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Comparison of some characteristics of homemade, local and national brands yoghurts

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Abstract. In the study, some physicochemical, viscosity, rheological properties, benzoic and sorbic acid contents of a total of 96 yoghurt samples (consisting of homemade, local and national) collected from different provinces of Turkey were investigated. It was determined that national yoghurt samples had the highest average dry matter (13.8%) and the lowest syneresis values (35.8%). Homemade yoghurts had the lowest average viscosity (at 20 rpm, 4079 cP; 50 rpm, 2142 cP), consistency coefficient values (44.4). It was determined that the flow behavior index values of all yoghurt samples were between 0 and 1 and showed pseudoplastic behavior. It was found that the national commercial yoghurt samples were higher than the homemade and regional samples in terms of dry matter, syneresis, viscosity and consistency coefficient. Although the mean benzoic acid values were detected between 5.43 and 31.9 mg kg^{-1}, sorbic acid was found in only one sample (local brand yoghurt sample).

***Keywords*:** yoghurt; rheological properties; syneresis; benzoic acid; sorbic acid.

1. Introduction

Fermented foods are products formed as a result of the activities of bacteria, yeast or molds. Fermentation is one of the oldest and most economical methods used in food preservation [1]. Fermented dairy products include many foods such as yoghurt, kefir, and ayran [2]. Yoghurt is the most known and consumed dairy product among fermented milk products [1, 3]. Yoghurt and similar products are known and consumed under different names in many parts of the world [2]. There is no definite information about where and how yoghurt was first produced [4]. However, it is thought that the word yoghurt derives from the Turkish word "jugurt" [2].

Yoghurt is produced by fermenting milk by starter culture consisting of *Streptococcus thermophilus* (*S. thermophilus*) and *Lactobacillus delbrueckii* subsp. *bulgaricus* (*L. bulgaricus*) bacteria [5]. Lactic acid is formed by the fermentation of lactose by the bacteria. Fermentation is effective for the texture and characteristic taste of yoghurt. Yoghurt is a suitable dairy product for people with lactose intolerance due to the fermentation of lactose. In addition, yoghurt is liked by consumers due to its desirable taste, rich nutritional content and resistance to pathogenic microorganisms [4, 6].

Yoghurt has been produced traditionally and industrially in Middle East countries and Turkey for centuries. In homemade production, yoghurts produced previously are used as starter cultures, while commercial starter cultures are used in industrial production [1, 4].

Yeast contamination in yoghurt is an important problem for spoilage and shelf life of yoghurts [7, 8]. The main reasons for the high yeast count in yoghurts are that milk is not heated sufficiently, air and materials used are dirty, use of previous yoghurts as starter culture, yoghurts are not stored at appropriate temperature, additives such as sugar, fruit and honey [7, 8].

Benzoic and sorbic acid can be used as antimicrobial and preservative agent against bacterial, yeast-mold and to extend the shelf life of products [9–11]. Although these preservatives are generally used to prevent the growth of yeast and molds, they also have effects on many bacteria such as antibacterial [10–12].

Studies have been carried out to examine many properties of commercial and homemade yoghurts. However, these studies generally examined yoghurts in a province or region [4, 13, 14]. In this study, benzoic and sorbic acid content, some physicochemical properties (dry matter, ash, syneresis, viscosity and rheological), benzoic and sorbic acid contents of homemade, local and national industrial yoghurts obtained from many provinces of Turkey were examined and compared.

2. Experimental

2.1. Materials

In this study, 63 homemade, 23 local and 10 national yoghurt samples were collected from 17 different provinces of Turkey. Industrial yoghurt samples (local and national) were randomly numbered. The yoghurt samples were brought to Atatürk University Food

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Engineering Laboratories under cold chain and the analyzes were carried out on the same day.

