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Physical Properties of Ice Cream Containing Cress Seed and Flaxseed Mucilages Compared with Commercial Guar Gum

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ABSTRACT
The effect of using ethanol precipitated cress seed (CSM) and flaxseed (FSM) mucilages in ice cream manufacture compared with commercial Guar Gum (GG) was studied. Ten treatments of ice cream mixes consisted of 10.0% milk fat, 11.5% MSNF and 15.0% sucrose were prepared. The CSM, FSM and GG were added separately at the rates of 0.025, 0.05 and 0.10% (w/w) to create 9 treatments. The latter batch had no polysaccharides' serve as a control. The results showed that the using of CSM and FSM had no significant effect on pH value, acidity content and surface tension of ice cream mix compared with GG or control mix. Protein load was the highest in ice cream mix containing 0.025% GG and CSM, however, protein load decreased, as GG or CSM concentration increased. The ice cream mix containing 0.025% GG exhibited lowest viscosity, while that containing 0.05% GG exhibited highest viscosity compared with those containing other polysaccharides at the same portion. As addition rate of 0.1%, mix containing FSM was higher than that containing CSM, however, mix containing GG separated into two layers. The overrun was the highest in the frozen ice cream containing 0.025% FSM or CSM but the lowest in that containing 0.05% GG. The decrease in hardness of ice cream was related to the increase in mix viscosity more than the increase in overrun percentage. Finally, addition of 0.025% FSM, CSM or commercial GG was the best percentage to improve the physical and sensorial properties of ice cream.

Key words: Ice cream, cress seed mucilage, flaxseed mucilage, guar gum, physical properties

INTRODUCTION
Ice cream, as a complex food consists of small air cells dispersed in a partially frozen, continuous aqueous phase. The quality of ice cream is related to sensory attributes (hardness, creaminess, chewiness, melting and flavour) and to physical attributes, such as the size of ice crystals, viscosity and freezing. Stabilizers or gums are commonly used in ice cream to improve mouth feel by to increase the viscosity of the mix, to improve air incorporation, air cell distribution, body and texture, storage stability and melting properties. Stabilizers also minimize the development of large crystals and ultimately to get finished structure in ice cream (Murtaza *et al*., 2004; Bahramparvar and Tehrani, 2011).

Mucilages are polysaccharides complexes formed from sugar and uronic acid units. They form slimy masses in water 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). Flaxseed is the seed from the plant (*Linum usitatissimum* L.) and is consumed as food. Health benefits claims of flaxseed are related to its components, such as lignans, α-linolenic acid and soluble dietary fibre or mucilage/gum (Hijova *et al*., 2011). Mucilage of flax consists of two polysaccharide components, acidic and neutral, at a ratio of 2: l. The neutral fraction contains L-arabinose, D-xylose and D-galactose. The acidic fraction contains L-rhamnose, L-fructose, L-galactose and D-galacturonic acid (Kaewmanee *et al*., 2014). Shan *et al.* (2000) reported that flaxseed gum had good formability, stability, emulsibility and salt resistance and that flaxseed gum has the same rheology as non-Newtonian flow. Guar gum is one of the important gums being used as stabilizer in ice cream manufacturing. It's a neutral polysaccharides consisting of mannose and D-galactose in a molecular ratio of 1.6:1 (Stephen and Churms, 2006). The backbone is a linear chain of β-(1-4)-linked mannose residues to which galactose residues are (1-6)-linked at every second mannose, forming short side-42 branches (Sujitha *et al*., 2013).

Physico-chemical properties of flaxseeds and cress seeds mucilage's were widely studied (Lin *et al*., 2005; Chen *et al*., 2006; Karazhiyan *et al*., 2009, 2011; Wang *et al*., 2011; Naji *et al*., 2012). However, there are few controversial reports in the literature for using flaxseeds and cress seeds mucilage's as dairy food supplements (Bhatty and Cherdkiatgumchai, 1990; Hussein *et al*., 2011; Behnia *et al*., 2013; Nikoofar *et al*., 2013). Therefore, the objective of this study was to evaluate the physical properties of ice cream containing cress seed and flaxseed mucilages compared with commercial guar gum.

