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RESEARCH ARTICLE

Effects of Some Stabilizers on the Textural Properties of Set-Type Yogurt

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ABSTRACT

This study was conducted to investigate the effect of various stabilizers on textural properties of set yogurt. Yogurt samples were prepared by using seven various stabilizers such as sodium caseinate, gelatin, carrageenan, xanthan gum, guar gum, locust bean gum and native corn starch. Control group samples were produced without using stabilizer. Textural analyzes were made with a TA-XT2i texture analyzer. As a result of the statistical analysis, it was determined that stabilizer and storage time had a significant effect ($p<0.01$) on all texture parameters of yogurt samples, the relaxation force values were not affected by only storage period ($p>0.05$). In conclusion, Na-caseinate was the most suitable stabilizer for yogurt texture compared to all stabilizers. These findings may contribute to the selection of stabilizer material or preparation of stabilizer mixtures that can be used in the production of set type yogurt for developing different textural parameters.

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Introduction

Yogurt, a functional food, is one of the most consumed fermented dairy products in the world (Buttriss, 1997; Mckinley, 2005; Weerathilake et al., 2014). Texture of yogurt is as important as its taste and flavor in terms of consumer preferences. (Sodini et al., 2004; Gonçalvez et al., 2005). However, the properties of the milk used in yogurt production, production and storage conditions or transportation to far sales points can lead to textural defects (Trachoo, 2002; Hematyar et al., 2012). Various stabilizers are used to prevent these problems and to create desirable textural characteristics (Keogh and O'Kennedy, 1998; Athar et al., 2000; Mohammadifar et al., 2007).

Stabilizers, called thickeners, gelling agents or hydrocolloids, can be obtained from different sources including animal connective tissues, sea and land plants and microorganisms (Imeson, 2010).

Sodium caseinate is the product obtained by drying after the neutralization of acid casein curd with sodium hydroxide (Supavititpatana et al., 2008). Gelatin, one of the most preferred stabilizers in yogurt production, is a natural protein derived from animal skins and bones. Supavititpatana et al. (2008) investigated the effect of using sodium caseinate and

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gelatin in corn milk yogurt at different proportions and they reported that the higher levels of concentrations of gelatin increased the acidity, hardness, adhesiveness and springiness. Ares et al. (2007) suggested that gelatin can be used in the production of low fat yogurt at 6 mg/g level.

Starch is obtained from various plants such as wheat, corn and potato. Schmidt et al., (2001) reported that characteristics of yogurt that natural wheat starch (NWS) is added into is similar to those of yogurt with gelatin; for this reason, NWS may be preferred as stabilizer in set-type yogurts.

Carrageenan is a polysaccharide derived from seaweed (Glicksman, 1987; Burey et al., 2008). Xanthan gum is obtained as a result of fermentation of the carbohydrate with the bacterium Xanthomonas campestris (García-Ochoa et al., 2000). Thaiudom and Goff (2003) stated that the xanthan gum was the most incompatible with milk proteins and it was followed by guar gum and LBG (locust bean gum). LBG, the endosperm of the locust tree seeds, and xanthan gum are commonly used in food industry (Ünal et al., 2003). Locust bean gum has synergic effects with other stabilizers to reduce serum separation and to increase viscosity (Köksoy and Kilic, 2004). Ünal et al. (2003) reported that LBG concentrations above 0.02% decreased WHC (water holding capacity) and viscosity while it increased syneresis.

Guar Gum is obtained from the seeds of guar plant (Cyamopsis tetragonalobus) (Tripathy and Das, 2013). It is soluble in water and swells to form high viscosity (Köksoy and Kilic, 2004). Mehmood et al. (2008) reported that 0.1% of guar gum in yogurt achieved the best result for low acidity and low pH.

The aim of this study was to determine the effect of different stabilizers such as sodium caseinate, gelatin, carrageenan, xanthan gum, guar gum, locust bean gum and native corn starch on instrumental texture parameters of plain set yogurt.

Materials and Methods

This research was conducted to identify the effect of stabilizers on textural properties of yogurt at Dairy Technology Research Laboratory of Atatürk University. Raw cow milk, starter culture and skimmed milk powder were obtained from Pilot Dairy Plant in Agricultural Faculty of Atatürk University. Stabilizers were supplied from ORKİM-Chemical Substance Trade. Ltd. Company in Turkey.