2.2. Methods

2.2.1. Physicochemical analysis. Dry matter (%) and ash (%) contents of yoghurt samples were determined by gravimetric method [15]. The method indicated by Flores-Mancha et al. [16] was used to determine syneresis. The separation of serum was calculated according to the formula below by weighing the supernatant (liquid part).

$$\text{Syneresis (\%)} = \frac{\text{weight of supernatant (g)}}{\text{weight of yoghurt sample (g)}} \times 100$$

Viscosity of yoghurt samples was determined by using the Brookfield Viscometer (Model DV-II, Brookfield Engineering Laboratories, Stoughton, MA, USA) device, with cap no. 5. Apparent viscosity values are given in centi-poise (cP) at 20 and 50 rpm. The power law model was used to determine the rheological properties of yoghurt samples. For this purpose, the viscosity values of the samples at 5, 10, 20, 50 and 100 rpm were used and the following formula was used:

$$\eta = K\gamma^{(n-1)}$$

The symbols η, K, γ and n in the formula represent the apparent viscosity (Pa·s), coefficient of consistency (Pa·s^n), shear rate (s^{-1}) and flow behavior index, respectively.

2.2.2. Benzoic and sorbic content

2.2.2.1. Apparatus. The benzoic and sorbic acid were determined by chromatographic analysis. This analysis was carried out in a high performance liquid chromatograph (Agilent Technologies) equipped with 1260 quantitative pump, 1260 infinity standard autosampler, and 1260 VWD UV detector. The chromatographic separation was achieved with a 4.6x250 mm analytical column.

2.2.2.2. Extraction of samples. The extraction was carried out according to NMKL 124 [17] with slight modification for benzoic and sorbic acid analysis. 5 g of samples was weighed and mixed with methanol-water (35:65). After 60 seconds of mixing, the flask diluted 100 ml with the methanol-water. Then, the solution was mixed for 60 seconds and passed through filter paper [17].

2.2.2.3. Chromatograph conditions. The mobile phase consisted of a mixture of acetate buffer-methanol (70:30) at a flow rate of 0.8 mL min^{-1}. The injection volume was 20 µL. The detection of benzoic and sorbic acids was carried out at 229 and 262 nm wavelengths, respectively [17].

2.2.2.4. Validation study. Calibration curve was prepared at 7 points (0.1, 1, 5, 10, 25, 100, and 250 ppm) for the determination of benzoic and sorbic acid by HPLC. Linearity of calibration curve of benzoic and sorbic acid is 0.99993 and 0.99982, respectively. For determination of limit of detection (LOD) and limit of quantitation (LOQ) of benzoic and sorbic acid, a blank yoghurt sample was spiked with standard solutions. LOD and LOQ were calculated with the following formula by using standard deviation (S) of results obtained from reading performed in ten replicates: LOD = 3S and LOQ = 10S. For recovery, a blank yoghurt sample was spiked with standard solutions (5 and 500 ppm final concentration) and the recovery was calculated according to results from the readings. Recovery values of benzoic and sorbic acid were 101 and 88% for 5 ppm, and 98.5 and 97.8% for 500 ppm, respectively (Table 1) [18].

Table 1. Parameters validated for benzoic and sorbic acid

Parameters validated	Results	
	Benzoic acid	**Sorbic acid**
Linear range (µg mL^{-1})	0.1-250	0.1-250
Calibration curve	y = 97.63445x+24.88712	y = 292.80127x+188.76147
R^2	0.99993	0.99982
LOD (µg mL^{-1})	0.330	0.481
LOQ (µg mL^{-1})	1.10	1.60
Recovery (%, 5 µg mL^{-1})	101	88.0
Recovery (%, 500 µg mL^{-1})	98.5	97.8

R^2: square of regression coefficient; LOD: limit of detection; LOQ: limit of quantification

2.3. Statistical analysis

SPSS 17 (SPSS 17 Corp. Inc.) package program was used for the statistical evaluation of the data obtained from the research. The differences between the production processes of the yoghurts used in the research were determined using Analysis of Variance (ANOVA). In addition, Duncan's multiple comparison test was used to determine the differences between mean values at the $P<0.05$ level. The correlation analysis between parameters was determined by using the SPSS program.

