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Some physicochemical and microbiological properties of butter produced in Erzurum

Die physikochemischen und mikrobiologischen Eigenschaften von Butter aus der Provinz Erzurum

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Summary

The goal of this study was to determine some physicochemical and microbiological properties of Erzurum butter. Random samples (n = 30) were collected from different retail markets throughout Erzurum province. The pH, acidity, and melting point values of samples were 3.88, 0.47%, and 30.03 °C, respectively. The salt, fat, and moisture values of some samples (sample no 1, 14, and 18) were not harmony with Turkish Food Codex. The highest and lowest peroxide, iodine, saponification, Reichert-Meissl (RM), and Polenske values were found to be in the range of 0-0.51 mEqO2/kg, 22.97-38.64, 195.45-228.54, 17.08-30.-56, and 0.72-1.80, respectively. The refractive index value (RI) was changed from 1.4591 to 1.4620. Total coliforms, aerobic mesophilic bacteria (TAMB), lactic acid bacteria (cultured in MRS and M17), and mould and yeasts mean counts were 1.07 log CFU g-1, 6.79 log CFU g-1, 6.45 log CFU g-1, 6.76 log CFU g-1, and 5.33 log CFU g-1, respectively. There were high differences in physicochemical and microbiological properties of butter might be attributed to a non-standard production process as well as non-standard raw material. In sum, the sanitation and storage conditions should be improved from production to consumption to improve the butter quality.

Keywords: butter, physicochemical properties, microbiological properties

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Introduction

Butter, of the desirable dairy products, is widely consumed all over the World (Krause et al., 2008; Ewe and Loo, 2016). It has been traditionally produced in Turkey for centuries (Sağdiç et al., 2002). While Yogurt was traditionally used in butter production, the cream was adopted for industrial production of butter (Sağdiç et al., 2002; Şenel et al., 2011). Butter must contain fat (at least 80%), water (maximum 16%), salt (maximum 2%), and other milk components according to Turkish Food Codex (2005).

Butter, one of the favorite food consumed at all ages, is used in meals, pastries, and breakfast (Sağdiç et al., 2002; Demirkol et al., 2016; Fındık and Andiç, 2017). Turkey Butter output reached 59217 ton in 2017 (TUIK, 2018). Butter is manufactured by different dairy processing plants (Kurdal and Koca, 1987), even though it is produced as intensely around Erzurum, Trabzon, Kars, Urfa, and Diyarbakır (Şengül et al., 1998). The different producing areas could impact the unique aromatic and nutritive characteristics of butter (Sağdiç et al., 2002; Demirkol et al., 2016; Fındık and Andiç, 2017). Factors that could influence the characteristics butter flavors include milk from different animal species (cow, goat, sheep, and water buffalo), animal feed compositions (composite or grazing feed) (Şengül et al., 1998; Krause et al., 2007), and differences in flora (Şengül et al., 1998). Additionally, diacetyl (produced during ripening by bacteria, Kurdal and Koca, 1987) gives ripened butter a distinctive flavor compared to non-ripening one. The physicochemical and microbiological properties of butter play a substantial role in its quality (Idoui et al., 2013). Chemical and microbiological reactions may cause serious defects, incuding putrid, cheesy or fruity odors, and rancid taste in butter (Idoui et al., 2010). Storage conditions, packaging materials, starter culture, and salt may have significant effect on sensory, physical, chemical, and microbiological properties of butter (Krause et al., 2007; Demirkol et al., 2016). Butter is a suitable medium for the microbial growth, because milk is a very good source for protein, lactose, water, vitamins and mineral elements (Idoui et al., 2010). Some microorganisms are beneficial for butter production, however, others may affect on physical, chemical, and sensory properties of butter (Idoui et al., 2013). Coliform and enterobacteria are responsible for the off-taste, whereas lipolytic bacteria can potentially lead to oxidation and lipolysis. Other microorganisms, molds, and yeasts may have a negative impact on sensory and color parameters of butter (Idoui et al., 2013). Chemical alternation, particulary oxidation, may also cause serious problems in butter (Ozkan et al., 2007; Méndez-Cid et al., 2017). Oxidation is the main reason for producing butyric, rancid, bitter, unclean or soapy tastes and abnormal color in butter (Méndez-Cid et al., 2017). It has to be noted that chemical changes could be considered as an indicator of butter quality (Demirkol et al., 2016).

