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Some chemical, physical, microbiological and sensorial properties of traditional water buffalo yogurts produced in Turkey

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In this study, it was aimed to determine some physical, chemical, microbiological and sensorial properties of yogurts traditionally made from water buffalo milk in the Western Black Sea Region (WBSR) in Turkey. Totally 86 yogurt samples were collected from producers or sellers in the cities of Kastamonu, Karabük, Bartın, Zonguldak, Düzce and Boluin WBSR and analyzed. As a result of the analysis, mean dry matter (%), fat (%), non-fat dry matter (%), protein (%), ash (%), lactose (%), pH, acidity (LA, %), color values L*, a* and b*were obtained as 17.13±3.524, 6.98±2.327, 9.92±1.362, 4.48±0.690, 0.84±0.102, 4.59±1.011, 4.20±0.208, 1.22±0.236,96.22±2.217, -3.30±0.412 and 8.50±1.513, respectively. Starch was determined in none of the samples. Average water holding capacity was 67.48±9.594% and viscosity was 1249.67±1077.762 mPa.s. In addition; firmness (g), consistency (g.sec), cohesiveness (g) and index of viscosity (g.sec) were found as 246.43±138.898, 4910.66±2234.522, 182.32±87.672 and 334.79±149.087, respectively. Acetaldehyde, ethanol, diacetyl, acetoin and aceton values were obtained as 8.93±4.205, 114.93±154.807, 0.95±0.014, 24.44±16.905 and 0.59±0.504 (mg/kg), respectively. Mean aerobic mesophilic count was found as 4.41±1.032 log cfu/g, coliforms as 2.37±1.077 log cfu/g, yeasts and molds as 4.16±1.076 log cfu/g and total lactic acid bacteria count as 5.96±0.923 log cfu/g. Sensorial analyses showed that average appearance score was 3.76±1.005, smell 4.03±0.978, taste 3.64±1.105, consistency by spoon 3.93±1.005 and consistency by mouth3.71±1.022 on scale 5. Important variations in properties analyzed were observed among the samples collected from different cities. For example, the values of dry matter, fat, protein, ash, water holding capacity, viscosity and color were the highest in the samples of Karabük city among the others.

Keywords: Traditional, Water Buffalo, Western Black Sea, Yogurt

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Water buffalos are double-hoofed and ruminants that belong to the family *Bovidae*[1]. Milk composition of water buffalos is highly different than that of cows' and water buffalo milk have higher amount of dry matter as 17%, in which fat 7%, protein 3.5-4.0%, lactose 5.0-5.5% and ash 0.8%. Since water buffalo milk has high amount of protein and dry matter than cow milk, it is more suitable for yogurt production. As dry matter or protein content increases in milk, firmness increases in yogurt as well. Therefore, yogurts from water buffalo and sheep milks are more acceptable than the yogurts of cow or goat milk in tradition in Turkey because water buffalo yogurt has more intense consistence and flavor. Therefore, no need to increase dry matter concentration (by evaporation for example) of water buffalo milk as in cow milk when making yogurt in Turkey. Another main difference is color of water buffalo milk. Water buffalos convert all amount of carotene from green feed into Vitamin A, and this makes the milk whiter than cow milk[2]. In addition; it has higher amounts of mineral contents as calcium, phosphate, magnesium and sodium than cows' milk[3]. Also, water buffalo milk and its products are a good source of conjugated linoleic acid. As brief, nutritionally water buffalo milk has more attention when compared with cow milk.

Water buffalo milk is suitable for production of butter, cream, ice cream, yogurt and cheese. Heat resistance of water buffalo milk protein is also higher than cow milk protein[4]. In Asian countries, it is used as drinking milk as well[2,5]. High dry matter content makes it important in converting into the added value dairy products as cheese[6].

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Kind of milk used in production of dairy products is important for taste, flavor and textural properties. Over time, decreasing in the number of water buffalos and thus in amount of water buffalo milk resulted with usage of cow milk instead in production of yogurt and cream etc. In Turkey, water buffalo milk has a portion of only 0.3% (69401 metric tonnes) in total produced milk according to the year 2017 records. Western Black Sea Region has the percentage of 29.71% of all water buffalo milk production in the country[7]. On contrast, water buffalo milk price is higher than that of cow milk (current price of cow milk is 2.5 TL/L, water buffalo milk is >10 TL/kg). Also, water buffalo milk and its products are preferred by the consumers in terms of superior properties as taste and flavor and health concerns.

There are limited researches on the properties of water buffalo yogurt produced and consumed in Turkey. Ertaş *et al.* (2014) studied some microbiological properties of water buffalo yogurts obtained from Kayseri city and its province[8]. Kayaalp *et al.* (2015) determined the presence of aflatoxin M_1 (AFM_1) in water buffalo yogurt samples in the same city[9]. Bilgin and Kaptan (2016) analyzed some physicochemical and microbiological properties of water buffalo yogurt samples obtained from small dairy plants and public bazaars[10].

The points like race, living area and nutrition regime affects the properties of water buffalo milk and of course the yogurt made from it. Also, the floras of starter culture and yogurt production technique have effects on yogurt properties. In Turkey, intense water buffalo breeding is done in the province of Western Black Sea Region, Turkey. Therefore this study was planned and done in the samples collected from this region. In the study, it was aimed to determine some physical, chemical, microbiological and sensorial properties of water buffalo yogurt samples from different cities in the region.

