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Effects of Carboxyl Methyl Cellulose and Edible Cow Gelatin on Physico-chemical, Textural and Sensory Properties of Yoghurt

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Abstract

Effects of carboxyl methyl cellulose (CMC) and edible cow gelatin (ECG) on physico-chemical, textural, and sensory properties of yoghurt were investigated. Yoghurts were manufactured from full-fat cow milk with addition of CMC and ECG in combination or solely, at concentrations of 0.25 and 0.50% (w/w). Sole CMC addition at a concentration of 0.25% contributed to higher viscosity (7175 cP in comparison with the control being 4526 cP on day 1) and firmness (561 g compared to the control being 294 g on day 1), but caused lower water holding capacity and higher syneresis compared to the control. However, sole ECG addition at concentration of 0.50% resulted in higher water holding capacity (69.29% in comparison with the control being 48.41%) and lower syneresis (0.22 compared to the control being 2.64, in mL per 100 mL initial sample), while also contributing to viscosity (5551 cP on day 1) and firmness (369 g on day 1). The results suggest ECG is suitable for yoghurt compared to CMC, giving an improved gel network structure with lower syneresis and higher water holding capacity along with higher viscosity and firmness, while causing no significant harm on sensory perception.

Keywords: Yoghurt; Viscosity; Texture; Sensory analysis

Introduction

Yoghurt is a fermented dairy product obtained by lactic acid fermentation of milk. It is gathered as a healthy food due to its high protein and calcium content. There are many varieties of yoghurt such as non-fat or low-fat due to health considerations as high level consumption of fat is attributed to many health problems (Chandan and Shahani, 1993). Beside yoghurts with modified fat levels, fruit or nut added yoghurts are also manufactured. Nevertheless, the common problem experienced in these products is low water holding capacity due to thermal treatment denaturing milk proteins partially. There are methods still being investigated to overcome this problem, including addition of thickening or gelling agents (Schmidt and Smith, 1992; Fiszman *et al.*, 1999; Sanchez *et al.*, 2000), use of special starter cultures producing exopolysaccarides (Hess *et al.*, 1997) and application of contemporary physical procedures like high hydrostatic pressure (Lopez-Fandino *et al.*, 1998).

Yoghurts drop some water during storage, which is known as syneresis or wheying-off. Yoghurt gets firmer that might arise as a problem with respect to its sensory properties. Many milk ingredients (e.g., non fat dry milk, milk protein concentrate and whey protein concentrate) and/or stabilizers (e.g., pectin, gelatin and starch) were used in yoghurt products to ensure appropriate texture by increasing the total solid content of milk.

In milk products like yoghurt, it is important that the hydrocolloids do not mask the natural flavour of the product and that they are effective at the typical pH range of the product i.e., 4.0-4.6. Considering these requirements, commonly used hydrocolloids often include carboxyl methyl cellulose (CMC), pectin, alginate, and gelatin (Williams and Phillips, 2003). CMC, also known as cellulose gum, is actually an abbreviated version of sodium carboxyl methyl cellulose, a cellulose derivative with sodium carboxyl methyl groups bound to some of the hydroxyl groups of glucose monomers. CMC stabilizes protein dispersions, especially near their isoelectric pH value. Thus, milk products are given improved stability against casein precipitation (Walstra, 1996). Gelatin, on the other hand is composed of partially hydrolyzed collagen fractions with a molecular weight higher than 30 kDa. Gelatin is a commonly used gelling agent both in foods and pharmaceuticals in addition to its many other uses.

In this study, above-mentioned two thickening agents commonly used in food products were employed in yoghurt to improve its textural endurance during cold storage without any harm on its sensory perception. For this purpose; these thickening agents at two different concentrations were studied using a full factorial design to determine their effects on physico-chemical, textural and sensory properties of yoghurt.

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Materials and Methods

Fresh milk was obtained from a local producer and immediately brought to the laboratory for preparation of yoghurt samples. Freeze dried lactic culture (YoFlex, YC-381) of Chr. Hansen (Hørsholm, Denmark) was used as a starter culture for yoghurt production. ECG was obtained from Rousselot Argentina S.A. (Hurlingham, Argentina) and edible grade CMC was purchased from a national provider, Uğur Selüloz Kimya A.Ş. (Aydın, Turkey). All other reagents were of analytical grade and obtained from Merck (Darmstadt, Germany) and Sigma (Taufkirchen, Germany).

