KSÜ Tarım ve Doğa Derg 23 (2): 493-505, 2020
KSU J. Agric Nat 23 (2): 493-505, 2020
DOI:10.18016/ksutarimdoga.vi.553970

Some Physicochemical and Microbiological Properties of Cow Milks Collected from Local Dairy Delicatessens in Erzurum, Turkey

Alper BARAN[1], Mehmet Cemal ADIGÜZEL[2]
[1]Department of Food Quality Control and Analysis, Vocational School of Erzurum, Atatürk University, Erzurum, [2]Deparment of Microbiology, Faculty of Veterinary Medicine, Atatürk University, Erzurum, Turkey
[1]https://orcid.org/0000-0002-3089-6624, [2] https://orcid.org/0000-0002-2385-9649
✉: alper.baran@atauni.edu.tr

ABSTRACT
In this study, some physicochemical and microbiological characteristics of 50 raw milk samples sold in local dairy delicatessens in Erzurum province were determined. As a result of the research, the non-fat dry matter (%), fat (%), total dry matter (%), pH, acidity (%), and density values of the milk samples were 7.6-10.5, 1.5-6.8, 10.9-15.1, 6.46-7.33, 0.121-0.252 and 1.026-1.034, respectively. When the data were evaluated according to the related standards, it was determined that 12% of the raw milk was not suitable for fat, 6% for non-fat dry matter and 12% for total acidity. The total aerobic of mesophilic bacteria counts in 98% of the samples were > 100.000 cfu/mL^{-1}, of the total coliform bacteria counts were in the range of 5.18-5.83 log cfu/mL^{-1} in 38%, the total Enterococcus spp. counts were in the range of 5.76-6.68 log cfu/mL^{-1}, the total number of Staphylococcus/Micrococcus spp. counts were in the range of 3.60-4.80 log cfu/mL^{-1} in 60% and the yeast-mold counts 4.38-5.07 log cfu/mL^{-1} in 36%. When all the results were taken into consideration, it was recognized that the samples were found to have worse microbiological quality than the chemical properties.

Research Article

Article History
Received : 15.04.2019
Accepted : 08.12.2019

Keywords
Raw milk
Physicochemical properties
Microbiological quality
Erzurum

Erzurum'da Yerel Süt/Süt Ürünleri Şarküterilerinden Toplanan İnek Sütlerinin Bazı Fizikokimyasal ve Mikrobiyolojik Özellikleri

ÖZET
Bu araştırmada Erzurum ilinde lokal süt şarküterilerinde satışa sunulan 50 adet çiğ süt örneğinin bazı fizikokimyasal ve mikrobiyolojik özellikleri belirlenmeye çalışılmıştır. Araştırma sonucunda süt örneklerinin yağsız kurumadde (%), yağ (%), toplam kurumadde (%), pH, asitlik derecesi (%), ve yoğunluk değerlerinin sırasıyla 7,6-10,5, 1,5-6,8, 10,9-15,1, 6,46-7,33, 0,121-0,252 ve 1,026-1,034 arasında değiştiği ve süt örneklerinin hepsinin karbonat testinin negatif olduğu saptanmıştır. Elde edilen veriler ilgili standartlara göre değerlendirildiğinde çiğ sütlerin %12'sinin yağ, %6'sının yağsız kurumadde, %12'sinin de asitlik değeri yönüyle uygun olmadığı saptanmıştır. Örneklerin, %98'inde toplam mezofilik aerobik bakteri sayısının >100.000 kob/mL^{-1}, %38'inde toplam koliform bakteri sayısının 5,18-5,83 log kob/mL^{-1} arasında, total Enterococcus türlerinin sayısının 5,76-6,68 log kob/mL^{-1} arasında, toplam Staphylococcus/Micrococcus türlerinin sayısının % 60'ında 3,60-4,80 log kob/mL^{-1} arasında ve maya-küf sayısının ise %36'sında 4,38-5,.07 log kob/mL^{-1} arasında olduğu belirlenmiştir. Elde edilen tüm sonuçlar göz önünde bulundurulduğunda incelenen örneklerin kimyasal özelliklerinden ziyade mikrobiyal kalitelerinin daha kötü olduğu tespit edilmiştir.

Araştırma Makalesi

Makale Tarihçesi
Geliş Tarihi : 15.04.2019
Kabul Tarihi : 08.12.2019

Anahtar Kelimeler
Çiğ süt
Fizikokimyasal özellik
Mikrobiyolojik kalite
Erzurum

To Cite : Baran M, Adıgüzel MC 2020. Some Physicochemical and Microbiological Properties of Cow Milks Collected from Local Dairy Delicatessens in Erzurum, Turkey. KSU J. Agric Nat 23 (2): 493-505. DOI: 10.18016/ksutarimdoga.vi.553970.

INTRODUCTION

Milk has an important role in nutrition in human life due to its protein, carbohydrates, vitamins and fat contents (Ullah et al., 2017). Additionally, it has beta-lactoglobulin, lactoferrin, lysozyme, galactosidase, conjugated linoleic acid, minerals, vitamins, hormones and peptides which are biologically active compounds with antiadhesive, antidiabetic, antimicrobial, angiotensin converting enzyme inhibitor, anticarcinogenic, antiobesitic, pre and probiotic properties which have important effects on human nutrition, health and metabolism (Park et al., 2013; Armas et al., 2016). In summary, milk is one of the most important animal products that contain many components needed by human metabolism in daily life in a sufficient and balanced rate (Singhal et al., 2017).

In addition to its vital importance, milk has great importance economically in terms of cattle breeding as the main agricultural activity of farmers in Turkey. The milk production rate in Turkey has increased over the years and is still upward trend due to improvements in the livestock sector. In 2000, the amount of bovine milk production, which was 8.372,00 tons, reached 18.762,000 tons in 2017. It can be observed that milk production does not only meet the needs in the country, but also contributes to the national economy when the its products are also sold in the foreign markets. For example, the rate of exports of dairy products realized in January 2019 increased by 21.06% compared to January 2018 (USK, 2019).

The type and quality of raw milk to be used in the production of dairy products are important in terms of product quality. In this respect, the physical, chemical and microbiological characteristics of raw milk is a matter to be emphasized. Qualified milk is a very important product in terms of economy and health, in this way it can make the farmer earn more money, as well as enables the industrial institutions and/or organizations to produce more and better-quality dairy products. Consumers tend to prefer the healthy milk products due to the increasing demand for hygienic and nutritionally high-quality ones (Chardon et al., 2016; Spreer, 2017).

There is a relationship between some physicochemical parameters that make up the structure of raw milk. Changes in some parameters that make up the composition also lead to a number of changes in the total content. This known situation has been put forward by many researchers. Therefore, any kind of adulteration that can be made in milk opens the door to a number of changes in the composition. When the relations of the subject matter are examined, valuable information is given about the quality of milk and the probabilities of adulteration. A similar situation is observed in microbial flops of milk (Antunac et al., 2002; Martin et al., 2004; Ropciuc, 2013).

In the production of milk and dairy products, Erzurum meets a large part of the regional production in the North-Eastern Anatolia Region. Nevertheless, it is reported that milk and dairy production is not sufficient in terms of hygiene and quality parameters (KUDAKA, 2013). Therefore, it is necessary to evaluate the current situation in milk in the the markets as a basis for the measures and activities in Erzurum province. In line with this aim, samples were taken from raw milk of the markets in Erzurum province and their physical, chemical and microbiological properties were determined. In addition, the relationships between the parameters of physicochemical and microbiological properties of the samples were evaluated.