Materials and methods

In the study, totally 86 water buffalo yogurt samples were collected from the producers or sellers of cities Kastamonu, Karabük, Bartın, Zonguldak, Düzce and Boluin Western Black Sea Region (WBSR) and analyzed. Sampling was proportionally done according to the water buffalo number of the cities. The samples from Bartın and Düzce were obtained from the project" Animals on buffalo" belong to the Ministry of Food, Agriculture and Stockbreeding. All samples were collected in August and September of 2017, and they were kept in an iced-sample transport box and brought to the laboratory of Food Engineering Department of Bolu Abant İzzet Baysal University.

Physicochemical analyses

The values of dry matter, ash, fat, protein and acidity (LA, %) and the presence of starch were determined according to the methods described by Metin (2012)[11]. Lactose value was obtained by extracting sum of fat, protein and minerals from dry matter. Digital pH meter (Hanna Instruments HI 83141, Italy) was used to determine pHs of the samples. Color values as CIE L*, a* and b* of the samples was measured by using a color measurement device (Konica Minolta CR400, Japan). To determine water holding capacities of the samples, 15 g sample was centrifuged at 3250 x *g* at 4°C. After removing serum phase, the retained mass was weighed and the following formula was used to obtain water holding capacity[12];

Water holding capacity (%) = (m_1/m_2) x 100; where m_1: mass of sediment after centrifugation (g); m_2: mass of yogurt sample (g).

To determine textural properties of the samples, a texture analyzer (Stable Micro Systems Texture Analyzer HD Plus, England) was used. Back extrusion test was used to determine firmness, consistency, cohesiveness and index of viscosity of water buffalo yogurt samples. All analyses were done by using 5 kg load cell and 35 mm disc (A/BE-d35). Yogurt sample was filled up to the rate of 75% of cylindrical chamber in diameter of 50 mm. Pretest speed was applied as 1 mm/s, and test speed as 1 mm/s, last test speed as 10 mm/s, trigger force as 10 g and test time 35 s. Textural analyses were done in the research center of YENIGIDAM of Bolu Abant İzzet Baysal University.

Method given by Güler *et al.* (2009) was modified and used to determine the volatile compounds acetaldehyde, diacetil, aceton and acetoin[13]. For this, 10 g sample was transferred into 20 mL vial and the vial was sealed up and kept at -18°C until analyzing. The frozen vials were kept +4°C for one night before analyzing and later on kept 60°C for 1 h and 75°C for 10 min. Sample injection was done with SPME method and gas chromatography (Shimadzu GC-2010)-mass spectrometer (QP2010-Plus MS) was used to determine volatile compounds. The column was RTX-Wax (30 m length×0.25 mm inner diameter×0.25 µm film thickness), injection temperature was 200°C, ion source temperature was 240°C and interface temperature was 240°C. Helium

was used as carrier gas. Column temperature was kept at 40°C for 3 min at beginning. After that, it was kept at 50°C for 5 min by increasing 2°C/min. Then, it increased up to 160°C by increasing 8°C/min and finally increased up to 200°C and kept 2 min by increasing the temperature 10°C/min. The analyses were also done in the research center of YENIGIDAM of Bolu Abant İzzet Baysal University.

The viscosity values of the samples were measured by a viscometer (AND Viscometer SV-10, Japan). The temperatures of the samples were adjusted to 10±1°C before measurement. The mean records of 20 s measurement intervals were taken into consideration within total 120 s measurement time.

Microbiological analyses

Plate Count Agar (Merck, Germany) was used for counting of total mesophilic aerobic microorganisms, Violet Red Bile Agar (Merck, Germany) for coliforms, Yeast Extract Glucose Chloramphenicol Agar (Sigma-Aldrich, Germany) for yeasts and molds and MRS agar (Merck, Germany) for lactic acid bacteria. The samples from dilution tubes were taken and transferred into petri dishes, then the plates were incubated at 35ºC for 48±3 h for total mesophilic aerobic microorganisms[14], at 35±1ºC for 24±2 h for coliforms[15], at 25ºC for 3-5 days for yeasts and molds[16]and at 37ºC for 72 h for lactic acid bacteria. After incubation, the formed colonies on agars were counted.

Sensorial analyses

Score test was used to evaluate sensorial properties of water buffalo yogurt samples and this evaluation was carried out by a panel group composed of 8 educated panelists[11].