Textural Analysis on Yogurt Samples

Texture profile analysis (TPA), Stress-Relaxation Tests, Back-Extrusion Tests and Firmness were performed with a TA-XT2i texture analyzer (Stable Microsystems, Goaldming, England). It was equipped with a 5 kg load cell and all analyzes were made on yogurt samples at 4 ^{o}C.

Texture Profile Analysis (TPA)

TPA was performed by using 25 mm cylindrical probe on yogurt samples in cylindric plastic cups in such conditions as at pre-test speed 1 mm/s, test speed 0.5 mm/s, post-test speed 1 mm/s, distance of 5 mm, trigger type auto-5 g, time 5 second, the depth of immersion 5 mm. Adhesiveness, cohesiveness, springiness and gumminess were calculated via force-time curve (Kumar and Mishra, 2004).

Stress-Relaxation Tests

Stress-relaxation tests were identified with compression test mode by using P25 probe. This test was performed at 0.5 test speed, strain 10%, trigger force 5g, hold time 60 sec. Initial maximum force (Fmax), minimum residual force (Fmin), relaxation force, % lost structure were obtained from force-relaxation curve that was monitored as a function of time (Vercet et al., 2002).

Back-Extrusion Tests

Back-Extrusion test was conducted by a modified method of Buriti et al. (2014). The sample container (52 mm diameter x 55 mm height) was filled with yogurt sample up to 50 mm high. Compression disk (35 mm diameter) was 50 mm above the sample surface. It was plunged into the yogurt sample 30 mm deep, and then it was returned to the start position. Test was made in six replications at a pre-test 1.0 mm/s, test of 1.0 m/s and post-test 10.0 mm/s. Consistency and index of viscosity were calculated via mean values obtained a force-time curve.

Firmness

Firmness was determined with a penetration test by using P15 probe at a constant speed. The Probe was driven in the samples with 15 mm depth at a speed of 0.5 mm/s. Maximum force in the force-time curves was calculated as firmness.

Statistical Analyses

All analyses were carried out in duplicate with six parallels. The SPSS statistical software program version 13 (SPSS Inc., Chicago, IL, USA) was employed to analyze experimental data and Duncan's multiple range tests were employed to determine differences between results (SPSS, 2004).

Results and Discussion

Texture Profile Analysis (TPA)

Fig 1 shows the changes in TPA values for the storage period. In samples SC, GG and LBG, three out of four TPA parameters were higher than those of control. The adhesiveness value of SC was similar to that of control, but other TPA values were higher than that of control. LBG increased all TPA values and decreased adhesiveness. Guar gum decreased gumminess while other parameters increased. Sample G had the highest and lowest values in terms of the adhesiveness and cohesiveness properties, and differed from other samples in this respect. It was thought that compounds formed by breaking gelatin of yogurt bacteria increased the adhesiveness and decreased cohesiveness during the storage period. Macit and Bakirci (2017) reported that the protein values of the gelatin-added yogurt sample decreased rapidly while the acidity values increased during the storage period. These results were partly different from the results reported by Kumar and Mishra (2004). They stated that gelatin additive increased adhesiveness, cohesiveness, springiness and gumminess compared to the control group without stabilizer. Kumar and Mishra (2004) could explain this effect by the fact that interactions between gelatin and casein provided a stronger three dimensional network (Gonçalvez et al., 2005; Ares et al., 2007).

According to Figure 1, all the TPA values of sample CR were lower than those of control. The TPA results of this yogurt sample containing carrageenan were probably related to the composition of commercial carrageenan. Because when calcium is present, κ-carrageenan forms a stiff and brittle gel, while ι-carrageenan forms a soft gel. However, λ-carrageenan is not capable of forming a gel but has a function of thickener (Glicksman, 1987).