MATERIAL and METHODS

Collection and Analysis of Milk Samples

Overall, 50 milk samples (n:50) collected from different local dairy delicatessens in Erzurum during the May-December 2018 were used as materials in this study. The raw milk samples were brought to the laboratories of the Erzurum Vocational School, Department of Food Processing under the cold chain and were subjected to analyzes on the same day.

Physicochemical and Chemical Analysis in Milk Samples

The pH of the milk samples was determined using pH meter (Hanna Orion, USA) and the acidity was determined by titrimetric method using phenolphthalein indicator (Metin and Öztürk, 2010). The fat content of milk samples was determined by using Gerber method (Metin and Öztürk, 2010) non-fat dry matter values by using refractometer, total dry matter content was determined by addition of fat content and non-fat dry matter and specific gravity values were determined by using lactodensimeter (Beykaya et al., 2017). The presence of carbonate was determined using rosalic acid (Metin and Öztürk, 2010).

Microbiological Analysis in Milk Samples

Prepared Samples for Microbiological Analyzes: 10 mL of milk samples were homogenized with 90 mL sterile physiological water (0.85%) (10^{-1} dilution) and dilutions (10^{-2}, 10^{-3} and 10^{-4}) were prepared for microbiological analysis. The logarithmic conversion to the obtained colony numbers was expressed in terms of log cfu mL^{-1}.

Total Aerobic Mesophilic Bacteria Count: Total aerobic mesophilic bacteria were enumerated on Plate Count Agar (PCA) (Merck, Germany) after incubating at 32 °C for 24-48 h in aerobic conditions (Motato et al., 2017).

Total Coliform Bacteria Count: Total coliform bacteria were enumerated on Violet Red Bile Agar (VRB) (Merck, Germany) after incubating at 35 °C for 24-48 h in aerobic condition (Asfidoajani and Scihani, 2018).

Yeast and Mold Count: Yeast and mold was enumerated on Rose Bengal Chloramphenicol Agar (RBC) (Merck, Germany) (VRB) after incubating at room temperature for 5 days (Zeng et al., 2013).

Staphylococcus/Micrococcus spp. Count: Staphylococcus/Micrococcus spp. was enumerated on Baird Parker Agar (BP) (Merck, Germany) supplemented with egg yolk tellurite emulsion after incubating at 37 °C for 24 h in aerobic conditions (Walcher et al., 2014).

Total Enterococcus spp. Count: Total Enterococcus spp. bacteria were enumerated on Kanamycin Aesculin Azide Agar (KAA) (Merck, Germany) supplemented with kanamycin after incubating at 37 °C for 24 h in aerobic conditions (Graham et al., 2017).

Statistical Analysis

Standard deviations were calculated to check the sensitivity of the examination and allow the comparison of raw milk contamination. Descriptive statistics including mean, standard deviation, variance, minimum and maximum values were obtained. To evaluate the association of psychochemical and microbiological properties in raw milk samples, we used Pearson correlations test. SPSS (SPSS Inc., Chicago, IL, USA) and Minitab Software (Minitab Inc., State College, Pennsylvania, USA) was used for statistical analysis.

RESULTS and DISCUSSION

Physicochemical Properties of Milk Samples

The results of the physicochemical analysis of the samples taken from raw milk sold in Erzurum are given in Table 1.

Intensity of the correlation between analyzed some parameters in milk samples was significant. (Table 2). In this study, statistically highly significant correlation ($p<0.01$) between NFDM and F contents in relationship with TDM in milk samples were established. A negative correlation was found between TA and pH properties ($p<0.01$). Also, a negative correlation between the content of milk fat and density was established. We detected significant correlation ($p<0.05$) between density and NFDM content.

Figure 1 shows that there were three components that contribute to the quality of cow milk. Both components explain 86% variability of the quality of milk based on physicochemical analyses.

Non-Fat Dry Matter and Total Dry Matter

The non-fat dry matter in milk consists of all solids such as lactose, minerals and vitamins. Non-fat dry matter content in milk is important in terms of flavor

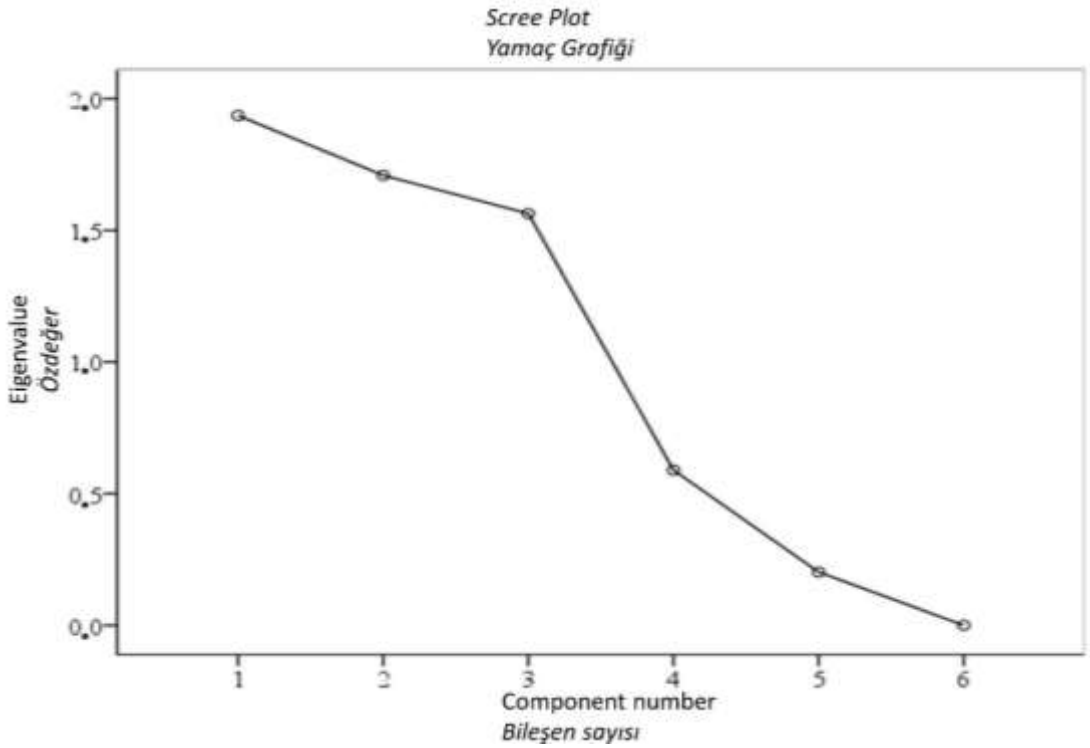

Figure 1. Factorial analyses of raw milk samples
Çizelge 1. Çiğ süt örneklerinin faktör analizi

Table 1. Some Physicochemical Properties of Raw Milk Samples (n: 50)
Tablo 1. Çiğ Süt Örneklerinin Bazı Fizikokimyasal Özellikleri (n: 50)

