3.35±0.22 b,c	5.13±0.04 e	25.9±0.56 b	41.29±0.26 b	22.49±0.10 b	0.93±0.07 a	5.3±0.02 a	2.87±0.03 b
	E5	50.01±0.01 e	3.74±0.07 b	3.29±0.28 b,c	5.87±0.09 b	24.8±0.42 b,c	42.2±0.62 b	20.57±0.04 c	0.66±0.01 b	4.51±0.01 e	1.93±0.04 c,d
	E6	56.92±0.02 a	4.46±0.15 a	3.70±0.14 a,b	6.10±0.12 b	27.6±0.07 a	45.99±1.52 a	24.52±0.16 a	0.98±0.05 b	4.67±0.00 d	3.56±0.07 a
	E7	57.12±0.02 a	4.45±0.06 a	4.01±0.27 a	7.18±0.10 a	27.45±0.21 a	47.58±0.77 a	25.02±0.69 a	1.05±0.05 b	5.07±0.02 b	3.28±0.04 a

a,b,c,d,e,f (↓) Within each type of cheese group, the values indicated by different letters in each column are statistically different from each other at the $p<0.05$ level.

Average fat content % in dry matter of Malkara Aged Kaşar Cheese, Ezine Cheese and Edirne Feta Cheese products with the geographical indication complied with the values given in the related registration documents and were higher than the other cheese types without the geographical indication in the same product group as seen in Table 1. However, this difference is statistically significant ($p<0.05$) only for Ezine Cheese and Edirne Feta Cheese with geographical indication. There were no defined criteria for protein content % in registration documents and related notifications (Turk patent, 2007; 2017; 2020).

Average protein content % in dry matter of Malkara Aged Kaşar Cheese, Ezine Cheese, and Edirne Feta Cheese products with the geographical indication were higher than the other cheese types without the geographical indication in the same product group. However, this difference was statistically significant ($p<0.05$) only for Ezine Cheese with the geographical indication (Table 1).

Titratable acidity rate (% lactic acid) of Malkara Aged Kaşar Cheese was the same as the other aged kaşar (matured) cheese. However, Ezine Cheese and Edirne Feta Cheese products with the geographical indication showed a statically significant difference ($p<0.05$) when compared with the other cheese types without the geographical indication in the same product group. On the other hand, in terms of pH values, only Edirne Feta Cheese with geographical indication indicated a statically significant difference ($p<0.05$) when compared with the other cheese types without the geographical indication in the same product group. As far as pH values of registered products were concerned, it can be stated that a sufficient amount of acidity development has been achieved for securing food safety. In this case, lowering the acidity values might be considered beneficial, bearing in mind that the acidity values stated in the registration may lead to a sourer perception of Edirne Cheese hence creating an unfavorable condition for the product in general. Likewise, the incompliance of all values with the registration criteria supported the idea that consumers may lead the producers in this direction.

Acid count (mg KOH/g fat) average values of Malkara Aged Kaşar Cheese and Ezine Cheese with geographical indication were lower compared to other cheese types without the geographical indication in the same product group, but it was higher for Edirne Feta Cheese (Table 1). Nevertheless, the mentioned differences were not statically significant ($p>0.05$). Additionally, acidity (mg KOH/g fat) has shown variabilities within the all-cheese groups. There are no defined criteria for acid count/free fatty acidity value in the registration documents of the mentioned cheeses.

The fatty acid compositions of all type of cheese mentioned in this study were shown in Table 2 (Malkara aged cheddar cheese), Table 3 (Ezine cheese), and Table 4 (Edirne Feta cheese samples). A significant amount of lauric (C12:0), myristic (C14:0), palmitic (C16:0), and stearic (C18:0) acids exist in the saturated fatty acids group. Oleic acid (C18:1) rate within the unsaturated fatty acids group was quite high compared to other unsaturated fatty acids, among which palmitoleic (C16:1), linoleic (C18:2), and linolenic (C18:3) acids occupied a significant place as unsaturated fatty acids. When cheeses were compared on the basis of having geographical indication or not, significant differences ($p<0.05$) between lauric acid rates among Malkara Aged Kaşar Cheese and other kaşar cheese, 5 important fatty acid rates (caprylic, capric, myristic, stearic and oleic acid) among Ezine cheeses and 5 important fatty acid rates (butyric, caprylic, capric, lauric and linolenic acids) among Edirne cheeses were determined.

