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Physico-chemical properties of yoghurt containing cress seed mucilage or guar gum

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Abstract The changes in physico-chemical properties of yoghurt containing cress seed mucilage (CM) compared with yoghurt containing guar gum (GG) or plain yoghurt during storage at 5 ± 2 °C for 15 days were evaluated. CM was prepared and added to standardized buffalo's milk (~3.2% fat and ~15.0% TS) at rate of 0.025%, 0.05% and 0.10% but GG was added at the rate of 0.025% and 0.05% to create 5 treatments. The latter batch had no CM or GG, serve as a control (C). No significant changes in pH values and proteolysis (SN/TN ratio) of all yoghurt samples throughout the storage period were observed. CM containing yoghurts showed adverse effect on the concentration of acetaldehyde and diacetyl until day 10 and day 15, respectively compared with C and that containing 0.025% GG. Yoghurt samples containing different levels from CM or 0.025% GG exhibited lower in wheying-off and whey syneresis compared with C. No significant changes in the firmness of the yoghurt containing 0.025% and 0.05% CM or 0.025% GG were found throughout the storage period, while yoghurt containing 0.05% GG exhibited lower firmness compared with other yoghurt samples. Apparent viscosity of yoghurt containing GG or CM was higher than that of C until day 10. However, yoghurt containing 0.025% and 0.05% CM or 0.05% GG showed continued increase in apparent viscosity until day 10 while for yoghurt containing 0.10% CM, the increase was observed until day 5 and decline thereafter.

Introduction

Food is a complex and heterogeneous system containing many different chemical types and species. In a product consisting of proteins, lipids, carbohydrates and electrolytes such as milk, cream, yoghurt, cheese, beverages, the interactions among various constituents need to be well balanced so that a stable system evolves (Samant et al., 2007). Edible hydrocolloids are used in the food industries as thickeners, stabilizer, gelling agents, syneresis control, emulsifiers or suspension stability and prebiotic (Lucey, 2002; Nikoofar et al., 2013). Recently, they have attracted much attention for their function as dietary fiber which is expected to lower cholesterol and blood pressure

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thus preventing life style related diseases. In the same time, they control flavor and aromas release (Zhao et al., 2009).

Mucilages are polysaccharide complexes formed from sugar and uronic acid units. They form slimy masses in water which are typically heterogeneous in composition. Mucilages are obtained mainly from seeds or other plant parts. Some are obtained from marine algae, and from selected microorganisms (Rangari, 2002). Plant mucilages have been widely explored as pharmaceutical excipients (Verma and Razdan, 2003) and have been known since ancient times for their medical uses (Murray et al., 2006). They are widely used in the industry as thickeners, water-retention agents, emulsion stabilizers, gelling agents, suspending agents, binders, film formers, and sustained-release agents (Kapoor et al., 1992; Reid and Edwards, 1995). Cress seeds (*Lepidium sativum*) contain large amounts of mucilaginous constituents when soaked in water and a transparent gel forms around the whole seed (Karazhiyan et al., 2009). Cress seed mucilage contains L-arabinose, D-xylose, D-galactose, L-rhamnose, D-galacturonic acid, and 4-O-methyl-D-glucuronic acid as major components with D-glucose and mannose as trace components. Cress seed mucilage is widely used in many traditional medicinal preparations such as cough syrups. It also has antihyperglycaemic properties which help to control glucose level in diabetics (Behrouzian et al., 2014).

Physico-chemical properties of cress seeds mucilage were widely studied (Lin et al., 2005; Karazhiyan et al., 2009; Karazhiyan et al., 2011; Naji et al., 2012). However, there are few controversial reports in the literature for using cress seed mucilage as dairy food supplement (Bhatty and Cherdkiatgumchai, 1990; Behnia et al., 2013). The growing awareness of the relationship between diet and health has led to an increased demand for food products that support health above and beyond providing basic nutrition (Karagul-Yuceer et al., 2001; Fiszman et al., 1999). Therefore, the objective of this study was to evaluate the physico-chemical properties of yoghurt containing cress seed mucilage compared with guar gum during storage at 5 ± 2 °C for 15 days to select the best concentration gives high quality.