Results and discussion

Physicochemical properties

The chemical properties of water buffalo yogurt samples are given in Table 1. Dry matter values of the samples showed a broad range from 8.40 to 32.88% in

Table 1 — Some chemical properties of water buffalo yogurt samples

Cities		DM (%)	Fat (%)	MSNF (%)	Protein (%)	Ash (%)	Lactose (%)	LA (%)	pH
Bartın (N=29)	m	14.82	5.40	8.64	3.46	0.78	2.65	0.87	3.95
	M	32.88	13.40	12.20	6.11	1.05	6.02	1.83	4.51
	x̄±SD	19.08	8.22	10.38	4.70	0.86	4.79	1.32	4.17
		±3.325	±1.735	±0.873	±0.586	±0.052	±0.777	±0.186	±0.150
Bolu (N=15)	m	8.40	0.80	5.21	2.61	0.41	2.18	0.48	4.02
	M	19.87	8.20	11.53	5.75	0.99	6.48	1.42	5.05
	x̄±SD	13.82	5.03	8.64	4.25	0.78	3.62	1.01	4.40
		±3.112	±2.406	±1.699	±0.874	±0.169	±1.080	±0.239	±0.284
Düzce (N=13)	m	12.35	2.40	7.78	3.21	0.61	3.12	0.76	3.99
	M	21.43	10.00	12.91	5.49	0.92	6.87	1.22	4.54
	x̄±SD	16.27	5.79	10.42	4.40	0.81	5.21	1.03	4.23
		±2.747	±2.056	±1.512	±0.643	±0.076	±1.220	±0.125	±0.187
Karabük (N=7)	m	16.67	7.40	9.10	4.30	0.80	2.93	1.17	3.93
	M	27.85	13.80	13.59	6.52	0.99	6.41	1.60	4.24
	x̄±SD	20.35	9.32	10.72	5.05	0.90	4.77	1.39	4.11
		±3.320	±2.160	±1.572	±0.625	±0.063	±1.154	±0.143	±0.110
Kastamonu (N=14)	m	13.26	3.40	8.65	3.07	0.71	3.82	1.02	3.88
	M	19.51	8.80	11.12	5.71	1.05	5.19	1.69	4.41
	x̄±SD	16.24	6.35	9.81	4.29	0.87	4.65	1.33	4.09
		±1.845	±1.516	±0.731	±0.589	±0.105	±0.449	±0.202	±0.175
Zonguldak (N=8)	m	14.52	4.40	7.98	3.31	0.71	3.09	0.96	3.93
	M	17.56	8.40	10.76	5.29	0.90	5.34	1.60	4.31
	x̄±SD	16.39	7.03	9.39	4.11	0.80	4.48	1.21	4.18
		±1.017	±1.275	±0.833	±0.543	±0.056	±0.767	±0.190	±0.115
General (N=86)	m	8.40	0.80	5.21	2.61	0.41	2.18	0.48	3.88
	M	32.88	13.80	13.59	6.52	1.05	6.87	1.83	5.05
	x̄±SD	17.13	6.98	9.92	4.48	0.84	4.59	1.22	4.20
		±3.524	±2.327	±1.362	±0.690	±0.102	±1.011	±0.236	±0.208

DM: dry matter, MSNF: milk solids nonfat, LA: acidity as lactic acid, N: number of samples analyzed, m: minimum, M: maximum, x̄: mean, SD: standard deviation

general. In addition, 54.65% of 86 water buffalo yogurt samples had dry matter between 15 and 19%, 23.26% of which were below <15% and the rest >19%. The lowest average value was obtained from the samples taken in Bolu while the highest value belonged to the samples of Karabük city. General average value was 17.13±3.524%. Similar results were reported in various studies[17-19]. Minimum values (like 8.40%) among the all samples may show water adulteration. On the other hand, the maximum values (like 32.88%) might be because of heating the milk long time or because of draining serum of the yogurt, both causing water loss.

Fat values of water buffalo yogurt samples ranged between 0.80% and 13.80% with average value 6.98±2.327% in general. The results are similar to those given by the other researchers[10,18,20]. As in dry matter, the lowest average fat value was obtained from the samples of Bolu city while highest ones was obtained for the samples of Karabük city. Of the 86 samples, 56.47% had fat ratio between 19-23%. In the cities of Bolu, Bartın and Düzce, fat of water buffalo milk is separated and processed into the cream mostly consumed in breakfast, thus yogurts produced from the milk-nonfat may result with low fat ratio in yogurt samples. This situation negatively affects the textural and sensorial properties of yogurts. High fat ratio may be because of high dry matter content as a result of removing serum from yogurt as mentioned before.

Average protein value of all samples was determined as 4.48±0.690%, which is in agreement with results of the other researchers[6,20,21]. Values were changed proportionally as the dry matter values changed.

Ash values of the samples were found between 0.41% and 1.05% (Table 1). Similar results for water buffalo yogurts were reported by the other researchers[6,19,21,22].

Lactose values were determined between 2.18% and 6.87% in general. However, 17.65%, 36.47% and 38.82% of the all water buffalo yogurt samples showed distribution between 3-4, 4-5 and >5% lactose values, respectively. Similar results were reported by many other researchers[6,10,22,23]. Low amount of lactose values were obtained from the samples of Bolu city. This brings water adulteration in mind.

As seen from Table 1, the general mean of acidity (%) of all samples was 1.22±0.236%. Acidity values of 75.58% of the 86 samples were between 0.8–1.4% and acidity of 22.09% of the samples were above 1.4%. The results were in agreement with the results of Hussein *et al.* (2011)[19] and Bilgin and Kaptan (2016)[10]. In traditional fermentation, stopping the incubation time has been done at random. Mostly the yogurts have acidic characters since the incubation is stopped in late. In addition, pH of 82.55% of all samples were in range of 4.00-4.50, general average 4.20±0.208. The lowest pH value (3.88) was obtained from the samples of Kastamonu. Similar results were reported by the other researchers[10,17,19].

