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Research Article

Assessment of aroma profiles and mineral content of buffalo yogurt marketed in Cukurova region of Turkey

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ABSTRACT

The purpose of this study was identification of some chemical compositions, mineral content and aroma profile of buffalo yogurt samples which were collected from Çukurova markets. For this purpose, some chemical analyses of 20 buffalo yogurt samples obtained from Mersin and Adana provinces were performed. As a result of the chemical analysis, the average dry matter content of buffalo yogurts was 19.37%, fat content was 6.54%, protein content was 4.10% and ash content was 1.37%. Aroma profile was evaluated by GC/MS (Gas Chromatography/ Mass Spectrometry) using SPME (Solid-Phase Microextraction) technique. A total of 35 volatile compounds were detected including four aldehydes, four ketones, six acids, seven alcohols, four esters and ten miscellaneous compounds. Alcohols were the largest class of volatile compounds while acid and ketone groups were the major compounds in buffalo yogurt. The analysis of minor mineral content was performed by LA-ICP/MS (Inductively Coupled Plasma/Mass Spectrometer) and major minerals were detected by AAS (Atomic Absorption Spectrometer). According to the results of mineral analysis, the average Ca, K, Mg, Na, Cu, Fe, Mn and Zn levels were found to be 900.52 mg/L, 1678.18 mg/L, 729.80 mg/L, 325.78 mg/L, 0.28 mg/L, 7.60 mg/L, 0.39 mg/L, and 24.64 mg/L, respectively.

INTRODUCTION

Buffalo yogurt is an important product which reflects the main characteristics of buffalo milk ideally (Güzeler et al., 2019). It has a creamy structure and higher amount of dry matter, fat and protein contents than other yogurt types which are obtained from other animal milks. Most of the buffalo milk in Turkey is processed into yogurt (Bilgin and Kaptan, 2016). Buffalo yogurt is preferred by many consumers because of its aroma and high fat content (Ghoneem et al., 2018). The network of buffalo yogurt is more porous and it contains more and larger fat globules than bovine yogurt (Nguyen et al., 2015). Buffalo yogurt also has higher acid production rate, extent of proteolysis and flavor development by lactic cultures (Yadav et al., 2018). It is possible to obtain buffalo yogurt with high yield and low syneresis and there is no need to add milk powder or hydrocolloid to buffalo milk for yogurt production because of its high dry matter content (Khalifa and Zakaria, 2019).

In 2019, the total number of buffaloes in Turkey was 184.192 (head). 2.934 of them were in the Mediterranean region and this region had the minimum number of buffaloes in Turkey. The total numbers of buffaloes (head) in Adana and Mersin provinces in Çukurova region which is located in the Eastern Mediterranean were 425 and 56, respectively. The total amount of buffalo milk produced in Turkey in 2019 was 79341 tons, 1181 tons were produced in the Mediterranean region, 155 tons in Adana and 24 tons in Mersin (TÜİK, 2020).

Because of limited production of buffalo milk and dairy products in Çukurova region, it is not possible to reach these products easily. Therefore, buffalo milk products are very valuable in Çukurova region. It is well known that geographical location affects the compositions of buffalo dairy products, processing steps and overall quality (Akgün et al., 2016). There is no information about characteristics of buffalo dairy products in Çukurova region and limited published data about mineral composition and aroma profile of buffalo yogurt. Research on buffalo yogurt, especially on their mineral contents and aroma profile are still limited. Only a few studies have been performed on this subject. Erkaya and Şengül (2012) investigated mineral contents of buffalo yogurt. Erkaya and Şengül (2011) and Emirmustafaoğlu et al. (2020) studied volatile compounds of buffalo yogurt. To fill this gap, the present investigation was performed to determine mineral compositions and aroma profiles of buffalo yogurt samples, which were collected from Çukurova markets.

MATERIAL AND METHOD

In this research, 20 samples of buffalo yogurt were collected from local producers in Mersin and Adana provinces in Çukurova region. Some compositional properties, mineral contents and aroma profiles of yogurt samples were examined at Çukurova University, Faculty of Agriculture, Department of Food Engineering, Milk Technology Laboratory.