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 (SMP), made in the USA was purchased from the local market at Cairo, Egypt. Flaxseed (*Linum usitatissimum*) and cress seed (*Lepidium sativum*) were purchased from local market (Cairo, Egypt) with moisture content of 6.64 and 6.84%, respectively. Commercial Guar Gum (GG) was purchased from Sigma (Sigma Aldrich Co., St. Louis, MO, USA). Commercial grade granulated sugar cane produced by Sugar and Integrated Industries Co. and Vanilla (chem. rein 100%) made by Boehringer Manheim GMB, Germany were purchased from local market, Cairo, Egypt.

Methods

Flaxseed or cress seed mucilage extraction: Flaxseeds or cress seed (100 g) were washed in water for 1 min to remove the surface dust and then mixed with 900 mL distilled water. The seeds and water were stirred for 5 h at a speed of 300 rpm min^{-1} at 60°C water bath, according to the method of Cui (2001). The extracted mucilage solution was filtered through 40-mesh screen and precipitated with two volumes of 95% ethanol. The mucilage was separated by centrifugation (Sigma 301, Western Germany) at 3000 rpm min^{-1} for 10 min. The precipitated mucilage was then dried in a hot air oven at 60°C over night. The moisture, protein and ash contents for resultant dried ethanol precipitated flaxseeds mucilage (FSM) were 3.76, 12.17 and 6.97% but for dried ethanol precipitated Cress Seed Mucilage (CSM) were 5.30, 13.97 and 9.78%.

Ice cream making: Ten treatments of ice cream mixes consisted of 10.0% milk fat (fresh cream) 11.5% milk solids not fat (fresh buffalo's skim milk and skim milk powder) and 15.0% sucrose (Marshall *et al*., 2003) were prepared. The CSM, FSM and GG were added separately at the rates of 0.025, 0.05 and 0.10% (w/w), to create 9 treatments. The latter batch had no FSM, CSM or GG, serve as a control. All components were added to fresh buffalos' skim milk slowly and dissolved by using a mixer (Heidolph No. 111, Type RZR1, Germany) to reach a completed hydration. All ice cream mixes homogenized using a laboratory homogenizer (EURO TURRAXT 20b, IKA lobortechnik 27000 min^{-1}) at 60°C for 5 min, pasteurized at 81.5°C and the aged overnight at 5.0±2°C. Just before freezing in a batch freezer (Taylor, Model, 103), 0.04% Vanilla was added to each mix. The resultant ice cream was filled into plastic cups, covered and hardened in a deep freezer at -20°C for 24 h before analysis.

Methods of analysis

pH and acidity: The pH value of ice cream mixes were measured using a laboratory pH meter with glass electrode (HANNA, Instrument, Portugal). Acidity content was determined by adding 0.1N NaOH to the phenolphthalein endpoint (Arbuckle, 1986).

Apparent viscosity: Apparent viscosities of ice cream mixes were determined using a Brookfield Synchro-Lectric viscometer (Model LVT; Brookfield Engineering Inc. Stoughton, MA). Readings were taken at the speed of 2-30 sec^{-1} using spindle-00 at 7°C for upward curve. Apparent viscosity was expressed as centipoises (CP).

Protein load: The adsorbed protein on the surface of fat globules was determined by measuring the protein content (AOAC., 2007) of the aqueous phase of formulated emulsion before and after centrifugation (Sigma Laborzentri Fugen, 2 K15, Germany) at 10,350x g for 30 min at 20ºC (Cano-Ruiz and Richter, 1997) and freezing at -20°C for 45 min. The adsorbed protein was calculated from the difference between the initial and final proteins of the aqueous phase and expressed as protein load.

Whipping ability: Whipping abilities of the ice cream mix was determined using mixer with 2.6 cm blades (Heidolph No. 50 111, Type RZRI, Germany) according to Baer *et al*. (1999). Briefly, the mix (150 mL) was placed at 4°C in a 600 mL glass mixing bowl, calibrated with known volumes of water and placed inside a 2 L bowl. Between the bowls, a mixture of ice and salt was used to cool the mix during whipping by mixer. A mixer speed setting of 10 was used for whipping the ice cream mix. Changes in the volume of ice cream mix were recorded at 5, 10, 15 and 20 min.

Melting resistance: Melting of frozen ice cream was determined according to Arndt and Wehling (1989), by carefully cutting the foamed plastic cups from the ice milk samples (~50 g), placing the samples onto wire mesh over a glass funnel fitted on conical flask and weighing the amount of ice cream drained into the conical flask at 25±2°C every 10 min until the entire sample had melted.