None of the analyzed water buffalo yogurt samples contained starch, which is not permitted by Turkish regulations to add into yogurts to increase the consistence of yogurts.

Some physical and textural characteristics of the water buffalo yogurt samples obtained from WBSR in Turkey are given in Table 2. The table shows that water holding capacity (WHC) of the samples changed between 38.52 and 94.51%. While the highest average value of WHC was obtained from the samples of Karabük, the lowest WHC value was obtained from Bolu samples. General WHC value was found as 67.48±9.594%. Yang *et al.* (2014) standardized dry matter as 14% and fat 7% of water buffalo milk to produce yogurt and in this yogurt they found WHC as 45%[12]. Heating milk results with increase in WHC in the yogurt, and this increase shows a correlation with denaturation ratio of serum proteins. Moreover, WHC mostly decreases in the yogurts having high pH values. In addition, the risk of separation of serum increases by falling down of pH below 3.9-4.0[24]. It was thought that since minimum pH value of the analyzed yogurt samples was 3.88, it increases the risk of serum separation and therefore caused to lower WHC. Serum draining of the some yogurt samples by some yogurt producers might result an increase in dry matter content and of course increase in protein ratio and this phenomenon may increase WHC. Akgün *et al.* (2016) stated that fat globules present in protein network may play an important role in increasing WHC[4].

Also the highest viscosity values were obtained from the water buffalo yogurt samples of Karabük city (8169.35 mPa.s) while the lowest value was obtained from the samples of Bolu city (50.82 mPa.s) (Table 2). The obtained findings are similar to those reported by the other researchers[4,25]. In traditional yogurt production, since controlling incubation temperature and incubation ending pH are done by

Table 2 — Some physical and textural properties of water buffalo yogurt samples

Cities		WHC (%)	V (mPa.s)	Color Values			F (g)	C (g.s)	Coh (g)	IV (g.s)
				L*	a*	b*				
Bartın (N=29)	m	56.02	227.74	91.88	-4.26	7.36	57.96	1396.62	36.90	90.24
	M	80.80	4396.38	99.84	-2.87	11.64	726.00	13049.13	503.26	800.80
	x̄±SD	71.75	1458.42	96.80	-3.33	8.79	258.53	5490.08	214.27	389.20
		±6.964	±964.172	±2.063	±0.286	±0.925	±123.115	±2146.643	±91.681	±146.609
Bolu (N=15)	m	38.52	50.82	89.29	-3.69	3.77	55.63	1059.37	15.92	4.92
	M	68.46	1633.95	99.02	-2.29	9.18	759.37	10560.94	289.98	361.96
	x̄±SD	58.43	523.82	95.95	-3.14	7.32	204.45	3694.96	114.11	187.32
		±8.875	±418.059	±2.370	±0.358	±1.404	±174.583	±2199.195	±65.861	±83.798
Düzce (N=13)	m	54.78	505.80	89.64	-3.73	5.38	148.74	2776.24	80.01	164.96
	M	74.75	2998.18	96.10	-2.13	10.11	388.86	6662.27	358.62	731.73
	x̄±SD	63.87	1057.95	93.75	-3.04	7.92	238.08	4549.20	159.73	318.93
		±6.512	±560.559	±1.236	±0.379	±1.307	±70.412	±1190.382	±73.486	±161.926
Karabük (N=7)	m	69.22	944.95	94.58	-4.30	7.83	149.53	2857.85	115.61	232.70
	M	94.51	8169.35	98.92	-2.48	13.10	624.46	12843.04	469.82	716.57
	x̄±SD	81.45	2198.74	97.81	-3.51	10.21	239.03	5119.38	212.01	402.83
		±9.302	±2413.130	±1.274	±0.510	±1.798	±171.626	±3482.583	±120.280	±165.554
Kastamonu (N=14)	m	49.90	135.87	93.02	-4.71	7.32	64.88	1479.24	63.29	162.84
	M	75.13	3174.09	99.83	-2.98	13.01	759.37	10560.94	352.73	684.59
	x̄±SD	65.50	1198.23	97.51	-3.58	9.34	281.91	5401.26	203.41	363.29
		±7.913	±814.628	±1.326	±0.475	±1.262	±179.513	±2540.295	±78.045	±132.495
Zonguldak (N=8)	m	60.59	754.71	91.93	-3.86	5.62	156.80	3429.07	136.09	265.01
	M	74.04	2000.37	98.15	-2.71	10.56	433.61	7361.97	228.04	438.10
	x̄±SD	66.04	1425.02	94.94	-3.21	7.50	234.80	4574.53	165.60	326.81
		±4.704	±339.759	±1.561	±0.352	±1.267	±99.095	±1420.687	±31.521	±61.021
General (N=86)	m	38.52	50.82	89.29	-4.71	3.77	55.63	1059.37	15.92	4.92
	M	94.51	8169.35	99.84	-2.13	13.10	759.37	13049.13	503.26	800.80
	x̄±SD	67.48	1249.67	96.22	-3.30	8.50	246.43	4910.66	182.32	334.79
		±9.594	±1077.762	±2.217	±0.412	±1.513	±138.898	±2234.522	±87.672	±149.087

WHC: water holding capacity, V: viscosity, F: firmness, C: consistency, Coh: cohesiveness, IV: index of viscosity, N: number of samples analyzed, m: minimum, M: maximum; x̄: mean, SD: standard deviation, L*: lightness (0= black, 100= white), a*: green (-) or red (+), b*: blue (-) or yellow (+)

experience (not by measuring), it affects the values of viscosity. Özer (2006) stated that decrease in incubation temperature results with weakness in curd stability of yogurt. Also stated that high viscosity is obtained for the yogurts whose pH ended between 4.4-4.2 in stirred yogurts and the viscosity of the yogurts whose pH ended between 4.7-4.8 substantially decrease[24]. Bilgin and Kaptan (2016) reported that production technique and the contents of dry matter and fat affected viscosity in yogurt[10].