Sample Preparation

Fresh cow milk was used in preparation of yoghurt samples. The milk was first divided into nine parts. Both CMC and ECG were gradually added separately or in combination at concentrations of 0.25 and 0.50% (w/w). After the addition of thickening agents, the mixtures were homogenized using a blender (Philips, Eindhoven, The Netherlands) until the thickening agents were homogeneously dispersed. Then, the mixtures were continuously stirred while heating up to 85°C. The homogenates were pasteurized at 85±1°C for 5 min and subsequently cooled to 47±1°C at which the homogenates were inoculated with freeze dried starter culture at a ratio of 1‰ (w/w) after reanimating the culture in a small amount of pasteurized milk. After that, the mixtures were poured into sterile petri dishes and glass jars and incubated (Nüve EN 500, Ankara, Turkey) at 43±1°C until pH was 4.6. Following the incubation, yoghurt samples were kept at room temperature for 30 min and then, were stored in a refrigerator at 4±1°C for 15 days. Physico-chemical, textural and sensory properties were determined periodically on day 1, 8 and 15.

Chemical Composition Analyses

Total dry matter was determined by drying the yoghurt samples at 105°C until the constant weight was obtained, using a drying oven (Binder, NY, USA). Similarly, crude mineral content was determined by incineration of the samples at 550°C for 8 hours, using an incineration oven (Nabertherm GmbH, Lilienthal, Germany) (AOAC, 1995). Total nitrogen content was measured by Kjeldahl method. The yoghurt samples were analyzed for their total nitrogen content using Kjeldahl digestion and distillation units (Şimşek, Ankara, Turkey; AOAC, 1995). The fat content of the samples was measured by the Gerber method as described by Case *et al.* (1985).

Measurements of Quality Parameters

The pH of the yoghurt samples was measured with a pH meter equipped with a glass electrode (Hanna Instruments, RI, USA). The titratable acidity (as percent lactic acid) was determined according to the method of AOAC (AOAC, 1995). Water holding capacity (WHC) was estimated as described by Parnell-Clunies *et al.* (1986) using a cooling centrifuge (Hettich GmbH, Tuttlingen, Germany). Yoghurt samples (2 g) were centrifuged at 13500 × *g* for 30 min at 10°C. WHC was expressed as the percentage pellet weight relative to original weight of the sample. For measuring syneresis, 10 g yoghurt sample was centrifuged at 222 × *g* for 10 min at 10°C. Syneresis is calculated as the percentage of clear supernatant per initial weight of yoghurt sample (Keogh and O'Kennedy, 1998).

Determination of Viscosity and Firmness

Firmness was measured using a TA-XT Plus (Stable Micro Systems, Surrey, England) texture analyzer equipped with a 5 kg load cell. Penetration test was carried out using a cylinder probe (12.7 mm in diameters) to apply a 4 mm penetration on yoghurt samples matured in petri dishes. Penetration speed of the probe was 1 mm/s during both penetration and relaxation. The measurements were carried out at 4±1°C, immediately after taking the samples out of the refrigerator. Viscosity measurement was carried out using a rheometer (Brookfield DV-III Ultra, MA, USA) equipped with a helipath stand and a T-bar spindle rotating at a speed of 20 rpm. Samples were stirred by hand using a spatula for a minute to break the original gel structure of matured yoghurts and to obtain homogenous samples for viscosity measurements.

Texture Profile Analysis

Texture profile analysis (TPA) was carried out by two cycles of penetration using a cylinder probe (25.4 mm in diameters) to apply a 4 mm penetration on both cycles with a penetration speed of 1 mm/s. TPA parameters were calculated using TPA macro of the official software (Exponent, Version 5.0.8.0., Texture Technologies Corp., NY, USA). Hardness was the maximum peak force during the first penetration cycle and given in g. Cohesiveness was the ratio of the positive force area during the second penetration to that during the first penetration. Springiness (originally called elasticity) was related to the height that the food recovers during the time that elapses between the end of the first bite and the start of the second bite. (Exponent, Version 5.0.8.0., Texture Technologies Corp., NY, USA).

Sensory Analysis

Sensory analysis was performed on day 1, 8 and 15 on weekly intervals. Yoghurt samples were stored at 4°C, served right after taking the samples out of the refrigerator, and immediately assessed by the panellists. Sensory panel was composed of 9 assessors, who had previous experience in sensory studies of yoghurt. The samples were served randomly in petri dishes coded with 3 digit random numbers. Sensory parameters tested were taste, appearance, consistency, and odour. Appearance was tested visually. Odour was tested by nose after removing the cover of petri dishes. Taste and consistency were evaluated in the mouth. Water and cracker were served for cleansing the palate between tasting different samples. Scaling was done using a 10 cm line scale.

