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Effects of Homogenization and Heat Treatment of Milk with Different Fat Content on Physical Properties of Ayran

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Abstract: In this research, the effects of different homogenization pressure levels (15, 40, 15/3 and 40/8 MPa) and heat treatments (95°C for 90 s and 300 s) of milk containing 1.5 and 2.5% of fat on some physical properties of ayran were investigated during storage at 4°C for 30 days. The individual effects of fat content of milk, homogenization, heat treatment, and storage period on the syneresis, apparent viscosity, consistency constant and thixotropy values of the ayran samples were statistically significant. Based on the results of rheological analysis, the power law model was more appropriate for all ayran samples.

Key words: Ayran, fat content, heat treatment, homogenization, physical properties.

INTRODUCTION

Fermented dairy products such as yoghurt, are produced and consumed in nearly every country of the world. Ayran is a yoghurt-based product, salty drink and popular in Turkey, as well as in many countries in Central Asia, the Balkans and the Middle East (Yildiz 2016). According to Turkish Food Codex Communique on Fermented Milk Products, ayran is defined as “dairy product prepared by the addition of water to yoghurt or by the inoculation of starter culture containing *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus* to standardized milk.” Besides, ayran should have a minimum titratable acidity of 0.5%, a minimum milk protein content of 2.0%, and a maximum salt content of 1.0%. In addition, in terms of fat content, ayran is classified into three different groups as full-fat, low-fat and non-fat. The full-fat and low-fat ayrans should have a minimum fat content of 1.8% and 0.8%, respectively (Ministry of Agriculture and Rural Affairs 2009).

Sensorial and physical properties are the most important determinants of food preference (van den Berg et al. 2008). Different methods such as consumer test using 9-point scale (García-Gómez et al. 2019), innovative methods based in consumer perception (Judacewski et al. 2019) and trained panel using quantitative descriptive analysis (QDA) and temporal methods (Silva et al. 2018) can be used for the sensory evaluation of fermented dairy products. Physical properties are among the main evaluation criteria in terms of consumer acceptability of fermented dairy products. Viscosity and water holding capacity are two of the most important physical characteristics affecting consumer preferences for ayran. Two of the desired physical properties in ayran are optimum viscosity for good mouthfeel and no serum separation. The viscosity and serum separation of ayran are affected by various factors such as total solids, fat and protein contents of milk, casein to whey protein ratio in milk, homogenization, heat treatment, acidity of ayran, and storage conditions (Koksoy & Kilic 2004, Kucukcetin et al. 2012).

Homogenization, which is commonly used in the production of ayran, mechanically reduces the size of the milk fat globules by pumping at high pressure through a small valve and is used to produce emulsion of uniform composition and higher stability of milk. The process breaks fat globules into much smaller globules (less than 1-2 µm). The fat globule size after homogenization of milk depends on several factors that mechanical properties of homogenization used, number of passes through valve (single- and double-stage), temperature of milk during homogenization, and homogenization pressure (low and high) (O'Connell & Fox 2003). As a result of the homogenization process, the fat globule size decreases and the fat globule surface area increases. The original amount of fat globule membrane material is not enough to cover this new surface area of fat globules. The fat globule surface is covered by casein micelles, or whey proteins if homogenization is combined with heat treatment (Sung & Sherbon 2002).

The role of heat treatment of milk on quality characteristics of ayran is particularly important. The application of heat treatment to milk used in the production of fermented dairy products prior to fermentation results in a number of different effects on the physical, microbiological and nutritional properties of fermented dairy products. There are a lot of differences in the physical properties between acid milk gels from unheated milks and severely heated milks. Heat treatment of milk at a temperature higher than the denaturation temperature of whey proteins increases gel firmness and reduces syneresis in fermented dairy products (Mulvihill & Grufferty 1995, Kucukcetin et al. 2012).

Although several studies have been published regarding the effects of casein to whey protein ratio of milk, water and salt contents of ayran, ultrasound, acoustic energy and using transglutaminase and hydrocolloids, there is meager information of the impacts of homogenization and heat treatment of milk on physical properties of ayran. The overall objective of this research was to study the combined effects of conditions of homogenization and heat treatment of milk with different fat contents on some physical properties of ayran during storage.