Samples ID *Örnek No*	NFDM (%) *Yağsız Kuru Madde (%)*	F (%) *Yağ (%)*	TDM (%) *Toplam Kuru Madde (%)*	pH	TA (LA%) *Titrasyon Asitliği (LA%)*	Density *Yoğunluk*	Carbonate *Karbonat*
s1	10.50	4.0	14.50	7.09	0.181	1.031	-
s2	10.00	4.5	14.50	6.71	0.230	1.031	-
s3	9.75	4.2	13.95	6.87	0.202	1.029	-
s4	10.50	3.5	14.00	7.01	0.179	1.031	-
s5	10.5	2.5	13.00	7.03	0.177	1.031	-
s6	9.10	3.5	12.60	6.90	0.194	1.030	-
s7	9.70	5.0	14.70	6.98	0.180	1.030	-
s8	9.30	4.7	14.00	6.85	0.186	1.029	-
s9	8.50	4.5	13.00	6.90	0.181	1.029	-
s10	9.60	4.9	14.50	6.79	0.190	1.028	-
s11	10.10	4.0	14.10	6.53	0.252	1.028	-
s12	9.30	4.1	13.40	7.03	0.178	1.031	-
s13	8.80	4.3	13.10	6.78	0.220	1.032	-
s14	8.30	3.9	12.20	6.86	0.175	1.028	-
s15	9.40	4.5	13.90	6.93	0.186	1.029	-
s16	7.60	4.0	11.60	6.66	0.225	1.029	-
s17	9.00	3.7	12.70	7.04	0.170	1.029	-
s18	8.90	3.9	12.80	6.67	0.216	1.028	-
s19	8.70	4.0	12.70	6.46	0.234	1.031	-
s20	9.30	4.0	13.30	6.50	0.250	1.030	-
s21	8.30	6.8	15.10	6.95	0.179	1.026	-
s22	8.40	4.5	12.90	6.97	0.175	1.031	-
s23	9.23	4.0	13.23	6.96	0.176	1.031	-
s24	8.90	4.4	13.30	6.83	0.160	1.030	-
s25	8.25	4.5	12.75	6.97	0.173	1.030	-
s26	8.70	3.5	12.20	7.01	0.160	1.029	-
s27	9.90	4.0	13.90	6.91	0.178	1.031	-
s28	8.70	3.5	12.20	6.87	0.170	1.031	-
s29	9.90	3.2	13.10	6.94	0.182	1.031	-
s30	9.80	3.5	13.30	7.03	0.133	1.030	-
s31	9.50	4.0	13.50	7.03	0.130	1.031	-
s32	9.90	4.5	14.40	6.94	0.179	1.030	-
s33	9.50	4.2	13.70	7.33	0.121	1.030	-
s34	9.10	3.5	12.60	6.74	0.180	1.030	-
s35	8.60	2.5	11.10	6.95	0.196	1.029	-
s36	9.80	3.5	13.30	6.73	0.190	1.030	-
s37	9.10	3.7	12.80	6.90	0.180	1.027	-
s38	10.00	3.5	13.50	6.66	0.216	1.034	-
s39	10.40	4.0	14.40	6.77	0.200	1.030	-
s40	9.40	1.5	10.90	7.01	0.138	1.032	-
s41	10.30	3.5	13.80	6.91	0.178	1.030	-
s42	9.40	4.0	13.40	6.98	0.170	1.031	-
s43	9.70	3.5	13.20	6.80	0.180	1.030	-
s44	10.30	3.0	13.30	6.73	0.192	1.031	-
s45	9.30	4.0	13.30	6.99	0.231	1.032	-
s46	8.70	4.5	13.20	7.19	0.122	1.030	-
s47	9.40	4.2	13.60	6.80	0.173	1.031	-
s48	8.70	3.5	12.20	6.82	0.180	1.031	-
s49	8.60	2.5	11.10	6.95	0.192	1.029	-
s50	9.40	3.5	12.90	7.03	0.130	1.031	-
MinV	7.60	1.5	10.90	6.46	0.121	1.026	
MaxV	10.50	6.8	15.10	7.33	0.252	1.034	
Variance	0.46	0.60	0.84	0.03	0.00	0.00	
SD	0.68	0.78	0.92	0.17	0.03	0.00	
SE	0.10	0.11	0.13	0.23	0.00	0.00	
Mean	9.32	3.89	13.21	6.89	0.183	1.030	

MinV: Minimum value; MaxV: Maximum value; SD: Standard Deviation; SE: Standard Error; NFDM: Non-Fat Dry Matter, F: Fat, TDM: Total Dry Matter, TA: Titratable Acidity.

Table 2. Data of correlation strength among physiochemical properties
Tablo 2. Fizikokimyasal özellikler arasındaki korelasyon gücünün verileri

	NFDM *Yağsız Kuru Madde*	F *Yağ*	TDM *Toplam Kuru Madde*	pH	TA *Titrasyon Asitliği*	Density *Yoğunluk*
NFDM *Yağsız Kuru Madde*	1					
F (*Yağ*)	-0.209	1				
TDM *Toplam Kuru Madde*	0.561**	0.692**	1			
pH	0.035	-0.028	0.002	1		
TA (*Titrasyon Asitliği*)	0.020	0.094	0.094	-0.792**	1	
Density (*Yoğunluk*)	0.338*	-0.376**	-0.068	0.049	-0.046	1

**Correlation is significant at the 0.01 level.
*Correlation is significant at the 0.05 level.

and nutritional value for the consumer and yield of the dairy products for producers (Liu et al., 2018). As shown in Table 1, it was determined that percentage of non-fat dry matter of the collected milk samples were between 7.6% and 10.5% and the mean value was 9.32%. Raw milk should be ≥ 8.5% for non-fat dry matter in cow's raw milk in the Communiqué on the supply of raw milk to the final consumer by local retailers (Official Newspaper , 2017). When the results of the analyzes were evaluated according to this communiqué, only 6% (n:3) of the samples were found to be unsuitable. Other samples were found to be above the value in the same communiqué. The percentage of non-fat dry matter of the raw milk samples sold in our country was examined by many researchers and Türkoğlu et al. (2003), Kesenkaş and Akbulut (2010), Akın et al. (2016), Beykaya et al. (2017), Göncü et al. (2017) reported that the percentage of non-fat dry matter of milk samples was 5.70-7.56%, 8.54%, 7.62-9.25%, 7.33-9.80%, and 7.77-8.97%, respectively.

The yield of dairy products depends on the total amount of dry matter. As the dry matter content increases, the yield of the products to be obtained increases as well.. Since the payment system for raw milk in the world is based on total dry matter content, it is very important to examine this parameter economically (Draayier et al., 2009). In the present study, the total dry matter content of the milk samples was determined by collecting fat content and non-fat dry matter. In fact, in the correlation analysis, it was found that the fat and non-fat dry matter contents in milk were related to the total dry matter content. In the light of the data obtained, it was observed that 44% (n:22), 28% (n:14), 8% (n:4), and 20% (n:10) of milk samples had a total dry matter percentage of between 13-14%, 12-13%, below 12% and above 14% above, respectively. Generally, it was determined that milk samples with a high total dry matter had a high-fat content. As stated above, the total dry matter content depends on its components, such as the protein, lactose and fat content. The average total dry matter percentage in the raw milk samples offered for sale in our country was investigated in many studies and Kavas and Akbulut (1993), Kesenkaş and Akbulut (2010), Akın et al. (2010), Beykaya et al. (2017) and Göncü et al. (2017) reported that the percentage of total dry matter of milk samples was 12.33%, 12.33-13.28%, 10.00-16.90%, and %9.35-12.39, respectively. The results are comparable with the data obtained from the current study and it is thought that the differences seen are due to the factors such as season, nutrition, geographic location, breed and age of animals.