Statistical Analysis

Results obtained were analyzed statistically using analysis of variance (ANOVA) to determine whether there was a significant difference among the samples and then using Tukey-Kramer test to find out which pairs of the samples were significantly different at a significance level of 0.05 ($P<0.05$) (SAS Institute Inc., 2009). JMP 8 statistics software (SAS Institute Inc., NC, USA) was used to run statistical tests and to draw the figures. All measurements were performed in triplicate.

Results and Discussion

The results obtained on chemical composition of yoghurt samples were presented in Table 1. There is no significant difference among the samples with respect to their crude fat contents. However, not only crude nitrogen and mineral but also total dry matter significantly increased with increasing amount of agents. This change was obviously due to the addition of agents and their contributions into above-mentioned components of yoghurt samples, by increasing the total solids of milk. As expected, total nitrogen of ECG added samples were higher compared to the control and CMC added samples due to high protein of ECG (above 90% as stated by the manufacturer). The highest values for total dry matter, total nitrogen and crude mineral were found for 0.50% CMC and 0.50% ECG added sample as expected.

Titratable acidity showed no significant difference among the samples during storage although there were limited differences at the beginning (Table 2). Acidity increased with storage due to lactic acid fermentation. Acidity of the samples varied between 0.89 and 1.12% and the highest acidity was determined in the control sample, indicating that addition of agents decreased (although mostly insignificant) acidity more or less probably due to dilution and serving as buffer between the starter culture and lactose, preventing lactic acid fermentation moderately. The pH values of the samples varied between 4.15 and 4.32 and the highest pH measured was for 0.50% CMC added sample (Table 2). The pH values of the samples were gradually decreased during the storage due to fermentation of lactose

Table 1: Chemical composition of yoghurt samples prepared with addition of ECG and CMC at varying concentrations

Yoghurt samples	Crude fat	Total dry matter	Crude mineral	Total nitrogen
(1) Control	3.10±0.03^{a}	12.46±0.11^{b}	0.80±0.04^{abcd}	0.58±0.00^{bc}
(2) %0.25 CMC	3.17±0.07^{a}	12.69±0.30^{ab}	0.83±0.02^{ab}	0.58±0.02^{bc}
(3) %0.50 CMC	3.14±0.02^{a}	12.43±0.01^{b}	0.82±0.00b^{abc}	0.55±0.01^{c}
(4) %0.25 ECG	3.09±0.03^{a}	12.50±0.05^{b}	0.73±0.03^{d}	0.58±0.00^{bc}
(5) %0.50 ECG	3.10±0.01^{a}	12.76±0.04^{ab}	0.73±0.00^{d}	0.62±0.01^{ab}
(6) %0.25 CMC+%0.25 ECG	3.06±0.01^{a}	12.37±0.16^{b}	0.75±0.00^{cd}	0.58±0.02^{bc}
(7) %0.25 CMC+%0.50 ECG	3.17±0.08^{a}	12.79±0.21^{ab}	0.84±0.00^{a}	0.60±0.00^{bc}
(8) %0.50 CMC+%0.25 ECG	3.04±0.00^{a}	12.49±0.04^{b}	0.76±0.02^{bcd}	0.61±0.00^{b}
(9) %0.50 CMC+%0.50 ECG	3.15±0.00^{a}	13.16±0.18^{a}	0.86±0.00^{a}	0.66±0.03^{a}

Different superscripted letters in each column indicates significant difference between the samples at a level of 0.05 ($P<0.05$). The values given were on weight basis (%, w/w). Values were given as average ± standard deviation

Table 2: Titratable acidity and pH of yoghurt samples prepared with addition of ECG and CMC at varying concentrations