So far, physical, chemical, and sensory characteristics of regional butter have been investigated elsewhere by others (Altun et al., 2011; Demirkol et al., 2016; Fındık and Andiç, 2017). However, reports on Erzurum butter are very scarce (Kurdal and Koca, 1987). Thence, this study was conducted to monitor some physicochemical and microbiological properties of butter produced in Erzurum, Turkey.

Material and Methods

Material

Butter samples (n=30) were randomly collected from different retail markets distributed throughout Erzurum province, Turkey. Samples were placed into sterile jar and transferred into icebox in the cold chain. Analyses were carried out at the laboratory of Food Engineering Department, Ataturk University. Samples were stored in the refrigerator at 4°C pending analyses.

Methods

Physical and chemical analyses

Titratable acidity (lactic acid %), melting point, salt %, fat%, and moisture contents %, were determined as described by Metin (2009). pH values were measured by a digital pH meter (pH 211, Hanna Instruments, Padua, Italy) according to IDF method (1981). The water activity (a_w) and Refractive index (RI) were measured using Lab Master-aw (Novasina AG, Switzerland)and Abbe refractometer, respectively (Metin, 2009). Melted samples at 40°C were filtered and then the RI was measured using Abbe refractometer.

Peroxide value (PV) was determined as described by Atamer (1993). Acetic acid: chloroform (3:2, v/v) was added to 5 g weighted samples. The saturated potassium iodide solution (0.5 mL) and 30 mL distilled water were placed. Then, the indicator (starch solution) was added. The sample was titrated (0,002 N sodium thiosulfate).

Iodine value (IV) was determined according to Hanus methods (Demirci and Gündüz, 2004) Saponification value (SV), Reichert-Meissl number (RM), and Polenske value were determined as reported by Demirci and Gündüz, (1994).

Microbiological analyses

Homogenized butter samples (10 g) were dispersed in 90 mL of sterile 0.85% NaCl solution and kept at 45°C for melting. VRBA (Merck, Darmstadt, Germany) was used for determination of coliforms. The medium was incubated at 35°C for 48 h (Speck, 1976). The total aerobic mesophilic bacteria (TAMB) were counted on Plate Count Agar (Oxoid CM0325, Basingstoke, UK) and incubated at 30±1°C for 48 h (Messer et al., 1985). Lactic acid bacteria (LAB) colonies were obtained using MRS (Oxoid CM0361, Basingstoke, UK) and M17 agar (Oxoid CM0785). MRS agar was incubated anaerobically at 35±1°C for 72 h. Afterward, colonies were enumerated (Speck, 1976). LAB colonies growing on M17 were counted following incubation at 35±1°C for 72 h (Cabezas et al., 2007). Yeasts and molds were detecting using Potato Dextrose Agar (Oxoid CM0139, Basingstoke, UK). The PDA was incubated at 25°C for 7 days (Frank et al., 1985).

Statistical Analyses

SPSS statistical software program version 17.0 (SPSS Inc., Chicago, IL, USA) was used for statistical analysis.

Results and Discussion

Physical and chemical properties

As shown in Table 1, the pH values ranged between 3.20-4.21 (mean = 3.88). The current pH values were in line with that reported by Idoui et al. (2010), Şenel et al. (2011), and (Idoui et al., 2013). There were a negative correlation (r=–569) between pH and titratable acidity ($P < 0.05$).

The lowest, highest, and mean titratable acidity values are compiled in Table 1. Titratable acidity value of butter must be the highest at 0.63% according to Butter Standard (Anonymous, 1995). The obtained acidity values were in harmony with Butter Standard, except for two samples. Kurdal and Koca, (1987) found that acidity values were between 0.39% and 0.74% in butter samples that collected from local markets in Erzurum province. The acidity values of Çanakkale butter samples were ranged between 0.22%–0.44% (Demirkol et al., (2016). On the other hand, acidity values of 0.18% and 0.30% were recorded for butter samples collected from Konya, Isparta, Afyon, and Antalya (Sağdiç et al., 2002). There was a positive correlation between titratable acidity and moisture; however, titratable acidity had a negative correlation with both Reichert-Meissl (RM) and Polenske (P<0.05).

