

Determination of physicochemical and microbiological properties and fatty acid composition of butter produced in Trabzon, Turkey

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ABSTRACT. In this study, the some physicochemical properties, fatty acid compositions and microbiological properties of butter samples were studied. Butter samples (n = 30) were randomly collected from different local markets. Thus, butter samples were evaluated in terms of Turkish regulations, food safety and quality. The mean values of the butter samples for peroxide value (PV), iodine value (IV), saponification value (SV), Polenske value, Reichert-Meissl (RM) and Refractive index (RI) values were determined as 0.85 mEqO₂ kg⁻¹, 30.03, 220.09, 1.30, 25.60 and 1.4611, respectively. The moisture and fat values were not in harmony with Turkish Food Codex Butter, Other Milk Fat Based Spreadable Products and Anhydrous Milkfat Notification (the highest moisture content 16%, the lowest fat content 80%) in 23 and 13 butter samples, respectively. The salt values were coherent with Turkish Food Codex in all butter samples. Conjugated linoleic acid (CLA) rate of the butter samples was ranged from 0.15 to 1.32%. The average values of coliforms, total aerobic mesophilic bacteria (TAMB) and mould and yeasts counts were determined as 1.67, 6.33 and 5.22 log CFU g⁻¹, respectively.

Keywords: butter; physicochemical characteristics; fatty acids; microbiological quality; food safety.

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Introduction

Milk and dairy products contain some of the most important nutrients for humans of every age (Abid et al., 2017). Milk fat contains many components which are beneficial for human health such as lipid soluble vitamins, antioxidants, unsaturated fatty acids (Månsson, 2008; Erkaya, Ürkek, Doğru, Çetin, & Şengül, 2015) and about 400 different fatty acids (Månsson, 2008). Butter contains a large amount of milk fat (at least 80%) and a lesser proportion of other milk components (Demirkol, Guneser, & Karagul, 2016; Méndez-Cid, Centeno, Martínez, & Carballo, 2017).

Regarded as one of the most popular dairy products, butter is frequently used in meals and pastries (Sağdıç, Arici, & Simşek, 2002; Demirkol et al., 2016), and as an essential part of breakfast (Fındık & Andıç, 2017) due to its aromatic characteristics and nutritive value. Butter is produced both traditionally and industrially (Sağdıç et al., 2004). In Turkey, yoghurt and cream have been used in butter production for centuries (Ewe & Loo, 2016). According to the Turkish Food Codex (Anonymous, 2005), butter must contain a minimum of 80 and a maximum of 90 milk fat, 2 non-fat milk solids and 16% water.

The type of animal (cow, goat, sheep and water buffalo), the animal's diet and seasons affect the butter's texture and flavor (Krause, Lopetcharat, & Drake, 2007). Thus every butter has its own specific properties depending on the province it was produced in (Şengül, Çakmakçı, & Ünsal, 1998). The butter that is produced in the province of Trabzon, Turkey has a particularly nice odor and taste, which are the result of the meadows and pasture flora of Trabzon (Adam, 1954; Eralp, 1969). The raw material of Trabzon butter is usually cow's milk. However, it has occasionally been produced from sheep's and goat's milk as well (Adam, 1954; Eralp, 1969; Şengül et al., 1998).

One of the major problems regarding butter is rancidification which is caused by the long term storage of butter (Méndez-Cid et al., 2017). Rancidification occurs as a result of lipolysis and oxidation (Abid et al., 2017; Méndez-Cid et al., 2017). Lipolysis leads to serious problems such as decrease in nutritional quality, off-flavors (butyric, rancid, bitter, unclean or soapy) in milk and dairy products (Méndez-Cid

et al., 2017). Lipolysis also causes microbial and indigenous milk enzymes (Ray, Chatterjee, Chakraborty, & Ghatak, 2013). Oxidation is another significant problem regarding fatty products that contain large amounts of unsaturated fatty acids (Simsek, 2011; Méndez-Cid et al., 2017).