Materials and methods

Materials

Fresh buffalo's skim milk and sweet cream (~40.0% fat) were obtained from the farm of Fac. Agric., Cairo Univ., Egypt. Skim milk powder (low heat) made in the USA was purchased from the local market at Cairo, Egypt. Cress seeds (*L. sativum*) were purchased from local market (Cairo, Egypt) with moisture content of ~6.84%. Guar gum was purchased from Sigma (Sigma Aldrich Co., St. Louis, MO, USA). *Lactobacillus delbrueckii* ssp. *bulgaricus* and *Streptococcus salivarius* ssp. *thermophilus* were obtained from stock cultures of Dairy Microbiology Lab., National Research Centre, Cairo, Egypt.

Methods

Cress seed mucilage extraction

Cress seeds (100 g) were washed in water for 1 min to remove the surface dust, and then mixed with 900 ml distilled water. The cress seeds and water were then stirred for 5 h at a speed of 300 rpm/min, in a 60 °C water bath, according to the method of Cui (2001). The extracted cress seed mucilage solution was filtered through 40-mesh screen and precipitated with two volumes of 95% ethanol. The cress seed mucilage was separated by centrifugation at 3000 rpm/min for 10 min. The precipitated cress seed mucilage was then dried in a hot air oven at 60 °C over night.

Yoghurt manufacture

Fresh buffalo's skim milk was standardized to ~3.2% fat and 15.0% total solids using skim milk powder and sweet cream, and divided into six equal portions. Cress seed mucilage was added to the milk at rate of 0.025%, 0.05% and 0.10% (CM_1, CM_2 and CM_3, respectively), but guar gum was added at the rate of 0.025% and 0.05% (GG_1 and GG_2, respectively) to create 5 treatments. The latter batch had no cress seed mucilage or guar gum, serve as a control (C). All mixtures were preheated to 60 °C, homogenized using laboratory double stage homogenizer (Rannie, Copenhagen, Denmark), 13.6 MPa first stage and 3.5 MPa second stage, then heated to 85 °C for 10 min and cooled to 42 °C. The treated yoghurt milks were inculcated with 3.0% of mixed starter culture (1:1), dispensed into plastic cups (150 ml) and incubated at 42 °C until a uniform coagulation was formed (Barrantes et al., 1994). The yoghurt samples were stored at 5 ± 2 °C and analyzed at day 1, 5, 10 and 15 of storage. Three replicates were made from each treatment.

Chemical analysis

The changes in pH in the yoghurt samples during storage were measured using a laboratory pH meter with glass electrode (HANNA, Instrument, Portugal). Total nitrogen and soluble nitrogen contents in the yoghurt samples were determined according to the methods described by AOAC (2007). The extent of proteolysis in the yoghurt samples during storage was calculated as a ratio of soluble nitrogen/total nitrogen (SN/TN ratio). The concentration of acetaldehyde and diacetyl in the yoghurt samples were measured using spectrophotometer (Shimadzu, 240-UV–Vis, Japan) as described by Less and Jago (1970).

Physical properties

Whey separation

The volume of whey on the surface of the plastic cup of yoghurt sample was taken as an indicator for wheying-off (ml/100 g yoghurt) according to the siphon method described by Amatayakul et al. (2006). Whey syneresis was estimated as mentioned by Aguilera and Kessler (1989). An amount of 25 g of the yoghurt sample was placed into centrifuge tube and centrifuged at 1290*g* for 20 min (Sigma Laborzentri Fugen, 2 K15, Germany). The weight fraction of the supernatant liquid was used as index of whey syneresis (ml/100 g yoghurt).

Apparent viscosity

The yoghurt samples were gently stirred 5 times in clockwise direction with a plastic spoon prior to viscosity measurements. Apparent viscosity was measured at 7 °C using a Brookfield digital viscometer (Model DV-II, Canada) fitted with spindle-4. The yoghurt sample was subjected to selected shear rates ranging from 3.0 to 20.0 S^{-1} for upward curve. Apparent viscosity was expressed as Pascal (Pa s).

Yoghurt firmness

Texture profile analysis (TPA) was performed on the yoghurt samples using the double compression test (TA-XT2 Texture Analyzer, Texture Technologies Crop, Scarsdale, NY) connected to a computer programmed with texture analysis software. An artificial plastic cylinder (45° Perspex Cone, 432-081) was attached to the moving crosshead. The crosshead speed was set at 70 mm/min in both upward and downward directions. The yoghurt sample was placed on a flat holding plate at 5 ± 2 °C and the plastic cylinder inserted 20 mm below the yoghurt surface. The firmness of yoghurt was calculated according to the method described by Steffe (1996).

Statistical analysis

Statistical analysis was performed using the GLM procedure with SAS (2004) software. Analysis of variance (ANOVA) and Duncan's multiple comparison procedure were used to compare the means. A probability of $P \leqslant 0.05$ was used to establish statistical significance.