TABLE 1: *Values belonging to the physical and gross chemical properties of Erzurum butter samples.*

	Min	Max	Mean	SD
pH	3.20	4.71	3.88	0.38
% Titratable acidity (LA)	0.21	0.84	0.47	0.14
Melting Point,°C	26.50	33.00	30.03	1.61
Salt, %	0.22	2.28	0.46	0.36
Fat, %	62.50	83.75	78.93	4.35
Moisture, %	9.33	25.43	17.19	3.41
PV (mEqO$_2$/kg)	0.00	0.51	0.06	0.13045
IV	22.97	38.64	32.30	3.05679
SV	195.48	228.54	211.78	6.25588
RM	17.08	30.56	26.52	2.76584
Polenske value	0.72	1.80	1.31	0.27219
RI	1.4591	1.4620	1.4605	0.00056

The melting point values of butter samples are shown in Table 1. The recorded melting point herein are consistent with those reported by Sağdiç et al., (2002). However, the values were lower than that reported by Demirkol et al., (2016) and were higher than those reported by Ewe and Loo, (2016).

Salt content must be higher than 2% according to Turkish Food Codex, (2005). Herein, only one sample had a higher salt content than Turkish Food Codex (2005). The salt value of sample 7 was 2.28% (Fig. 1). The rest of the samples were in line with Turkish Food Codex. A minimum of 0.02% and maximum of 1.83% salt values were reported in by Kurdal and Koca, (1987) in Erzurum butter. Sağdiç et al., (2002) investigated the physicochemical and microbiological properties of butter samples collected from Isparta, Konya, Antalya, and Afyon; the salt values were in between 0.04% and 2.25%.

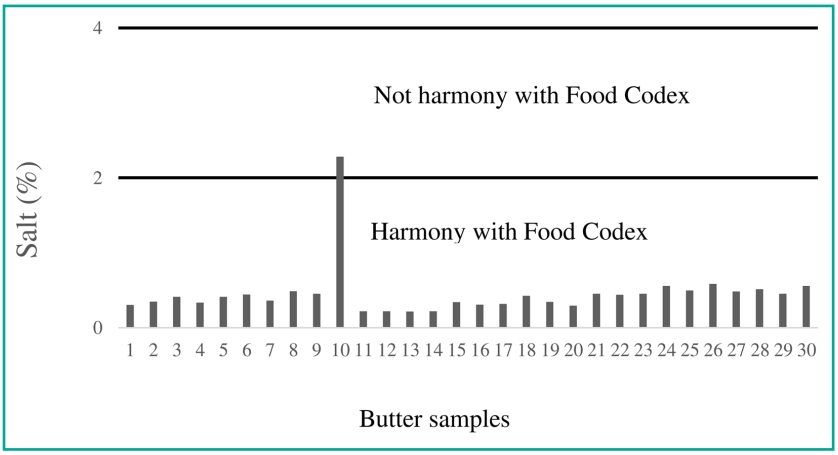

FIGURE 1: *The salt values of Erzurum butter samples.*

Sample 8 had the lowest fat (62.50%), whereas sample 23 had the highest fat (83.75%) value. According to the Turkish Food Codex, the minimum fat content is 80%. Notably, 16 samples were in line with above stated guidelines , however, the rest of the samples (14) had lower values compared to the guidelines (Fig. 2). The fat content was 78.93%; the value which is inconsistent with the Turkish Food Codex. The lowest 75.50% and the highest 84% fat contents were recorded by Kurdal and Koca (1987) in butter samples. They found that 27% of the samples were not homogenious with the regulation. Moreover, Altun et al., (2011) report a fat value n between 51.50% to 83.20% in Van butter. The fat content had a negative correlation with moisture (r=-0.898), whereas it had a positive correlation with IV (r=0.564).