There are many researches regarding the physical, chemical and sensorial properties of butter (Sağdıç et al., 2002; Altun, Andıç, Tunçtürk, Çeçen, & Fındık, 2011; Simsek, 2011; Demirkol et al., 2016). However, the number of researches relevant to Trabzon butter is limited (Adam, 1954; Şengül et al., 1998; Şengül, Ünsal, & Çakmakçı, 2003). The aim of this study was to identify the different physical, chemical and microbiological properties of Trabzon butter. The butter samples were evaluated in terms of the Turkish legislations and standards.

Material and methods

Material

In this study, 30 different samples of butter were randomly collected from various regions (Ortahisar, Akçaabat, Vakfikebir, Tonya, Sürmene and Yomra districts) in the province of Trabzon, Turkey. The samples were transported in cold chains to a laboratory within the Department of Food Engineering at Ataturk University directly after the collection. The butter samples were stored in sterile closed plastic containers at 4°C until further analysis. In order to determine the fatty acid composition of Trabzon butter, a portion was taken from each butter sample and stored at -20°C until further analyses were carried out.

Physical and chemical analyses

Moisture, fat and salt contents, melting points, titratable acidity (lactic acid %) were determined according to the methods of Kurt, Çakmakçı, and Çağlar (1993). The pH values of the samples were measured using a digital pH meter (pH 211, Hanna Instruments, Italy). The water activity (a_w) of the butter samples was measured using LabMaster-aw (Novasina AG, Switzerland). The refractive index (RI) of the butter samples was measured using Abbe refractometer (Kurt et al., 1993). The samples were melted at 40°C and filtered via filter paper. Then, the RI was determined by using Abbe refractometer.

Peroxide values (PV) were determined as defined by Atamer (1993). The butter samples were weighted as 5 g and acetic acid-chloroform (3:2 v v⁻¹) was added to the samples. A saturated potassium iodide solution (0.5 mL) was incorporated. 30 mL distillate water and an indicator (starch solution) was added and the mixture was titrated with 0,002 N sodium thiosulfate.

Iodine value (IV) was determined using the Hanus method. The sample (0.5 g) was weighted and melted in 15 mL chloroform. An iodine mono bromide solution (25 mL) was added to the sample. A potassium iodide solution (20 mL) and freshly boiled and chilled distilled water (100 mL) was included in the sample. An indicator (starch solution) was added and the mixture was titrated with 0,1 N sodium thiosulfate (Kurt et al., 1993).

The saponification value (SV), Polenske value and Reichert-Meissl number (RM) of the butter samples were determined according to the methods of Kurt et al. (1993).

The color measurement of the butter samples was performed using a Minolta Colorimeter (CR-200 Minolta). The measurements were determined as L^* , a^* and b^* where L^* represents brightness (0: black; 100:white), while a^* and b^* indicate the colors red (+)-green (-) and yellow (+)-blue (-), respectively.

Fatty acid composition

Fatty acid methyl esters (Fame) were prepared as described by Erkaya et al. (2015) and Metcalfe and Schmitz (1961). 50 mg of each butter samples was weighed and placed into glass tubes. 1.5 mL of NaOH (2M) solution was added and the tubes were filled with nitrogen gas. The tubes were heated at 80°C for an hour 2 mL of BF₃ (25%, in methanol w v⁻¹) solution was added to the tubes after cooling and heated again at 80°C for 30 min. 1 mL of hexane and 1 mL of ultradistilled water were added to the tubes which were then vortexed. The upper layers were transferred to gas chromatography (GC) vials. The esters were injected into a GC system (Agilent 6890N, HP, USA) equipped with a flame ionization detector (Agilent Tech. Inc.) and DB-23 column (60 m x 0.25 mm x 0.25 mm) at 200°C on a split mode. One µL of the sample was injected. Helium was used as the carrier gas and C_{19:0} was used as the internal standard.