Hardness: The Hardness of frozen ice cream was measured using fruit pressure tester (Penetrometer ST 207, Tecnotest, Italy). Samples were tempered to -19°C in chest-type freezer for

18 h before testing. The force required (kg cm^{-2}) for a cylindrical probe (diameter = 0.5 cm and length = 1.5 cm) to penetrate the sample were taken as a function of the hardness of frozen ice cream.

Sensory properties evaluation: Frozen ice cream samples were scored for sensory properties by a regular taste panel from staff members of Department of Dairy Science, National Research Centre. Frozen ice cream was sensory evaluated using a scheme of 10 points for appearance 10 points for melting quality, 30 points for body and texture and 50 point for flavor according to Magdoub *et al*. (1989).

RESULTS AND DISCUSSION

Properties of ice cream mixes

pH, acidity content and surface tension: The some physical properties of ice cream mixes containing Cress Seed Mucilage (CSM) or flaxseed mucilage (FSM) and commercial Guar Gum (GG) are presented in Table 1. There was no difference in pH value, acidity percentage and surface tension of ice cream mix containing CSM or FSM compared with control mix (C) that containing GG ($p>0.05$). The values ranged between 6.67-6.57 for pH, 0.30-0.32% for acidity and 50.38-51.54 dyne for surface tension. These results were within the normal range reported by Marshall *et al*. (2003). The same effect was observed in ice milk mixes containing waxy maize or modified starch by Abd El-Aziz *et al*. (2004), they reported that different levels or types of polysaccharides had not affected the acidity contents, pH values and surface tension of ice milk mixes. Also, in this respect, Alakali *et al*. (2009) found that the local food binder namely: *Afzelia africana*, *Deuterium microcapum* and *Taro tuber*, at all concentrations (0.3, 0.5 and 0.7%) had no significant ($p>0.05$) effect on the pH of ice cream mix. Cheng *et al*. (2015) found that the surface tension of milk had no affected by addition of 0.05-0.30% CMC or 0.05-0.20% GG.

Protein load: Lipid emulsion is stabilized by a layer of protein adsorbed at the surface of fat globules (Millqvist-Fureby *et al*., 2001). Therefore, the formation of a thicker coating between the oil-water interfaces, contribute to the increase in emulsion stability. As shown in Table 2, protein load in ice cream mix was influenced with the type and concentration of polysaccharides. Protein load in ice cream mix containing 0.025% GG or CSM was the highest ($p<0.05$) compared with other treatments. Also, the protein load in ice cream mix containing 0.05% CSM or 0.025, 0.05 and 0.10% FSM was higher as a compared to control mix and that containing 0.05% GG, however, the

Table 1: Some physical properties of ice cream mixes containing cress seed mucilage or flaxseed mucilage compared with commercial guar gum

	Physical properties of ice cream mixes			
Ice cream mixes-base treatments	pH	Acidity (%)	Surface tension (dyne)	Protein load (%)
C	6.61 ± 0.038^{AB}	0.32 ± 0.009^{A}	50.39 ± 0.16^{A}	40.6 ± 2.97^{BC}
GG_1	6.64 ± 0.024^{A}	0.31 ± 0.009^{A}	51.29 ± 0.46^{A}	55.2 ± 3.21^{A}
GG_2	6.60 ± 0.033^{AB}	0.32 ± 0.006^{A}	51.31 ± 0.13^{A}	41.9 ± 3.66^{BC}
GG_3	This treatment has been excluded for separation into two layers			
CSM_1	6.66 ± 0.017^{A}	0.32 ± 0.006^{A}	51.27 ± 0.23^{A}	54.5 ± 3.37^{A}
CSM_2	6.66 ± 0.025^{A}	0.31 ± 0.009^{A}	50.13 ± 0.32^{A}	44.9 ± 2.53^{BC}
CSM_3	6.67 ± 0.024^{A}	0.30 ± 0.009^{A}	50.38 ± 0.32^{A}	36.2 ± 2.83^{C}
FSM_1	6.57 ± 0.017^{B}	0.30 ± 0.003^{A}	51.54 ± 0.41^{A}	44.3 ± 2.94^{BC}
FSM_2	6.63 ± 0.026^{AB}	0.31 ± 0.003^{A}	51.14 ± 0.50^{A}	44.0 ± 3.85^{BC}
FSM_3	6.59 ± 0.025^{AB}	0.31 ± 0.006^{A}	51.13 ± 0.19^{A}	47.1 ± 3.62^{AB}