Fat

The fat content is an important milk quality parameter that determines the nutritional value of milk. However, fat is the most variable component in bovine milk. In addition, it is easily separated from milk because it is lower than other milk components. Therefore, the amount of fat can be reduced with milk adulteration. For all these reasons, routine analysis of milk fat is critical (Kucheryavskiy et al., 2014; Zhu et al., 2015). Although the standard on raw milk is repealed according to the Turkish Food Codex Raw Milk Communiqué, it has been stated that the fat content in raw milk should be ≥ 3.4% in Communiqué on the supply of raw milk to the final consumer by local retailers (Official Newspaper , 2017).

In the present study, the fat content of raw milk samples were varied from 1.5%, to 6.8% (Table 1). When raw milk is evaluated by Communiqué on the supply of raw milk to the final consumer by local retailers, it is observed that 12% (n:6) is below 3.4% and is not in compliance with the standard. Beykaya et al. (2017) analyzed the average fat content of raw milk samples in Sivas province as 3.89%, while Kesenkaş and Akbulut (2010) reported that this percentage was about 3.79% in İzmir province. The percentage of fat in milk samples reported in these studies are consistent with the current study data. On the other hand, the fat content of raw milk samples was determined by Sezgin and Koçak (1982) (3.34%),

Sezgin and Bektaş (1988) (3.0%), Kavas and Akbulut (1993) (3.30%) and Türkoğlu et al. (2003) (3.20%) was found to be higher than the values they found. It is predicted that the difference of fat content of raw milk is derived from the factors such as the type and body condition of the cattle, feeding, lactation stage, season and ambient temperature.

On the other hand, we found a positive correlation between total solid and fat content in milk samples. Indeed, Luliana et al. (2014) and Khatun et al. (2018) reported that they had found a strong correlation between fat and total solid contents in milk.

pH and Acidity

Acidity of milk, which is naturally an acidic animal product, is of vital important parameter to determine the milk quality in dairy farms. In the subsequent stages of milk processing, pH also becomes an important component. Examination of both parameters provides information on the total acid concentration in the milk (Isildak and Gones, 2018). As is known, there is a negative correlation between pH and titratable acidity in raw milk (Fava et al., 2014). In fact, the statistical analysis obtained in the present study proves the accuracy of this relationship. Measurement of milk pH is important in tests of impurity, deterioration and mastitis infection symptoms. The pH of fresh milk is about 6.7. When the pH of the milk drops below pH 6.7, it typically shows deterioration by bacterial degradation. An acidic pH in milk is transformed into "sour milk" in which coagulation or curl occurs with its characteristic odor and taste (Kurwijila, 2006). Milk with a pH higher than 6.7 indicates that milk is from cows infected with mastitis. Typically, in milk, a somatic cell count is performed to detect mastitis infection, but a pH measurement is a rapid pathway for infection screening (Anema, 1998). The pH values of the raw milk samples taken in the study are given in Table 1. As shown in the Table 1, the pH values of raw milk samples ranged from 6.46 to 7.33 and found to be 6.89 on average. There is no standard regarding the pH values of raw milk in Turkish Food Codex. With regard to the pH of raw milk in different regions of Turkey, pH values were found to be 4.89-6.70, 6.30-7.00, 6.41-6.63, and 6.37-6.62 by Beykaya et al. (2017), Kesenkaş and Akbulut (2010), Akın et al. (2010), and Göncü et al. (2017), respectively.

In dairy technology, acidity is often expressed and evaluated in terms of lactic acid and SH° (Soxhlet Henkel). As it is known, a multiplication of 0.0225 coefficients is applied in order to convert the SH° degree to lactic acid%. The total acidity values of the raw milk samples examined in the present study were found between 0.120% and 0.252%. Turkish Food Codex "Communiqué on Raw milk and Heat-Treated Drinking Milk" reported that the acidity of the raw milk should be between 0.125-0.200% in terms of lactic acid (Türk Gıda Kodeksi, 2000). According to the Turkish Food Codex in terms of acidity, 84% (n:42) of the milk samples examined were found to be suitable, and 12% (n:6) were found to have high titratable acidity. 4% (n:2) was found to have low titration acidity. In 6 (12%) of the raw milk samples analyzed, it was observed that the pH was below 6.7. It was observed that there was a harmony between the pH values of the milk samples and the acidity values. Sezgin and Bektaş (1988) reported that 69% of the milk sold in Trabzon, Beykaya et al. (2017) reported that 60% of the milk from dairy farms in Sivas showed a high degree of acidity. In another study, Türkoğlu et al. (2003) stated that the acidity of the milk sold in Sanliurfa ranged from 4.2 to 9.65 SH° and 73.7% of the milk samples examined were in accordance with the values given in the Turkish Food Codex, and 10.5% were below, 10.5% were above these values. On the other hand, Kesenkaş and Akbulut (2010) reported that 2% of the raw milk samples they examined had acidity below 0.135. Titratable acidity in raw milk with related studies conducted in different regions of Turkey, Göncü et al. (2017) and Akın et al. (2010) reported that titration acidity was varied between 0.142-0.258% and 0.164-0.220%, respectively. On the average of raw milk examined by this value, Sezgin and Bektaş (1988) and Türkoğlu et al. (2003) stated that 0.196% and 0.162%, respectively. Although there are some differences between the reported results and the data in the current study, there are some relatively compatible results.

Density

Determining the density of milk is one of the important methods that give insight into the adulteration of milk. Milk density varies with the effect of all substances in its composition. While the density decreases with increasing the amount of fat, raises with increasing protein, lactose and mineral content and/or decreasing fat content. When the correlation analysis was performed on the data obtained from this study, it was observed that there was a negative relationship between fat content and density of raw milk samples. As a matter of fact, as stated in the previous sentence, this shows that the specific gravity of fat in milk is low. Hence, adulteration such as weaning, water and/or starch /sugar addition may lead to a change in density (Luther et al., 2017). It has been stated in Turkish Food Codex "Communiqué on Raw milk and Heat-Treated Drinking Milk" that the density should be between 1.028 and 1.037 g/cm^3 (Turkish Food Codex, 2000). In the current study, the specific density of the raw milk samples changed between 1.0260 and 1.0340 g /cm^3, with an average of 1.030 g/cm^3 (Table 1). It was determined that the density of the milk samples examined was within the range specified in the

legislation. Beykaya et al. (2017), Türkoğlu et al. (2003), Yaylak et al. (2007), Tasci (2011), Diler and Baran (2014) and Göncü et al. (2017) reported that density of raw milk samples was varied between 1.0230-1.0312 g/cm^3, 1.0212-1.0401 g/cm^3, 1.0278-1.028 g/cm^3, 1.016-1.034 g/cm^3, 1.0283-1.0291 g/cm^3 and 1.0283-1.0323 g/cm^3, respectively.

Carbonate Test

NaOH (Caustic soda) is used to milk adulteration to neutralize the acidic effect. Caustic soda containing sodium can cause danger for individuals with hypertension and heart diseases. In addition, caustic soda deprives lysine in the milk, which is essential for the growth of infants. Such a milk adulteration is dangerous for all sections of society, but is more harmful for pregnant women. Addition of carbonate and bicarbonate to milk may cause deterioration of the hormone signals regulating development and reproduction. Carbonates also causes gastrointestinal problems such as stomach ulcers, diarrhea, colon ulcers and electrolyte discomfort (Reddy et al., 2017). As seen in Table 1, carbonate test was found negative in all milk samples examined. This means that the raw milk samples that are sold local diary delicatessens in Erzurum do not include caustic soda to reduce acidity.