Microbiological analysis

10 g of each butter sample was weighed and dispersed in 90 mL of sterile 0.85% NaCl solution. The solution was melted by heating it up to 45°C and homogenized by using a stomacher. Total aerobic mesophilic bacteria (TAMB) were enumerated on Plate Count Agar (Oxoid CM0325) after incubation at 30±1°C for 48 hours (Messer, Behney, & Leudecke, 1985). All species of lactobacilli (LAB) were determined using MRS medium (Oxoid CM0361). The LAB colonies were enumerated after incubation at 37±1°C for 72 hours anaerobically (Speck, 1976). Lactococci colonies were counted on M17 agar (Oxoid CM0785). The mediums were incubated at 30±1°C for 48 hours (Cabezas, Sánchez, Poveda, Seseña, & Palop, 2007). Coliforms were determined on Violet Red Bile Agar (VRBA) (Merck) and incubated at 35°C for 48 hours (Speck, 1976). Yeast and mould were enumerated on Potato Dextrose Agar (Oxoid CM0139) after incubation at 25°C for 7 days (Frank, Hankin, Koburger, & Marth, 1985).

Statistical analysis

Descriptive and correlation analyses were performed using SPSS statistical software program version 17.0 (SPSS Inc., Chicago, IL, USA).

Result and discussion

Physical and chemical properties

The physical and chemical values of the butter samples are shown in Table 1. The pH values of the samples changed from 3.23 to 4.87, and their mean value was found as 3.99. The pH values were lower than those reported by Şenel, Atamer, and Öztekin (2011) and Erkaya et al. (2015). The minimum, maximum and mean value of the butter sample's acidity values were determined as 0.32, 3.37 and 0.86%, respectively. 18 butter samples out of 30 were not in harmony with the Turkish standards. Because, the highest acidity value in butter should be 0.63% according to the Turkish standards (Anonymous, 1995). Simsek (2011) reported that the acidity values of yayık butter were between 0.11 and 0.14%, while Demirkol et al. (2016) found the acidity values of commercial butter to be between 0.22 and 0.42%. These results were lower than the results found in this study. Adjunct starter cultures or microbial contamination may be caused by the decrease in pH and increase in acidity.

The melting point of the butter samples are shown in Table 1. In this study, the mean value of the melting point was lower than those reported by Sağdıç, Dönmez, and Demirci (2004) and Demirkol et al. (2016). Ewe and Loo (2016) determined the melting points of butter produced with *Lactobacillus helveticus* to be between 24.87 and 24.37°C. These values were lower than those found in the present study. The melting point is one of the adulteration indicators in butter and is usually between 27 and 33°C. When herbal oil is added into butter, its melting point decreases. However, the melting point of butter increases when animal fat is added.

Table 1. Minimum, maximum and mean values of physical and gross chemical properties of butter samples.

	Min	Max	Mean	SD
pH	3.23	4.87	3.99	0.44
% Titratable acidity (LA)	0.32	3.37	0.86	0.53
Melting point, °C	26.50	33.00	29.77	1.92
a_w	0.83	0.94	0.92	0.03
Salt, %	0.04	1.30	0.33	0.27
Fat, %	41.13	85.00	78.43	8.16
Moisture, %	8.72	31.63	18.90	5.15
PV (mEqO ₂ kg ⁻¹)	0.00	6.84	0.85	1.70
IV	21.73	37.34	30.03	3.67
SV	176.04	234.21	220.09	11.49
RM	5.04	31.46	25.60	6.13
Polenske value	0.78	3.00	1.30	0.40
RI	1.4596	1.4630	1.4611	0.001
L^*	72.08	88.22	83.99	3.27
a^*	-4.42	-0.89	-2.83	0.77
b^*	21.73	45.12	32.63	5.14

SD: Standard deviation, LA: Lactic acid, a_w : water activity, PV: Peroxide value, IV: Iodine value, SV: Saponification value, RM: Reichert-Meissl Value, RI: Refractive index.