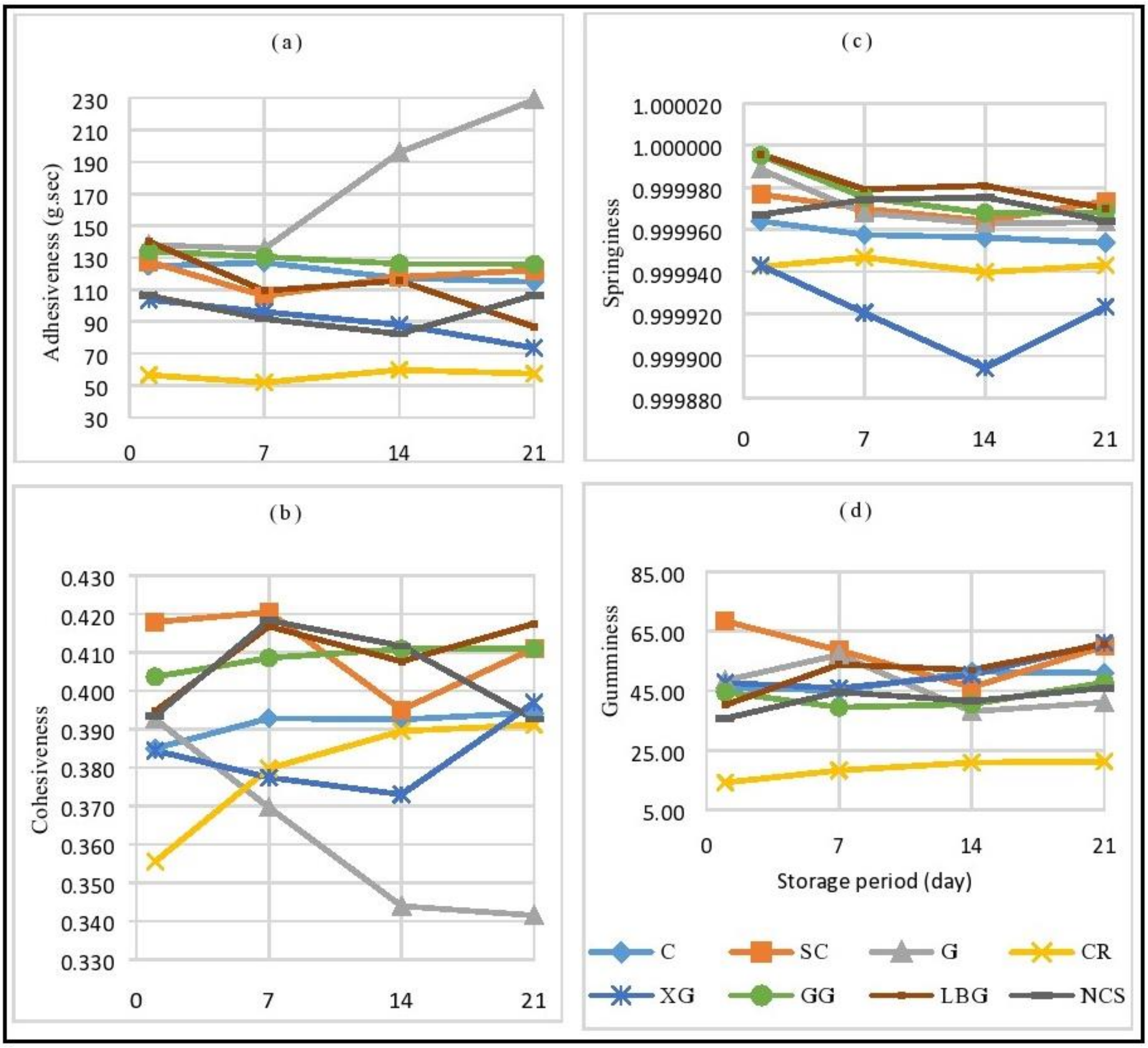

Figure 1. Change of TPA values of yogurt samples during storage period

Stress Relaxation Tests

The stress-relaxation values of yogurt samples were given in Table 1. Stabilizers significantly ($p<0.01$) affected stress-relaxation values of yogurt samples. SC was outstanding sample of this test. Because all stress relaxation values of the SC were higher than those of control. It was thought that the % lost structure value of this sample was higher than that of the control was a proportional increase. The maximum force value of the sample G was the same as the control. While its minimum force value and the % lost structure value were higher than those of control, relaxation force value was lower. All other stabilizers adversely affected stress relaxation values. The highest stress-relaxation values was recorded on day 21.