3. Results and discussion

3.1. Physicochemical properties

Physical properties of yoghurt such as syneresis and viscosity have an important place in the quality and appreciation by consumers [5].

In order to produce yoghurt of the desired quality, the dry matter of the milk should be around 15-16% [2, 3]. The highest and lowest dry matter values of yoghurt samples are shown in Table 2. The lowest dry matter value was determined as 9.11% in locally produced yoghurts and the highest as 18.35 in homemade yoghurts. The change of dry matter values of homemade yoghurts was highest and that of nationally produced yoghurts was lowest. It was determined that effect of the production type on dry matter values of yoghurt samples was statistically significant (P<0.01). Comparing average of dry matter values of all yoghurt samples, the highest value was 13.8% (national yoghurt) and the lowest was 12.0% (homemade yoghurt).

Table 2. Minimum and maximum values of some physicochemical and rheological properties with benzoic acid content of yoghurt samples

Yoghurt samples	Homemade		Local		National	
	The lowest	The highest	The lowest	The highest	The lowest	The highest
Dry matter (%)	9.2	18.4	9.1	17.1	11.6	15.6
Ash (%)	0.476	0.906	0.550	1.18	0.666	0.982
Syneresis (%)	21.0	68.9	20.3	65.0	27.7	47.4
Viscosity (20 rpm; cP)	805	13063	1574	16230	5418	18272
Viscosity (50 rpm; cP)	490	6906	897	7296	2843	7292
Concistency coefficient (K; Pa. s^n)	4.67	203	12.6	316	146	395
Flow behaviour index (n)	0.025	0.472	0.007	0.437	0.012	0.116
Benzoic acid (mg kg^{-1})	ND	55.2	1.55	322	ND	13.9
Sorbic acid (mg kg^{-1})	ND	ND	ND	21.53	ND	ND

cP: centi-poise; ND: not detected

Karacaoğlu and Özdemir [19] investigated some microbiological and physicochemical properties of national and local yoghurts in Erzurum. They determined that dry matter values of national yoghurts were between 13.78% and 15.27%, while local samples between 12.35% and 14.37%. Çetinkaya [20] found that dry matter values of 15 homemade yoghurts were between 12.79% and 17.44%, and average value of them was 15.26%. Tavşanlı et al. [21] determined that dry matter values of 50 yoghurt samples from Balıkesir ranged between 11.04% and 18.55%, and the average value of them was 15.15%. Tolu and Altun [22] investigated some properties of 15 homemade and 15 commercial yoghurts obtained from Van. They determined that dry matter values of homemade yoghurts were between 12.20% and 16.69%, and that of commercial yoghurts between 11.10% and 15.19%. They reported that average dry matter values of homemade yoghurts (14.55%) were higher than commercial yoghurts (13.77%). The dry matter values from this study are lower than the values by Tavşanlı et al. [21], Karacaoğlu and Özdemir [19], Çetinkaya [20] and Tolu and Altun [22].

Difference between lowest and highest ash values of yoghurt samples was high in local samples, while it was low in national samples (Table 2). It was determined that ash values of the yoghurt samples were significantly affected by type of production (P<0.01). There was no statistically significant difference between average ash contents of local and national yoghurt samples (P>0.05), while that of homemade yoghurts were higher (P<0.05).

Karahan Eren [23] determined the average ash value of 20 homemade yoghurts obtained from Batman (Turkey) to be 0.912%. Demirkaya and Ceylan [14] investigated some microbiological and chemical properties of 30 homemade yoghurts (obtained from Bilecik, Turkey). They determined that ash content of the samples was between 0.63% and 1.14%, and average 0.95%. Jiménez et al. [24] determined that the ash values of Greek and traditional yoghurt samples were 0.67% and 0.69%, respectively.