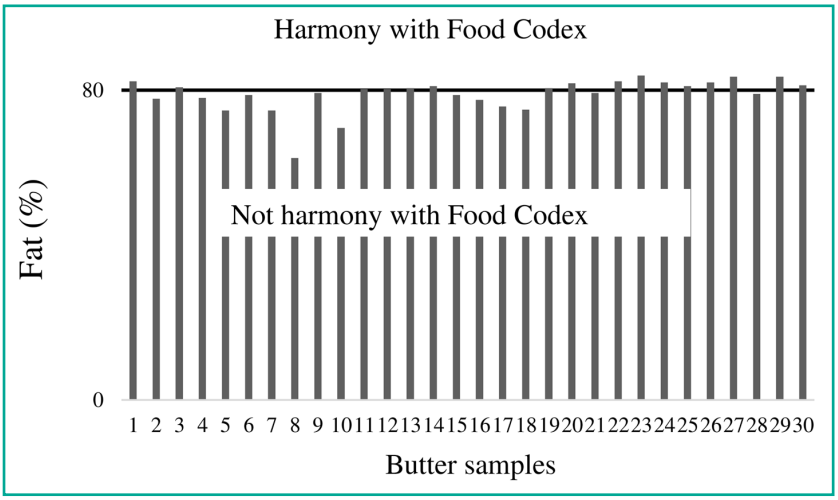

FIGURE 2: *The fat values of Erzurum butter samples.*

The minimum, maximum, and mean moisture values of butter samples are presented in Table 1. The moisture value of 18 out of 30 samples were higher than that stated by Turkish Food Codex. Turkish Food Codex, (2005) stated that butter must contain a maximum of 16% moisture content (Fig. 3). Our results are supported with those reported by others (Kurdal and Koca, 1987); Altun et al., 2011). Reported values by Ewe and Loo (2016) were higher than ours; however, values reported by Sağdiç et al., (2002) were lower than the present study. The moisture had negative correlations (P<0.05) with both RM (r=-0.403) and Polenske (r=-0.413). The fat and moisture values of some butter samples are not in harmony with the Turkish Food Codex. This finding might be attributed to error mistakes during the technological process (churning and working, salting) or lack of a standard production method.

PV is an indicator of autoxidation for high fatty products. PV is a non-stable compound, which is quickly decomposed to ketones, alcohol, and carbonyl, etc. These components cause off-flavor in final products (Erkaya et

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al., 2015). Herein, PVs were 0 $mEqO_2$ kg-1 in 22 butter samples (Tab. 1). The maximum PVs were 0.51 $mEqO_2$ kg^{-1} and the mean was 0.06 $mEqO_2$ kg^{-1}. According to Turkish Butter Standard, peroxide values must be greater than 5 $mEqO_2$ kg^{-1} (Anonymous, 1995). In the present study, the PVs of butter samples were lower than the recommended value by Butter Standard. Moreover, All samples had lower PVs than 3 $mEqO_2$ kg^{-1}, which is the threshold for oxidative rancidity according to Altun et al., (2011). PVs of Erzurum butter samples in Kurdal and Koca, (1987) study changed from 0.98 $mEqO_2$ kg^{-1} to 1.75 $mEqO_2$ kg^{-1}. Altun et al., (2011) and Fındık and Andiç, (2017) found that the PVs of Van butter samples were ranged between 2.52-12.79 $mEqO_2$ kg^{-1} and 1.2-7.4 $mEqO_2$ kg^{-1}, respectively. Results in the current study were lower than that reported by Kurdal and Koca, (1987), Altun et al., (2011) and Fındık and Andiç, (2017). There were significant negative correlations between PV and RM (r=-0.403; $P<0.01$) and PV and Polenske (r=-0.413; $P<0.05$).

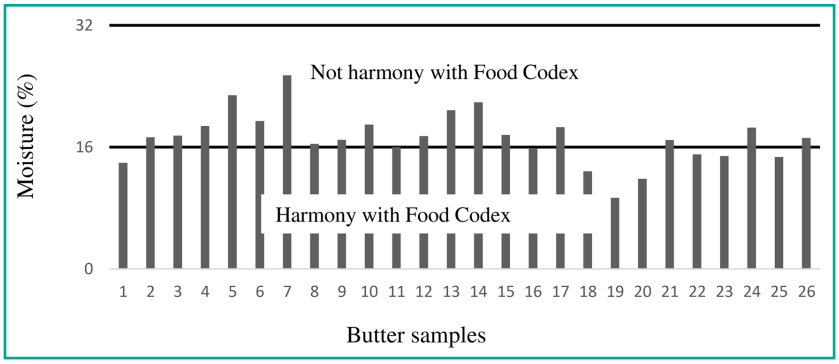

FIGURE 3: *The moisture values of Erzurum butter samples.*

The IV gives an idea about the amount of unsaturated fatty acids in oil. The IV of milk fat is normally ranged between 26 and 35 (Demirci and Gündüz, 2004). However, cow's milk fat has a lowest IV of 21 and a highest value of 53 (Kurt et al., 1993). Herein, the IVs of the tested samples ranged from 22.97 to 38.64. Sample 30 had the highest IV, whereas, sample 8 had the lowestvalue. Our results were lower than those reported by Kurdal and Koca, (1987) and similar to that reported by Sağdiç et al., (2002). IV had positive correlation with RI (r=0.414; $P<0.05$), and negative correlation with SV (r=-0.547; $P<0.01$).

