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Influence of exopolysaccharide producing starter cultures and incubation temperatures on the physical and rheological properties of low fat set type yogurt

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1. Summary

Different strains of yogurt starter cultures and different incubation temperatures were investigated in the production of low fat set yogurt. Milk samples were incubated with 2% X-11 (exopolysaccharide (EPS) producing) and CH-1 (non-EPS producing), and then incubated at 37, 42 and 45ºC until the pH reached 4.7. Whey separation, water holding capacity (WHC), firmness, storage modulus (G') and loss modulus (G") were measured as quality criteria on the yogurt samples. Results showed that all determined parameters was influenced by starter culture type (except firmness) and incubation temperature, ($p<0.05$). Interaction effect only on firmness was significant. Maximum values of firmness, G' and G" in samples of both starter cultures was found in 42Ċ. Increase in incubation temperature and using EPS producing culture resulted in higher WHC and lower synersis, storage and loss modulus values. Synersis was decrease more with EPS producing culture produced at 37Ċ than with yogurts made with non-EPS producing culture at higher incubation temperature.

Keywords: Low fat set yogurt, Rheology, Synersis, Incubation temperature, Exopolysaccharide

2. Extended Abstract

Physical characteristics of set yogurt are one of main quality parameters. Two major defects in set yogurt are low in firmness and high level of syneresis or whey separated on the surface [1]. There has been an increasing trend in the use of yogurt starter cultures that are able to produce exopolysaccharide (EPS) in yogurt manufacture. This is due to their water binding ability and texture promoting properties of EPS [2]. Incubation temperature is another factor that has major effects on physical properties of yogurt. There have been several studies on the effect of incubation temperature on physical and microstructural properties of yogurt gels. [3, 4, 5, 6, 7] The objective of this study was to investigate the effects of EPS producing cultures on the rheological and physical properties of low fat set yogurt.

Yogurt samples prepared from reconstituted skim milk powder with fresh cream to standardized fat content on 1.5 % and total solid of 12%. Reconstituted milk was heat treated at 90ºC for 10 min, Homogenized (APV Gaulin Lab60, Germany) at 200 M Pa at 65ºC. Then cooled down to incubation temperatures and incubated with tow types of starter cultures until pH of samples reached 4.7. Firmness of samples was measured using Universal Testing Machine (Hounsfield H5KS, England). The constant crosshead velocity of 0.5 mms^{-1}, to a sample depth of 35 mm and maximum force (N) to penetrate the probe in 35mm depth was recorded. The whey separation of yogurt gels was determined using the method of Lucey, Munro & Singh (1998a) [7]. Water holding capacity (WHC) was measured by the centrifuge method. A 50 g sample was centrifuged at 1350 rev/min with for 20 min at 10Ċ. The supernatant was removed, and the pellet weight was recorded. WHC was calculated as [(pellet weight/initial sample weight)] ×100. Rheological properties were determined using a UDS-200 Paar Physica rheometer (Physica Messtechnik GmbH, Stuttgart, Germany) by means of frequency sweep with the measurement of storage modulus (G') and loss modulus (G"). Test conditions were frequency 0.1 to 50 Hz. and maximum strain was < 0.05, to maintain in linear viscoelastic region [8, 9]. Data in 1 Hz was selected and statistically analyzed. A 2-factor (3×2) ANOVA with interaction was used to investigate the effect of starter culture type and incubation temperature on the physical and rheological properties of yogurt gels. Each experiment was performed in triplicate. Significance was established at $p< 0.05$. The statistical analysis system, MINITAB version 14, was used to perform all statistical analyses.

Table 1 Shows analysis of variance for rheological and physical parameters. As shown all determined parameters was influenced by starter culture type (except firmness) and incubation temperature, ($p<0.05$). Interaction effect only on firmness was significant. Yogurts made using EPS^+ starter cultures had lower level of synerisis (spontaneous appearance of whey (serum) on milk gel surfaces) and higher WHC compared to yogurts made using EPS^- starter cultures (Figure 1&2). This may be due to the higher water binding capacity of EPS [10, 11, 12) as well as the modification of yogurt microstructure by EPS producing cultures [13, 14]. Whey separation decreased as used EPS^+ culture and incubation temperature decreased. (Figure 1). Maximum values of firmness, G' and G" in samples of both starter cultures was found in 42ºC (Figure 3, 4& 5). Although G' obtained in 45ºC was slightly higher than that of 37ºC, the difference was not statistically significant ($p<0.05$). In agreement with previous studies, samples produced with EPS^+ starter had lower G' compared to samples produced with EPS^- starter [8, 12, 15]. The incompatibility between EPS and proteins may result in depletion induced attraction of casein micelles by EPS leading to difference in the protein aggregation mechanisms and the structure of protein network between yogurts made using EPS^+ and EPS^- starters [16]. All yogurts exhibited characteristics typical of a weak viscoelastic gel, with G' greater than G'' at all the frequencies investigated, and both showing some frequency dependence.