Mean L*, a* and b* values of the yogurt samples analyzed were found as 96.22±2.217, -3.30±0.412 and 8.50±1.513, respectively. The highest mean value was obtained from the samples of Karabük city while the lowest mean value was obtained from the samples of Düzce city Dimitreli *et al.* (2014) reported the mean L, a, and b values in control yogurts made with water buffalo milks as 91.28, 2.59 and 4.50, respectively[26]. As known, L* value shows lightness and since water buffalos convert the carotenes from green feed into vitamin A, their milk is lighter than cow milk[2]. L* and b* values obtained in our study were found to be higher than the values determined in the studies on yogurt made from cow's milk[27-29]. Fat globules and casein in yogurt reflect light, resulting with white color milk and yogurt. Also riboflavin is responsible from green (negative 'a' value) and yellow color (positive 'b' value) in yogurt[26].

The range of firmness values of the water buffalo yogurt samples changed from 55.63 g (in Bolu city samples) to 759.37 g (in Kastamonu city samples). The range were between 1059.37 and 13049.13 g.s, 15.92 and 503.26 g, 4.92 and 800.80 g.s for consistency, cohesiveness and index of viscosity, respectively (Table 2). As understood, there are big variations between minimum and maximum values of textural properties analyzed. This might be mainly due to the variations in fat and protein ratios (Table 1)

of the yogurt samples[30], and also kind of starter culture, heating, homogenization, incubation temperature, acidity, mechanical applications and storage[24]. In traditional production, separation of milk cream may cause textural properties of yogurts, and water adulteration as well.

The amounts of volatile compounds in the water buffalo yogurt samples are presented in Table 3. As seen from the table, main volatile compounds were detected as acetaldehyde, ethanol, diacetyl, acetoin and acetone, and the mean amounts were 8.93±4.205, 114.93±154.807, 0.95±0.014, 24.44±16.905 and 0.59±0.504 mg/kg, respectively. Interestingly, amount of ethanol was highest among them. Also, the samples from Bolu city had the highest amount of ethanol than the others. The second highest volatile compound was acetoin. Güler *et al.* (2009) reported that the concentrations of acetaldehyde and ethanol were higher in set-type yogurts[13]. Erkaya and Şengül (2011) stated that main volatile compounds of yogurt were acetaldehyde, diacetyl and acetoin[31]. Acetaldehyde is accepted as main component of taste and flavor of yogurt and it is produced by starter culture in lactose metabolism mainly as a result of pyruvate decarboxylation. There is no importance of less amount of ethanol in yogurt taste and flavor produced during lactic acid fermentation and it is not desired in high quality of yogurt[31-32]. Acetaldehyde is easily converted to ethanol by alcohol dehydrogenase which is synthesized by *Streptococcus thermophilus* and active in low pH's[13,31]. Low acetaldehyde concentration resulted with increment in activity of the enzyme alcohol dehydrogenase, thus acetaldehyde is degraded to ethanol and ethanol concentration increases while acetaldehyde amount decreases[32]. Similarly, Güler *et al.* (2009) reported that as the ratio of acetaldehyde decreased in yogurt samples during storage, the amount of ethanol increased[13].

Table 3 — Volatile compounds of water buffalo yogurt samples

Cities		Volatile Compounds (mg/kg)				
		Acetaldehyde	Ethanol	Diacetyl	Acetoin	Acetone
Bartın (N=29)	n	13	25	28	28	7
	m	nd	nd	nd	nd	nd
	M	17.19	427.12	1.00	68.34	1.61
	x̄*±SD	9.65±3.873	84.80±115.339	0.96±0.014	33.87±15.429	0.59±0.548
Bolu (N=15)	n	5	13	12	13	0
	m	nd	nd	nd	nd	nd
	M	16.14	712.61	0.95	37.01	nd
	x̄*±SD	7.53±4.812	235.97±248.587	0.95±0.005	19.96±11.292	nd
Düzce (N=13)	n	0	10	13	13	0
	m	nd	nd	0.94	2.40	nd
	M	nd	189.23	0.96	33.39	nd
	x̄*±SD	nd	59.96±57.095	0.94±0.006	16.41±9.768	nd
Karabük (N=7)	n	1	6	5	7	2
	m	nd	nd	nd	4.40	nd
	M	5.02	402.48	0.95	23.55	0.45
	x̄*±SD	5.02±0.000	199.95±167.708	0.94±0.006	14.93±6.864	0.23±0.305
Kastamonu (N=14)	n	1	12	12	13	0
	m	nd	nd	nd	nd	nd
	M	4.84	176.91	0.96	31.42	nd
	x̄*±SD	4.84±0.000	56.29±63.665	0.94±0.007	14.09±8.779	nd
Zonguldak (N=8)	n	1	8	7	8	2
	m	nd	4.59	nd	5.90	nd
	M	14.65	375.10	1.02	101.26	1.21
	x̄*±SD	14.65±0.000	105.27±144.089	0.96±0.028	36.86±29.251	0.93±0.395
General (N=86)	n	21	74	77	82	11
	m	nd	nd	nd	nd	nd
	M	17.19	712.61	1.02	101.26	1.61
	x̄*±SD	8.93±4.205	114.93±154.807	0.95±0.014	24.44±16.905	0.59±0.504