Parameters	Samples	Storage time (days)		
		1	8	15
Titratable acidity (%)	(1) Control	1.12±0.08^{aA}	1.13±0.02^{aA}	1.19±0.06^{aA}
	(2) %0.25 CMC	1.07±0.03^{aB}	1.12±0.01^{aAB}	1.16±0.01^{aA}
	(3) %0.50 CMC	1.05±0.02^{abB}	1.11±0.03^{aAB}	1.22±0.03^{aA}
	(4) %0.25 ECG	0.89±0.05^{bB}	1.12±0.01^{aA}	1.18±0.03^{aA}
	(5) %0.50 ECG	0.96±0.01^{abB}	1.09±0.04^{aA}	1.14±0.09^{aA}
	(6) %0.25 CMC+%0.25 ECG	1.03±0.01^{abB}	1.10±0.01^{aA}	1.17±0.02^{aA}
	(7) %0.25 CMC+%0.50 ECG	1.03±0.07^{abA}	1.07±0.02^{aA}	1.19±0.00^{aA}
	(8) %0.50 CMC+%0.25 ECG	1.07±0.01^{aB}	1.13±0.02^{aB}	1.24±0.02^{aA}
	(9) %0.50 CMC+%0.50 ECG	1.07±0.01^{aA}	1.16±0.07^{aA}	1.29±0.07^{aA}
pH	(1) Control	4.26±0.02^{abcA}	4.01±0.62^{dB}	4.00±0.02^{dB}
	(2) %0.25 CMC	4.25±0.03^{abcA}	4.04±0.01^{cdB}	4.08±0.02^{bcB}
	(3) %0.50 CMC	4.32±0.02^{aA}	4.09±0.01^{bB}	4.09±0.02^{bB}
	(4) %0.25 ECG	4.15±0.03^{dA}	4.01±0.01^{dB}	4.02±0.01^{dB}
	(5) %0.50 ECG	4.21±0.04^{cdA}	4.07±0.04^{bcB}	4.04±0.01^{cdB}
	(6) %0.25 CMC+%0.25 ECG	4.15±0.02^{dA}	4.01±0.01^{dB}	4.02±0.03^{dB}
	(7) %0.25 CMC+%0.50 ECG	4.29±0.03^{abA}	4.17±0.03^{aB}	4.15±0.01^{aB}
	(8) %0.50 CMC+%0.25 ECG	4.16±0.02^{dA}	4.05±0.01^{bcdB}	4.03±0.02^{dB}
	(9) %0.50 CMC+%0.50 ECG	4.23±0.03^{bcA}	4.15±0.01^{aB}	4.12±0.01^{abB}

Different lower case letter in the same column indicates significant difference among the samples for the same parameter. Different upper case letter in the same row indicates significant difference among the days for the same sample and parameter. The significance level was set to 0.05. Values were given as average ± standard deviation into lactic acid, which is consistent with the results reported by Voutsinas *et al.* (1996). It is observed that there was no significant difference between pH values among the samples both initially and after the storage, concluding that addition of stabilizers at the levels studied had no significant effect on pH, which was desired to ensure proper level of fermentation and consequently formation of the traditional taste in yoghurt.

Considering the results on water holding capacity (WHC), 0.50% ECG added sample was seen to be the superior among the samples, giving the highest WHC value (Fig. 1). This again, was probably due to the gelling nature of gelatin, while CMC were serving more like a thickener and binder. Thus, ECG positively contributed to the gel structure of yoghurt samples while CMC served more like as a thickener and it damaged the network structure after some critical concentration, which was evident visually. Addition of CMC at a level of 0.50% (w/w) did not improve WHC, in fact negatively affected. Syneresis values decreased during the storage as expected due to moderate drying and improved the gel structure (Fig. 2). Kumar and Mishra (2004) reported that the level of syneresis was greatly affected by the type and concentration of stabilizer (gelatin, sodium alginate, and pectin at concentrations of 0.20, 0.40 and 0.60%) and the highest stabilizer concentration caused the lowest level of syneresis in mango soy fortified set type yoghurt. Abou-Dawood *et al.* (1993) reported that addition of 0.40% gelatin before homogenization decreased syneresis in yoghurt. Tayar *et al*. (1995) confirmed that addition of gelatin at varying concentrations (0.20, 0.40 and 0.60%) decreased syneresis in yoghurts. Fiszman and Salvador (1999) also reported that addition of gelatin at varying concentrations was quite effective in prevention of syneresis. In the present study, addition of stabilizers increased viscosity compared to the control with an exception of 0.25% ECG added sample (no significant difference between these two). The highest viscosity value was measured for 0.25% CMC and 0.50% ECG added sample, which was higher compared to that of 0.50% CMC and 0.50% ECG added sample, indicating antagonistic effect of CMC in combination with ECG (Fig. 3). It is observed that 0.50% CMC added samples were not significantly different from the control with respect to their viscosity. Ödéhn (1990) reported that 0.15-0.27% CMC addition improved the texture of ice cream, while causing syneresis if used alone; therefore its use is suggested in combination with stabilizers like gelatin and carrageenan, improving WHC and defeating syneresis problem. Similarly, ECG solely did not cause any significant difference in viscosity at both concentrations, while resulting in a significant increase in combination with CMC. It is reported that addition of gelatin resulted in significant increases in viscosity at concentrations no lower than 0.50% (Guinee *et al.*, 1995; Güven, 1998; Keogh and O'Kennedy, 1998; Köksoy and Kılıç, 2004).