The SVs is used for detection of adulteration in butter. The SVs should be in the range of 209 to 238 (Kurt et al., 1993). The lowest, highest, and the mean SVs are presented in Table 1. The SVs were ranged between 124.70 and 272.00 in 15 butter samples collected from Trabzon as reported in the study carried out by Şengül et al., (1998). In another study (Sağdiç et al., 2004) the SVs of butter samples made from cow, goat and ewe yogurts were 221.00, 222.50, and 229.50, respectively.

The RM is an indicator for the liberation of volatile with water vapor and soluble in water and alcohol such as butyric, caproic, caprylic, and capric acids. That RM value ranged between 17 and 35 (Demirci and Gündüz, 2004). In the present study, the highest RM value (30.56) was recorded for sample 24, whereas the lowest value (17.08) was reported for sample 21. The RM values of only two butter samples were not consistent with Butter Standard. The lowest RM value must be 24 according to Butter Standard (Anonymous, 1995). In a study carried out by Kurdal and Koca, (1987), the RM values were found to be 26.58-28.55, Compared to the present study, Sağdiç et al., (2004) found higher RM values. The RM had a negative correlation with RI (r=-0.633; $P<0.05$) and a positive correlation with Polenske (r=0.670; $P<0.01$).

The Polenske is the measure of the steam volatile and water insoluble fatty acids (caprylic, caproic and lauric acids) l. The reported Polenske values are in between 1 and 3.5 in butter (Demirci and Gündüz, 2004). The minimum, maximum, and the mean values of Polenske are shown in Table 1. Similar results were reported by Şengül et al., (1998); Sağdiç et al., (2002); and Sağdiç et al., (2004). Polenske values reported by Kurdal and Koca, (1987) were ranged between 1.93-272 in Erzurum butter samples. Various factors, such as the stage of lactation, feeding regime, seasons, and type of animals may have an impact on IV, RM, and Polenske numbers (Illingworth et al., 2009).

The RI is commonly used for detection of adulteration and imitation in butter. The RI values should be in the range of 1.4520 to 1.4620 at 40 °C (Demirci and Gündüz, 2004). Herein, the RI values of the tested samples were ranged between 1.4591-1.4620, with a mean value of 1.4605. In this context, Demirkol et al., (2016) found the RI values of 1.3331 and 1.4672 in butter samples collected from Çanakkale. On the other hand, Sağdiç et al., (2004) recorded RI values of 1.4562 to 1.4596 in butter samples made from cow, goat, and ewe yogurts. The lowest RM and Polenske values and the highest RI values are noticed in sample 21. The highest RM and Polenske values, and the lowest RI values can be seen in sample 24.

Microbiological properties

The important microbial spoilage in butter are putridity and hydrolytic rancidity (Jay, 2000). Additionally, some other defects, such as skunk-like odor, malty flavor, and black discoloration can be observed in butter (Jay, 2000). In particular, *Pseudomonas* spp. can potentially be the source of both putridity and rancidity. Proteases and lipases, which may be resistant to pasteurization, are produced by *Pseudomonas* genera. Microbial and nonmicrobial lipases lead to rancidity in butter (Jay, 2000).

TAMB counts are shown in Table 2. The obtained results herein are similar to those reported by Idoui et al., (2010); Idoui et al., (2013); and Erkaya et al., (2015). The high TAMB count may be abbributed to insufficient pasteurization, absence of salt (Idoui et al., 2010), a high rate of microbial load in raw milk, and recontamination during the production process (Idoui et al., 2013).