Means±SE, (n = 3) with the same letters in the same column are not significantly different at $p\leq0.05$, C: Ice cream mix without polysaccharides; GG_1: Ice cream mix containing 0.025% guar gum, GG_2: Ice cream mix containing 0.05% guar gum, GG_3: Ice cream mix containing 0.10% guar gum, CSM_1: Ice cream mix containing 0.025% cress seed mucilage, CSM_2: Ice cream mix containing 0.05% cress seed mucilage, CSM_3: Ice cream mix containing 0.10% cress seed mucilage, FSM_1: Ice cream mix containing 0.025% flaxseed mucilage, FSM_2, ice cream mix containing 0.05% flaxseed mucilage, FSM_3: Ice cream mix containing 0.10% flaxseed mucilage

Table 2: Whipping ability of ice cream mixes containing cress seed mucilage or flaxseed mucilage compared with commercial guar gum

	Whipping ability of ice cream mixes (%)			
Ice cream mixes-base treatments	5 min	10 min	15 min	20 min
C	66.7±4.91^{Aa}	75.0±2.64^{Aa}	74.0±4.35^{Aa}	67.7±3.84^{ABCa}
GG_1	48.0±2.64^{Ca}	48.0±4.04^{Ca}	50.3±2.84^{Da}	56.0±4.50^{CDa}
GG_2	44.3±2.33^{Ca}	50.7±4.41^{Ca}	49.3±3.17^{Da}	48.3±2.33^{Da}
CSM_1	64.0±3.78^{ABa}	64.0±5.13^{ABa}	65.3±1.88^{ABCa}	69.0±3.05^{ABa}
CSM_2	49.0±2.64^{Ca}	51.7±4.17^{Ca}	51.7±3.65^{Da}	55.3±4.17^{CDa}
CSM_3	53.0±3.60^{BCa}	57.0±3.60^{BCa}	57.0±3.60^{CDa}	55.3±2.60^{CDa}
FSM_1	66.7±3.75^{Aa}	72.3±4.19^{Aa}	72.0±1.15^{ABa}	72.0±1.15^{ABa}
FSM_2	61.0±6.35^{ABb}	70.0±3.46^{Aab}	74.0±3.46^{Aa}	74.0±3.46^{Aa}
FSM_3	49.8±2.56^{Ca}	55.5±4.09^{BCa}	61.0±4.56^{BCDa}	60.0±1.73^{BCDa}

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 $p \leq 0.05$, C: Ice cream mix without polysaccharides, GG_1: Ice cream mix containing 0.025% guar gum, GG_2: Ice cream mix containing 0.05% guar gum, CSM_1: Ice cream mix containing 0.025% cress seed mucilage, CSM_2: Ice cream mix containing 0.05% cress seed mucilage, CSM_3: Ice cream mix containing 0.10% cress seed mucilage, FSM_1: Ice cream mix containing 0.025% flaxseed mucilage, FSM_2: Ice cream mix containing 0.05% flaxseed mucilage, FSM_3: Ice cream mix containing 0.10% flaxseed mucilage

difference was not significant (p>0.05). Such an effect was observed by Cheng *et al.* (2015) in the stability of ice cream model emulsions, SMP/GG mixed emulsions were distinguished by a higher rate of creaming compared to SMP/CMC mixed models with the same levels of polysaccharides (except for 0.1%).

Concerning to polysaccharide concentrations, protein load in ice cream mix decreased, as GG or CSM concentration increased (p>0.05). Langendorff *et al.* (2000) have reported that κ-Carrageenan is added in ice cream as a secondary stabilizing agent at levels lower than 0.05% to control phase separation. Addition of 0.10% GG caused the separation of the mix into two layers. Separated protein phase was observed by Goff *et al.* (1999) in solution containing both Locust Been Gum (LBG) and GG. These results could be attributed to because some polysaccharides (especially at higher concentrations) can be incompatible in solution with milk proteins, phase separation occur (Bahramparvar and Tehrani, 2011). Thaiudom and Goff (2003) reported that different gums have different effects on phase separation, for example, xanthan gum was the most incompatible with milk proteins, followed by guar gum and locust been gum. However, there was no significant difference in protein load in mix containing different concentrations of FSM (p>0.05).