It was determined that the lowest syneresis of yoghurts was in regional samples with 20.30%, and the highest in homemade samples with 68.90% (Table 2). It was determined that mean values of syneresis were significantly affected by type of production (P<0.05). The mean syneresis values of national yoghurts were lower (P<0.05) than homemade and regional samples (Table 3). The mean syneresis values of regional yoghurt samples (49.16%) were higher than those of homemade (46.36%), but the difference was statistically insignificant (P>0.05).

Karacaoğlu and Özdemir [19] indicated syneresis of national yoghurts were between 15.58% and 23.71%, and that of yoghurts produced in local companies was between 19.36% and 38.81%. In addition, they reported that the average syneresis of national yoghurts was lower than local yoghurts. Tolu and Altun [22] determined that average syneresis of homemade yoghurts were similar to those of commercial yoghurts. The results reported by Tolu and Altun [22] do not agree with the values in this study. It has been reported that syneresis decreases due to the increase in dry matter content of yoghurts. That is due to increase interaction between proteins [3, 25]. In the study, it was thought that reason why syneresis was higher in homemade and regional yoghurt samples compared to national yoghurts was due to difference of dry matter content.

In terms of physicochemical properties of national yoghurts, it can be said that they are generally of good quality compared to homemade and regional yoghurts. In this case, it turns out that homemade yoghurts are produced randomly/spontaneously. There is no regulation regarding dry matter, ash and syneresis of yoghurts in the Turkish Food Codex [26]. It was determined that there was a negative correlation between dry matter and syneresis, while a positive correlation between dry matter and ash (P<0.01).

3.2. Rheological properties

The production type was statistically significant (P<0.01) on viscosity of yoghurt samples. Viscosity values of yoghurt samples at 20 rpm ranged between 805 cP and 13063 cP in homemade yoghurts, and between 5412 cP and 18272 cP in national yoghurts (Table 2). The highest viscosity values were in national yoghurts and the lowest in homemades (Table 3).

The lowest viscosity value of yoghurt samples at 50 rpm was in homemade yoghurt samples with 490.59, and highest in regional yoghurt samples with 7296 cP

(Table 2). The highest viscosity values at 50 rpm were determined in national yogurt samples with 5704.57, and lowest in homemades with 2142 cP (Table 3). Karacaoğlu and Özdemir [19] determined that viscosity of national yogurts at 50 rpm (2958.23-4180.70 cP) were higher than local yoghurts (1522-3594 cP).

Table 3. Effect of production method on some physicochemical and rheological properties of yoghurt samples

Yoghurt samples	Homemade	Local	National
Dry matter (%)	12.04±1.53b	12.85±2.52ab	13.82±1.15a
Ash (%)	0.722±0.081b	0.836±0.163a	0.824±0.097a
Syneresis (%)	46.4±12.2a	49.1±12.2a	35.8±5.86b
Viscosity (20 rpm; cP)	4079±2916c	7048±4715b	14471±3031a
Viscosity (50 rpm; cP)	2142±1459c	3261±1863b	5704±995a
Concistency coefficient (K; Pa. s^n)	44.4±44.3c	109±95.3b	283±81.8a
Flow behaviour index (n)	0.283±0.108a	0.191±0.120b	0.048±0.036c
R^2	0.994±0.009	0.989±0.012	0.994±0.006

cP: centi-poise

Many factors such as the starter culture used in production, applied heat treatment and dry matter content affect the viscosity of yoghurts [27]. In the study, the higher viscosity values of national yoghurts compared to other yoghurts show direct proportion with the dry matter content (Table 3). There was positive correlation between viscosity (20 and 50 rpm) and dry matter/ash, and negative correlation between viscosity and syneresis (P<0.01).