MATERIALS AND METHODS

Ayran production

Raw cow milk (pH value of 6.7, non-fat milk solids content of 8.1%, fat content of 3.3% and protein content of 3.0%) was obtained from the Cattle Farm in Akdeniz University. The process flow diagram of ayran production was shown in Figure 1. Raw milk was heated to 55°C and then the fat content of milk was standardized to 1.5% and 2.5% using a separator (G140 model, SMS Ltd. Sti., Kayseri, Turkey). The fat-standardized milk and deionized water were mixed in order to a total solids content of approximately 8%. The mixture, called ayran milk, was heated at 55°C and homogenized using a laboratory double-stage homogenizer (Buffalo Series Homolab 2, H.P. Homogenizers FBF, Parma, Italy). Four different homogenization treatments were performed at a gauge pressure of either 15 or 40 MPa as single-stage homogenization and at a gauge pressure of either 15/3 or 40/8 MPa as double-stage homogenization. After the homogenization treatments, ayran milk was heated at 95°C for 90 s or at 95°C for 300 s, cooled to 42°C, inoculated with ayran starter culture containing *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus* (Mystarter culture RV1 A, Maysa Food Industry and Trade Inc., Istanbul, Turkey) at a ratio of 2% (w/v), and incubated at 42°C until pH reached

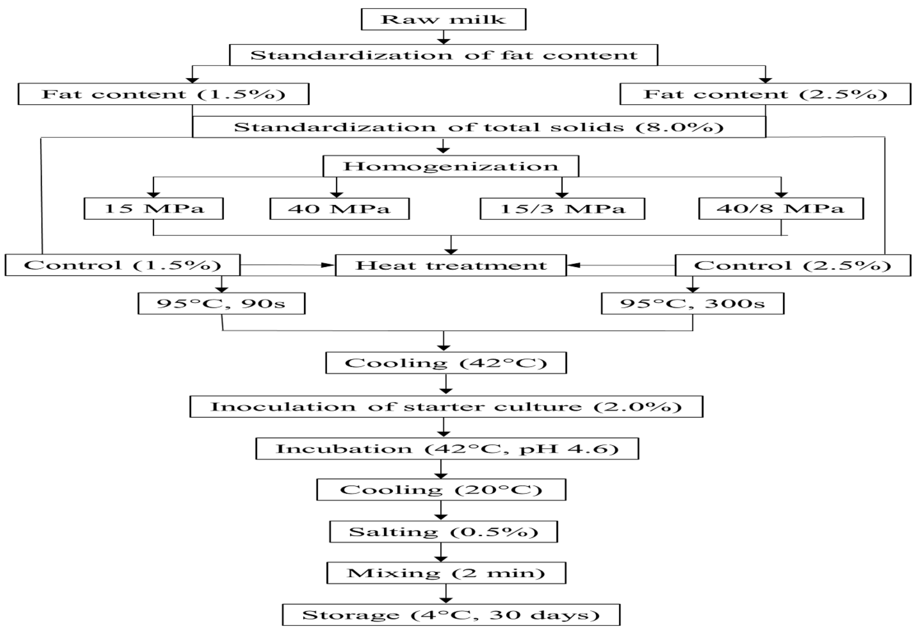

Figure 1. The process flow diagram of ayran production.

to 4.6. After the incubation, the samples were cooled to 20°C. Then, 0.5% (w/v) salt (Billur Tuz Co., Ltd., İzmir, Turkey) was added to the samples and the samples were mixed thoroughly with mechanical mixer (Bosch, Mixxo Quattro MSM 7700, Jesenice, Slovenia) during 2 min. Ayran produced from non-homogenized milk was the control group of the study. The ayran samples packaged in 170 mL cups with lids were stored at 4ºC for 30 days and the physical properties of the ayran samples were determined on days 1, 15 and 30 of the storage.

Analyses for the milk and ayran samples

The total solids, protein, fat and ash contents of milk samples were determined according to the Association of Official Analytical Chemist methods (AOAC 1997). The particle size distributions of non-homogenized and homogenized ayran milks before heat treatment were determined using a Malvern Mastersizer 2000 particle size analyser (Malvern Instruments Ltd., Worcestershire, UK) according to the method of Jensen et al. (2010).

The ayran samples were analysed for total solids content by drying samples using an air oven, for fat content using the Gerber method, for protein content by the Kjeldahl method and for ash content by heating samples in a muffle furnace at 550°C for 8 h. Percentage of titratable acidity for the samples was measured by the method of Erkaya et al. (2015). The pH values of the milk and ayran samples were determined using a pH-meter (Thermo Scientific Orion 2-Star, Bremen, Germany). Syneresis analysis of the ayran samples was performed according to the method of Koksoy & Kilic (2004). The ayran samples were placed in volumetric cylinder and the volume of separated whey at the top was measured during the storage.

Rheological properties of the ayran samples were determined using concentric cylinder double gap (DG3) measuring system in a Brookfield R/S plus rheometer (Brookfield, Middleboro, MA, USA) controlled stress rheometer at 10°C using a water bath (Brookfield TC-502). After gentle mixing by ten up and down movements of a spoon in the ayran cup, 19 ml of ayran sample was deposit the gap of rheometer.