Results and discussions

pH values

The changes in pH values of plain set yoghurt and yoghurt containing cress seed mucilage or guar gum during storage at 5 ± 2 °C for 15 days are presented in Table 1. There was no significant variation ($P > 0.05$) in pH value of plain set yoghurt (C) and that containing different levels from guar gum (GG) or cress seed mucilage (CM) throughout storage period. Nikoofar et al. (2013) have a similar observation in yoghurt containing quince seed mucilage. During storage period, all yoghurt samples showed continued decreased until day 10, the difference being significant only at day 10 ($P < 0.05$). Thereafter, no significant change in pH value ($P > 0.05$) in all yoghurt treatments was observed at day 15 compared with day 10. The changes in pH during storage were found to be similar in low-fat yoghurts containing waxy maize (Walter, 1993) or inulin (Ramchandran and Shah, 2008). Thus, using CM in yoghurt manufacture had no influence either on the fermentation process or on the final pH value.

Soluble nitrogen

The changes in the SN/TN ratio of C and yoghurt containing CM or GG during storage at 5 ± 2 °C for 15 days are presented in Table 2. There was no significant difference ($P < 0.05$) in the SN/TN ratio between C and that containing GG or CM until day 15, even if the SN/TN ratio was numerically higher in yoghurt containing CM at day 1. A similar observation was found by Abd El-Aziz et al. (2004) in free-fat yoghurt containing waxy maize. Tamime and Robinson (1999) mentioned that the proteinase activity of *L. bulgaricus* hydrolyses casein to yield polypeptides, which in turn are broken down by the peptidases of *S. thermophilus* with the liberation of amino acids. Over storage period, all yoghurt samples showed continued increase in SN/TN ratio, the increase being significant ($P < 0.05$) at day 10 and 15 for C and yoghurt containing GG, whereas for yoghurt containing CM, the changes were significant only at day 15 ($P < 0.05$). The increase in SN/TN ratio during storage was found to be similar in plain set type yoghurt (Guzel-Seydim et al., 2005) and in low-fat yoghurt containing exopolysaccharides (EPS) producing *S. thermophilus* (Ramchandran and Shah, 2010). These results indicating that yoghurt containing different concentrations from CM had no significant effect on extent of proteolysis compared with C and that containing GG.

Flavor compounds

The changes in flavor compounds of yoghurt samples, as measured by the concentration of acetaldehyde and diacetyl are given in Table 3. The concentration of acetaldehyde in CM or GG containing yoghurt was lower than that of C. The reduction being significant at day 1, 5 and 10 for yoghurt containing 0.05% and 0.1% CM ($P < 0.05$) whereas for yoghurt containing 0.05% GG or 0.025% CM, the reduction was significant at 5 and 10 day ($P < 0.05$). At 15 day, the concentration of acetaldehyde in C was lower than other yoghurt samples; the difference was not significant ($P > 0.05$). Such an effect has been found by Farahat (1999) in low-fat yoghurt containing 0.2% Slendid® and Abd El-Aziz et al. (2004) in

Table 1 Changes in pH of plain yoghurt and yoghurt containing cress seed mucilage or guar gum during storage period at 5 ± 2 °C for 15 days.

Treatments	Storage period (days)			
	1	5	10	15
C	$4.75^{Aa} \pm 0.036$	$4.65^{Aa} \pm 0.020$	$4.51^{Ab} \pm 0.032$	$4.51^{Ab} \pm 0.022$
GG_1	$4.76^{Aa} \pm 0.054$	$4.69^{Aa} \pm 0.041$	$4.54^{Ab} \pm 0.040$	$4.52^{Ab} \pm 0.041$
GG_2	$4.74^{Aa} \pm 0.040$	$4.66^{Aa} \pm 0.035$	$4.49^{Ab} \pm 0.026$	$4.49^{Ab} \pm 0.015$
CM_1	$4.72^{Aa} \pm 0.023$	$4.63^{Aa} \pm 0.037$	$4.48^{Ab} \pm 0.045$	$4.45^{Ab} \pm 0.033$
CM_2	$4.71^{Aa} \pm 0.038$	$4.64^{Aa} \pm 0.031$	$4.50^{Ab} \pm 0.026$	$4.51^{Ab} \pm 0.026$
CM_3	$4.68^{Aa} \pm 0.026$	$4.63^{Aa} \pm 0.056$	$4.59^{Ab} \pm 0.023$	$4.50^{Ab} \pm 0.017$