The a_w has a restrictive effect on the growth of microorganisms as usable water rate by microorganisms decreases. The minimum a_w value is different for each microorganism growth such as for bacteria between 0.75-0.87, for mould and yeasts between 0.60-0.85 (Beuchat et al., 2013). The highest a_w value was 0.94, while the lowest value was 0.83 in the butter samples in the present study (Table 1). Altun et al. (2011) found that the a_w values of commercial butter samples from markets in Van (a province in the eastern Anatolia region, Turkey) changed between 0.87 and 1.00, and the mean value was 0.97. Fındık and Andiç (2017) reported that the a_w values varied between 0.96 and 1.00. In the present study, the a_w values were slightly lower than those reported by the researchers mentioned above. There were negative correlations between a_w and salt, moisture and PV ($p < 0.01$).

Salt has been used for the protection foods against spoilage and extends self-life for centuries. Salt has antimicrobial properties and inhibits microbial growth by reducing water activity and changing osmotic balance. However, it has negative effects on human health (Doyle and Glass, 2010). The lowest, highest and mean salt values of the samples were 0.04, 1.30 and 0.33%, respectively. These results were lower than those reported by Méndez-Cid et al. (2017) who studied the chemical and physical characteristics of salted butter during storage and by Sağdıç et al. (2002) who studied the commercial butter samples from the province of Konya, Turkey. In the present study, all salt values complied with the Turkish Food Codex (Anonymous, 2005) (Figure 1).

The fat contents of the butter samples, which were in harmony with the Turkish Food Codex, are shown in Figure 2. Similar results were determined by various researchers (Altun et al., 2011; Fındık & Andiç, 2017). These results are not in agreement with the results obtained by Demirkol et al. (2016) who studied the physical and chemical properties of commercial butter samples from the Çanakkale province. In the present study, the fat values of 13 butter samples were lower than the stated regulations (Figure 2). The fat values found in this study that are considered to be low according to the Turkish Food Codex could be the result of faulty and/or fraudulent production. The fat content had negative correlations with both L^* and a^* ($p < 0.05$), while it had positive correlations with moisture and RM ($p < 0.01$).

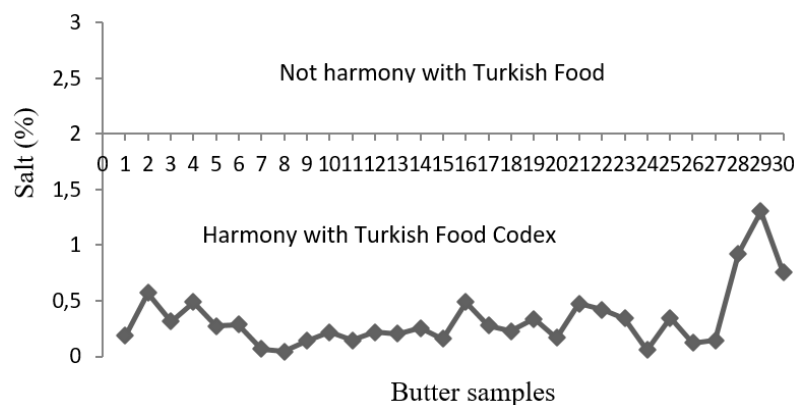


Figure 1. The salt values of butter samples.

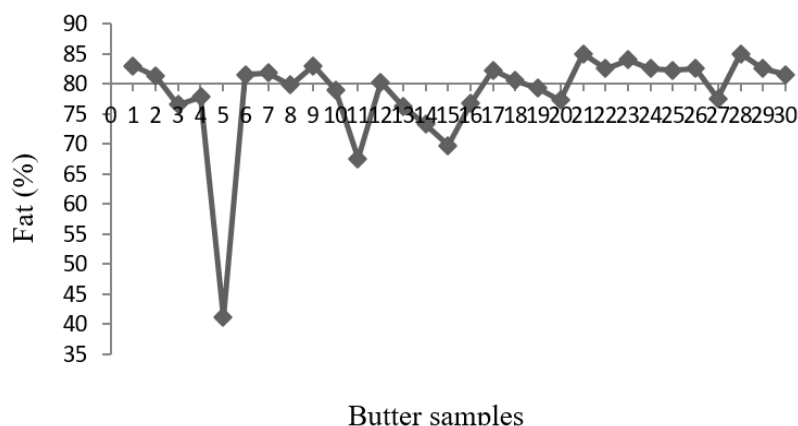


Figure 2. The fat values of butter samples.