Chemical composition

Dry matter content was determined gravimetrically by drying the samples at 100°C until constant weighing (IDF, 2005). Fat content was determined according to Gerber method (TSE, 2002). Micro Kjeldahl method was used for determining total nitrogen content and total nitrogen content was multiplied by factor 6.38 for determining protein content (IDF, 2014). Ash content was calculated by burning the samples at 550°C, cooling in the desiccator and weighing (Kurt et al., 2007).

Aroma profile analysis

SPME fibers were placed on the injection port of Agilent 7890B gas chromatograph at 250°C for 5 minutes for preconditioning and placed on the gas phase flask for extraction for 60 minutes. Desorption was performed at 250°C for 3 minutes and a temperature programmed route was used for chromatography. The temperature was kept at 35°C for 3 minutes and then raised to 140°C at the rate of 4°C /min. The temperature was kept at 140°C for 1 minute and increased to 250°C in 3 minutes. The transfer line temperature was set at 250°C. Helium was used as carrier gas at a flow rate of 1.0 mL / min. For mass spectroscopy, electron ionization was performed at 70 eV and the ion source temperature was at 230°C, mass scanning range was m/z 33-450 AMU and emission current was 100 µA (Dan et al., 2019).

Mineral composition

The concentrations of Cu, Fe, Mn and Zn of the samples were determined by LA-ICP/MS (Perkin Elmer Nexion 2000 P) and as applied by Khan et al. (2014). For this purpose, 2 mg of sample was taken into Teflon tubes and 5 mL of 65% HNO_3 and 1 mL of 30% H_2O_2 were added to it. The samples were heated in microwave oven (Berghof speedwave MWS-2 Germany) at 170°C for 10 minutes, at 200 °C for 15 minutes and at 100 °C for 10 minutes. 1 mL of the distillate obtained by heating in the microwave oven was taken and completed to 10 mL with distilled water and mineral content was determined with LA-ICP/MS.

AAS (Perkin Elmer PinAAcle 900T) device was used to determine Ca, Mg, K and Na concentrations. 3 grams of sample was placed in Teflon cups and 5 mL of deionized water and 5 mL of concentrated HNO3 were added to it. Teflon cups were taken to the microwave mineralization device after shaking to mix the solution. After the microwave heating process, the samples were filtered through filter paper and completed to 50 cm^3 with deionized water. Measurements of the samples were carried out on AAS device at certain wavelengths (Capcarova et al., 2017).

RESULTS AND DISCUSSION

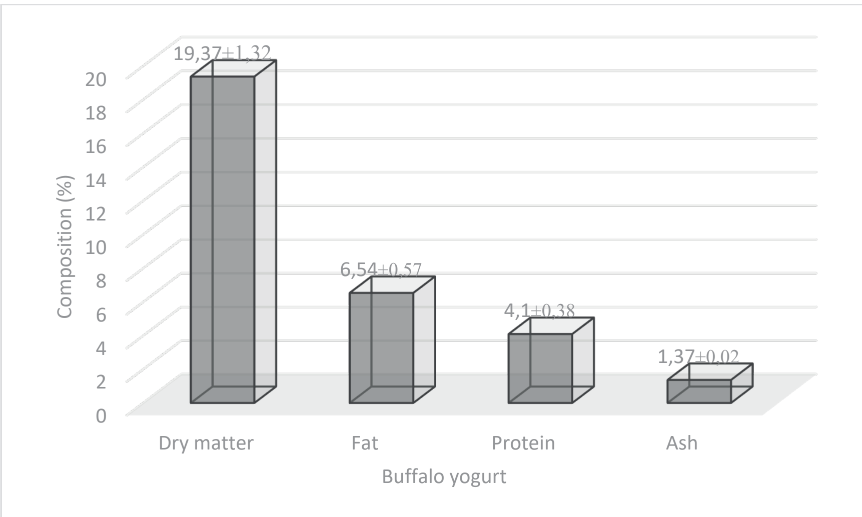
Chemical Composition

The mean values for the chemical compositions of buffalo yogurt samples collected from Çukurova markets are given in Figure 1.

The average dry matter content of buffalo yogurt samples was 19.37%. It was determined that buffalo yogurt samples collected from Çukurova markets had higher dry matter content than other buffalo yogurt samples which were collected from other places such as Erzurum (17.87%) in Turkey, Cairo (14.91-16.61%) and Damietta Governorate (17.70-18.01%) in Egypt and Karnal (13.11-14.11%) in India (Erkaya and Şengül, 2011; El-Shibiny et al., 2018; Ghoneem et al., 2018; Yadav et al., 2018).