Means (±SE, $n = 3$) with the same capital letters in the same column or the same small letters in the same row are not significantly different at $P \leqslant 0.05$; C, control yoghurt made without guar gum or cress seed mucilage; GG_1; yoghurt made with 0.025% guar gum; GG_2, yoghurt made with 0.05% guar gum; CM_1, yoghurt made with 0.025% cress seed mucilage; CM_2, yoghurt made with 0.05% cress seed mucilage; CM_3, yoghurt made with 0.10% cress seed mucilage.

free-fat yoghurt containing waxy maize. However, the concentration of acetaldehyde in yoghurt samples lies in the normal range recorded by Gaafar (1992), who reported that weak flavored yoghurt, contained less than 4.0 ppm and well-flavored yoghurts contained greater than 8.0 ppm acetaldehyde. Over storage period, all yoghurt samples showed continued decrease in the concentration of acetaldehyde being significant at 10 and 15 day for C ($P < 0.05$) and that containing 0.025% GG whereas for other yoghurt samples, the decrease was significant at 5, 10 and 15 day ($P < 0.05$). The decrease in the concentration of acetaldehyde during storage was found by Hussein et al. (2011) in yoghurt containing plant polysaccharides.

Also, as shown in Table 3, the concentration of diacetyl in CM containing yoghurt was lower compared with C and GG containing yoghurt, the difference was significant only at day 5, 10 and 15. Opposite to acetaldehyde, the concentration of diacetyl in yoghurt samples gradually increases as the time of storage increase ($P < 0.05$). Law (1981) reported that in mixed culture, diacetyl production is enhanced by the rapid drop in pH which is associated with the growth of *streptococci*. A similar observation was found by Abd El-Aziz et al. (2004) in low yoghurt containing waxy maize and Gaafar (1992).

Whey separation

Whey separation is not desirable in yoghurt, where it can occur as a result of a weak body. Spontaneous separation of the liquid phase from the gel, without the application of external pressure, is called wheying-off, but when the gel is mechanically disrupted, for example by cutting or agitation is called whey syneresis. On day 1, the percent of wheying-off was significantly ($P < 0.05$) higher in yoghurt containing 0.05% GG and C than in yoghurt containing 0.025% GG, and that containing 0.025%, 0.05% and 0.10% CM (Table 4). Also, the percent of wheying-off was significantly ($P < 0.05$) higher in yoghurt

Table 2 Changes in soluble nitrogen/total nitrogen ratio of plain yoghurt and yoghurt containing cress seed mucilage or guar gum during storage period at 5 ± 2 °C for 15 days.

Treatments	Storage period (days)			
	1	5	10	15
	(%)			
C	$11.73^{Ac} \pm 0.61$	$12.53^{Abc} \pm 0.72$	$13.67^{Aab} \pm 0.27$	$14.31^{Aa} \pm 0.32$
GG_1	$11.90^{Ab} \pm 0.42$	$13.51^{Aab} \pm 0.33$	$14.01^{Aa} \pm 0.33$	$14.50^{Aa} \pm 0.41$
GG_2	$11.90^{Ac} \pm 0.68$	$13.53^{Abc} \pm 0.70$	$14.60^{Aab} \pm 0.36$	$15.14^{Aa} \pm 0.67$
CM_1	$12.13^{Ab} \pm 0.94$	$13.36^{Aab} \pm 0.74$	$14.00^{Aab} \pm 0.15$	$14.60^{Aa} \pm 0.50$
CM_2	$12.04^{Ab} \pm 0.34$	$13.12^{Aab} \pm 0.37$	$13.90^{Aab} \pm 0.36$	$14.40^{Aa} \pm 0.28$
CM_3	$12.38^{Ab} \pm 0.61$	$13.08^{Aab} \pm 0.58$	$13.82^{Aab} \pm 0.47$	$14.98^{Aa} \pm 0.75$

Means (±SE, $n = 3$) with the same capital letters in the same column or the same small letters in the same row are not significantly different at $P \leqslant 0.05$; C, control yoghurt made without guar gum or cress seed mucilage; GG_1; yoghurt made with 0.025% guar gum; GG_2, yoghurt made with 0.05% guar gum; CM_1, yoghurt made with 0.025% cress seed mucilage; CM_2, yoghurt made with 0.05% cress seed mucilage; CM_3, yoghurt made with 0.10% cress seed mucilage.

Table 3 Changes in acetaldehyde and diacetyl of plain yoghurt and yoghurt containing cress seed mucilage or guar gum during storage period at 5 ± 2 °C for 15 days.