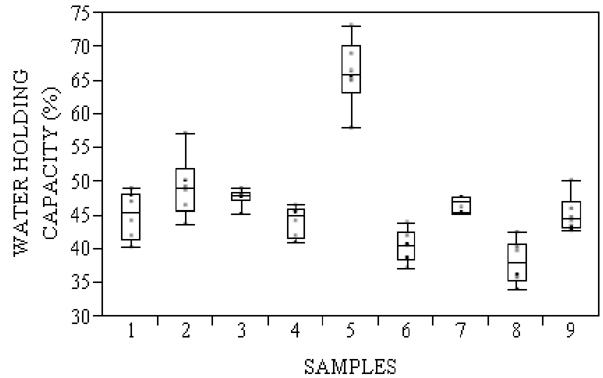

Fig. 1: WHC values obtained for the yoghurt samples prepared with addition of CMC and ECG at varying concentrations

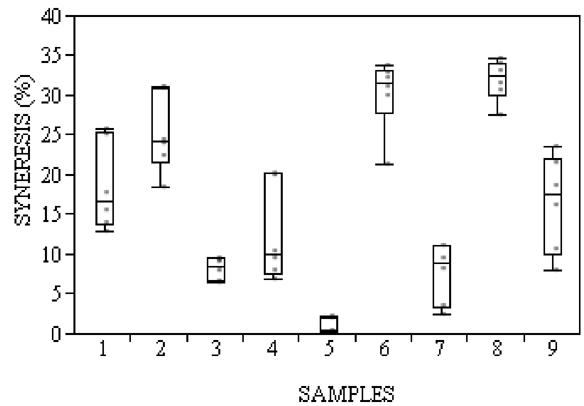

Fig. 2: Syneresis levels calculated for the yoghurt samples prepared with addition of CMC and ECG at varying concentrations

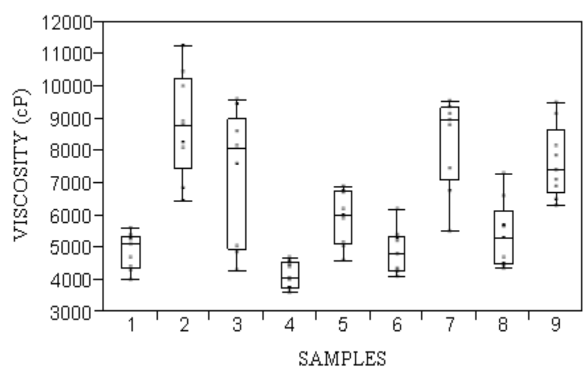

Fig. 3: Viscosity values determined for the yoghurt samples prepared with addition of CMC and ECG at varying concentrations

In TPA parameters, an interesting increment was observed in almost every parameter, becoming even more evident with further storage, in 0.25% CMC added sample, suggesting that 0.25% (w/w) CMC was just right about amount, resulting in the highest viscosity and hardness (Table 3) among the samples, while the higher amount of

Table 3: TPA parameters calculated for yoghurt samples prepared with addition of ECG and CMC at varying concentrations