The average fat content of buffalo yogurt samples from Çukurova markets was found close to the results (6.10%) specified by Bezerra et al. (2012) from north-eastern Brazil, lower than the results (8.40% and 7.10-7.20%, respectively) specified by Erkaya and Şengül (2011) and Ghoneem et al. (2018) and higher than the results (3.25% and 3.50-5.90%, respectively) specified by Yadav et al. (2018) and El-Shibiny et al. (2018). These differences might be due to the different production methods of yogurt samples.

Figure 1. Chemical compositions of buffalo yogurt samples collected from Çukurova markets



The average nitrogen content of yogurt samples was found to be 0.64% and the average protein content was calculated as 4.10%. El-Shibiny et al. (2018) stated that the nitrogen contents of buffalo yogurts from Cairo in Egypt were between 0.68-0.73%. Some researchers stated the protein content of buffalo yogurt samples as 4.67% (Erkaya and Şengül, 2011), 3.10% (Bezerra et al., 2012) and 3.98-4.30% (Yadav et al., 2018). These findings were generally found nitrogen and protein content.

The average ash content of the yogurt samples was found as 1.37% and it was concluded that the ash content of buffalo yogurt samples from Çukurova region was higher than other researchers' findings (0.87%, 0.70%, 0.74-1.17%, 1.14-1.17% and 0.81-0.92%, respectively) from other places (Erkaya and Şengül, 2011; Bezerra et al., 2012; El-Shibiny et al., 2018; Ghoneem et al., 2018; Yadav et al., 2018).

Volatile aroma profile

A total of 35 volatiles including four aldehydes, four ketones, six acids, seven alcohols, four esters and ten miscellaneous compounds were identified in buffalo yogurts from Çukurova region, as shown in Table 1.

Aldehydes were not major compounds in buffalo yogurt samples because of transforming to alcohols or corresponding acids. It is known that acetaldehyde, diacetyl and acetoin are main flavor compounds in yogurts (Tian et al.,

Table 1. Volatile compounds of buffalo yogurt samples collected from Çukurova markets

Compounds		Relative peak area (%)	RT (min)	Molecular formula
Aldehydes	Octanal	0.244±0.023	3.283	$C_8H_{16}O$
	Acetaldehyde	0.401±0.066	3.489	C_2H_4O
	Benzaldehyde	1.104±0.360	30.092	C_7H_6O
	3-Hydroxybutanal	1.020±0.204	32.000	$C_4H_8O_2$
Ketones	2,3-Pentanedione	1.579±0.293	10.938	$C_5H_8O_2$
	2-Heptanone	3.093±0.479	16.330	$C_7H_{14}O$
	Acetoin	20.731±0.889	20.838	$C_4H_8O_2$
	2-Nonanone	0.626±0.219	25.466	$C_9H_{18}O$
Acids	2-(Methylsulfonyl)acetic acid	0.376±0.067	11.411	$C_3H_6O_4S$
	Acetic acid	35.249±2.995	27.518	$C_2H_4O_2$
	Butanoic acid	4.742±0.561	34.239	$C_4H_8O_2$
	Isovaleric acid	1.755±0.152	36.155	$C_5H_{10}O_2$
	Hexanoic acid	3.047±0.443	42.043	$C_6H_{12}O_2$
	Caprylic acid	0.648±0.160	47.463	$C_8H_{16}O_2$
Alcohols	Cyclobutanol	0.211±0.061	2.994	C_4H_8O
	trans-1,2-Cyclopentanediol	0.270±0.022	16.918	$C_5H_{10}O_2$
	Isoamyl alcohol	5.349±0.758	17.596	$C_5H_{12}O$
	3-Methyl-2-pentanol	2.629±0.338	24.032	$C_6H_{14}O$
	3-Methyl-1,2-cyclopentanediol	1.083±0.227	29.185	$C_6H_{12}O_2$
	2,3-Butanediol	0.301±0.051	30.735	$C_4H_{10}O_2$
	2-Phenylethanol	0.201±0.006	43.627	$C_8H_{10}O$
Esters	Ethyl Acetate	1.685±0.526	5.654	$C_4H_8O_2$
	Vinyl formate	0.274±0.062	5.913	$C_3H_4O_2$
	Vinyl acetate	4.224±0.614	7.982	$C_4H_6O_2$
	Benzyl carbazate	0.421±0.125	10.156	$C_8H_{10}N_2O_2$
Miscellaneous	Carbon dioxide	2.026±0.410	2.897	CO_2
	Dimethylphosphine	0.388±0.167	3.817	C_2H_7P
	Butanimidamide	0.629±0.189	4.465	$C_4H_{10}N_2$
	Formamide	1.888±0.163	6.855	CH_3NO
	D-Limonene	0.258±0.060	17.188	$C_{10}H_{16}$
	1-Nonyne	0.445±0.242	18.667	C_9H_{16}
	Tetramethyloxirane	3.062±0.417	23.347	$C_6H_{12}O$
	Dimethyl trisulfide	0.214±0.018	24.934	$C_2H_6S_3$
	2-Imino-3-methylthiazolidine	0.283±0.028	30.330	$C_4H_8N_2S$
	Oxime-, methoxy-phenyl-	0.289±0.007	39.696	$C_8H_9NO_2$