The ayran samples were started to be analysed after waiting for approximately 2 min in the measuring gap to achieve thermal equilibrium. The ayran samples were sheared by linearly increasing shear rate from 0.1 to 300 s^{-1} for 5 min and reducing back to 0.1 s^{-1} in the next 5 min. Rheological properties of the ayran samples were determined by the power law model using Rheo3000 software (RheotecMesstechnik GmbH, Berlin, Germany). Viscosity values in the up-ward viscosity to shear rate curves at a shear rate of 50 s^{-1} were taken as the apparent viscosity of the ayran samples (Koksoy & Kilic 2004).

Statistical analysis

All experiments were performed in duplicate using a complete factorial experimental design (fat content of milk, homogenization, heat treatment, and storage time, 2x4x2x3). The data were analysed using SAS Statistical Software (release for Windows, SAS Institute Inc., Cary, NC, USA). Duncan's multiple range test was conducted to detect differences between the treatment means.

RESULTS AND DISCUSSION

The mean contents of total solids, non-fat milk solids, fat, protein and ash in ayran milks with different fat contents varied from 8.04 to 8.05%, from 5.60 to 6.56%, from 1.48 to 2.45%, from 2.06 to 2.41% and from 0.53 to 0.60%, respectively (Table I). The contents of non-fat milk solids, protein and ash decreased with increasing the fat contents of the milk samples. The volume average diameter (D [4,3]), volume-surface area diameter (D [3,2]) and specific surface area values of non-homogenized and homogenized ayran milks with different fat contents were given in Figure 2. Moreover, as seen in Table II, results of ANOVA analysis showed that fat content of ayran milk, and homogenization significantly ($p<0.001$) affected the D [4,3], D [3,2] and specific surface area values of the ayran milks. The D [4,3] and D [3,2] values of the homogenization-treated ayran milks were lower than those of the ayran milk without homogenization, while the specific surface area value of non-homogenized ayran milk was lower than those of all homogenization-treated ayran milks. The switching from single-stage to double-stage homogenization lead to decrease in the D [4,3] and D [3,2] values and increase in the specific surface area values of the ayran milks. It may be related that the double-stage of homogenization distributes fat clusters formed during the single-stage of homogenization (Maurice & Muir 1983). Moreover, the ayran milks have lower the D [4,3] and D [3,2] values and higher the specific surface area values with increasing homogenization pressure. In a study by Hayes & Kelly (2003), compared the effects of conventional homogenization at 15/3 MPa with double-stage homogenization

Table I. Composition of standardized milks.

Contituents (%)	Milk with 1.5% fat	Milk with 2.5% fat
Non-fat milk solids	6.56±0.03	5.60±0.01
Fat	1.48±0.01	2.45±0.05
Protein	2.41±0.01	2.06±0.02
Ash	0.60±0.02	0.53±0.03

Values are the means ± standard error (n = 2).

processes on fat globule size of whole bovine milk. In this study, the D [4,3] values of non-homogenized whole milk, homogenized whole milk at 15/3 MPa and 50°C and homogenized whole milk at 45/5 MPa and 48°C were determined as 3.08, 1.05 and 0.49 µm, respectively. Borcherding et al. (2008) found that D [4,3] and D [3,2] values of non-homogenized whole milk, homogenized whole milks at 5 MPa, 10/5 MPa, 20/5 MPa and 25/5 MPa were 3.06 and 2.69 µm, 1.50 and 0.51 µm, 0.76 and 0.36 µm, 0.44 and 0.25 µm, 0.39 and 0.24 µm, respectively, while specific fat globule surface values were 84, 450, 630, 890 and 940 m^2kg^{-1}, respectively. They reported that in whole milk samples, the D [4,3] and D [3,2] values decreased but the specific surface area values increased with using homogenization as well as increasing total pressure of homogenization. In our study, the D [4,3] and D [3,2] values of the ayran milks also increased with increasing fat contents. The results of the particle size measurements of the ayran milks in the present study are in agreement with other researches mentioned above.