Mix viscosity: The viscosity (CP) of ice cream mixes containing CSM or FSM compared with those containing GG or control mix are shown in Fig. 1. It can be observed that all ice cream mixes exhibit non-Newtonian and shear thinning (pseudoplastic) behaviors. These results are agreement with other researches as well (Farhoosh and Riazi, 2007; Karazhiyan *et al*., 2011). Also, addition of polysaccharides affected the viscosity behavior of ice cream mixes. In particular, the mix viscosity and shear thinning behavior increased by increasing the proportion of CSM, FSM and GG in ice cream mixes. A similar observation was found by Alakali *et al*. (2009), they reported that viscosity of ice cream mix increased, as local food binder (*Afzelia africana*, *Deuterium microcapum* and *Taro tuber*) concentrations increased. However, the ice cream mix containing 0.025% CMS exhibited higher viscosity than those containing GG or FSM at the same portion. At middle percentage of polysaccharides (0.05%), mix containing GG was higher in viscosity than those containing CSM or FSM. Inversely, ice cream mix containing 0.10% FSM exhibited higher viscosity compared with other treatments. The observed variations of the mix viscosity with both type and concentration of polysaccharides (CSM, FSM or GG) could be explained by the effect of sugar, proteins and salts on the functional properties of polysaccharides. For example, the intrinsic viscosity of CSM initially decreases as the concentration of sucrose and lactose increase to 20 and

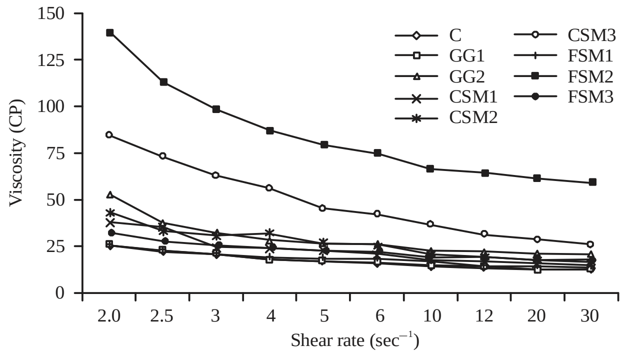

Fig. 1: Viscosity behavior of ice cream mixes containing cress seed mucilage or flaxseed mucilage compared with commercial guar gum. C, ice cream mix without polysaccharides, GG_1: Ice cream mix containing 0.025% guar gum, GG_2, ice cream mix containing 0.05% guar gum, CSM_1: Ice cream mix containing 0.025% cress seed mucilage, CSM_2,: Ice cream mix containing 0.05% cress seed mucilage, CSM_3: Ice cream mix containing 0.10% cress seed mucilage, FSM_1: Ice cream mix containing 0.025% flaxseed mucilage, FSM_2: Ice cream mix containing 0.05% flaxseed mucilage, FSM_3: Ice cream mix containing 0.10% flaxseed mucilage

5%, respectively. The decrease in the intrinsic viscosity could be due to either a reduction in solvent quality or a reduction in polymer/polymer association (Behrouzian *et al*., 2014). Whistler and BeMiller (1993) reported that the hydration rates of GG are reduced in the presence of dissolved salts and other water-binding agents such as sucrose. Also, in this respect, the hydrocolloid mixture (locust bean gum and CMC) with λ-carrageenan (LCG) presented higher viscosity values than ι-carrageenan (ICG) at the same proportion. However, mixtures with higher ICG proportion resulted in a softer texture enhancing melting properties; longer first drop time and lower melting rate (Pintor and Totosaus, 2012).