RT: Retention time

The values were expressed by average ± standard deviation.

2019). However, acetaldehyde level was found to be low and diacetyl wasn't detected among ketone groups in buffalo yogurts. Acetoin which is a reduced form of diacetyl and produces mild creamy flavor in yogurts (Cheng, 2010) had the highest level among ketone groups in buffalo yogurts. *Lactococcus lactis* can generate acetoin during fermentation (Walsh, 2016). Other identified ketones in buffalo yogurts were responsible sweet, fruity, buttery and creamy flavor of samples (Sidira et al., 2017). Erkaya and Şengül (2011) detected acetaldehyde and hexanal as aldehydes, diacetyl, acetoin, 2,3-pentanedione, 2-heptnone, 2-nonanone and 2-undecanone as ketones in buffalo yogurts. Emirmustafaoğlu et al. (2020) also found that the main volatiles of buffalo yogurts were acetaldehyde, diacetyl, acetoin and acetone.

Acetic acid was the compound which had the highest level among all volatile compounds. It is produced by hetero fermentative lactic acid bacteria and produces excess vinegar flavor if its concentration is too high (Tian et al., 2019). Butanoic and hexanoic acids were other important acids in buffalo yogurts. Butanoic acid gives cheesy flavor while hexanoic acid contributes spicy, rancidity and floral flavor (Tian *et al*., 2019). Erkaya and Şengül (2011) detected acetic acid, butanoic acid, hexanoic acid, caprylic acid, capric acid and benzoic acid in buffalo yogurt samples.

Alcohols were the largest class of volatile compounds in the samples. The most dominant alcohol in buffalo yogurt samples was isoamyl alcohol. It contributes fruity flavor (Costa et al., 2019). Kavaz Yüksel and Bakırcı, (2015) and Costa et al. (2019) also determined isoamyl alcohol in cow milk yogurts. Erkaya and Şengül (2011) and Emirmustafaoğlu et al. (2020) found ethanol as the only alcohol in buffalo yogurts. However, ethanol was not identified in the samples collected from Çukurova region.

Among the esters, vinyl acetate had the highest level in buffalo yogurts. However, no study was found in the literature about presence of vinyl acetate in yogurt samples. Erkaya and Şengül (2011) identified ethyl acetate (pineapple and fruity flavor), ethyl octanoate and diethyl phthalate in buffalo yogurts. Su et al. (2017), Zhao et al. (2018) and Fang et al. (2020) also found ethyl acetate in yogurt samples obtained from different milk types.

Tetramethyloxirane, carbon dioxide and formamide were the majors among miscellaneous compounds. However, no study was found in the literature about presence of tetramethyloxirane in yogurt samples. Carbon dioxide was observed in buffalo yogurt samples depending on the activities of yogurt starters (Rysstad and Abrahamsen, 1987). Formamide contributes ammonia-like flavor (Hohn, 1999). No information could be found about presence of formamide in yogurt samples in the literature.

Mineral composition

Mineral concentrations of milk and dairy products vary depending on the animal species, breed, nutrition, lactation stage and health conditions (Paszczyk et al., 2019). The data about mineral compositions in terms of major and minor elements of buffalo yogurt are shown at Table 2.