Treatments	Storage period (days)			
	1	5	10	15
Acetaldehyde (μmol/100 g yoghurt)				
C	$77.88^{Aa} \pm 4.41$	$72.80^{Aa} \pm 3.48$	$59.84^{Ab} \pm 3.58$	$32.64^{Ac} \pm 3.54$
GG_1	$72.76^{ABa} \pm 5.14$	$67.44^{Aa} \pm 3.78$	$53.95^{Ab} \pm 2.11$	$35.40^{Ac} \pm 2.86$
GG_2	$74.64^{ABa} \pm 3.41$	$52.67^{Bb} \pm 3.14$	$47.11^{Bb} \pm 2.51$	$37.04^{Ac} \pm 3.69$
CM_1	$69.01^{ABa} \pm 4.26$	$55.15^{Bb} \pm 3.55$	$47.02^{Bb} \pm 2.57$	$37.88^{Ac} \pm 2.66$
CM_2	$65.88^{Ba} \pm 3.84$	$51.40^{Bb} \pm 3.12$	$44.44^{Bb} \pm 3.33$	$33.78^{Ac} \pm 3.55$
CM_3	$65.40^{Ba} \pm 3.74$	$50.72^{Bb} \pm 3.11$	$43.57^{Bbc} \pm 3.17$	$34.44^{Ac} \pm 2.88$
Diacetyl (μmol/100 g yoghurt)				
C	$0.36^{Ad} \pm 0.03$	$5.22^{Ac} \pm 0.50$	$7.14^{Ab} \pm 0.54$	$9.04^{Aa} \pm 0.69$
GG_1	$0.38^{Ad} \pm 0.03$	$4.38^{ABc} \pm 0.68$	$6.07^{Ab} \pm 0.53$	$9.48^{Aa} \pm 0.51$
GG_2	$0.34^{Ad} \pm 0.03$	$3.50^{Bc} \pm 0.41$	$6.10^{Ab} \pm 0.22$	$9.04^{Aa} \pm 0.60$
CM_1	$0.31^{Ad} \pm 0.04$	$3.27^{Bc} \pm 0.31$	$3.52^{Bb} \pm 0.26$	$6.45^{Ba} \pm 0.43$
CM_2	$0.23^{Ac} \pm 0.05$	$3.83^{ABb} \pm 0.25$	$4.18^{Bb} \pm 0.17$	$7.34^{Ba} \pm 0.94$
CM_3	$0.28^{Ac} \pm 0.03$	$3.58^{Bb} \pm 0.20$	$4.09^{Bb} \pm 0.19$	$5.68^{Ba} \pm 0.24$

Means (±SE, $n = 3$) with the same capital letters in the same column or the same small letters in the same row are not significantly different at $P \leqslant 0.05$; C, control yoghurt made without guar gum or cress seed mucilage; GG_1; yoghurt made with 0.025% guar gum; GG_2, yoghurt made with 0.05% guar gum; CM_1, yoghurt made with 0.025% cress seed mucilage; CM_2, yoghurt made with 0.05% cress seed mucilage; CM_3, yoghurt made with 0.10% cress seed mucilage.

containing 0.05% GG than in C. Throughout the storage period, the percent of wheying-off was higher in control yoghurt than other yoghurt samples, the difference was significant only between C and that containing different levels from CM ($P < 0.05$). However, there was no significant in the percent of wheying-off among yoghurt samples containing 0.025% GG and that containing 0.025%, 0.05% or 0.10% CM. The behavior of the percent of wheying-off during storage period was found to be similar in low-fat yoghurt containing EPS (Ramchandran and Shah, 2010).

As shown in Table 4, the percent of whey syneresis was the lowest ($P < 0.05$) in yoghurt containing different levels from CM compared with C and that containing GG throughout the cold storage period. A similar observation was found by Nikoofar et al. (2013) in yoghurt containing 0.03%, 0.05% or 0.10% quince seed mucilage. They concluded that quince seed mucilage has a similar behavior as carrageenan and pectin with casein micelles that caused an improvement of casein micelle association, increase the serum phase preservation and decrease the yoghurt synerеsis. However, there was no significant difference in percent of whey syneresis ($P > 0.5$) between C and that containing GG. As storage periods increased, the percent of whey syneresis in C and that containing GG showed a slight decrease ($P > 0.05$), but remained stable in yoghurt containing CM at day 5 and 10, and declined thereafter. The changes in the percent of whey syneresis during storage period were found to be similar in yoghurt containing quince seed mucilage (Nikoofar et al., 2013). The decrease in the percent of whey syneresis throughout the storage period may be attributed to that at lower temperature the bonds between the particles of the gel are stronger or their numbers are greater. Presumably, this is because the particles are more swollen and are thereby connected to each other over a larger area (Walstra et al. 1999). Doleyres et al. (2005) found that

Table 4 Changes in whey separation of plain yoghurt and yoghurt containing cress seed mucilage or guar gum during storage period at 5 ± 2 °C for 15 days.