N: number of total samples analyzed, n: the number of samples in which volatile compounds obtained, m: minimum, M: maximum, x̄*: mean value of n, SD: standard deviation, nd: not determined

Microbiological properties

Table 4 shows the results of microbiological analysis of water buffalo yogurts obtained from different cities of WBSR. In the Table, the average values ($\bar{x}$*) were calculated by taking consideration of only positive results.

Total aerobic mesophilic count (TAMC) were found between range of 2.00-6.32 log cfu/g (general mean 4.41±1.032 log cfu/g) from 73 samples while they showed no growth on 13 yogurt samples. The lowest mean value (4.09±1.103 log cfu/g) was obtained from the samples of Bartın city. Nahar *et al.* (2007) found total aerobic mesophilic count as 5.996 log cfu/mL in water buffalo yogurts[33]. On the other hand, Ertaş *et al.* (2014) and Bilgin and Kaptan (2016) reported higher values for water buffalo yogurts, 7.72 log cfu/g and 7.10-8.57 log cfu/mL respectively[8,10].

Coliform microorganisms were found only in 32 water buffalo yogurt samples and 54 yogurt samples contained no coliforms. Mean value was 2.37±1.077 log cfu/g for 32 samples. The results are similar to those given by the other researchers[10,33]. The growth of coliforms shows contamination or unhygienic production since they are sanitation indicator.

In 16 yogurt samples, yeasts and molds showed no growth. The rest of the samples contained yeasts and molds, and general mean value was 4.16±1.076 log cfu/g. Similar results were reported by the other researchers[4,8,33]. In yogurts, the presence of molds and yeasts is known as contamination indicator and has important effect on sensorial properties and shelf-life[10].

Lactic acid bacteria grew in the most (77) of yogurt samples and the range was between 3.62-7.02 log cfu/g. Ertaş *et al.* (2014) reported the count of lactic acid bacteria as 6.58 log cfu/g while Bilgin and Kaptan (2016) reported lactobacillus between 6.29-7.49 log cfu/mL[8,10].

Table 4 — Some microbiological properties of water buffalo yogurt samples

Cities		Groups of microorganisms (log cfu/g)			
		TAMC	Coliforms	Molds-Yeasts	LAB
Bartın (N=29)	n	24	13	21	28
	m	nd	nd	nd	nd
	M	5.58	4.58	5.49	6.99
	$\bar{x}$*±SD	4.09±1.103	2.76±1.144	4.18±1.033	6.32±0.413
Bolu (N=15)	n	13	7	13	15
	m	nd	nd	nd	3.62
	M	6.00	3.40	5.96	6.91
	$\bar{x}$*±SD	4.80±0.893	1.88±1.004	4.55±1.076	5.81±0.973
Düzce (N=13)	n	8	1	11	9
	m	nd	nd	nd	nd
	M	5.07	1.51	5.04	5.12
	$\bar{x}$*±SD	4.73±0.181	1.48±0.041	3.86±1.182	4.47±0.509
Karabük (N=7)	n	6	4	7	7
	m	nd	nd	3.40	6.49
	M	5.92	4.69	5.35	6.97
	$\bar{x}$*±SD	5.09±0.526	2.44±1.193	4.40±0.629	6.69±0.161
Kastamonu (N=14)	n	14	2	13	10
	m	2.00	nd	nd	nd
	M	5.86	3.19	5.13	7.02
	$\bar{x}$*±SD	4.26±1.113	2.42±1.270	3.98±0.987	5.94±1.230
Zonguldak (N=8)	n	8	5	5	8
	m	2.15	nd	nd	5.26
	M	6.32	3.23	5.10	6.85
	$\bar{x}$*±SD	4.15±1.272	2.07±0.673	3.83±1.545	6.17±0.500
General (N=86)	n	73	32	70	77
	m	nd	nd	nd	nd
	M	6.32	4.69	5.96	7.02
	$\bar{x}$*±SD	4.41±1.032	2.37±1.077	4.16±1.076	5.96±0.923

TAMC: total aerobic mesophilic count, LAB: lactic acid bacteria, N: number of samples analyzed, n: the number of samples in which the microorganisms grew, m: minimum, M: maximum, $\bar{x}$*: mean value of n, SD: standard deviation, nd: not determined