Coliform and TAMB counts is accepted as a hygienic indicator (Gökçe et al., 2010). The microbiological properties of Erzurum butter are presented in Table 2. Coliform counts ranged between<1 and 4.21 log CFU g^{-1} . The counts of coliform bacteria were below the detectable level in 17 samples. The coliform count in butter is restricted as 2 log CFU g^{-1} by Butter Standard (Anonymous, 1995). In the pre-

TABLE 2: *Values belonging to the microbiological properties of Erzurum butter samples (log CFU g^{-1}).*

	Min	Max	Mean	SD
Coliforms	<1	4.21	1.07	1.49
TAMB	5.65	7.96	6.79	0.64
LAB_{MRS}	4.65	7.49	6.45	0.63
LAB_{M17}	5.30	8.08	6.76	0.63
Mould and yeasts	<2	6.86	5.33	1.52

sent study, coliform bacteria counts were higher (in eight samples) than that ascribed in Butter Standard. It has to be noted that coliform bacteria was not detected in any butter samples in the study carried out by Sağdiç et al., (2002). Gökçe et al., (2010) investigated the microbiological quality of karin butter samples. The coliform bacteria counts were found to be <10 and 6.3×10^2 CFU g^{-1} in karin butter samples. Idoui et al., (2010) found that coliform counts of traditional butter ranged between 0 and 0.2×10^4 CFU g^{-1}. The presence of coliforms indicate the possibility of inadequate heat treatment or recontamination (Gökçe et al., 2010).

The lowest and highest counts of LAB growth in MRS and M17 agars are presented in Table 2. LAB counts (on MRS and M17 agar) were recorded between 4.20-7.00 log CFU g^{-1} and 5.60-7.00 log CFU g^{-1}, respectively, by Fındık and Andiç, (2017), who studied the chemical and microbiological characteristics of commercial butter. During storage, the counts of LAB on MRS and M17 agar ranged between 6.03-6.68 log CFU g^{-1} and 6.46-7.20 log CFU g^{-1}, respectively, as reported by Erkaya et al., (2015).

Molds are one of the main spoilage factors in butter. Molds usually cause a greenish color in butter, but other colored (red, black, and brown) molds can be seen (Gökçe et al., 2010). Defects in butter can be caused by *Rhizopus, Geotrichum, Penicillium, Alternaria, Aspergillus, Mucor,* and *Cladosporium* (Jay, 2000; Kornacki et al., 2001). Yeasts and molds are more resistant to low water activity and moisture compared to bacteria (Kornacki et al., 2001). Yeasts and molds can grow faster than bacteria (Gökçe et al., 2010). They cause hydrolytic rancidity in butter (Kornacki et al., 2001). Surface growth of various molds and yeasts on butter can produce colored spores (Jay, 2000). As presented in Table 2, sample 20 and 24 had the lowest yeasts and molds count (<2 log CFU g^{-1}), meanwhile the maximum yeasts and molds count were observed in sample 8 (6.86 log CFU g^{-1}). Similar results were reported by Erkaya et al., (2015) and Fındık and Andiç, (2017). Yeasts and molds counts were found to be 1.0×10^2 CFU g^{-1} and 2.1×10^5 CFU g-1in karin butter as reported by Gökçe et al., (2010). The maximum yeasts and molds counts must be 2 log CFU g^{-1} according to Butter Standard (Anonymous, 1995). Herein, only three butter samples have had lower yeasts and molds counts according to Butter Standard. The high counts of yeasts and molds are indicators of wrong production process and pachaging. After manufacture, the yeasts and molds can be contaminated through air or water (Kurdal and Koca, 1987; Gökçe et al., 2010).

Conclusions

In this study, some physical, chemical, and microbiological properties of butter samples collected from local retail markets in Erzurum were investigated. There were substantial differences among the tested butter samples in terms of the evaluated properties. Salt values were in conformity with Turkish Food Codex except for 1 butter sample out of 30. The fat and moisture contents did not comply with the Turkish Food Codex for sample 14 and 18, respectively. PVs of all Erzurum butter samples were lower than 3.00 $mEqO_2$ kg^{-1}; the threshold value of rancidity. Coliforms and yeasts and molds counts were not detected in sample 17 and 2; their mean values were a bit high. The butter samples had high TAMB counts. To improve the chemical and microbiological qualities of butter, the raw materials should be of high-quality, follow the recommended personal hygiene and sanitation rules of equipment used in production, and using a standard production process. It is necessciated to conduct further research works on domestic butter produced from local brands.

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Conflict of interest

The authors declare that they have no conflict of interest.

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