It was determined that effect of production type on consistency coefficient and flow behavior index of the yoghurt samples was statistically significant (P<0.01). The lowest and highest consistency coefficient and flow behavior index values of yoghurt samples are shown in Table 2. The national yoghurt samples had the highest average consistency coefficient (283 Pa·s^n) and the lowest flow behavior index (0.048). On the other hand, the lowest average consistency coefficient (44.4 Pa·s^n) and the highest flow behavior index (0.283) values were determined in homemade samples (Table 3).

Flow behavior index (n) values of homemade, regional and national yoghurt samples were between 0.025-0.472, 0.007-0.437 and 0.012-0.116, respectively. It was determined that differences between the average flow behavior index of the samples were statistically significant (P<0.05). All samples had pseudoplastic flow behavior. It has been reported by many researchers that yoghurts show pseudoplastic behavior [5, 25, 28–31].

Dry matter and protein content of milk has significant effect on rheological properties of yoghurt. In addition, fat content and other additives (such as stabilizers and carbohydrates) affect the rheological properties of yoghurt [28]. There was a direct correlation between dry matter content and consistency coefficient of the yoghurt samples (Table 3). It was determined that there was a positive correlation between consistency coefficient and dry matter, ash and viscosity, and a negative correlation between consistency coefficient and syneresis (P<0.01).

3.3. Benzoic and sorbic acid contents

Benzoic acid is widely used as an antimicrobial, sorbic acid has a less toxic effect than benzoic acid [10]. The acceptable daily intake dose of benzoic and sorbic acid has been determined by FAO/WHO as 5 mg kg^{-1} and 25 mg kg^{-1} body weight, respectively [32–34].

Bezoic acid is produced in dairy products at low concentrations by microorganisms during fermentation [9, 32]. Unlike sorbic acid, benzoic acid can be produced by lactic acid bacteria used in yoghurt production [7]. It is known that bacteria such as *Lactococcus lactis*, *Lactobacillus casei*, *Streptococcus thermophilus*, *Lactobacillus helveticus*, *Escherichia coli* and *Pseudomonas fluorescens* produce benzoic acid [9, 33]. For this reason, naturally occurring benzoic acid can be found in fermented products such as yoghurt.

The highest and lowest benzoic acid values of the yoghurt samples are shown in Table 2. The highest benzoic acid content in all yoghurt samples was determined as 322 mg kg^{-1} in the national yoghurt sample. Average benzoic acid contents of the yoghurt samples are given in Fig 1. The highest average value was determined as 31.9 mg kg^{-1} in regional yogurt samples, and the lowest average value was determined as 5.43 mg kg^{-1} in national samples. Sorbic acid was determined as 21.2 mg kg^{-1} in only one regional yoghurt sample (Table 2).

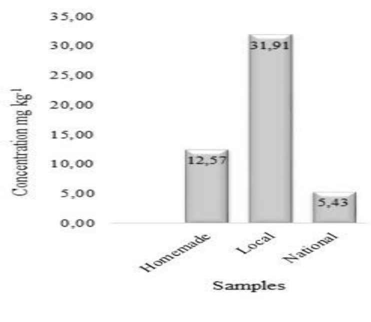

Figure 1. The mean content of benzoic acid of yoghurt samples

Cakir and Cagri-Mehmetoglu [34] examined the benzoic and sorbic acid contents of 21 yoghurt samples collected from markets. They determined that the benzoic acid content ranged from 0 to 159.9 mg kg^{-1}, the mean value was 35.2 mg kg^{-1}. They detected sorbic acid in 2 yoghurt samples. Yildiz et al. [35] determined that the average amount of benzoic acid in commercial yoghurts from 5 different provinces was between 9.35 and 26.21 mg kg^{-1}. Bartáková et al. [9] determined the benzoic acid content of homemade and commercial yoghurts between 13.38 and 18.65 mg kg^{-1}. Mroueh et al. [7] found that the benzoic acid content of 30 yoghurt samples collected from Lebanon varied between 12.0

and 479.1 mg kg^{-1}, while the sorbic acid content between 0 and 3719.1 mg kg^{-1}.