Microbiological Properties of Raw Milk Samples

The results of the microbiological analysis of the samples taken from raw milk offered for sale in Erzurum are given in Table 3.

Intensity of the correlation between analyzed some microbiological parameters in milk samples was found significantly in Table 4. In this study, statistically highly significant correlation ($p<0.01$) between TAMB and TC and TE in milk samples were established. A positive correlation was found between TE and S-M count ($p<0.01$). Also, positive correlation between the Y&M and S-M count was established. We detected significant correlation ($p<0.05$) between number of TE and Y&M.

Total Aerobic Mesophilic Bacteria (TAMB)

The high total bacterial count (10^8 log cfu mL^{-1}) in raw milk can indicate the presence of various pathogenic microorganisms, and it is an important health hazard that the consumption of pasteurized or boiled milk from this milk may cause swallowing of heat-resistant toxins from microorganisms. The high total number of bacteria does not only pose a threat to public health, but is also a source of great concern as it causes regional economic losses. It is accepted that milk with high total bacterial counts is not maintained and stored under hygienic conditions (Millogo et al., 2010; Oliveira et al., 2011).

The lowest, highest and average aerobic mesophilic bacteria (TAMB) count were 5.00 log cfu mL^{-1}, 8.42 log cfu mL^{-1} and 6.96 log cfu mL^{-1}, respectively. It has been reported that the total number of aerobic mesophilic bacteria in raw cow's milk should be 100.000 cfm mL^{-1} in the Turkish Food Codex "Communiqué on Raw milk and Heat-Treated Drinking Milk" (Turkish Food Codex, 2000). This value is 5 when logarithmic transformation is performed. When this value is taken as a base, it is determined that only 1 of the milk samples is suitable for the communiqué and the remaining 49 is above the value specified in the communiqué (Table 3). This situation shows that the bacteriological quality of 98% of the raw milk samples is very bad. This situation indicates the presence of problems related to milking practices, milk transportation and holding. Göncü et al. (2017) reported that the number of TAMB in street milk sold in Şanlıurfa was between 6.06-7.74 log cfu mL^{-1}. According to the results of the same study, it was found that TAMB in all the raw milk samples analyzed was not suitable for the Turkish Food Codex. In this respect, it is compatible with the data of our current study. The analysis performed in raw milk in different parts of Turkey; Kesenkaş and Akbulut (2010), Diler and Baran (2014), and Akın et al. (2010) reported that the TAMB count were 4.2-7.4 log cfu mL^{-1}, 2.8-6.8 log cfu mL^{-1}, and 4.89-7.94 log cfu mL^{-1}, respectively.

The number of TAMBs gives information about the microorganism load of the milk which changes depending on the natural or rough factors. In fact, as given in this study, total coliform and total Enterococcus spp. numbers were correlated with the increase in the number of TAMB. The high number of microorganisms in this group, which is an important hygiene indicator, shows that milk is contaminated in environments where milk is obtained, stored and sold with an increase proportional to the number of TAMBs. Similar findings have been identified by different researchers (Torkar and Teger, 2008; Mohamed et al., 2017).

Total Coliform

Coliforms are defined as microorganisms that are aerobic or facultatively anaerobic, Gram-negative, non-spore-forming rods capable of fermenting lactose with the production of acid and gas at 32-35 °C (Martin et al., 2016). Detection of coliforms plays an important role in the dairy industry because coliforms reflect contamination in milk, soil and water, and poor hygiene practices. Therefore, legal limits have been set by many countries for the presence of coliforms in milk and dairy products. The high coliform number also indicates that contaminated milk by pathogenic bacteria important to public health, such as *Escherichia coli* (Masiello et al., 2016). As show in Table 3, the lowest, highest and average total coliform count were <2 log cfu/mL^{-1}, 6.48 log cfu/mL^{-1} and 5.47

Table 3. Microbiological properties of raw milk samples
Tablo 3. Çiğ süt örneklerinin mikrobiyolojik özellikleri

Samples ID *Örnek no*	TAMB (*Toplam Aerobik Mezofilik Bakteri*)	TC (*Toplam Koliform*)	TE (*Toplam Enterokok*)	S-M *Stafilikok-Mikrokok*	Y&M *Maya&Küf*
s1	7.91	5.94	6.19	4.91	5.88
s2	8.42	6.48	6.74	4.86	4.70
s3	7.49	5.81	5.94	5.30	5.18
s4	6.25	<2	6.41	5.02	4.78
s5	6.11	<2	6.04	5.02	3.60
s6	7.75	6.26	5.05	4.40	4.89
s7	7.45	6.45	6.13	4.81	5.97
s8	7.41	5.63	6.16	4.30	4.33
s9	7.83	5.68	6.72	4.76	5.20
s10	6.71	5.51	5.51	4.50	4.08
s11	7.40	6.06	6.06	4.32	4.37
s12	5.90	3.88	3.00	3.78	4.10
s13	6.18	4.85	3.48	<2	3.30
s14	7.30	5.84	5.60	3.60	4.08
s15	5.30	4.90	3.00	3.30	3.93
s16	5.11	5.94	5.60	4.60	4.60
s17	6.34	5.81	3.30	3.00	4.60
s18	7.54	6.13	4.98	4.45	5.32
s19	7.90	6.02	6.03	4.04	4.76
s20	7.81	5.52	6.02	3.00	3.70
s21	6.19	4.73	4.30	3.90	3.88
s22	7.65	5.72	6.13	4.46	5.36
s23	7.20	5.38	5.98	4.34	4.28
s24	7.49	5.62	5.98	4.00	5.78
s25	7.83	4.08	5.92	4.30	5.26
s26	6.60	5.26	5.80	4.48	3.85
s27	7.98	5.98	5.68	4.48	4.70
s28	7.18	5.13	6.20	4.48	3.90
s29	7.75	4.32	6.03	3.70	3.81
s30	6.13	5.89	5.66	3.00	5.15
s31	6.60	5.66	4.99	4.00	3.85
s32	6.90	6.00	5.70	5.87	4.48
s33	5.60	6.15	3.30	4.90	4.48
s34	6.90	6.00	5.70	5.87	4.48
s35	6.78	5.66	5.62	4.26	5.20
s36	7.67	5.51	5.72	4.40	4.00
s37	5.00	4.48	4.70	4.28	5.88
s38	6.79	5.56	4.30	4.52	4.00
s39	7.95	4.40	6.23	<2	3.00
s40	8.10	5.11	<2	<2	3.00
s41	6.30	4.00	5.03	3.95	4.60
s42	5.30	<2	<2	3.30	4.48
s43	6.23	4.30	5.48	4.30	5.04
s44	7.59	5.30	4.78	4.60	4.95
s45	8.18	5.73	5.88	4.90	4.85
s46	6.00	5.60	6.23	4.70	4.90
s47	6.30	5.05	5.72	4.00	5.77
s48	7.76	6.41	5.97	4.60	5.53
s49	6.49	5.59	4.30	5.30	5.00
s50	7.56	5.54	5.94	5.18	4.78
MinV	5.00	<2	<2	<2	3.00
MaxV	8.42	6.48	6.74	5.87	5.97
Variance	0.87	1.62	2.53	1.84	0.60
SD	0.93	1.27	1.59	1.36	0.77
SE	0.13	0.21	0.20	0.17	0.10
Mean	6.96	5.47	5.44	4.38	4.59