Regarding Malkara aged kaşar cheese, there was not a significant difference between the fatty acid profile of samples with PDO and without PDO except for lauric acid and palmitoleic acid. The lauric acid content of the Malkara, aged kaşar cheese with PDO was higher than the cheese sample without PDO. However, the palmitoleic acid was lower in the cheese with PDO than the cheese sample without PDO. For Ezine cheese samples, there were statistically significant differences in saturated and unsaturated fatty acids. The saturated fatty acids of Ezine cheese with PDO was 70.03 %, while it was 68.49 % for Ezine cheese without PDO. Anyhow, the polyunsaturated fatty acid profile of both cheese samples with and without PDO was not significantly different. When Edirne feta cheese samples were examined, there was no significant difference in the saturated and unsaturated fatty acids, but the polyunsaturated fatty acids in cheese without GI was higher than in cheese with GI.

Table 2. Comparison of mean fatty acid compositions (%) of Malkara aged kaşar cheese with PDO and other aged cheddar cheese (ripened) cheese samples without PDO

FATTY ACIDS (%)	with PDO	without PDO
	AVERAGE (%)	AVERAGE (%)
Butyric acid (C4:0)	2.17±0.01 a	2.21±0.04 a
Caproic acid (C6:0)	1.90±0.25 a	1.84±0.16 a
Caprylic acid (C8:0)	1.68±0.11 a	1.56±0.24 a
Capric acid (C10:0)	4.80±0.31 a	4.35±0.86 a
Lauric acid (C12:0)	3.58±0.08 a	3.35±0.13 b
Myristic acid (C14:0)	11.26±0.45 a	11.31±0.12 a
Palmitic acid (C16:0)	30.70±0.77 a	31.27±0.81 a
Palmitoleic acid (C16:1)	1.18±0.03 a	1.30±0.26 b
Stearic acid (C18:0)	12.82±0.47 a	13.22±0.43 a
Oleic acid (C18:1)	23.12±0.10 a	22.87±0.43 a
Linoleic acid (C18:2)	2.38±0.05 a	2,35±0.05 a
Linolenic acid (C18:3)	0.56±0.04 a	0.49±0.13a
Total saturated fatty acids Σ SFA	71.46±0.24 a	71.56±0.16 a
Total unsaturated fatty acids Σ UFA	28.55± 0.24 a	28.44±0.31 a
Monounsaturated fatty acids Σ MUFA	25.34±0.11 a	25.31±0.20 a
Polyunsaturated fatty acids ΣPUFA	3.2±0.33 a	3.13±0.09 a

a,b (→) The values shown with different letters in each row are statistically different from each other at the $p<0.05$ level.

Table 3. Comparison of mean fatty acid compositions (%) of Ezine cheese samples with PDO and without PDO

FATTY ACIDS (%)	with PDO	Without PDO
	AVERAGE (%)	AVERAGE (%)
Butyric acid (C4:0)	2.32±0.37 a	2.35±0.18 a
Caproic acid (C6:0)	1.94±0,22 a	1.88±0.12 a
Caprylic acid (C8:0)	1.62±0.38 a	1.27±0.08 b
Capric acid (C10:0)	4.58±1.70 a	2.99±0.22 b
Lauric acid (C12:0)	3.49±0.24 a	3.37±0.15 a
Myristic acid (C14:0)	11.23±0.55 b	11.69±0.28 a
Palmitic acid (C16:0)	30.89±1.95 a	30.70±1.80 a
Palmitoleic acid (C16:1)	1.26±0.25 a	1.36±0.23 a
Stearic acid (C18:0)	11.57±0.63 b	12.19±1.21 a
Oleic acid (C18:1)	24.32±1.60 b	25.66±1.09 a
Linoleic acid (C18:2)	2.40±0.40 a	2.50±0.14 a
Linolenic acid (C18:3)	0.39±0.22 a	0.31±0.05 a
Total saturated fatty acids Σ SFA	70.03±1.86 a	68.49±1.10 b
Total unsaturated fatty acids Σ UFA	29.97±1.86 b	31.53±1.10 a
Monounsaturated fatty acids Σ MUFA	26.79±1.85 b	28.39±0.89 a
Polyunsaturated fatty acids ΣPUFA	3.18±0.36 a	3.15±0.22 a

a,b (→) The values shown with different letters in each row are statistically different from each other at the $p<0.05$ level.