Treatments	Storage period (days)			
	1	5	10	15
Wheying-off (ml/100 g yoghurt)				
C	$2.75^{Ba} \pm 0.56$	$2.82^{Aa} \pm 0.54$	$3.13^{Aa} \pm 0.66$	$3.28^{Aa} \pm 0.41$
GG_1	$0.86^{Ca} \pm 0.36$	$1.12^{ABa} \pm 0.32$	$1.57^{ABa} \pm 0.57$	$1.58^{ABa} \pm 0.57$
GG_2	$6.43^{Aa} \pm 0.43$	$1.77^{ABb} \pm 0.27$	$2.45^{ABb} \pm 0.64$	$3.21^{Ab} \pm 0.29$
CM_1	$2.19^{BCa} \pm 0.18$	$1.04^{Ba} \pm 0.42$	$1.16^{Ba} \pm 0.53$	$1.15^{Ba} \pm 0.25$
CM_2	$0.00^{Ca} \pm 0.00$	$1.25^{ABa} \pm 0.45$	$1.41^{Ba} \pm 0.42$	$1.12^{Ba} \pm 0.04$
CM_3	$0.00^{Ca} \pm 0.00$	$0.23^{B} \pm 0.11$	$1.38^{Ba} \pm 0.41$	$1.03^{Ba} \pm 0.13$
Syneresis (ml/100 g yoghurt)				
C	$23.97^{Aa} \pm 0.89$	$19.72^{Ab} \pm 0.55$	$18.55^{ABb} \pm 0.98$	$17.70^{Ab} \pm 0.69$
GG_1	$21.51^{Aa} \pm 0.99$	$18.61^{Aab} \pm 0.95$	$20.84^{Aa} \pm 1.19$	$16.77^{ABb} \pm 1.00$
GG_2	$21.55^{Aa} \pm 0.96$	$21.52^{Aa} \pm 0.79$	$19.56^{ABab} \pm 1.16$	$17.25^{Ab} \pm 0.63$
CM_1	$16.42^{Ba} \pm 0.87$	$14.29^{Ba} \pm 1.09$	$14.74^{Ca} \pm 0.88$	$14.13^{Ba} \pm 0.53$
CM_2	$16.41^{Ba} \pm 0.96$	$16.05^{Ba} \pm 0.47$	$17.04^{BCa} \pm 0.67$	$14.21^{Ba} \pm 1.13$
CM_3	$15.82^{Ba} \pm 0.85$	$15.64^{Ba} \pm 0.89$	$14.93^{Ca} \pm 0.77$	$16.78^{ABa} \pm 1.01$

Means (±SE, $n = 3$) with the same capital letters in the same column or the same small letters in the same row are not significantly different at $P \leqslant 0.05$; C, control yoghurt made without guar gum or cress seed mucilage; GG_1; yoghurt made with 0.025% guar gum; GG_2, yoghurt made with 0.05% guar gum; CM_1, yoghurt made with 0.025% cress seed mucilage; CM_2, yoghurt made with 0.05% cress seed mucilage; CM_3, yoghurt made with 0.10% cress seed mucilage.

Table 5 Changes in the firmness of plain yoghurt and yoghurt containing cress seed mucilage or guar gum during storage period at 5 ± 2 °C for 15 days.

Treatments	Storage period (days)			
	1	5	10	15
Firmness (N)				
C	$0.97^{ABb} \pm 0.071$	$1.27^{Aab} \pm 0.042$	$1.23^{Aab} \pm 0.049$	$1.31^{ABa} \pm 0.079$
GG_1	$1.03^{ABc} \pm 0.105$	$1.17^{Abc} \pm 0.061$	$1.40^{Aab} \pm 0.045$	$1.57^{Aa} \pm 0.061$
GG_2	$0.88^{Bb} \pm 0.074$	$1.08^{Aab} \pm 0.040$	$1.23^{Aa} \pm 0.122$	$1.17^{Ba} \pm 0.071$
CM_1	$1.13^{ABc} \pm 0.094$	$1.20^{Abc} \pm 0.115$	$1.45^{Aab} \pm 0.064$	$1.55^{Aa} \pm 0.087$
CM_2	$1.00^{ABc} \pm 0.115$	$1.22^{Abc} \pm 0.111$	$1.37^{Aab} \pm 0.075$	$1.53^{Aa} \pm 0.075$
CM_3	$1.15^{Aa} \pm 0.041$	$1.18^{Aa} \pm 0.165$	$1.20^{Aa} \pm 0.115$	$1.30^{ABa} \pm 0.045$