In this study, benzoic acid contents of all yoghurt samples except for one sample (322.06 mg kg^{-1}) were suitable for Codex Alimentarius (maximum 300 mg kg^{-1}) [36], while benzoic acid contents of all yoghurt samples were not suitable according to Turkish Food Codex (2013), except for two yoghurt samples. In terms of sorbic acid content, all samples were suitable for Codex Alimentarius (maximum 1000 mg kg^{-1}) [36], but the sorbic acid content of only one local yoghurt sample was not suitable for Turkish Food Codex [37].

According to Codex Alimentarius, fermented milk products should contain a maximum of 1000 mg kg^{-1} sorbic acid and 300 mg kg^{-1} benzoic acid [36]. According to the Turkish Food Codex, the addition of benzoic and sorbic acid in fermented milk products is not allowed adding [37]. It has been reported that naturally occurring benzoic acid in yoghurts is below 50 mg kg^{-1} during fermentation [12, 32, 35]. Therefore, it is not known whether benzoic acid is natural or added in fermented milk products. This can cause problems [9]. Therefore, it is important to examine benzoic and sorbic acid contents of fermented products such as yoghurt.

4. Conclusion

It was determined that effect of yoghurt production on the dry matter, ash, viscosity, consistency coefficient, flow behavior index and syneresis was statistically significant ($P<0.01$). Homemade yoghurts had the lowest average dry matter and ash content and the highest average syneresis. National samples had the highest average viscosity (20 and 50 rpm) and consistency coefficient values. Flow behavior index of the samples were listed as homemade, regional and national samples, from largest to smallest. In Turkish Food Codex, there is no limit for the dry matter, ash, syneresis, viscosity and consistency coefficient values of yoghurt samples. National yoghurt samples had better results than other samples in terms of dry matter, syneresis, viscosity and consistency coefficient, which are quality parameters of yoghurt. It can be said that use of modern production techniques has positive effect on the quality parameters of yoghurt. The benzoic acid contents of all yoghurt samples did not comply with the Turkish Food Codex, except for two samples. Sorbic acid was determined in only one (local) yoghurt sample.

Conflict of interest

The authors declare that they have no conflict of interest.

References

[1]. B. Kabak, A.D.W. Dobson, An introduction to the traditional fermented foods and beverages of Turkey, Critical Reviews in Food Science and Nutrition 51 (2011) 248–260. DOI: 10.1080/10408390903569640

[2]. A.Y. Tamime, H.C. Deeth, Yogurt: Technology and biochemistry, Journal of Food Protection 43 (1980) 939–977. DOI: 10.4315/0362-028x-43.12.939

[3]. I. Sodini, F. Remeuf, C. Haddad, G. Corrieu, The relative effect of milk base, starter, and process on yogurt texture: A review, Critical Reviews in Food Science and Nutrition 44 (2004) 113–137. DOI: 10.1080/10408690490424793

[4]. Y. Durak, F. Keleş, A. Uysal, M.O. Aladağ, Investigaion of microbiological properties of fresh home made yogurt in Konya surround, Selçuk Üniversitesi Ziraat Fakültesi Dergisi 22 (2008) 113–117

[5]. W.J. Lee, J.A. Lucey, Formation and physical properties of yogurt, Asian-Australasian Journal of Animal Sciences 23 (2010) 1127–1136. DOI: 10.5713/ajas.2010.r.05

[6]. Ö. Özoğlu, R. Çolak Şaşmazer, Z. Erginkaya, M. Korukluoğlu, Investigation of production and characteristics of homemade yogurt by using a commercıial probiotic culture Gida / the Journal of Food 45 (2020) 814–824. DOI: 10.15237/gida.gd20028

[7]. M. Mroueh, D. Issa, J. Khawand, B. Haraty, A. Malek, Z. Kassaify, I. Toufeili, Levels of benzoic and sorbic acid preservatives in commercially produced yoghurt in Lebanon, Journal of Food, Agriculture & Environment 5 (2008) 61–66.