Parameters	Samples	Storage time (days)		
		1	8	15
Hardness (g)	(1) Control	1057 ± 28^{eA}	1109 ± 217^{cA}	1104 ± 39^{eA}
	(2) %0.25 CMC	2955 ± 225^{abA}	4480 ± 1452^{aA}	5097 ± 400^{aA}
	(3) %0.50 CMC	1411 ± 142^{dB}	2463 ± 167^{bcA}	2692 ± 342^{cdA}
	(4) %0.25 ECG	1058 ± 46^{eB}	1236 ± 30^{cA}	1312 ± 74^{eA}
	(5) %0.50 ECG	1653 ± 31^{dB}	1887 ± 126^{bcAB}	2143 ± 198^{dA}
	(6) %0.25 CMC+%0.25 ECG	2633 ± 32^{bC}	2989 ± 131^{abB}	3473 ± 84^{bA}
	(7) %0.25 CMC+%0.50 ECG	3189 ± 20^{aB}	3391 ± 231^{abB}	4955 ± 160^{aA}
	(8) %0.50 CMC+%0.25 ECG	2264 ± 113^{cB}	3327 ± 444^{abA}	3093 ± 507^{bcAB}
	(9) %0.50 CMC+%0.50 ECG	2301 ± 159^{cB}	3422 ± 632^{abA}	3674 ± 169^{bA}
Cohesiveness	(1) Control	0.396 ± 0.014^{bA}	0.372 ± 0.041^{bA}	0.388 ± 0.010^{cA}
	(2) %0.25 CMC	0.535 ± 0.052^{aA}	0.502 ± 0.046^{aA}	0.554 ± 0.014^{aA}
	(3) %0.50 CMC	0.459 ± 0.004^{abA}	0.460 ± 0.014^{abA}	0.510 ± 0.033^{abA}
	(4) %0.25 ECG	0.415 ± 0.015^{bA}	0.439 ± 0.012^{abA}	0.417 ± 0.017^{cA}
	(5) %0.50 ECG	0.461 ± 0.007^{abA}	0.471 ± 0.011^{aA}	0.465 ± 0.009^{abcA}
	(6) %0.25 CMC+%0.25 ECG	0.473 ± 0.020^{abA}	0.484 ± 0.054^{aA}	0.432 ± 0.081^{bcA}
	(7) %0.25 CMC+%0.50 ECG	0.450 ± 0.041^{bB}	0.474 ± 0.022^{aAB}	0.536 ± 0.013^{aA}
	(8) %0.50 CMC+%0.25 ECG	0.433 ± 0.011^{bC}	0.489 ± 0.015^{aB}	0.541 ± 0.026^{aA}
	(9) %0.50 CMC+%0.50 ECG	0.468 ± 0.049^{abA}	0.469 ± 0.038^{aA}	0.469 ± 0.020^{abcA}
Springiness	(1) Control	0.826 ± 0.005^{eB}	0.844 ± 0.015^{cAB}	0.855 ± 0.007^{cA}
	(2) %0.25 CMC	0.872 ± 0.002^{cdB}	0.893 ± 0.010^{aA}	0.896 ± 0.007^{aA}
	(3) %0.50 CMC	0.886 ± 0.000^{bcB}	0.906 ± 0.012^{aA}	0.889 ± 0.002^{abAB}
	(4) %0.25 ECG	0.871 ± 0.009^{cdA}	0.859 ± 0.002^{bcA}	0.866 ± 0.003^{bcA}
	(5) %0.50 ECG	0.871 ± 0.002^{cdB}	0.885 ± 0.008^{abAB}	0.890 ± 0.006^{abA}
	(6) %0.25 CMC+%0.25 ECG	0.865 ± 0.012^{dA}	0.893 ± 0.007^{aA}	0.868 ± 0.016^{bcA}
	(7) %0.25 CMC+%0.50 ECG	0.918 ± 0.012^{aA}	0.890 ± 0.003^{abB}	0.885 ± 0.002^{abB}
	(8) %0.50 CMC+%0.25 ECG	0.897 ± 0.007^{bA}	0.901 ± 0.008^{aA}	0.876 ± 0.005^{abcB}
	(9) %0.50 CMC+%0.50 ECG	0.890 ± 0.003^{bcA}	0.898 ± 0.021^{aA}	0.887 ± 0.014^{abA}

Different lower case letter in the same column indicates significant difference among the samples for the same parameter. Different upper case letter in the same row indicates significant difference among the days for the same sample and parameter. The significance level was set to 0.05. Values were given as average ± standard deviation

CMC (i.e., 0.50%) was binding on and consequently isolating the proteins even more and therefore damaging the network structure partially, decreasing the viscosity and hardness comparably. In case of using pectin at low levels, pectin molecules normally adsorbs onto casein micelles and consequently flocculation happens but, high concentrations of pectin completely wrap up casein micelles so molecular attraction between casein micelles decreases (Maroziene and Kruif, 2000). Interaction between CMC and casein micelles happens in a similar way. Therefore, this situation explains why 0.25% CMC added samples resulted in higher levels of viscosity and hardness compared to that of 0.50% CMC added samples. The results suggest that increasing amount of ECG leads to a higher increment in viscosity compared to that of CMC as ECG actually serves as an enhancer of gelling structure, while CMC serves more like a thickener and binder on proteins. While some decreases were observed in viscosity of no or 0.25% ECG added samples, viscosity of 0.50% ECG added samples was higher with a general decrease upon storage. The highest cohesiveness was measured for 0.25% CMC added sample (Table 3). Values of hardness, firmness (Fig. 4), and cohesiveness were generally higher for 0.25% CMC added samples in contrast to that of 0.50% CMC added samples. The same holds true for 0.50% ECG added samples in contrast to 0.25% ECG added samples. Similar effects of gelatin on yoghurt were reported by several other researchers (Guinee *et al.,* 1995; Güven, 1998; Keogh and O'Kennedy, 1998; Fiszman *et al.*, 1999). Kumar and Mishra (2004) reported that use of gelatin, pectin and sodium alginate at levels of 0.20, 0.40 and 0.60% (w/w) increased hardness of mango soy fortified set type yoghurt at all levels compared to that of control. They also reported that the highest hardness value was obtained for samples including these agents at a level of 0.40% and the same was true for cohesiveness value. Springiness values of all treated samples were higher compared to the control.