Table 1: Analysis of variance for rheological and physical parameters

	Independent variables[1]								
	S			IT			S × IT		
	df	MS	P	df	MS	P	df	MS	P
Synersis	1	0.73413	*	2	0.42743	*	2	0.02936	NS
WHC	1	25.514	*	2	42.677	*	2	0.338	NS
Firmness	1	0.02408	NS	2	0.19540	**	2	0.07090	*
G'	1	357765	**	2	32983	**	2	8160	NS
G"	1	34133.3	**	2	2186.3	*	2	902.3	NS

[1]S= Starter Culture type, IT= Incubation temperature, and S×IT= Interaction between Starter culture type and Incubation temperature. *,**, significantly different at $P<0.05$ and $P<0.01$, respectively

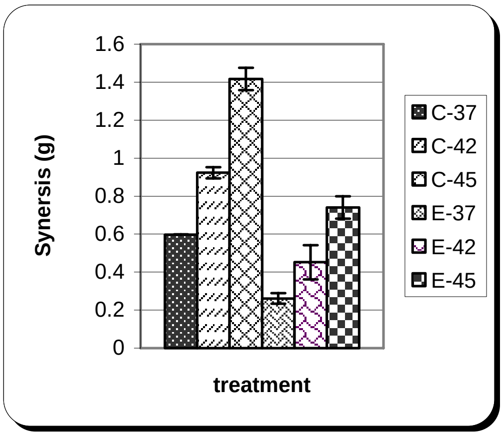

Figure 1: synersis values of yogurt samples produced with different starter culture and incubation temperatures (C: EPS- starter culture, E: EPS+ starter culture)

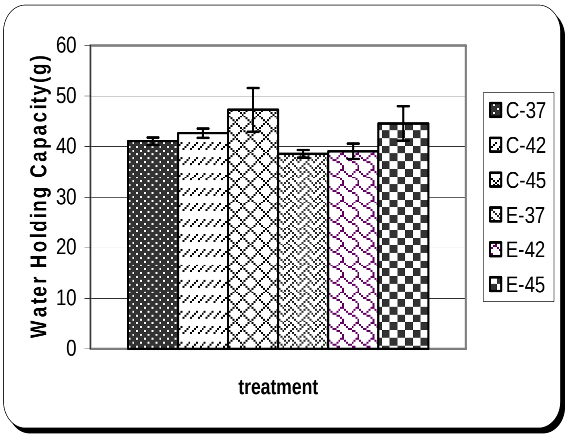

Figure 2: WHC values of yogurt samples produced with different starter culture and incubation temperatures (C: EPS- starter culture, E: EPS+ starter culture)

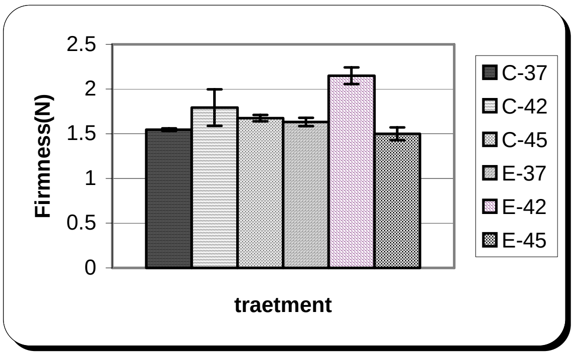

Figure. 3: Firmness values of yogurt samples produced with different starter culture and incubation temperatures

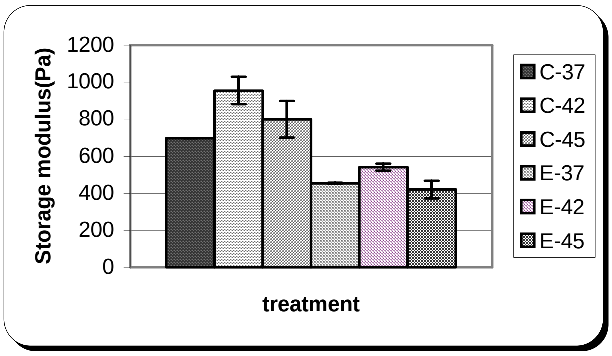

Figure 4: Storage modulus (G') values of yogurt samples produced with different starter culture and incubation temperatures at frequency 1 Hz.

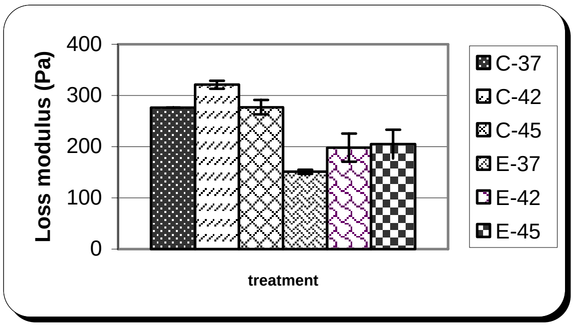

Figure5. Loss modulus (G’) values of yogurt samples produced with different starter culture and incubation temperatures at frequency 1 Hz.

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