[8]. A. Y. Sirhan, Optimization and validation of an HPLC-UV method for determination of benzoic acid and sorbic acid in yogurt and dried-yogurt products using a design of experiment, Indonesian Journal of Chemistry 18 (2018) 522–530. DOI: 10.22146/ijc.27675

[9]. K. Bartáková, L. Vorlová, S. Dluhošová, I. Borkovcová, Š. Bursová, J. Pospíšil, B. Janštová, Effect on benzoic acid production of yoghurt culture and the temperatures of storage and milk heat treatment in yoghurts, Foods 10 (2021) 1535.

[10]. N. Koyuncu, V. Uylaser, Benzoic acid and sorbic acid levels in some dairy products consumed in Turkey, Asian Journal of Chemistry 21 (2009) 4901–4908.

[11]. L. Wang, X. Zhang, Y. Wang, W. Wang, Simultaneous determination of preservatives in soft drinks, yogurts and sauces by a novel solid-phase extraction element and thermal desorption-gas chromatography, Analytica Chimica Acta 577 (2006) 62–67. DOI: 10.1016/j.aca.2006.06.030

[12]. L. Gücer, O. Yerlikaya, S. Meric, E. Aydin, M. Kilincer, G. Kurtulus, H. Yagli Gur, Determination of benzoic acid content of dairy products consumed in Turkey, Journal of Food Safety and Food Quality 67 (2016) 93–112. DOI: 10.2376/0003-925X-67-107

[13]. İ. Bakırcı, G.Ş. Tohma, A. Kavaz Yüksel, Determination of pysical, chemical, microbiological and sensory properties of yoghurts sold in Erzurum, Turkey, Akademik Gıda 13 (2015) 127–134.

[14]. A.K. Demirkaya, Z.G. Ceylan, Investigation of chemical and microbiological quality of yoghurts marketed in Bilecik province, Atatürk University Journal of Veterinary Sciences 8 (2013) 202–209. DOI: 10.17094/avbd.77404.

[15]. M. Metin, Milk and Products Analysis Methods.

İzmir, Turkey: EÜ, Ege Meslek Yüksekokulu Yay. No: 24, 2009.

[16]. M.A. Flores-Mancha, M.G. Ruíz-Gutiérrez, A.L. Rentería-Monterrubio, R. Sánchez-Vega, J. Juárez-Moya, E. Santellano-Estrada, A. Chávez-Martínez, Stirred yogurt added with beetroot extracts as an antioxidant source: Rheological, sensory, and physicochemical characteristics, Journal of Food Processing and Preservation 45 (2021) e15628. DOI: 10.1111/jfpp.15628

[17]. NMLK124, Nordic Committee on Food Analysis, Method no. 124, 1997.

[18]. J. Burana-Osot, L. Arunsingkharat, M. Naksuk, S. Naungnamjai, T. Saetun, Validation of a HPLC method for the determination of benzoic acid and sorbic acid in noodles, Chiang Mai Journal of Science 41 (2014) 370–82.

[19]. Ş. Karacaoğlu, S. Özdemir, Comparison of some microbiological, physical and chemical properties of yoghurts produced at local and national level and offered to consumption in Erzurum, European Journal of Science and Technology 22 (2021) 381–392. DOI: 10.31590/ejosat.845025.

[20]. A. Çetinkaya, Determination of physical and chemıcal propertıes of yoghurts, white cheese and Kars Kashar cheese sold in Kars, Turkey Gida / the Journal of Food 46 (2021) 1233–1242. DOI: 10.15237/gida.gd21060.