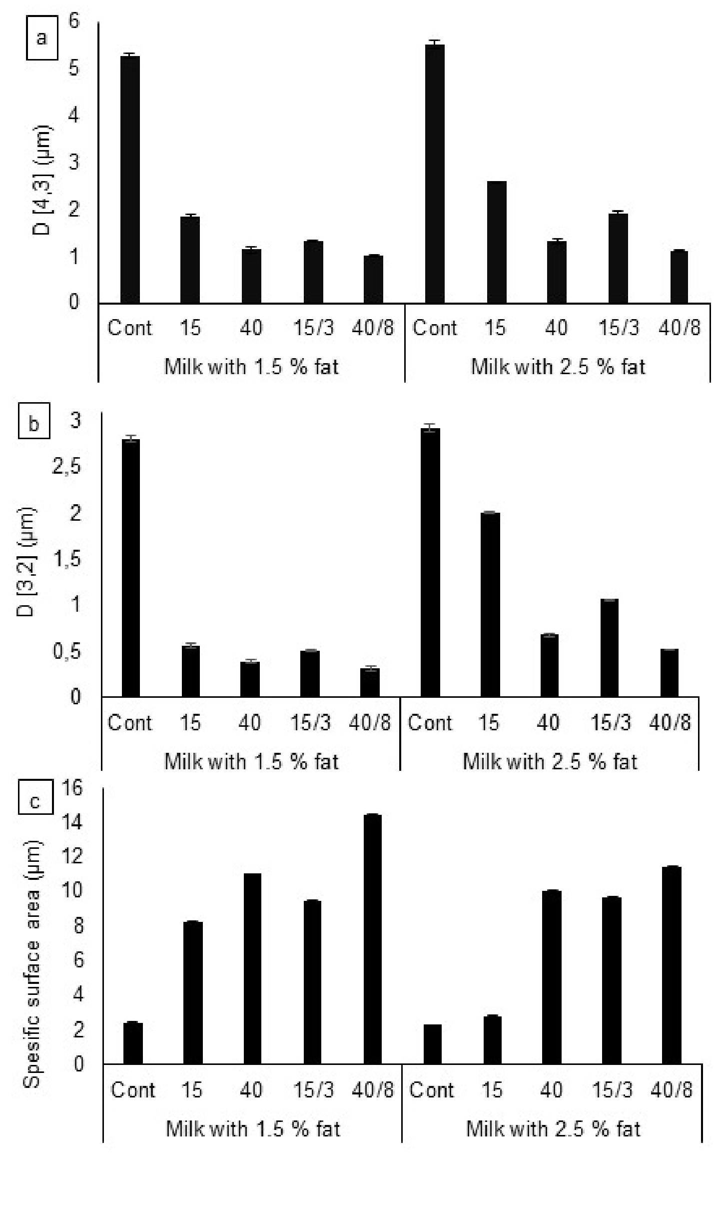

Figure 2. (a) D [4,3], (b) D [3,2] and (c) specific surface area values of the ayran samples. The bars represent mean values, and the error bars represent standard error of the mean.

The mean total solids, fat, protein and ash contents of the ayran samples ranged from 7.97 to 8.12%, from 1.44 to 2.52%, from 1.98 to 2.49%, and from 0.75 to 0.92%, respectively. The pH values of the samples varied from 4.62 to 4.53 and from 4.48 to 4.35 between the first day and 30 days of storage. The titratable acidity values ranged between 0.65% and 0.77% for one-day stored samples and between 0.82% and 1.02% for 30-day stored samples, in agreement with criteria set by Turkish Food Codex Communique on Fermented Milk Products.

The syneresis values of the ayran samples varied from 1.1 to 30.9% during the storage (Figure 3a-b). The fat content of milk, homogenization, heat treatment and storage time significantly ($p<0.001$) influenced the syneresis values of the samples (Table III). The syneresis values of the samples produced from milk heated at 95°C for 90 s were higher than those from milk heated at 95°C for 300 s. The denaturation degree of whey protein in milk increased with the severity of heat treatment (Remeuf et al. 2003). Akkerman (2014) found that denaturation degrees of β-lactoglobulin and α-lactalbumin in milk heat-treated at 95°C for 60 s by using a tubular heating exchanger were approximately 80% and 20%, respectively. Moreover, the researcher determined that as the holding time of heat treatment at 95°C increased from 60 s to 300 s, the denaturation degrees of β-lactoglobulin and α-lactalbumin were approximately 98% and 50%, respectively. The denatured whey proteins have the tendency associate with casein micelles during fermentation of milk, which results in a firmer protein network and large volumes of water held in yoghurt gel (Remeuf et al. 2003). Cayot et al. (2003) showed that level of syneresis in acid gels produced from skim milk decreased with increasing of denaturation degree of β-lactoglobulin. Similar to our study, Kücükcetin (2008) determined that the syneresis of yoghurt samples produced from milk heated at 95°C for 80 s and 256 s were 22.5% and 23.7%, respectively. In this study, the syneresis value of the sample produced from milk containing with 1.5% fat was significantly higher than that produced from milk containing with 2.5% fat. Raju & Pal (2009) studied the effect of milk fat reduction on the quality of misti dahi (sweet yoghurt) which is produced from milk fermented by *Streptococcus thermophilus* and *Lactobacillus bulgaricus*. The