Table 5 — Results of sensorial analysis of water buffalo yogurt samples

Cities		Appearance	Smell	Taste	Consistency with spoon	Consistency with mouth
Bartın (N=29)	m	1	2	1	1	1
	M	5	5	5	5	5
	x̄±SD	4.06±0.915	4.37±0.712	3.88±1.039	4.16±0.897	3.96±0.993
Bolu (N=15)	m	1	1	1	1	1
	M	5	5	5	5	5
	x̄±SD	3.02±0.944	3.47±1.083	2.87±1.211	3.18±1.026	2.99±0.941
Düzce (N=13)	m	1	1	1	1	1
	M	5	5	5	5	5
	x̄±SD	3.47±0.873	3.55±0.982	3.57±1.089	3.88±0.982	3.49±0.930
Karabük (N=7)	m	2	2	2	3	2
	M	5	5	5	5	5
	x̄±SD	4.08±0.948	4.22±1.000	3.91±0.849	4.30±0.830	3.98±0.917
Kastamonu (N=14)	m	1	1	1	1	2
	M	5	5	5	5	5
	x̄±SD	3.79±0.986	4.04±0.966	3.72±0.965	3.94±0.998	3.80±0.993
Zonguldak (N=8)	m	3	1	2	3	2
	M	5	5	5	5	5
	x̄±SD	4.13±0.839	4.42±0.841	4.02±0.839	4.24±0.783	4.11±0.791
General (N=86)	m	1	1	1	1	1
	M	5	5	5	5	5
	x̄±SD	3.76±1.005	4.03±0.978	3.64±1.105	3.93±1.005	3.71±1.022

N: number of samples analyzed, m: minimum, M: maximum, x̄: mean, SD: standard deviation

Sensorial properties

Sensorial properties of water buffalo yogurt samples were tested by a panelist group and the results are shown in Table 5. The panelists tested the properties of appearance, smell, taste, consistency with spoon and consistency with mouth of the samples. The results showed that the lowest scores from all properties tested were belong to water buffalo yogurt samples of Bolu city while the highest values for all properties were obtained from the samples of Zonguldak, except consistency with spoon from Karabük city samples. Also the panelists used minimum score 1 and maximum score 5 for all properties tested. Some panelists stated that they felt different taste, smell and rancidity from fat layer of the yogurt samples. This might be because of high amount of fat ratio of water buffalo yogurts, thus might caused high feeling of rancidity. Since fat layer absorbs smell from environment, it affects sensorial properties of yogurt. In addition, some producers separate fat from water buffalo milk in order to produce cream and this process results with low amount of fat in yogurts, reducing taste scores. Also, some producers may adulterate milk with water addition or the serum draining of yogurt may affect the scores of appearance, consistency and taste. Some panelists stated that some of the samples were more acidic and some of them were less acidic. Since some producers end incubation time in late in traditional production, yogurts show more acidic character. Minimum pH value of the samples was obtained as 3.88 and this value might result with acidic character. On the other hand, maximum pH value of the samples was 5.05 and this might cause the product as less acidic.

Conclusion

In this study, it was aimed to reveal the physical, chemical, microbiological and sensorial properties of water buffalo yogurts traditionally produced by the villagers in the Region of Western Black Sea in Turkey, where the quantity of water buffalo is the highest. In terms of the analyzed properties, it was determined that there were big differences among the samples. These differences may sourced most probably from the availability of different race of water buffalos in the region, feeding regime, differences in tradition of yogurt production processes (incubation time, incubation ending pH etc), differences in the flora of starter culture (coming from previous day), addition of water or cow milk into water buffalo milk when making yogurt, separation of

fat from milk, drain of yogurt serum and heating milk more or less.