Mansson (2008) stated that the mean values of lauric, myristic, and palmitic fatty acids in cow milk are 3.30%, 10.9%, and 30.60%, respectively, in sheep milk 5.37%, 10.18%, and 22.04%, goat milk. It was determined as 7.64%, 11.94%, and 26.40% in milk. Blasi et al. (2008) 3.9% lauric acid, 13.1% myristic acid, and 31.6% palmitic acid in cow milk, 3.8% lauric acid, 8.8% myristic acid, and 23.1% palmitic acid in goat milk, they determined lauric acid 3.0%, myristic 7.0% acid and palmitic acid 19.8% in sheep milk. Caprylic fatty acid (C8:0) content in cow's milk is 1.69% (Ahmad et al., 2013), 1.4% (Mansson, 2008); 1.92% in sheep milk (Ahmad et al., 2013); In goat milk, it can vary in values of 3.66% (0.463%-9.722%) (Saroha et al., 2014). When compared with the literature studies, it was determined that the caprylic fatty acid ratios found were in line with the results of the studies. Capric fatty acid (C10:0) content in cow milk fat Ahmad et al. (2013) 2.87%, Mansson (2008) 2.7%, in sheep milk fat Ahmad et al. (2013) averaged 3.0% between 2.95% and 3.5%; an average of 6.75% in goat milk (Saroha et al., 2014), Strazalkowska et al. (2009) 6.54%, Ahmad et al. (2013) determined it as 3.01%. When compared with the literature studies, it was determined that the capric fatty acid ratios found were in line with the results of the studies.

Table 4. Comparison of average fatty acid compositions (%) of Edirne Feta cheese samples with GI and without GI

FATTY ACIDS (%)	with GI	without GI
	AVERAGE (%)	AVERAGE (%)
Butyric acid (C4:0)	2.48±0.12 a	2.16±0.33 b
Caproic acid (C6:0)	1.80±0.07 a	1.90±0.26 a
Caprylic acid (C8:0)	1.22±0.18 b	1.54±0.34 a
Capric acid (C10:0)	2.78±0.18 b	4.16±1.37 a
Lauric acid (C12:0)	3.27±0.16 b	3.56±0.40 a
Myristic acid (C14:0)	11.52±0.50 a	11.12±0.72 a
Palmitic acid (C16:0)	31.40±2.48 a	29.67±3.22 a
Palmitoleic acid (C16:1)	1.30±0.39 a	1.18±0.49 a
Stearic acid (C18:0)	12.46±1.35 a	12.19±1.31 a
Oleic acid (C18:1)	24.95±1.42 a	25.55±4.01 a
Linoleic acid (C18:2)	2.42±0.17 a	2.44±0.30 a
Linolenic acid (C18:3)	0.36±0.14 b	0.52±0.22 a
Total saturated fatty acids Σ SFA	69.41±2.23 a	68.64±3.57 a
Total unsaturated fatty acids Σ UFA	30.59±2.21 a	31.28±3.68 a
Monounsaturated fatty acids Σ MUFA	27.52±1.66 a	27.92±3.41 a
Polyunsaturated fatty acids ΣPUFA	3.07±0.86 b	3.45±0.36 a

a,b (→) The values shown with different letters in each row are statistically from each other at the $p<0.05$ level.