MinV: Minimum value; MaxV: Maximum value; SD: Standard Deviation; SE: Standard Error; TAMB: Total Aerobic Mesophilic Bacteria, TC: Total Coliform, TE: Total Enterococcus spp., S-M: Staphylococcus/Micrococcus spp., Y&M: Yeast and Mold

Table 4. Data of correlation strength among microbiological properties
Tablo 4. Mikrobiyolojik özellikler arasındaki korelasyon gücünün verileri

	TAMB *Toplam Aerobik Mezofilik Bakteri*	**TC** *Toplam Koliform*	**TE** *Toplam Enterokok*	**S-M** *Stafilikok-Mikrokok*	**Y&M** *Maya&Küf*
TAMB *Toplam Aerobik Mezofilik Bakteri*	1				
TC *Toplam Koliform*	0.404**	1			
TE *Toplam Enterokok*	0.409**	0.272	1		
S-M *Stafilikok-Mikrokok*	-0.004	0.111	0.472**	1	
Y&M *Maya&Küf*	0.046	0.229	0.324*	0.537**	1

**Correlation is significant at the 0.01 level.
*Correlation is significant at the 0.05 level.

log cfu/mL^{-1}. The coliform count, which are seen as general hygiene indicator in obtaining raw milk and found in our present study, reinforce the existence of problems related to non-hygienic milking and unsuitable milk holding practices in Erzurum. In studies conducted in order to reveal the microbiological quality of the raw milk samples which are offered for sale in different provinces, the count of coliforms was reported as 0.75-6.0 log cfu/mL^{-1}, 4.31-6.21 log cfu/mL^{-1}, 3.03 log cfu/mL^{-1} by Kesenkaş and Akbulut (2010), Göncü et al. (2017) and Diler and Baran (2014), respectively.

Enterococcus spp.

The bacteria of the genus *Enterococcus spp.*, also known as enterococci, constitute an important part of environmental, food and clinical microbiology. Depending on the strain, they are considered as indicator, distortion or potentially pathogenic organisms. They contaminate the milk and milk products via water, equipment, unhealthy and unhygienic production conditions. They are blamed as direct or indirect disease agents caused by milk and dairy products (Garg et al., 1991). On the other hand, some types of Enterococcus spp. are also known for their probiotic roles as they contribute to human digestibility (Franz et al., 2003). Because they are of faecal origin, their presence in milk is seen as an indicator for hygiene practices. As seen in Table 3, the total number of Enterococcus spp. in raw milk samples was <2 log cfu/mL^{-1}, 6.00 log cfu/mL^{-1} and 5.44 log cfu/mL^{-1}. 42% of the raw milk samples had a total Enterococcus spp. number between 5.76-6.68 log cfu/mL^{-1}.

The correlation of the number of coliforms and *Enterococcus spp.* with total bacterial count was understandable, they represented a part of the total bacterial count, because a lot of coliform and *Enterococcus spp.* bacteria are capable to growth at law temperatures (Torkar and Teger, 2008). Enterococcus spp. are resistant to heat stress and have a good specific competitiveness in environment with complex microflora, hence, they can easily adapt to the hot climate prevailing in the regions from where most of our samples were taken. Foschino et al. (2002) report that *Enterococcus spp.* did not correlate with any variable their investigated. For this reason, they emphisased that finding of *Enterococcus spp.* does not appear to be associated directly with faecal contamination or poor hygiene. On the contrary our results showed that there was the relation between total *Enterococcus spp.* and Staphylococcus/Micrococcus spp. or yeast and mold number. These results suggest that *Enterococcus spp.* would be faecal contamination in this study.

Tasci (2011) reported that the lowest, highest and average total number of Enterococcus spp. was found to be <10^2 cfu/mL^{-1}, 6.6x10^6 cfu/mL^{-1} and 3.2x10^4 cfu/mL^{-1} in the raw milk samples in Burdur province. When the logarithmic transformation is made, it is seen that the data obtained in this study is lower than the data obtained in the current study.

Staphylococcus/Micrococcus spp.

Staphylococcus species, which is a member of Micrococcaceae family, are Gram positive, 0.5-1.5 µm diameter coke-shaped, non-spore forming, non-motile, catalase positive, facultative anaerobic bacteria. There are 28 species and 32 subspecies in this genus. Staphylococci contamination is particularly alarming given the fact that many isolates can produce thermostable enterotoxin and consequently cause food-borne intoxication in consumers. The presence of *Staphylococcus aureus*, the most important member of this group, in raw milk is usually due to cow mastitis, handler or insufficient hygiene. When found in milk, it can quickly reach a high number under favorable conditions (de Oliveira et al., 2011). In view of this

situation, according to the Turkish Food Codex "Communiqué on Raw milk and Heat-Treated Drinking Milk", the number of *Staphylococcus aureus* should be maximum $5.0x10^2$ cfu/mL^{-1} in 2 and $1.00x10^2$ cfu/mL^{-1} in 3 of the raw milk samples (Türk Gıda Kodeksi, 2000).

As seen in Table 3, the total number of Staphylococcus/Micrococcus spp. in raw milk samples was <2 log cfu/mL^{-1}, 5.87 log cfu/mL^{-1} and 4.38 log cfu/mL^{-1}, respectively. Overall, 60% of the raw milk samples had Staphylococcus/Micrococcus spp. number between 3.60 and 4.80 log cfu/mL^{-1}. Kesenkaş and Akbulut (2010) reported that almost all of the raw milk samples examined had values between 3.0 and 5.4 log cfu/mL^{-1}. In another study, Tasci (2011) reported that lowest, highest and average number of Staphylococcus/Micrococcus spp. was <2 cfu/mL^{-1}, $1.3x10^6$ cfu/mL^{-1}, and $2.45x10^4$ cfu/mL^{-1}, respectively.in the raw milk samples in Burdur province. Diler and Baran (2014) reported that the number of Staphylococcus/Micrococcus spp. in their raw milk samples was 3.7 log cfu/mL^{-1}. The data obtained in the aforementioned studies are seen to be lower than those of current study.

We also found Staphylococcus/Micrococcus spp. had a positive correlation with yeast and mold number suggesting that there is necessarily exist a relationship between the Staphylococci and yeast in heavily contaminated milk.

Yeast and Mold

Milk provides all the nutrients and conditions necessary for growth, because raw milk is often considered an ideal growth medium for microorganisms, including many fungal species. Microscopic fungus formation in raw milk can occur during milking, transport, storage and other pretreatment activities; it is also affected by the physiological state of the animal, air and reproductive conditions. These microorganisms may pose a risk of deterioration in raw milk as well as the risk of public health due to mycotoxins which are secondary metabolites of fungus (Engin et al, 2009). However, there is no information on the number of yeast-molds required to be present in raw milk in the Turkish Food Codex.