Table 1. The mean stress relaxation values and standard deviations of yougrt samples

	Sample code	Maximum force (N)	Minimum residual force (N)	Relaxation force (N)	% lost structure
	C	1.275 ± 0.032^{b}	0.164 ± 0.015^{c}	1.111 ± 0.038^{b}	13.242 ± 1.041^{d}
	SC	1.364 ± 0.059^{a}	0.203 ± 0.039^{b}	1.141 ± 0.047^{a}	15.137 ± 2.290^{b}
	G	1.282 ± 0.015^{b}	0.215 ± 0.017^{a}	1.062 ± 0.027^{c}	16.783 ± 1.227^{a}
Yogurt Samples (Treatment)	CR	0.553 ± 0.023^{f}	0.067 ± 0.002^{h}	0.486 ± 0.022^{g}	12.199 ± 0.423^{ef}
	XG	1.112 ± 0.108^{c}	0.135 ± 0.017^{e}	0.974 ± 0.093^{d}	12.416 ± 0.894^{e}
	GG	1.087 ± 0.056^{c}	0.128 ± 0.008^{f}	0.956 ± 0.049^{d}	11.701 ± 0.414^{g}
	LBG	1.104 ± 0.099^{c}	0.132 ± 0.016^{ef}	0.971 ± 0.088^{d}	11.999 ± 0.940^{fg}
	NCS	1.025 ± 0.109^{d}	0.156 ± 0.004^{d}	0.867 ± 0.095^{e}	15.559 ± 0.974^{b}
	P	742.586**	952.970**	875.213**	187.409**
	1	1.055 ± 0.275^{b}	0.141 ± 0.042^{c}	0.915 ± 0.241^{ab}	13.415 ± 2.047^{c}
	7	1.056 ± 0.244^{b}	0.146 ± 0.048^{b}	0.905 ± 0.200^{b}	13.917 ± 2.226^{b}
Storage time (Day)	14	1.063 ± 0.240^{b}	0.141 ± 0.034^{c}	0.923 ± 0.209^{a}	13.361 ± 1.664^{c}
	21	1.091 ± 0.250^{a}	0.159 ± 0.056^{a}	0.920 ± 0.208^{a}	14.480 ± 2.231^{a}
	P	7.643**	82.734**	2.747	32.863**

Mean values ± standart devitions of yogurt samples produced in two parallel. The letters a, b, c, d, d, e, f, g and h indicates means that significantly different at $P < 0.01$ level. **$P < 0.01$

The Back Extrusion and Firmness

The back-extrusion and firmness results were shown in Figure 2. Consistency values of yogurt samples increased during storage period and the highest value was recorded on day 21. Other samples except CR and GG had higher consistency values than that of the control group. The highest consistency value was recorded in the XG example. Xanthan gum is an anionic hydrocolloid and anionic hydrocolloids can interact with positive particles such as proteins or calcium ions in milk. These interactions strengthen the protein network (Soukoulis et al., 2007; Sun et al., 2007). Results regarding consistency values obtained from the current study were partly similar to the findings reported by some researchers. Keogh and O'Kennedy (1998) reported that while xanthan, gelatin and LBG increased the consistency values of stirred yogurt, wheat starch did not show the same effect.

Yogurt samples had the highest index of viscosity value on day 1. This value decreased on day 7 and progressively increased in the later storage period. The highest index of viscosity was detected in the sample SC and NCS. The sodium caseinate is a casein-based product and creates this effect by increasing the density of the protein matrix in the yogurt structure (Remeuf et al., 2003; Amatayakul et al., 2006; Supavititpatana et al., 2009). The starch swells by taking water when it is heated and it increases solution viscosity by forming a gel after a certain temperature.