The minimum, maximum and mean moisture values of 30 butter samples are shown in Table 1. As seen from Figure 3, only seven butter samples were in accordance with the Turkish Food Codex (Anonymous, 2005). Şengül et al. (1998) reported that the moisture values of Trabzon butter were between 7.05 and 18.03% and their mean values were 12.87%. In addition, according to the results of Şengül et al. (1998), the moisture values of five butter samples out of 15 were not in accordance with the Turkish Food Codex (Anonymous, 2005), while Demirkol et al. (2016) found that three butter samples out of 11 collected from the Çanakkale province were not in accordance with the Turkish Food Codex (Anonymous, 2005). The diversities among the butter samples in terms of moisture may be caused by the differences in production methods, season, type of butter and storage conditions.

Peroxide is the primary oxidation product (Altun et al., 2011; Erkaya et al., 2015) and PV decreases with advanced oxidation. The threshold value for sense of oxidative rancidity can be accepted as $3.00 \text{ mEqO}_2 \text{ kg}^{-1}$ in butter (Altun et al., 2011). However, according to the Turkish standards, the highest PV of butter should be $5 \text{ mEqO}_2 \text{ kg}^{-1}$ (Anonymous, 1995). The PVs of the samples were between 0.00 and $6.84 \text{ mEqO}_2 \text{ kg}^{-1}$ while PVs were found to be $0.00 \text{ mEqO}_2 \text{ kg}^{-1}$ in 13 butter samples. The PVs of 26 butter samples were lower than the threshold value. The values of only two butter samples complied with the Turkish standards. These results were generally lower than those reported by Altun et al. (2011), but higher than those reported by Sağdıç et al. (2002; 2004). Simsek (2011) reported that PVs ranged from 0.42 to $0.80 \text{ mEqO}_2 \text{ g}^{-1}$ during 60 days in storage. Şenel et al. (2011) determined the PVs of yayık butter samples made of yoghurt produced from cow's, sheep's and goat's milk over 30 days storage period. The peroxide mean values were found to be 0.50, 1.20 and $2.45 \text{ mEqO}_2 \text{ kg}^{-1}$ for the butters made from cow's, sheep's and goat's milk, respectively. Şengül et al. (1998) determined the maximum, minimum and mean values of PV for the Trabzon butter samples as 0.00, 0.70 and $0.38 \text{ mEqO}_2 \text{ kg}^{-1}$, respectively. In the present study, the PVs of four butter samples were higher than the threshold value of oxidative rancidity.

IV is accepted as an indicator for unsaturated fatty acid amount. IVs belonging to 30 butter samples are presented in Table 1. These results were slightly lower than those reported by Şengül et al. (1998) and were in conformity with Sağdıç et al. (2002; 2004). The IVs of the butter samples may have been affected by season, lactation period and type of butter (unsalted, salted, extra salted, cooking).

The mean values of SV, RM and Polenske were determined as 220.09, 25.60 and 1.30 in 30 Trabzon samples, respectively. In the present study, the SV and Polenske mean values of the butter samples were in accordance with Şengül et al. (1998), but the RM mean value was lower than those found by Sağdıç et al. (2002; 2004). The lowest RM value in butter should be 24 (Anonymous, 1995). 25 butter samples out of 30 were in harmony with the Turkish standards. A positive correlation ($p < 0.05$) was found between RM and Polenske.