Na, Mg, K, Ca, P, Fe, Cu, Mn, Zn, and Al mineral materials of all cheese samples were determined by ICP-OES and shown in Table 5-6. When determined mineral content of the samples was compared on the basis of having geographical indication or not, a significant difference ($p<0.05$) was found only in the Mn amount of Edirne Feta Cheese and K, P, and Zn amount of Ezine Cheese. On the other hand, when Malkara Aged Kaşar Cheese with geographical indication was compared with other aged kaşar (matured) cheese, a significant difference ($p<0.05$) was found in the mineral amounts except for K, Cu, and A1.

Table 5. Average mineral composition of Malkara aged kaşar cheese with PDO and other aged cheddar cheese (ripened) cheese samples without PDO (mg/100g)

MINERAL	with PDO	without PDO
Na	2316.63±223.21 b	2653.92±95.35 a
Mg	50.87±5.85 b	56.72±3.16 a
K	298.138±42.96 a	304.36±35.22 a
Ca	1243,43±145.89 b	1380.74±102.08 a
P	1081.64±61.84 b	1217.57±72.77 a
Fe	0.364±0.05 b	0.498±0.14 a
Cu	0.089±0.01 a	0.079±0.01 a
Mn	0.047±0.02 a	0.014±0.00 b
Zn	6.29±0.45 b	7.27±0.63 a
Al	0.526±0.07 a	0.573±0.22 a

a,b(→)The values shown with different letters in each row are statistically from each other at the $p<0.05$ level.

Table 6. Average mineral composition of Ezine cheese samples (mg/100g)

MINERAL	with PDO	without PDO
Na	3851.45±1329.49 a	3743.51±986.76 a
Mg	50.43±5.31 a	50.55±12.49 a
K	289.26±26.39 a	258.13±44.79 b
Ca	1166.27±99.45 a	1046.32±222.07 a
P	970.12±86.64 a	852.97±147.60 b
Fe	0.680±0.45 a	1.124±1.00 a
Cu	0.074±0.01 a	0.087±0.02 a
Mn	0.015±0.01 a	0.027±0.02 a
Zn	6.15±0.65 a	4.94±1.30 b
Al	0.650±0.71 a	0.645±0.05 a

a,b (→)The values shown with different letters in each line are different from each other at the $p<0.05$ level.

Table 7. Average mineral composition of Edirne white cheese samples (mg/100g)

MINERAL	with GI	without GI
Na	3188.16±331.59 a	3225.55±444.405 a
Mg	42.21±6.91 a	44.35±4.19 a
K	265.38±37.21 a	268.89±34.44 a
Ca	1027.04±265.49 a	988.91±131.73 a
P	883.45±153.86 a	828.10±86.38 a
Fe	0.579±0.43 a	1.043±1.28 a
Cu	0.076±0.01 a	0.090±0.02 a
Mn	0.033±0.01 a	0.016±0.02 b
Zn	5.19±0.75 a	4.99±0.64 a
Al	0.672±0.2 a	0.687±0.11 a

a,b (→)The values shown with different letters in each line are different from each other at the p<0.05 level.