The lowest, highest and average yeast-mold numbers of the raw milk samples were found to be 3.00 log cfu/mL^{-1}, 5.97 log cfu/mL^{-1} and 4.59 log cfu/mL^{-1}, respectively (Table 3). In 18 samples (36%), yeast mold-number was determined to be between 4.38-5.07 log cfu/mL^{-1}. The high number of yeast-molds determined indicates that the milk does not comply with the hygiene and sanitation rules during the milking stages and conditions. Similarly, Engin et al. (2009), Kesenkaş and Akbulut (2010), Göncü et al. (2017), and Beykaya et al. (2017) reported that the number of yeast mold in raw milk samples was 4.14-5.96 log cfu/mL^{-1}, 0.60-5.40 log cfu/mL^{-1}, 3.89-6.33 log cfu/mL^{-1}, <1-$9.6x10^6$ cfu/mL^{-1}

CONCLUSION

The highest value in the production of agricultural products in Turkey belongs to raw milk for last 10 years. In 2013, the production of raw milk in the agricultural production valued of 190 billion Turkish liras (TL) in Turkey. When only these values are considered, it will be seen that the milk and dairy products sector is a very important sub-sector in terms of the added value provides to the country's economy and the realization of rural development. In spite of all these reasons, small and scattered dairy farms and low quality of milk cause problems in domestic and foreign trade of milk. Milk enterprises should be safeguarded both in terms of market conditions and global realities, as well as their competitiveness in terms of public health. To this end, it is also necessary to fulfill the closing criteria of the "Food Safety, Veterinary and Phytosanitary" chapter, which is still open for negotiations with the EU. For this reason, rather than supporting the enterprises in different ways, the necessary improvements should be made in agriculture and livestock sectors which are the raw material source of the sector and milk supply should be provided as safe raw materials.

Although the physicochemical parameters of 50 milk samples collected from the Erzurum region examined in this study show that they are suitable in terms of quality, microbial analysis shows that their quality is not sufficient and a significant portion of them do not comply with the Turkish Food Codex.

We also notice a very significant positive correlation index between NFDM and fat content in relationship with TDM. Density is significantly negatively correlated with the fat content. As expected, a negative correlation was found between pH and TA (LA%). Similar correlations have been observed in some microbiological parameters and the increase in the number of TAMBs together with microorganisms known as hygiene indicators have shown that raw milk is contaminated at any stage of production.

The quality and composition of raw cow milk depends on the changing physico-chemical parameters of small, medium or large-scale farms. It is also influenced by various factors such as breed, feed intake, dietary patterns, milking incidence, milking process, seasonal changes, lactation time and adulteration. On the other hand, the high level of microbial loads in the raw milk provided by the farmers in the dairy industry under unhygienic conditions reduces the milk quality. Considering all these factors, the following should be done to improve the qualities of raw milk offered for sale in our province:

- Controls carried out by authorized units regarding the supply of raw milk should be made frequent and continuous.
- An effective control mechanism should be established and the milk coming from local farms should be recorded.
- The effects of possible damages on the individual and therefore on public health of raw milk reaching the consumer from the producer in unhealthy conditions should be explained by using non-formal education facilities. In this regard, universities, the media, the relevant ministries should work in coordination and provide awareness to the individuals and/or enterprises responsible for the primary processes until they reach the consumer.
- In order to increase the consumption of healthy and safe milk, national campaigns should be initiated and all groups, especially the younger generation, should be involved in this campaign.

Statement of Conflict of Interest

Authors have declared no conflict of interest.

Author's Contributions

The contribution of the authors is equal.

REFERENCES

Akın MS, Yapık Ö, Akın, MB 2016. Adıyaman ilinde süt üretim çiftliklerinden ve toplayıcılardan sağlanan sütlerin bazı özellikleri. Harran Tarım ve Gıda Bilimleri Dergisi, 20(4): 253-265.

Anema SG 1998. Effect of milk concentration on heat-induced, pH-dependent dissociation of casein from micelles in reconstituted skim milk at temperatures between 20 and 120 C. Journal of Agricultural and Food Chemistry, 46(6): 2299-2305.

Armas LA, Frye CP, Heaney RP 2016. Effect of Cow's Milk on Human Health. (Beverage Impacts on Health and Nutrition, Springer, Switzerland: Ed. Wilson T, Temple Norman J) 131-150.

Asfidoajani FA, Sichani MM 2018. Comparison of Coliform Contamination and Endotoxin Levels in Raw Cow's Milk. Zahedan Journal of Research in Medical Sciences, 20(5): e59333.

Beykaya M, Özbey A, Yıldırım Z 2017. Determination of physical, chemical and microbiological properties of milk from some dairy plants in Sivas Province. Turkish Journal of Agriculture-Food Science and Technology, 5(4): 388-396.

Chardon J, Swart A 2016. Food consumption and handling survey for quantitative microbiological consumer phase risk assessments. Journal of Food Protection, 79(7): 1221-1233.

de Oliveira LP, Silva V, Cirqueira M 2011. Study of Staphylococcus aureus in raw and pasteurized milk consumed in the Reconcavo area of the State of Bahia, Brazil. Journal of Food Processing and Technology, 2(6): 2-6.

Diler A, Baran A 2014. Erzurum'un Hınıs ilçesi çevresindeki küçük ölçekli işletme tank sütlerinden alınan çiğ süt örneklerinin bazı kalite özelliklerinin belirlenmesi. Alınteri Zirai Bilimler Dergisi, 26(1): 18-24.

Draaiyer J, Dugdill B, Bennett A, Mounsey J 2009. Milk testing and payment systems. Resource book: a practical guide to assist milk producer groups. Milk testing and payment systems. Resource book: a practical guide to assist milk producer groups.

Engin B, Güneser O, Yüceer YK 2009. Ultraviyole ışınlarının sütün mikrobiyel özellikleri üzerine etkisi. GIDA/The Journal of Food, 34(5): 303-308.

Fava LW, Külkamp-Guerreiro IC, Pinto AT 2014. Evaluation of physico-chemical characteristics of fresh, refrigerated and frozen Lacaune ewes' milk. Arquivo Brasileiro de Medicina Veterinária e Zootecnia, 66: 1924-1930.

Franz CM, Stiles ME, Schleifer KH, Holzapfel WH 2003. Enterococci in foods--a conundrum for food safety. International Journal of Food Microbiology, 88(2-3): 105-122.

Garg SK, Mital BK 1991. Enterococci in milk and milk products. Critical Reviews in Microbiology, 18(1): 15-45.

Graham K, Rea R, Simpson P, Stack H 2017. Development of a rapid, one-step screening method for the isolation of presumptive proteolytic enterococci. Journal of Microbiological Methods, 132: 99-105.

Göncü BG, Çelikel A, Akın MB, Akın MS 2017. Şanlıurfa'da satışa sunulan sokak sütlerinin bazı kimyasal ve mikrobiyolojik özelliklerinin belirlenmesi üzerine bir araştırma. Harran Üniversitesi Mühendislik Dergisi, 2(2): 15-23

Gulbe G, Valdovska A 2014. Diversity of microscopic fungi in the raw milk from Latvian organic farms. Proceedings of the Latvia University of Agriculture, 31(1): 46-53.

Isildak I, Gones AG 2018. Simultaneous SIA analysis of pH and total acidity measurements in milk. Journal of Food Measurement and Characterization, 12(1): 403-411.

Kavas G, Akbulut N 1993. İzmir ilinde satılan sokak sütlerinin fiziksel-kimyasal özellikleri üzerinde bir araştırma. EÜ Ziraat Fakültesi Dergisi, 30(1-2): 81-88.