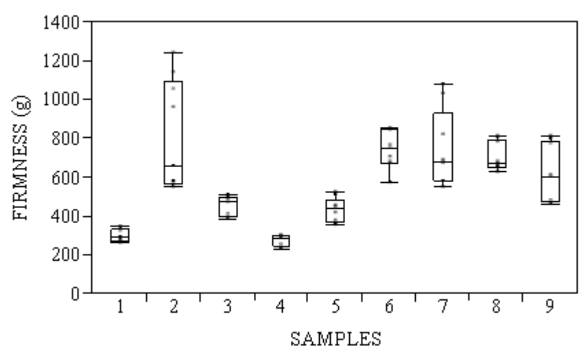

Fig. 4: Firmness of the yoghurt samples prepared with addition of CMC and ECG at varying concentrations

Table 4: Changes in sensory properties of yoghurt samples due to storage and addition of ECG and CMC at varying concentrations

Parameters	Samples	Storage time (days)		
		1	8	15
Appearance	(1) Control	7.2±3.4^{aA}	7.8±3.7^{aA}	5.7±3.2^{aA}
	(2) %0.25 CMC	7.6±2.5^{aA}	7.1±3.0^{abA}	6.0±3.2^{aA}
	(3) %0.50 CMC	8.0±2.0^{aA}	3.9±2.9^{bcB}	6.7±2.2^{aA}
	(4) %0.25 ECG	7.4±3.0^{aA}	6.6±2.9^{abcA}	6.9±2.3^{aA}
	(5) %0.50 ECG	8.3±2.0^{aA}	6.5±3.4^{abcB}	6.7±2.4^{aAB}
	(6) %0.25 CMC+%0.25 ECG	7.3±2.8^{aA}	3.3±2.6^{cB}	4.9±2.2^{aAB}
	(7) %0.25 CMC+%0.50 ECG	5.9±3.2^{aA}	4.4±2.1^{abcA}	5.0±2.1^{aA}
	(8) %0.50 CMC+%0.25 ECG	7.5±3.1^{aA}	5.3±3.4^{abcA}	6.6±2.7^{aA}
	(9) %0.50 CMC+%0.50 ECG	6.5±2.8^{aA}	5.2±3.4^{abcA}	6.7±2.4^{aA}
Odour	(1) Control	7.2±2.8^{aA}	7.7±3.7^{aA}	5.8±2.5^{aA}
	(2) %0.25 CMC	7.1±3.0^{aA}	6.2±2.6^{abA}	5.0±2.1^{aA}
	(3) %0.50 CMC	8.0±1.6^{aA}	4.9±2.9^{bB}	6.3±2.4^{aAB}
	(4) %0.25 ECG	7.3±2.4^{aA}	5.1±3.2^{abA}	6.3±2.6^{aA}
	(5) %0.50 ECG	7.3±2.2^{aA}	6.2±3.0^{abA}	5.6±3.2^{aA}
	(6) %0.25 CMC+%0.25 ECG	7.4±2.3^{aA}	6.2±2.9^{abA}	6.3±3.1^{aA}
	(7) %0.25 CMC+%0.50 ECG	6.7±2.9^{aA}	5.9±2.9^{abA}	4.8±3.1^{aA}
	(8) %0.50 CMC+%0.25 ECG	7.7±2.9^{aA}	6.8±2.7^{abA}	5.4±2.8^{aA}
	(9) %0.50 CMC+%0.50 ECG	5.9±2.9^{aA}	6.7±3.0^{abA}	6.2±2.6^{aA}
Consistency	(1) Control	7.5±2.5^{aA}	7.7±2.8^{aA}	6.5±2.5^{abA}
	(2) %0.25 CMC	3.5±3.2^{bA}	4.9±3.1^{abcdA}	3.2±2.9^{dA}
	(3) %0.50 CMC	7.7±2.0^{aA}	4.0±2.2^{cdB}	4.6±2.8^{abcdB}
	(4) %0.25 ECG	5.8±3.0^{abB}	7.4±2.3^{abA}	7.0±2.4^{aAB}
	(5) %0.50 ECG	8.1±2.5^{aA}	6.5±2.6^{abcA}	6.3±2.2^{abcA}
	(6) %0.25 CMC+%0.25 ECG	3.8±3.2^{bA}	3.1±2.4^{dA}	2.6±1.5^{dA}
	(7) %0.25 CMC+%0.50 ECG	4.7±3.6^{abA}	4.5±2.6^{bcdA}	3.7±1.3^{cdA}
	(8) %0.50 CMC+%0.25 ECG	5.8±3.5^{abA}	6.4±2.8^{abcA}	4.5±2.9^{abcdA}
	(9) %0.50 CMC+%0.50 ECG	6.0±3.5^{abA}	4.7±3.1^{abcdA}	4.1±3.2^{bcdA}
Taste	(1) Control	5.6±2.1^{abAB}	6.6±4.0^{aA}	2.6±3.1^{bB}
	(2) %0.25 CMC	2.3±1.6^{bA}	2.4±1.8^{cA}	2.8±2.9^{bA}
	(3) %0.50 CMC	4.5±2.4^{abA}	3.5±2.6^{abcA}	4.1±2.7^{abA}
	(4) %0.25 ECG	5.6±3.1^{abA}	5.6±3.1^{abcA}	5.5±2.3^{aA}
	(5) %0.50 ECG	6.6±2.9^{aA}	6.1±3.0^{abA}	3.8±2.8^{abA}
	(6) %0.25 CMC+%0.25 ECG	3.8±3.8^{abA}	2.7±3.0^{cA}	2.5±2.9^{bA}
	(7) %0.25 CMC+%0.50 ECG	3.4±2.4^{abA}	3.3±2.8^{bcA}	3.4±2.6^{abA}
	(8) %0.50 CMC+%0.25 ECG	4.9±3.8^{abA}	5.0±3.8^{abcA}	4.0±3.4^{abA}
	(9) %0.50 CMC+%0.50 ECG	4.6±3.9^{abA}	4.1±2.7^{abcA}	3.5±2.8^{abA}