Table 8. Color values of cheese samples

CODE	L*	a*	b*
MC1	80.16±0.34 a	- 1.87±0.06 a	19.07±0.27 b
MC2	76.38±0.83 b	-1.81±0.02 a	20.56±0.60 a
mean	78.27±2.08 A	-1.84±0.05 A	19.82±0.89 A
M1	69.98±0.30 c	0.61±0.02 a	25.84±1.11 a
M2	70.87±0.32 b,c	-1.59±0.00 c	19.59±0.38 c
M3	72.55±1.41 a,b	-2.59±0.07 d	15.98±1.17 d
M4	73.10±1.72 a	-1.14±0.01 b	23.90±0.03 b
mean	71.63±1.66 B	-1.18±1.19 A	21.34±4.00 A
ÇC1	83.90±0.24 b	1.12±0.01 a	15.29±0.18 b
ÇC2	83.84±1.28 b	- 1.17±0,10 d	11.71±0.77 e
ÇC3	81.25±0.11 c	1.21±0.00 a	18.04±0.02 a
ÇC4	84.61±0.11 b	0.10±0.00 b	15.72±0.07 b
ÇC5	88.47±0.36 a	- 0.30±0.03 c	14.09±0.28 c
ÇC6	67.55±0.20 d	- 0.20±0.07c	12.83±0.29 d
mean	81.60±6.76 A	0.12±0.84 A	14.62±2.10 A
Ç1	85.07±0.14 b	- 0.95±0.00 e	14.94±0.01 a
Ç2	87.78±0.92 a	0.22±0.03 b	12.68±0.48 c
Ç3	79.18±0.31 d	- 1.64±0.00 f	15.49±0.54 a
Ç4	84.09±0.39 b	0.16±0.02 c	10.27±0.21 d
Ç5	84.70±0.39 b	0.78±0.00 a	15.38±0.04 a
Ç6	82.58±0.55 c	- 0.29±0.03 d	13.84±0.11 b
mean	83.90±2.70 A	- 0.29±0.82 B	13.77±1.89 A
EC1	85.40±1.59 b	- 0.32±0.02 d	8.23±0.54 e
EC2	87.68±0.89 a	0.59±0.03 a	12.54±0.14 c
EC3	84.20±0.85 b	- 0.17±0.11 c	9.28±0.39 d
EC4	87.54±0.99 a	0.47±0.06 b	14.05±0.76 b
EC5	85.95±0.12 a,b	- 0.76±0.00 e	15.05±0.02 a
mean	86.15±1.62 A	- 0.04±0.52 B	11.83±2.74 A
E1	87.06±0.51 b	1.48±0.02 a	13.40±0.18 b,c
E2	85.22±0.81 c	0.11±0.04 d	13.46±0.18 b,c
E3	82.87±0.89 d	0.21±0.09 c	13.77±0.31 b
E4	81.89±0.86 d	0.22±0.00 c	13.20±0.00 c
E5	78.19±0.15 e	- 0.49±0.00 e	7.21±0.02 d
E6	89.36 ±0.70 a	0.49±0.02 b	14.95±0.13 a
E7	86.95±1.08 b	0.23±0.03 c	14.66±0.38 a
mean	84.51±3,62 B	0.32±0,55 A	12.95±2.46 A

a, b, c, d, e (↓) Within each cheese group, the values indicated by different letters in each column are different from each other at the p<0.05 level.

A, B(↓) The mean values of each cheese type, indicated by different letters in each column, differ from each other at the p<0.05 level.

When cheese samples were compared for L*, a*, and b* average values on the basis of having geographical indication or not, a significant difference (p<0.05) was found only between the a* value among Ezine cheeses, L* and a* values among Edirne Feta cheeses and L* value among Malkara Aged Kaşar and other aged kaşar (matured) cheeses without the geographical indication. As for the b* values, there was no significant difference (p>0.05) among the cheese groups. The color of the related cheese in the geographical indication registration documents was defined as “from dirty straw yellow to dark

straw yellow", "light yellow color tending to white" or "light yellowish color generating from the local milk fat" with no solid definition (Turk patent, 2007; 2017; 2020).

4. Conclusion

In the Turkish Food Codex Declaration (Anonymous, 2015), the "characteristic specifications" statement is used for all cheese registered with geographical indication. In the registration documents of Ezine Cheese, Edirne Feta Cheese, and Malkara Aged Kaşar Cheese products, fatty acid compositions (%), dry matter (%), salt in dry matter (%), titratable acidity (lactic acid %) and pH values are given. However, whether the given fatty acid % in the Edirne Feta Cheese registration document is based on dry material or not is not stated, and likewise, titratable acidity % and pH values of Malkara Aged Kaşar Cheese are not given in the registration documents. The differences of the mentioned cheese types within their own product group, as well as their discriminating characteristics among the similar cheese types produced in diverse regions, should be stated with much broader and more solid data. Since registered products have characteristic specifications, the sustainability and traceability of their discriminating physical, chemical, sensory and similar properties play a profound role in securing the product quality and identifying product imitations/adulterations. With this study, it was suggested that fatty acid composition, protein content, acidity (free fat acidity %), and color (L*, a*, b*) values should be included in the characteristic specifications in the registration documents. Furthermore, detailed revision of the registration documents of the mentioned cheese types by including aroma-active components to the aroma characterization and scientific data related to texture specifications to the characteristic features through a broader study is advised.

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