Means (±SE, $n = 3$) with the same capital letters in the same column or the same small letters in the same row are not significantly different at $P \leqslant 0.05$; C, control yoghurt made without guar gum or cress seed mucilage; GG_1; yoghurt made with 0.025% guar gum; GG_2, yoghurt made with 0.05% guar gum; CM_1, yoghurt made with 0.025% cress seed mucilage; CM_2, yoghurt made with 0.05% cress seed mucilage; CM_3, yoghurt made with 0.10% cress seed mucilage.

yoghurts containing EPS-producing cultures had better water holding capacity, which increased during storage and thereby lower whey syneresis.

Firmness

Data presented in Table 5 showed the changes in firmness of C and yoghurt containing GG or CM during storage at 5 ± 2 °C for 15 days. Generally, there was no difference in the firmness of yoghurt containing 0.025% and 0.05% CM or 0.025% GG until day 5, after which slight improvement ($P > 0.05$) in the firmness was observed compared with C. These results are differing from that found by Ramchandran and Shah (2010) in low-fat yoghurts containing EPS. Also, Nikoofar et al. (2013) have reported that yoghurt samples containing quince seed mucilage (0.03%, 0.05% and 0.10%) have lower firmness

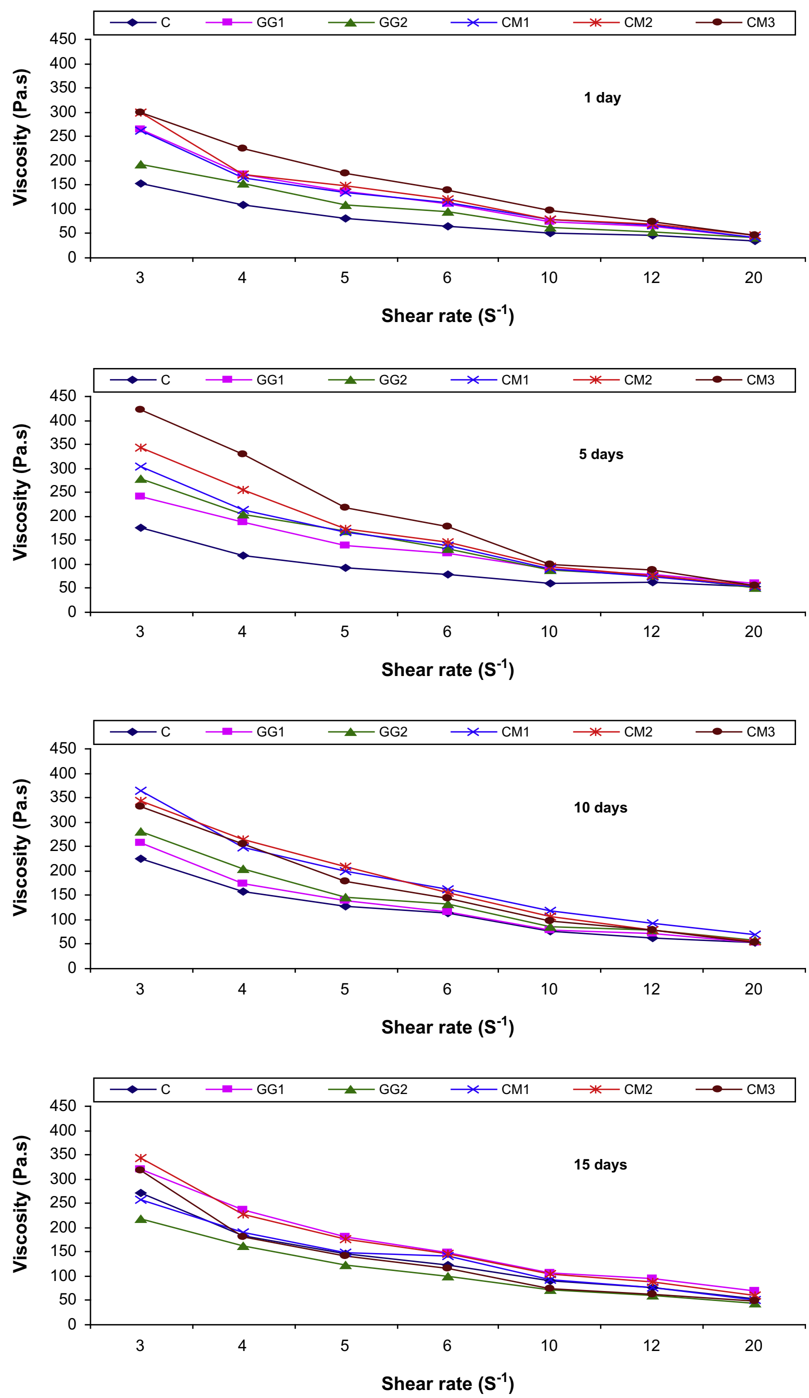

Fig. 1 Changes in viscosity of plain yoghurt and yoghurt containing cress seed mucilage or guar gum during storage period at 5 ± 2 °C for 15 days (C, control yoghurt made without guar gum or cress seed mucilage; GG_1; yoghurt made with 0.025% guar gum; GG_2, yoghurt made with 0.05% guar gum; CM_1, yoghurt made with 0.025% cress seed mucilage; CM_2, yoghurt made with 0.05% cress seed mucilage; CM_3, yoghurt made with 0.10% cress seed mucilage).

than control yoghurt. In contrary, yoghurt containing 0.05% GG had the lowest firmness throughout the storage period compared with the other yoghurt samples. Over storage, all yoghurt samples showed continued increase in the firmness, the increase was significant at day 10 and 15 for yoghurt containing 0.025% and 0.05% GG or CM ($P < 0.05$) whereas for C the increase was significant at day 10 ($P < 0.05$). However, the increase in firmness for yoghurt containing 0.10% CM during storage period was not significant ($P > 0.05$). The increase in the firmness during storage was found to be similar in yoghurt containing quince seed mucilage (Nikoofar et al., 2013). The increase in yoghurt firmness during storage may be due to rearrangement within the network produced by attractive forces between individual casein particles leading to contraction of the milk gel (Walstra et al., 1985).