The RI values of the 30 butter samples were are presented in Table 1. Şengül et al. (1998) found that the RI values of the Trabzon butter ranged from 1.4539 to 1.4558 in 15 samples, while Demirkol et al. (2016) found this range to be between 1.3331 and 1.4672 in 11 butter samples collected from the Çanakkale province.

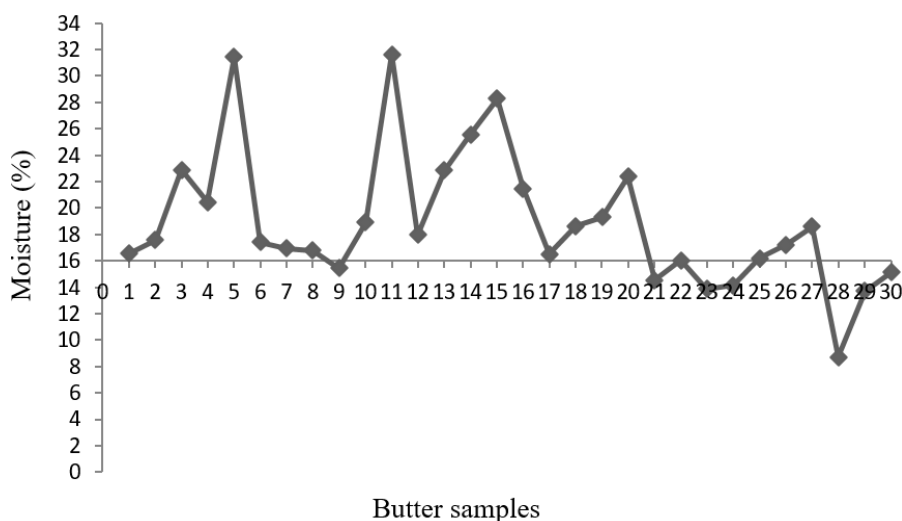


Figure 3. The moisture values of butter samples.

The L^* , a^* and b^* mean values of the butter samples were 83.99, -2.83 and 32.63, respectively, in the present study. Demirkol et al. (2016) reported that the L^* , a^* and b^* values of the butter samples collected from Çanakkale ranged between 88.34 and 96.11, 1.92 and 4.42, 15.07 and 33.14, respectively. Hurtaud, Faucon, Couvreur, and Peyraud (2010) found that the L^* , a^* and b^* values of the butter samples ranged between 92.9 and 93.4, -2.63 and -2.68, 16.3 and 17.0, respectively. Shukla, Bhaskar, Rizvi, and Mulvaney (1994) determined the L^* , a^* and b^* values in butter produced from supercritically fractionated milk fat and control samples (collected from retail markets). The L^* , a^* and b^* values were found to be 84.08, -1.95 and 30.85 in the experimental butter sample, and 88.67, -1.07 and 24.12 in the control sample, respectively. Color has an important effect on the perception of consumers. A yellowish color is one of the most important factors for consumers when choosing butter (Krause et al., 2007; Demirkol et al., 2016). Trabzon butter is known to be more yellow among the public. The b^* (+) values indicate the yellow color. In this study, the b^* values were higher than those reported by Shukla et al. (1994), Hurtaud et al. (2010) and Demirkol et al. (2016). The region in which the animals graze can be the reason behind the high b^* (+) values as the carotene rate in milk increases in direct proportion to the amount of pasture the animal grazes on.