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References

1 Soysal MI, *Manda veürünleriüretimi*, (Tekirdağ, Turkey), 2009.
2 Metin M, *Süt teknolojisi (Sütünbileşimiveişlenmesi*, (Ege Univ Faculty of Engineering Publ, İzmir, Turkey), 2005.
3 Ahmad S, Gaucher I, Rousseau F, Beaucher E, Piot M, *et al*, Effects of acidification on physico-chemical characteristics of buffalo milk: A comparison with cow's milk, *Food Chem,*106 (2008)11-17.
4 Akgun A, Yazici F & Gulec HA, Effect of reduced fat content on the physicochemical and microbiological properties of buffalo milk yoghurt, *LWT-Food Sci Technol*, 74 (2016) 521-527.
5 Menard O, Ahmad S, Rousseau F, Briard-Bion V, Gaucheron F & Lopez C, Buffalo vs. cow milk fat globules: Size distribution, zeta-potential, compositions in total fatty acids and in polar lipids from the milk fat globule membrane, *Food Chemi,* 120 (2010) 544-551.
6 Han X, Lee FL, Zhang L, Guo MR, Chemical composition of water buffalo milk and its low-fat symbiotic yogurt development, *Funct Food Health Dis,* 2(4) (2012) 86-106.
7 TUIK (Turkish Statistical Institute), Livestock statistics in Turkey, Available online with updates at http://www.tuik.gov.tr (2018).
8 Ertaş N, Al S, Karadal F & Gönülalan Z, Microbiological quality of water buffalo yoghurts retailed in Kayseri, *J Fac Vet Med Istanbul Univ*, 40(1) (2014) 83-89.
9 Kayaalp O, Ertaş N & Al S, Determination of aflatoxin M_1 level in water buffalo yoghurt consumed in Kayseri region, *J Fac Vet Med Erciyes Univ,* 12(1)(2015)19-23.
10 Bilgin B & Kaptan B, A study on microbiological and physicochemical properties of homemade and small scale dairy plant buffalo milk yoghurts, *Int J Pharm Res Allied Sci*, 5(3) (2016) 29-36.
11 Metin M, *Sütvemamüllerianalizyöntemleri*, (Ege Univ Faculty of Engineering Publ, İzmir, Turkey), 2012.
12 Yang T, Wu K, Wang F, Liang X, Liu Q, *et al*, Effect of exopolysaccharides from lactic acid bacteria on the texture and microstructure of buffalo yoghurt, *Int Dairy J*, 34 (2014) 252-256.
13 Güler Z, Taşdelen A, Şenol H, Kerimoğlu N & Temel U, The determination of volatile compounds in set-type yogurts using static headspace gas chromatographic method, *J Food,* 34(3) (2009) 137-142.
14 Doğan HB & Tükel Ç, *Gıda mikrobiyolojisiveuygulamaları,* (2nd Ed, Ankara University, Faculty of Agriculture, Department of Food Engineering, Ankara, Turkey), 2000.
15 Çakır I, *Gıda mikrobiyolojisiveuygulamaları,* (2nd Ed, Ankara University, Faculty of Agriculture, Department of Food Engineering, Ankara, Turkey), 2000.
16 Halkman AK, *Merck gıdamikrobiyolojisiuygulamaları,* (2nd Ed, Başak Co, Ankara, Turkey), 2005.
17 Ghadge PN, Prasad K & Kadam PS, Effect of fortification on the physico-chemical and sensory properties of buffalo milk yoghurt, *Elect J Environm Agric Food Chem*, 7(5) (2008) 2890-2899.
18 Bano P, Abdullah M, Nadeem M, Barbar ME & Khan GH, Preparation of functional yoghurt from sheep and goat milk blends, *Pak J Agri Sci,* 48(3) (2011) 211-215.
19 Hussein MM, Hasan FAM, Abdel Daym HH, Salama A, Enab AK & Abd El-Galil AA, Utilization of some plant polysaccharides for improving yoghurt consistency, *Annals of Agric Sci*, 56(2) (2011) 97-103.
20 Soomro AH, Dars AG, Sheikh SA, Khaskheli SG, Magsi AS, *et al*, Effect of milk source and stabilizers on the compositional and sensorial quality of yoghurt, *Pure Appl Biol,* 5(4) (2016) 1316-1322.
21 Anwer M, Ahmad S, Sameen A & Ahmed S, Effect of different heating temperatures on the rheological properties of lactic gel from buffalo milk, *J Food Chem Nutr*, 1(1) (2013) 33-41.
22 Ahmed N, Elahi S, Salariya AM & Rashid AA, Physico-chemical and organoleptic comparison of buffalo, cow and goat milk and their yogurt samples*, Pak J Sci*, 66(3) (2014) 225-231.
23 Mahmood A, Abbas N & Gilani AH, Quality of stirred buffalo milk yogurt blended with apple and banana fruits, *Pak J Agric Sci*, 45(2) (2008) 275-279.
24 Özer B, *Yoğurtbilimiveteknolojisi*, (Toprak Co, İzmir, Turkey), 2006.
25 Hanif MS, Zahoor T, Iqbal Z, Haq I & Arif AM, Effect of storage on rheological and sensory characteristics of cow and buffalo milk yogurt, *Pak J Food Sci*, 22(2) (2012) 61-70.
26 Dimitreli G, Petridis D, Akakiadou P & Chrysalidou S, Effect of protein supplementation, fat globule size and storage time on the rheological and sensory properties of buffalo milk stirred yogurt, *J Food Res*, 5(3) (2014) 31-44.
27 Şimşek B, Gün İ & Çelebi M, Protein profiles of concentrated yoghurts produced in Isparta and Burdur regions and their relationship with the chemical properties, *YYUJ Agric Sci*, 20(3) (2010) 208-213.
28 Tarakçı Z, Influence of kiwi marmalade on the rheology characteristics, color values and sensorial acceptability of fruit yogurt, *J Fac Vet Med Kafkas Univ*, 16(2) (2010) 173-178.
29 Temiz H, Tarakçı Z, Karadeniz T & Bak T, The effect of loquat fruit (*Eriobotrya japonica*) marmalade addition and storage time on phsico-chemical and sensory properties of yogurt, *J Agric Sci*, 18 (2012) 329-338.
30 Yang TX, Wu KY, Li H, Wang F, Liu XL, *et al*, Effect of buffalo breeds on rheological and textural properties of acid milk gel, *Agro Food Ind Hi Tech*, 24(5) (2013) 44-48.
31 Erkaya T & Şengül M, Comparison of volatile compounds in yoghurts made from cows, buffaloes, ewes' and goats' milks, *Int J Dairy Technol*, 64(2) (2011) 240-246.
32 Pinto SM, Clemente MDG & Abreu LRD, Behaviour of volatile compounds during the shelf life of yoghurt, *Int J Dairy Technol*, 62(2) (2009) 215-223.
33 Nahar A, Amin MA, Alam MK, Wadud A & Islam MN, A comparative study on the quality of Dahi (yoghurt) prepared from cow, goat and buffalo milk, *Int J Dairy Sci*, 2(65) (2007) 260-267.