[21]. H. Tavşanlı, M. Gökmen, A. Önen, Balıkesir ilinde semt pazarlarında satışa sunulan yoğurtların fiziko-kimyasal ve mikrobiyolojik kalitesinin araştırılması, Journal of Balıkesir University Institute of Science and Technology 22 (2020) 318–326. DOI: 10.25092/baunfbed.680814.

[22]. A. Tolu, I. Altun, Comparison of homemade and commercial yoghurt in Van province, Turkey, Food Science and Technology 42 (2022) e08321. DOI: 10.1590/fst.08321

[23]. L. Karahan Eren, Chemical and textural properties of yoghurts marketed in Batman province), Batman University Journal of Life Sciences 6 (2016) 59–65.

[24]. M.E. Jiménez, L.M.H. García, L.G.R. Mérida, M. Alcano, N.S.P.S. Richards, Greek vs traditional yogurts: Sensory and physicochemical comparison, Revista Chilena de Nutrición 49 (2022) 167–172.

[25]. A. Kalyas, B. Ürkek, Effect of flaxseed powder on physicochemical, rheological, microbiological and sensory properties of yoghurt, Brazilian Archives of Biology and Technology 65 (2022) e22210012.

[26]. Anonymous 2009/25. Communique on Fermented Milk Products (2009).

[27]. M.A. Marand, S. Amjadi, M.A. Marand, L. Roufegarinejad, S.M. Jafari, Fortification of yogurt with flaxseed powder and evaluation of its fatty acid profile, physicochemical, antioxidant, and sensory properties, Powder Technology 359 (2020) 76–84. DOI: 10.1016/j.powtec.2019.09.082

[28]. J. Domagala, M. Sady, T. Grega, G. Bonczar, The influence of storage time on rheological properties and texture of yoghurts with the addition of oat-maltodextrin as the fat substitute, International Journal of Food Properties 8 (2005) 439–448. DOI: 10.1080/10942910500267489

[29]. M. Azari-Anpar, H. Payeinmahali, A. Daraei Garmakhany, A. Sadeghi Mahounak, Physicochemical, microbial, antioxidant, and sensory properties of probiotic stirred yoghurt enriched with Aloe vera foliar gel, Journal of Food Processing and Preservation 41 (2017) 1–9. DOI: 10.1111/jfpp.13209

[30]. D. Sun-Waterhouse, J. Zhou, S.S. Wadhwa, Drinking yoghurts with berry polyphenols added before and after fermentation, Food Control 32 (2013) 450–460. DOI: 10.1016/j.foodcont.2013.01.011

[31]. M. Yekta, S. Ansari, Jujube mucilage as a potential stabilizer in stirred yogurt: Improvements in the physiochemical, rheological, and sensorial properties, Food Science and Nutrition 7 (2019) 3709–3721. DOI: 10.1002/fsn3.1230

[32]. R. Sieber, U. Bütikofer, J.O. Bosset, Benzoic acid as a natural compound in cultured dairy products and cheese, International Dairy Journal 5 (1995) 227–246.

[33]. H. Yu, N. Lee, H. Jeon, S.J. Eom, M. Yoo, Benzoic acid production with respect to starter culture and incubation temperature during yogurt fermentation using response surface methodology, Korean Journal for Food Science of Animal Resources 36 (2016) 427–434.

[34]. R. Cakir, A. Cagri-Mehmetoglu, Sorbic and benzoic acid in non-preservative-added food products in Turkey, Food Additives and Contaminants: Part B Surveillance 6 (2013) 47–54. DOI: 10.1080/19393210.2012.722131

[35]. A. Yildiz, S. Erdogan, A. Saydut, C. Hamamci, High-performance liquid chromatography analysis and assessment of benzoic acid in yogurt , ayran , and cheese in Turkey, Food Analytical Methods 5 (2012) 591–595. DOI: 10.1007/s12161-011-9288-z

[36]. Anonymous, Standard for Fermented Milks (CXS 243-2003) (2018).

[37]. Turkish Food Codex, Regulation on Food Additives (2013).

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