Table II. The effects of fat content and homogenization on the D[4,3], D[3,2] and specific surface area values of the ayran milks

Fat content (%)	D[4,3] (μm)	D[3,2] (μm)	Specific surface area (m^2g^{-1})
1.5	2.12±1.60 b[a]	0.92±0.95 b	9.10±3.94 a
2.5	2.49±1.58 a	1.44±0.91 a	7.26±3.89 b
Homogenization (MPa)			
Non-homogenized	5.40±0.14 a	2.87±0.08 a	2.35±0.05 e
15	2.22±0.37 b	1.29±0.73 b	5.52±2.70 d
40	1.23±0.10 d	0.53±0.14 d	10.55±0.48 b
15/3	1.63±0.29 c	0.79±0.28 c	9.56±0.12 c
40/8	1.06±0.08 e	0.42±0.11 e	12.93±1.48 a

[a]Values are the means ± standard error (n = 2); different superscript letters for each parameter in a column show significant difference at p<0.05.

authors pointed out that fat globules interacted with casein micelles and whey proteins in gel network, thus leading formation of gel structure and decreasing syneresis. In the ayran samples, using double-stage homogenization instead of single-stage homogenization and increasing total homogenization pressure during homogenization of the ayran milks resulted in lower syneresis. A single-stage homogenizer is more utilized than a two-stage homogenizer during processing of milk for production of yoghurt. However, the double-stage homogenization increases the efficiency of homogenization and prevents the clustering of fat globules occurred following the single-stage homogenization. The reduction of the fat globule size leads increases in the globule surface area and if enough protein, especially casein, is available to cover the surface area of new fat globules that occurs after homogenization of milk, globules behave like casein micelles. This helps in improving stability of the protein complex and increases water holding capacity and viscosity of gel (Yildiz 2016).

The apparent viscosity values of the day 1 and day 30 ayran samples varied from 99.3 to 296.4 mPas and from 67.2 to 245.6 mPas, respectively (Figure 3c-d). The apparent viscosity values of the samples were significantly ($p<0.001$) influenced by the fat content of milk, homogenization, heat treatment and storage time (Table III). In comparison with the ayran samples produced from milk heated at 95°C for 90 s, the higher apparent viscosity values were observed in the ayran samples produced from milk heated at 95°C for 300 s. Our results were similar to those reported by Remeuf et al. (2003) who found that the apparent viscosity values of yoghurt samples produced from milk bases with a high ratio of whey protein to casein