Erkaya and Şengül (2012) examined mineral contents of yogurts which were made from different milk types collected from Erzurum province in Turkey. They determined the buffalo yogurts' Ca, K, Mg, Na, Fe, Mn and Zn were 1697 mg/kg, 1164 mg/kg, 156 mg/kg, 344 mg/kg, 13.57 mg/kg, 0.15 mg/kg and 63.95 mg/kg, respectively. When the mineral contents were compared, it was seen that Ca content of buffalo yogurt from Çukurova region was lower than Ca content of the samples in Erzurum. On the other hand, Mg levels of Çukurova buffalo yogurts were quite higher than those samples. The levels of Na, Fe and Zn were also found lower while K and Mn levels were higher.

Mineral composition analyses were generally performed in yogurts made by cow, goat or sheep milks by other researchers. According to literature data, mineral compositions vary between 430-1936 mg/kg Ca, 890-3508 mg/kg K, 83-406 mg/kg Mg, 390-2550 mg/kg Na, 0.09-1.68 mg/kg Cu, 0.29-19.00 mg/kg Fe, 0.02-0.16 mg/kg Mn and 2.56-60.68 mg/kg Zn for cow milk yogurt, between 1455-2178 mg/kg Ca, 511-2486 mg/kg K, 150-587 mg/kg Mg, 375-568 mg/kg Na, 0.15 mg/kg Cu, 0.75-16.79 mg/kg Fe, 0.14 mg/kg Mn and 4.46-75.03 mg/kg Zn for goat milk yogurt, between 1879-2352 mg/kg Ca, 1133-1944 mg/kg K, 186-197 mg/kg Mg, 410-567 mg/kg Na, 0.12 mg/kg Cu, 0.26-12.79 mg/kg Fe, 0.19 mg/kg Mn and 6.10-72.99 mg/kg Zn for sheep milk yogurt (Güler, 2007; Isleten and Karagul-Yuceer, 2008; Güler and Şanal, 2009; Abou Jaoude et al., 2010; Navarro-Alarcón et al., 2011; Erkaya and Şengül, 2012; Cano-Sancho *et al*., 2015; Luis et al., 2015; Curti et al., 2017; Pimentel et al., 2018; Paszczyk et al., 2019; Souza et al., 2019). It was concluded that Mg content of buffalo yogurt was quite higher than cow, goat and sheep milk yogurts, while Na content of buffalo yogurt was quite lower. Buffalo yogurt had higher Cu and Mn contents and lower Ca content than goat and sheep milk yogurts. It was observed that the contents of other mineral compounds of buffalo yogurt were close to other animal milk yogurts.

CONCLUSION

In this research, some chemical properties, aroma profile and mineral content of buffalo yogurt samples marketed in Çukurova region were determined. As a result of the research, it was concluded that dry matter and ash contents of buffalo yogurt from Çukurova region were higher than other buffalo yogurt samples from different regions. According to mineral composition analysis of buffalo yogurt samples collected from Çukurova region, the levels of Mg, K and Mn were higher and the levels of Ca, Na, Fe and Zn were lower than buffalo yogurt from Erzurum province. When the mineral content of buffalo yogurt was compared with other animal milk yogurts, it was determined that the level of Mg was quite higher when the level of Na was quite lower than cow, goat and sheep milk yogurts. Additionally, Ca level of buffalo yogurt was lower and Cu and Mn levels were higher than goat and sheep milk yogurts. A total of 35 volatile compounds were detected in buffalo yogurt samples. These were determined as four aldehydes, four ketones, six acids, seven alcohols, four esters and ten miscellaneous compounds. The major volatile compound groups of buffalo yogurt were acid and ketone groups. Alcohols were the largest class of volatile compounds in the samples.

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Table 2. Mineral contents of buffalo yogurt samples collected from Çukurova markets

	Yogurt			
Minerals (mg/L)	**Mean**	**SD**	**Min.**	**Max.**
Ca	900.52	78.89	811.69	962.43
K	1678.18	179.45	1532.22	1878.54
Mg	729.80	45.73	685.17	776.56
Na	325.78	24.33	298.33	344.70
Cu	0.28	0.23	0.08	0.54
Fe	7.60	3.89	3.68	11.47
Mn	0.39	0.32	0.05	0.71
Zn	24.64	3.70	20.75	28.13

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