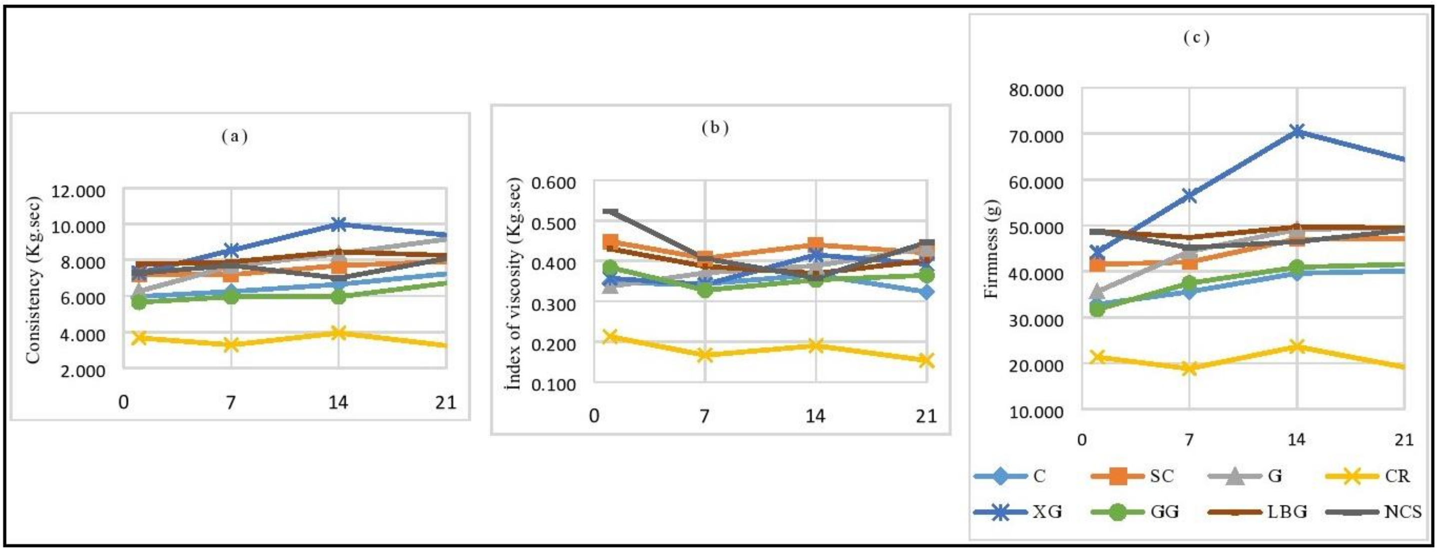

Figure 2. Change of back-extrusion tests and firmness values of yogurt samples during storage period

Therefore, the addition of the starch into yogurt enhances the viscosity (Ares et al., 2007; Schmidt et al., 2001; Mishra and Rai 2006; Williams et al., 2003). Schmidt (2001) reported that there is an electrostatic interaction between starch and protein. At pH<4.6, casein molecules are positively charged and can interact with negatively charged starch molecules. As the pH value decreases, calcium ions of casein dissociate by dissolving from casein and is bound to the starch molecule. These changes make the yogurt gel stronger. The indexes of viscosity values of the other samples were higher than the control group. Hematyar et al. (2012) informed that yogurt samples containing 0.1% xanthan gum had the highest viscosity during ten days of storage. Wei and Xin-huai (2006) reported that gelatin increased the viscosity of yogurt but locust bean gum and guar gum decreased the viscosity. When the addition level of thickeners was 0.1% (w/w), the thickener had a significant effect on texture of yogurt.

The firmness is a commercially important characteristic for yogurt (Damin et al., 2009). The highest average firmness value was detected in the XG sample. The sample CR received the lowest values during the storage period. Köksoy and Kilic (2004) and El-Sayed et al. (2002) reported that xanthan gum can dissolve in the hot and cold water and even the small addition of this stabilizer forms high viscosity.

Conclusion

This study reveals the effect of various stabilizers on the instrumental texture parameters of set type yogurts. SC, GG and LBG in the TPA analyzes, the SC in the stress-relaxation tests were outstanding samples. Except for CR and GG, back-extrusion and firmness values of all other samples were higher than the control. Na-caseinate was the most suitable stabilizer for yogurt texture compared to all stabilizers, since all textural parameters of the yogurt samples added Na-caseinate were higher than that of control. These findings may contribute to the selection of stabilizer material or preparation of stabilizer mixtures that can be used for developing different textural parameters in the production of set type yogurt.

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