Different lower case letter in the same column indicates significant difference among the samples for the same parameter. Different upper case letter in the same row indicates significant difference among the days for the same sample and parameter. The significance level was set to 0.05. Values were given as average ± standard deviation

However, considering the agents added and their level of addition, there was no significant difference between the treated samples. The lowest and the highest springiness values were obtained for 0.25% CMC and 0.25% ECG added sample, and for 0.50% CMC and 0.25% ECG added sample, respectively.

Results of sensory analysis (Table 4) show that agents at the levels studied had almost no significant effect on sensory perception of yoghurt samples modified with CMC and ECG initially. Nevertheless, further storage resulted in some significant loss in perceived quality of appearance and odour among the samples. In another study, Güven (1998) reported that 0.50% gelatin addition had no significant effect on odour of yoghurt. However, Köksoy and Kılıç (2004) claimed that 0.25% gelatin addition had a negative and significant effect on odour, while causing no significant effect on texture of ayran, a traditional water added drink manufactured from yoghurt. The highest consistency and taste values were obtained for 0.50% ECG added sample. With respect to consistency, all samples except 0.50% CMC added sample and 0.50% ECG added sample gave lower consistency values compared to the control. Güven (1998) reported that 0.25% gelatin addition had no significant effect on consistency level of ayran, which confirms what is obtained in the present study. With respect to the effects of stabilizers on taste of yoghurt samples, ECG added samples had generally higher scores compared to CMC added samples. The highest taste score was obtained for 0.50% ECG added sample, which confirmed what was previously reported by Güven (1998). It was reported that 0.50% gelatin addition had no negative effect on taste of yoghurt (Güven, 1998), while 0.40% gelatin addition improved its texture and appearance (Abou-Dawood *et al.*, 1993). Similarly, it was concluded that gelatin was the best among agar, Arabic gum, CMC, pectin, and starch in improving sensory perception of yoghurt at a level of 0.30% (w/w)

(Khalafalla and Roushdy, 1997). Conversely, Köksoy and Kılıç (2004) reported that, at even low concentrations (as low as 0.25%, w/w), gelatin addition had significant negative effects on taste of ayran. Gallardo-Escamilla *et al.* (2007) reported that 0.16% CMC addition had masked the typical yoghurt aroma in lactic drinks manufactured from whey and yoghurt culture. In another study where gelatin, pectin, and sodium alginate were used in production of mango soy fortified set type yoghurt; it is reported that addition of these agents up to 0.40% improved sensory properties while level of 0.60% negatively affected the sensory perception of yoghurt samples. In the same study, it is determined that gelatin added samples gave the highest scores on colour, appearance, texture, and aroma of yoghurt (Kumar and Mishra, 2004). In the present study, the obtained results mostly confirmed the results previously reported in the literature.

Conclusion

The results obtained suggest that CMC might be a suitable agent to be used as a thickening and/or viscosity enhancer in yoghurt while causing no significant harm on its sensory perception at levels as low as 0.50%. However, due to CMC's nature and interaction with casein, use of CMC at high concentrations might harm the formation of network structure in yoghurt, which is necessary for yoghurt's traditional and typical sensory perception. The results obtained suggests that gelatin is much more suitable compared to CMC, in overcoming syneresis problem in yoghurt, improving textural properties of yoghurt, while giving no significant harm on its sensory properties. It is concluded that gelatin might be considered as a convenient food ingredient in fermented milk products especially in yoghurt, to overcome syneresis problem especially during storage at relatively high temperatures that might occur during transportation, and to enhance the water holding capacity.

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