Apparent viscosity

Apparent viscosity is defined as the viscosity of non-Newtonian fluid. That means that, the apparent viscosity changes, as the shear rate is changed. As shown in Fig. 1, apparent viscosity of yoghurt containing GG or CM was higher than that of C at day 1, 5 and 10. A similar observation was found by Behnia et al. (2013) in fresh yoghurt containing cress seed gum. They reported that cress seed gum can bond water in samples and consequently increase the viscosity, but this increment in up to 0.1% gum concentration which shows some possible variations in protein–protein interactions in three dimensional protein networks in samples. Also, the apparent viscosity of yoghurt samples increased with the increasing of addition level of CM until day 10, after which the apparent viscosity of yoghurt containing 0.10% CM was lower than that of yoghurt containing 0.025% or 0.05% CM. At day 15, yoghurt containing 0.025% GG or 0.05% CM had the highest apparent viscosity, while yoghurt containing 0.05% GG had the lowest apparent viscosity. The remaining three yoghurt treatments had medium apparent viscosity.

Over storage period, a steady increase in the apparent viscosity of C was observed until day 15. However, yoghurt containing 0.025% and 0.05% CM and 0.05% GG showed continued increase in apparent viscosity until day 10 while for yoghurt containing 0.10% CM, the increase was observed until day 5 and declined thereafter. These results are confirmed by the higher firmness of yoghurt containing 0.025% and 0.05% CM and 0.05% GG at day 10 and 15 as compared to yoghurt containing 0.10% CM or 0.05% GG. The apparent viscosity of yoghurt containing CM during cold storage was found to be similar in free-fat yoghurt containing waxy maize (Abd El-Aziz et al., 2004).

Conclusion

From chemical view, using of GG or CM did not affect fermentation time, pH value and proteolysis extent of set-yoghurt throughout storage cold period. Physically, using of GG or CM in yoghurt manufacture exhibited a positive relationship with yoghurt quality parameters; caused an increase in both apparent viscosity and firmness while decrease of whey separation. Also, the addition of 0.025% GG or 0.05% CM was sufficient to improve the quality of set-yoghurt as compared with the polysaccharide-free yoghurt during storage period at 5 ± 2 °C for 15 days.

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