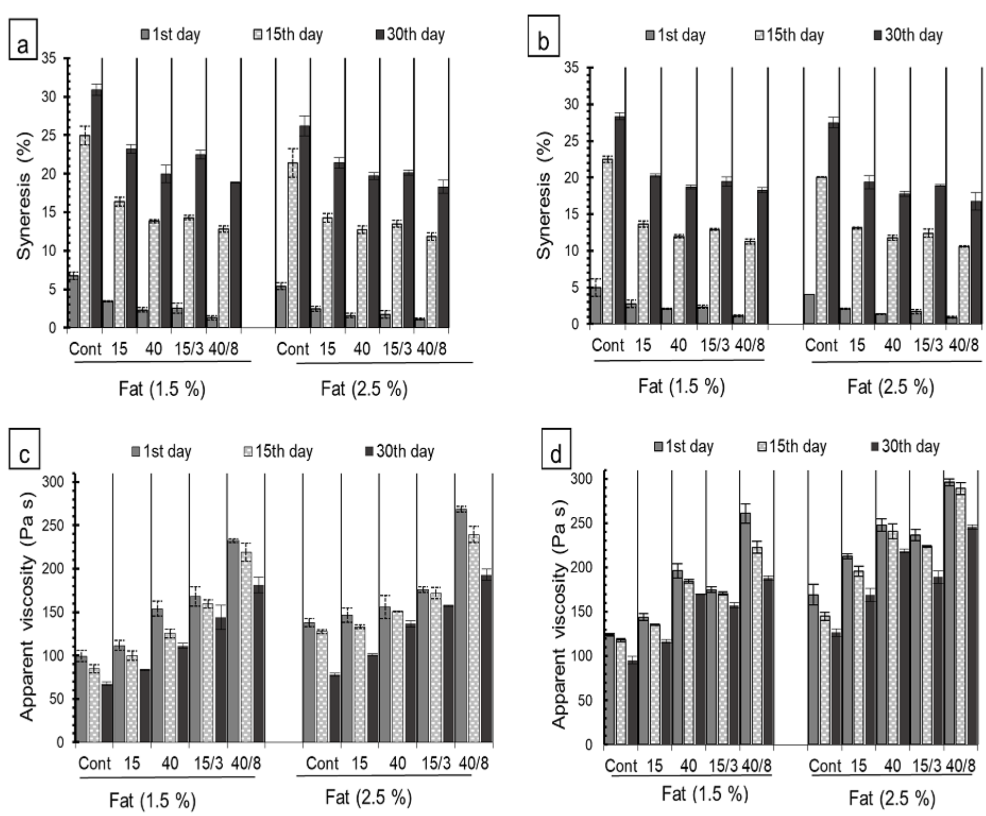

Figure 3. (a) syneresis and (c) apparent viscosity values of the ayran samples produced from milk heat treated at 95°C for 90 s. (b) syneresis and (d) apparent viscosity values of ayran samples produced from milk heat treated at 95°C for 300 s. The bars represent mean values, and the error bars represent standard error of the mean.

increased with prolongation of holding time of heat treatment at 90°C from 1 to 5 min. The apparent viscosity value of the ayran samples obtained from milk containing 2.5% fat was significantly (p<0.05) higher than that from milk containing 1.5% fat. In another study, it was indicated that the viscosity value of yoghurt made from buffalo milk increased as the fat content of yoghurt milk increased because of the fat globules in the protein network in milk improved water-holding capacity of yoghurt (Akgun et al. 2016). The apparent viscosity values of the ayran samples increased with increasing in total homogenization pressure. Moreover, the apparent viscosity values of the ayran samples produced from milks homogenized at 15 and 40 MPa were significantly (p<0.05) lower than, respectively, those from milks homogenized at 15/3 and 40/8 MPa. Lanciotti et al. (2004) investigated the effect of homogenization of milk at different pressures (15, 30, 45, 60 and 75 MPa) on rheological characteristic of yoghurts. They found that apparent viscosity values of yoghurts increased with increasing homogenization pressure. The increase in homogenization pressure enhances the interaction capacity of fat globules with casein micelles and denatured whey proteins, and this leads more stable gel (Ciron et al. 2012). Dimitreli et al. (2014) determined that the apparent

Table III. The effects of fat content of milk, homogenization, heat treatment and storage time on the values of syneresis, apparent viscosity, flow behaviour index, consistency constant and thixotropy of ayran samples.

	Syneresis (%)	Apparent viscosity (mPa s)	Flow behaviour index (n)	Consistency constant (Pa s^n)	Thixotropy (Pa s^{-1})
Fat content					
1.5 %	13.48±8.70 a[a]	150.01±47.70b	0.33±0.03a	0.77±0.18b	968.57±207.51b
2.5 %	12.33±8.15b	185.98±54.92a	0.32±0.01a	1.19±0.20a	1214.14±223.97a
Homogenization					
Control	18.58±9.86a	114.38±29.21e	0.35±0.02a	0.79±0.27e	840.26±171.48e
15 MPa	12.69±7.69b	137.43±37.94b	0.34±0.02ab	0.88±0.25d	964.81±166.34d
40 MPa	11.15±7.14d	179.45±40.39d	0.32±0.03ab	1.05±0.27b	1201.78±177.67c
15/3 MPa	11.87±7.54c	172.34±30.23c	0.33±0.02ab	1.01±0.27c	1097.06±164.33b
40/8 MPa	10.25±7.02e	236.39±37.02e	0.29±0.02b	1.15±0.20a	1352.87±181.96a
Heat treatment					
95°C, 90 s	13.53±8.67a	147.12±49.04b	0.33±0.03a	0.88±0.26b	1025.20±235.98b
95°C, 300 s	12.28±8.18b	188.87±51.60a	0.32±0.02a	1.07±0.28a	1157.51±242.76a
Storage time					
1st day	2.59±1.56c	185.67±54.96a	0.31±0.03b	1.05±0.27a	1198.79±235.13a
15th day	14.81±4.01b	171.87±52.83b	0.32±0.02ab	0.99±0.28b	1095.73±230.60b
30th day	21.32±3.86a	146.45±48.00c	0.35±0.03a	0.89±0.28c	979.55±229.21c

[a]Values are the means ± standard error (n = 2); different superscript letters for each parameter in a column show significant difference at p<0.05.

viscosity values of yoghurt samples produced from milks having large fat globule size (2.9 μm) were lower than those from milk having small fat globule size (0.87 μm). A possible reason for this was explained by the authors that because of increased hydrodynamic volume of the fat-protein complex, the resistance to flow is increased, which resulting in the increase of apparent viscosity values of yoghurt samples. In the present study, the apparent viscosity values of all ayran samples decreased during 30-day storage at 4°C. This results may be related to degradation of gel structure due to the bacterial activities such as post-acidification and proteolysis (Gomes et al. 2013).