Fatty acid composition

The fatty acid composition of Trabzon butter is shown in Table 2. The mean values of butyric, caproic, caprylic and capric acids were determined in the butter samples as 0.47, 0.61, 0.65 and 1.87%, respectively. The medium chain fatty acids and lauric and myristic acids of the butter samples ranged between 1.68 and 4.36%, 3.40 and 14.42%, respectively. The palmitic acid values ranged from 28.84 to 43.50%, while stearic acid content was found to be between 8.00 and 19.52%. The mean values of unsaturated fatty acids were 1.32 (myristoleic acid), 0.45 (palmitoleic acid), 28.93 (oleic acid) and 2.10% (linoleic acid). In this study, the myristic, palmitoleic, stearic and oleic acids were the main fatty acids of the butter samples. Ozcan, Akpinar-Bayizit, Yilmaz-Ersan, Cetin, and Delikanli (2016) examined the fatty acid composition of Trabzon butters in sold retail. They determined the mean values of palmitic and oleic acids as 32.65 and 25.70%, respectively. These results were lower compared to the present study. Similarly, Ozcan et al. (2016), Erkaya et al. (2015) and Altun et al. (2011) reported myristic, palmitic, stearic and oleic acids as the major fatty acids in the butter samples.

Milk and dairy products are rich in terms of conjugated linoleic acid (CLA) (Erkaya et al., 2015). The minimum, maximum and mean average CLA values of the butter samples are shown in Table 2. Yilmaz-Ersan (2013) reported that the CLA rate was 0.84% in all the butter samples. Erkaya et al. (2015) found that the CLA values of probiotic butter samples changed between 0.71 and 0.99% during storage. Findik and Andiç (2017) investigated the CLA values of butter and butter oil in 10 samples. The CLA values were determined between 0.5-1.7 g 100 g⁻¹ total fatty acids for butter and 0.2-0.9 g 100 g⁻¹ total fatty acids for butter oil.

Table 2. Minimum, maximum and mean values of fatty acids composition (%) of butter samples.

Fatty Acids	Min	Max	Mean	SD
C _{4:0}	0.13	0.73	0.47	0.15
C _{6:0}	0.16	0.95	0.61	0.16
C _{8:0}	0.29	1.19	0.65	0.19
C _{10:0}	0.34	3.25	1.87	0.58
C _{12:0}	1.68	4.36	2.74	0.69
C _{14:0}	3.40	14.42	10.77	2.21
C _{14:1}	0.25	1.87	1.32	0.31
C _{16:0}	28.84	43.50	35.15	3.13
C _{16:1}	0.21	1.94	0.45	0.40
C _{18:0}	8.00	19.52	14.19	2.25
C _{18:1}	21.25	38.97	28.93	3.91
C _{18:2}	0.98	7.26	2.10	1.22
CLA	0.15	1.32	0.75	0.35
SFA	56.31	75.20	66.45	4.43
MUFA	22.87	40.68	30.70	3.79
PUFA	1.21	7.41	2.85	1.22

CLA: Conjugated linoleic acid, SFA: Saturated fatty acid, MUFA: Monounsaturated fatty acid.

The saturated fatty acid (SFA) content of the Trabzon butter samples changed between 56.31 and 75.20%, while the monounsaturated fatty acid (MUFA) and polyunsaturated fatty acid (PUFA) rates were between 22.67 and 40.68%, 1.21 and 7.41%, respectively. The SFA values found in this study were in conformity with those found by Altun et al. (2011) who studied the chemical properties and fatty acids composition of butter samples collected from the Van province. However, the MUFA values were higher than those reported by Altun et al. (2011) and the PUFA values were lower than those found by Yilmaz-Ersan (2013). Each region has special pasture and meadow flora. Flora diversity has an important effect on aroma, taste and fatty acid composition of butters (Ozcan et al., 2016). On the other hand, the fatty acid composition is also affected by many factors such as the animal's age, gender and diet, seasons, use of starter culture, type of starter culture. For this reason, a standard fatty acid composition cannot be expected due to the impacts of many different factors. In addition, fraudulent production has serious effects on the fatty acid composition.