Kesenkaş H, Akbulut N 2010. İzmir ilinde satılan sokak sütleri ile orta ve büyük ölçekli çiftliklerde üretilen sütlerin özelliklerinin belirlenmesi. Ege Üniversitesi Ziraat Fakültesi Dergisi, 47(2): 161-169.

Khatun MA, Roy BK, Hossain A, Rahman A, Munshi K, Islam M, Hossain A, Bhuiya MAI, Rahman M, Huque R 2018. Biochemical and Microbial Quality Attributes of Cow's Milk in Respect to Regional Discrimination in Bangladesh. Archives of Current

Research International, 12(4): 1-12.

Kucheryavskiy S, Melenteva A, Bogomolov A 2014. Determination of fat and total protein content in milk using conventional digital imaging. Talanta, 121: 144-152.

Kurwijila LR 2006. Hygienic milk handling, processing and marketing: reference guide for training and certification of small-scale milk traders in Eastern Africa. Regal Press Kenya Limited, Nairobi, Kenya.

Kuzeydoğu Anadolu Kalkınma Ajansı (KUDAKA) 2013. Kuzeydoğu Anadolu Bölgesi Süt Ve Süt Ürünleri Sektörü. https://www.kudaka.org.tr/ekler/907ac-kuzeydogu_anadolu_bolgesi_sut_ve_sut_urunleri_sektoru.pdf (Accessed date: 10/02/2019)

Liu Q, Guo W, He H, Zhu X 2018. Effect of solids-not-fat content on dielectric properties of skim milk. International Journal of Food Science & Technology, 53(11): 2560-2566.

Luliana G, Gabriel G, Mimi D, Gabriel C 2014. Determination ofrelationships betweenmilk composition and cheese yield usingprincipal component analysis and logitmodel. Bulletin UASVM Veterinary Medicine, 71(1): 62-65.

Luther Jamie L, Henry de Frahan V, Lieberman M 2017. Paper test card for detection of adulterated milk. Analytical Methods, 9(38): 5674-5683.

Martin NH, Trmčić A, Hsieh TH, Boor KJ, Wiedmann M 2016. The evolving role of coliforms as indicators of unhygienic processing conditions in dairy foods. Frontiers in Microbiology, 7(1549): eCollection 2016.

Masiello SN, Martin NH, Trmčić A, Wiedmann M, Boor KJ 2016. Identification and characterization of psychrotolerant coliform bacteria isolated from pasteurized fluid milk. Journal of Dairy Science, 99(1): 130-140.

Metin M, Öztürk GF 2010. Süt ve mamülleri analiz yöntemleri:(duyusal, fiziksel ve kimyasal analizler). Ege Üniversitesi Yayınları, İzmir, Türkiye.

Millogo V, Svennersten Sjaunja K, Ouédraogo GA, Agenäs S 2010. Raw milk hygiene at farms, processing units and local markets in Burkina Faso. Food Control, 21(7): 1070-1074.

Mohamed AF, Fourreh AE, Okieh AA, Said CN, Mérito A 2017. Evaluation of Microbiological Quality of Raw Milk from Farmers and Dairy Producers in Six Districts of Djibouti. Journal of. Food Microbiology Safety and Hygiene, 2, 124.

Motato KE, Milani C, Ventura M, Valencia FE, Ruas-Madiedo P, Delgado SA 2017. Bacterial diversity of the Colombian fermented milk "Suero Costeño" assessed by culturing and high-throughput sequencing and DGGE analysis of 16S rRNA gene amplicons. Food Microbiology, 68: 129-136.

Oliveira CJB, Hisrich ER, Moura JFP, Givisiez PEN, Costa RG, Gebreyes WA 2011. On farm risk factors associated with goat milk quality in Northeast Brazil. Small Ruminant Research, 98(1): 64-69.

Park YW, Albenzio M, Sevi A, Haenlein GF 2013. Milk Quality Standards and Controls. (Milk and dairy products in human nutrition: production, composition and health, John Wiley & Sons, USA: Ed. Park YW, Haenlein GF) 261-287.

Reddy DM, Venkatesh K, Reddy CVS 2017. Adulteration of milk and its detection: a review. International Journal of Chemical Studies, 5(4): 613-617.

Sezgin E, Koçak C 1982. Ankara'da satılan sokak sütlerinin bazı nitelikleri üzerinde araştırmalar. Gida/The Journal of Food, 7(6): 281-287.

Sezgin E, Bektaş S 1988. Trabzon'da satılan sokak sütlerinin bazı nitelikleri üzerinde araştırmalar. Gida/The Journal of Food, 13(6): 399-408.

Singhal S, Baker RD, Baker SS 2017. A Comparison of the Nutritional Value of Cow's Milk and Nondairy Beverages. Journal of Pediatric Gastroenterology and Nutrition, 64(5): 799-805.

Spreer E 2017. Milk and dairy product technology. Routledge, UK, p59.

Tasci F 2011. Microbiological and chemical properties of raw milk consumed in Burdur. Journal of Animal and Veterinary Advances, 10(5): 635-641.

TC Resmi Gazete 2017. Çiğ Sütün Arzina Dair Tebliğ. http://www.resmigazete.gov.tr/eskiler/2017/04/20170427-2.htm (Accessed date: 10/12/2018)

Türk Gıda Kodeksi 2000. Çiğ süt ve ısıl işlem görmüş içme sütleri tebliği. Resmi Gazete, 14(23964). http://www.resmigazete.gov.tr/eskiler/2019/02/20190227-5.htm (Accessed date: 21/12/2018)

Türkoğlu H, Atasoy F, Özer B 2003. Şanlıurfa ilinde üretilen ve satışa sunulan süt, yoğurt ve urfa peynirlerinin bazı kimyasal özelikleri. Harran Üniversitesi Ziraat Fakültesi Dergisi, 7(3-4): 69-76.

Torkar KG and Teger SG 2008. The microbiological quality of raw milk after introducing the two day's milk collecting system. Acta Agriculturae Slovenica, 92(1): 61-74.

Ullah R, Khan S, Ali H, Bilal M, Saleem M 2017. Identification of cow and buffalo milk based on Beta carotene and vitamin-A concentration using fluorescence spectroscopy. PLOS ONE, 12(5): e0178055.

Ulusal Süt Konseyi (USK) 2019. Türkiye Süt Sektör İstatistikleri Özet Raporu. https://ulusalsutkonseyi.org.tr/turkiye-sut-sektor-istatistikleri-ozet-raporu-2450/ (Accessed date: 10/02/2019)

Walcher G, Gonano M, Kummel J, Barker GC, Bereuter O, Ehling-Schulz M, Wagner M, Stessl B 2014. Staphylococcus aureus reservoirs during traditional Austrian raw milk cheese production. The Journal of Dairy Research, 81(4): 462-470.

Yaylak E, Alçiçek A, Konca Y, Uysal H 2007. İzmir ilçelerinde mandıralarca kış aylarında toplanan

sütlerde bazı besin madde ve fiziksel özelliklere ait değişimLerin saptanması. Hayvansal Üretim, 48(1): 26-32.

Zeng X, Xia W, Jiang Q, Yang F 2013. Effect of autochthonous starter cultures on microbiological and physico-chemical characteristics of Suan yu, a traditional Chinese low salt fermented fish. Food Control, 33(2): 344-351.

Zhu X, Guo W, Liang Z 2015. Determination of the fat content in cow's milk based on dielectric properties. Food and Bioprocess Technology, 8(7): 1485-1494.