Rheological properties of the ayran samples were presented in Figure 4 and Table III. The Newtonian flow, Power law, Bingham and Herschel-Bulkey model were compared in this study to analyse the flow behaviour of the ayran samples. The rheological properties were described by the Power law model with high correlation coefficient ranged from 0.83 to 0.94 (data not shown). The Power law model was also used by Koksoy & Kilic (2004) and Kucukcetin et al. (2012) for describing the rheological properties of ayran. The flow behaviour index

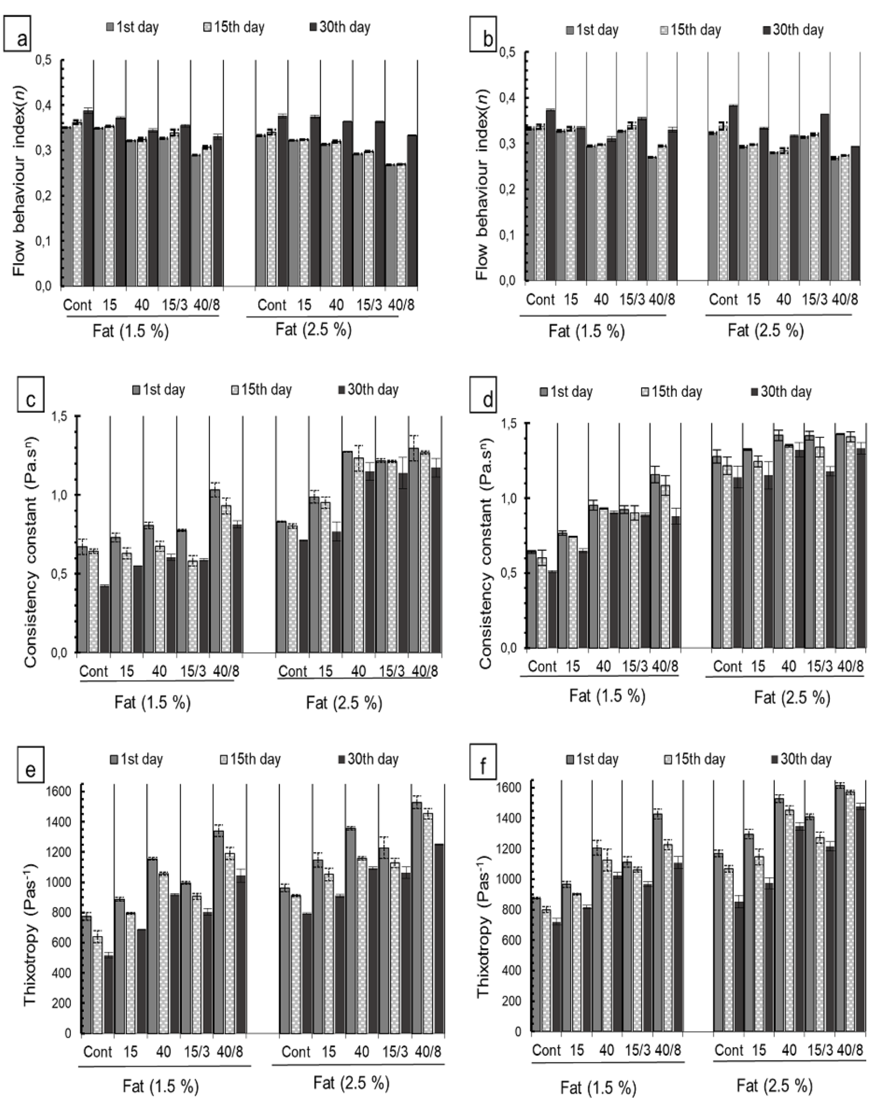

Figure 4. **(a) flow behaviour index, (c) consistency constant and (e) thixotropy values of the ayran samples produced from milk heat treated at 95°C for 90 s. (b) flow behaviour index, (d) consistency constant and (f) thixotropy values of ayran samples produced from milk heat treated at 95°C for 300 s. The bars represent mean values, and the error bars represent standard error of the mean.**

values varied from 0.27 to 0.39 and showed that all ayran samples behaved as a non-Newtonian pseudoplastic fluid (Figure 4a-b). The flow behaviour index values of the ayran samples obtained from milks containing 1.5% fat and heated at 95°C for 90 s were found to be slightly higher than the ayran samples produced from milks containing 2.5% fat and heated at 95°C for 300 s. Increasing total homogenization pressure and using double-stage homogenization instead of single-stage homogenization during homogenization of the ayran milks resulted in lower the flow behaviour values in the ayran samples.