Microbiological properties

The microbiological properties of the butter samples are shown in Table 3. Erkaya et al. (2015) found that the TAMB counts of probiotic butter samples changed from 6.60 to 7.16 log CFU g⁻¹ during storage. Gökçe, Aslanalp, and Herken (2010) determined between 5 and 6.64 log CFU g⁻¹ in karın butter which was collected from local markets. These results were similar with the results of the presented study. There is no legal restriction regarding TAMB counts in butter in Turkey. However, according to Hocalar (2003), the TAMB of a high quality butter should be under 3.7 log CFU g⁻¹. All TAMB counts in the present study were higher than those reported by Hocalar (2003).

The counts of LAB in growth MRS and M17 agar varied between and 7.55 log CFU g⁻¹, 4.30 and 7.67 log CFU g⁻¹, respectively. These results were higher than those reported by Sağdıç et al. (2002), but were similar with the bacteria counts determined by Fındık and Andıç (2017).

Coliforms were not determined in 13 butter samples, however the coliform mean count of the butter samples was found as 1.67 log CFU g⁻¹ (Table 3). Coliform counts of the 19 butter samples out of 30 complied with the Turkish standards which state that the highest coliform count must be 2 log CFU g⁻¹ (Anonymous, 1995). Sağdıç et al. (2004) did not determine coliform in butter samples. Karagözlü and Ergönül (2008) investigated the microbiological properties of Turkish butters sold under market conditions in the province of Manisa. They determined that coliform counts of traditional butter samples changed < 3 to ≥ 1400 CFU g⁻¹. Similar results were determined by Gökçe et al. (2010) who studied the microbiological properties of karın butter obtained from markets.

The mould is one of the main reason of spoilage in butter. It causes color, taste and aroma changes in butter (Gökçe et al., 2010). As shown in Table 3, the mean count for mould and yeast was 5.22 log CFU g⁻¹. However, mould and yeast were not determined in only one sample. The highest mould and yeast counts must be 2 log CFU g⁻¹ according to the Turkish Food Codex Microbiological Criteria Notification (Anonymous, 2009) and Turkish Standard (Anonymous, 1995). Only two samples out of 30 (6.66%) complied with the Turkish Food Codex (Anonymous, 2009). These results were higher than those reported by Sağdıç et al. (2004) who studied the chemical and microbiological properties of butter samples collected from different regions. Karagözlü and Ergönül (2008) found that only three butter samples out of 40 were under the legal limit.

High coliforms and mould-yeast counts could be explained by the lack of hygiene rules in production processes, microbial contamination, deficient thermal processing (inadequate pasteurization or non-pasteurization) and bad storage conditions.

Table 3. Minimum, maximum and mean values of microbiological properties of butter samples (log CFU g⁻¹).

	Min	Max	Mean	SD
TAMB	4.67	7.86	6.33	0.76
LAB _{MRS}	3.78	7.55	6.47	0.75
LAB _{M17}	4.30	7.67	6.65	0.79
Coliforms	<1	4.55	1.67	1.73
Yeasts and moulds	<4<2	6.89	5.22	1.36

SD: Standard deviation, TAMB: Total aerobic mesophilic bacteria, LAB: Lactic acid bacteria.

Conclusion

In this study, various physical, chemical and microbiological properties and fatty acid compositions of butter were determined using butter samples collected from different regions. High differences were found among the butter samples in terms of chemical properties and fatty acid compositions. The salt contents of all of the samples complied with the Turkish Food Codex (Anonymous, 2005), while the fat values of only 17 samples out of 30 and the moisture values of only 7 of the samples were in accordance with the Turkish Food Codex (Anonymous, 2005). The PVs were higher than the threshold value of oxidative rancidity ($3.00 \text{ mEqO}_2 \text{ kg}^{-1}$) in four of the butter samples. Trabzon butter samples had intensive yellow color. The CLA rate in the butter samples were 0.75% as mean. The microbiological quality of samples was not good in terms of especially the TAMB and mould-yeast counts. To improve the quality of Trabzon butter, (a) hygiene conditions should be improved in all stages of production and (b) to manufacture Trabzon butter at a standard quality, regional milk should be used through a standard process. The number of researches in relation to butter should be increased to produce high quality butter.

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