The consistency constant values of the ayran samples varied from 0.42 to 1.42 Pa.s^n during the storage (Figure 4c-d). Koksoy & Kilic (2003) reported that during storage of traditionally manufactured ayran, the consistency constant values ranged from 0.02 to 1.21 Pa.s^n. Erkaya et al. (2015) studied the effect thermosonication at different temperatures and times on rheological properties of ayran during storage and determined that the consistency constant values of ayran samples were between 0.06 and 1.08 Pa.s^n. The differences between the findings of our study and other studies can be attributed to differences in ayran milk composition and processing methods. The consistency constant values of the ayran samples produced from milks containing 2.5% fat and homogenized at double-stage were found to be significantly ($p<0.05$) higher than those from milk containing 1.5% fat and homogenized at single-stage (Table III). Ciron et al. (2012) investigated the effects of different microfluidization pressures (25, 50, 100 and 150 MPa) on structural properties of low-fat yoghurt (1.5%). In their study, milks with 1.5 and 3.5% fat contents were homogenized at 20/5 MPa using conventional valve homogenizer for use in the production of control yoghurt samples. It was showed that the consistency value of control yoghurt sample containing 3.5% fat was higher than that containing 1.5% fat, which was similar to those of our study. They also found that the highest and lowest consistency values were determined in low-fat yoghurt samples produced from milks homogenized by microfluidization at 150 MPa and 25 MPa, respectively. In present study, the consistency constant values of the ayran samples produced from milk heated at 95°C for 90 s were lower than those from milk heated at 95°C for 300 s. Similarly, Parnell-Clunies et al. (1986) reported that the constant consistency values of yoghurt increased with prolonged heat treatment time. Thixotropy is the result of structural break down in a dispersion system under shear and is determined by calculating the area of the hysteresis loop between the upward and downward curves of the shear stress versus shear rate. The breaking of weak particles or bonds in a suspension under shear stress causes structural break down in a dispersion system (Koksoy & Kilic 2004). The thixotropy values of day 1 and day 30 ayran samples ranged from 775.8 to 1614.5 Pa.s^{-1} and from 517.9 to 1477.9 Pa.s^{-1}, respectively, as shown in Figure 4. In present study, similar to the apparent viscosity values, the ayran samples produced from milks homogenized at 15 and 40 MPa had lower thixotropy and consistency constant values when compared with those from milks homogenized with at 15/3 and 40/8 MPa, respectively (Table III). Moreover, the higher thixotropy values were observed in the ayran samples produced from milk containing 2.5% fat and heated at 95°C for 300 s than those from milks containing 1.5% fat and heated at 95°C for 90 s (Figure 4e-f). As a result of increase in fat content of milk and homogenization pressure, more fat-protein complex may occur in ayran samples because of decrease in fat globule size and increase in surface area. The presence of more denatured whey proteins in the ayran samples with prolongation of holding time of heat treatment at 95°C from 95 s to 300 s led to more interactions between casein and whey proteins, thus resulting higher thixotropy values. Kucukcetin et al. (2012) found that thixotropy values of ayran samples produced from milks with different casein to whey protein ratios ranged between 153.8 and 487.9 Pa.s^{-1}. Koksoy & Kilic (2004), in a study on investigation of the effect of using different stabilizers in production of ayran, reported that thixotropy values of ayran samples varied from 42 to 271 Pa.s^{-1}. Moreover, these studies also presented that increase in consistency coefficient and thixotropy values appeared to be associated with increased apparent viscosity values in ayran samples. Our findings are generally in agreement with the above-mentioned studies.

CONCLUSIONS

This study has shown that fat content of milk, homogenization, heat treatment and storage time significantly affected the physical properties, such as syneresis and rheological characteristics, of the ayran samples. As the ayran sample was produced from milk containing 2.5% fat instead of from milk containing 1.5% fat or the ayran milk was heated at 95°C for 300 s instead of for 90 s, the apparent viscosity, consistency constant and thixotropy values of the ayran samples increased, but the syneresis values decreased. The ayran samples produced from milk homogenized with double-stage homogenizer had higher apparent viscosity, consistency constant and thixotropy values and lower syneresis values when compared with those homogenized with single-stage homogenizer and non-homogenized. All ayran samples behaved as a non-Newtonian pseudoplastic fluid. As a result, it is possible to improve physical properties of ayran with different fat content by adjusting conditions of homogenization and heat treatment. However, in order to evaluate the results more clearly, in the future studies, in addition to analysis of physical properties of ayran, sensory analysis should be performed.

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