Whipping ability: Table 2 shows the whipping ability (increase the volume with the time) of ice cream mixes containing cress seed mucilage or flaxseed mucilage compared with control mix and that containing guar gum. The results revealed that control mix and that containing 0.025% FSM or CSM flowed by that containing 0.05% FSM showed the highest whipping ability after 5 min ($p<0.05$). Inversely, mix containing 0.025 or 0.05% GG and that containing 0.05 or 0.10% CSM as well as that containing 0.10% FSM presented the lower whipping ability ($p>0.05$) compared with other treatments. Such results were found by Camacho *et al*. (2001) in formulated cream with LBG/λ-carrageenan mixtures and by Adapa *et al*. (2000) in ice cream containing carbohydrate-based fat replacers. These results could be attributed to these mixtures had higher viscosity, which prevent air incorporation. High viscous systems do not favor foaming capacity but do favor foam stability (Stanley *et al*., 1996). Camacho *et al*. (2001) suggests that hydrocolloids cause kinetic hindrance to the cream foaming which could be due not only to the increase in the liquid-phase viscosity but also to stabilizer-protein interactions that could partially inhibit the foaming properties of milk proteins. Bahramparvar and Tehrani (2011) reported that addition of stabilizer reduced air cell size compared to a similar ice cream mix made without stabilizer. Changes in air cell size could be directly attributed to changes in rheological properties of the ice cream during freezing. As freezing commenced, the apparent viscosity increased, which caused a reduction in maximum air cell size due to the increased shear stress applied to disrupt the air cells. However, slight increased was observed in volume percentage of most ice cream mixtures after 10 min (p>0.05). Thereafter, no changes in the volume of most ice cream mixtures were observed during whipping time. Concerning polysaccharides types, the ice cream mixes containing GG showed lower whipping ability than those containing CSM and FSM at the same concentration.

Frozen ice cream

Overrun percentage: Ice cream is a complex systems consisting of air cells, ice crystals, fat globules partially coalesced a continuous aqueous phase in which the polysaccharides, proteins, lactose and mineral salts are dispersed (Marshall *et al*., 2003). Polysaccharides in ice cream are important due their effect on whipping ability and ice crystals structure formation. The results in Table 3 show that, addition of 0.025% FSM increased significantly (p<0.05) the overrun percentage as a compared to overrun of control ice cream and that containing GG. A similar but less marked, improvement of overrun was found when the same concentration of CSM was added, the difference was not significant (p>0.05). A similar trend was found by Akesowan (2008) in ice cream containing 0.27% konjac flour and 0.03% κ-carrageenan, who reported that hydrocolloids enhance emulsion stability binding free water, increase viscosity and overrun improving air incorporation. These results could be attributed to FSM and CSM improved the mix viscosity, stabilize the protein in the mix, create stable foam with easy cutoff and stiffness at the barrel and freezer for packaging and inhibited air cell coarsening (Chang and Hartel, 2002; Marshall *et al*., 2003). Bahramparvar and Tehrani (2011) reported that increasing ice cream volume is one role of stabilizers, brought about through increasing viscosity and maintaining the air bubbles. Marshall and Arbuckle (1996) reported that air cells in ice cream are stabilized by surface active components such as proteins, phospholipids and stabilizers. However, there was no significant difference in overrun percentage in ice cream containing 0.025% GG compared with control ice cream (p>0.05).

At higher concentrations, addition of 0.05 or 0.10% CSM or FSM% had no significant effect on the overrun percentage, even if the overrun percentage was numerically higher than that in control ice cream. Such an effect was found by Chang and Hartel (2002) in ice cream containing different stabilizer levels (0, 0.3 and 0.5%), which contained 12% carrageenan, 33% guar gum and 55% CMC. Inversely, addition of 0.05% GG had adverse effect on the overrun of resultant ice cream compared with control ice cream; the difference was not significant (p>0.05). The negative impact of with high concentrations of polysaccharides on overrun percentage may be due to an increase in the viscosity of the ice cream mixtures. Marshall *et al*. (2003) reported, as the viscosity increases, the resistance to melting and the smoothness of texture increases but the rate of whipping decreases. Finally, it can be concluded that the volume increase (overrun) requires a certain level of viscosity depends on the type and proportions of ingredients in the ice cream mixture.

Hardness of ice cream: Hardness of ice cream as affect by addition of polysaccharides (CSM, FSM and GG) is presented in Table 3. The results show that the hardness of control ice cream was the highest compared with those containing polysaccharides. Also, as a concentration of CSM, FSM and GG increased, the hardness of frozen ice cream decreased. However, the difference being significant only in ice cream containing 0.05% GG, 0.10% CSM and that containing both 0.05 and 0.10% FSM compared with control ice cream (p<0.05). The decrease in hardness was found to be similar in ice cream containing hydrocolloids mixtures containing LBG and

Table 3: Overrun and hardness of ice cream containing cress seed mucilage or flaxseed mucilage compared with commercial guar gum

	Physical properties of frozen ice cream	
Ice cream mixes-base treatments	Overrun (%)	Hardness (kg cm^{-2})
C	46.75±2.15^{BC}	3.22±0.16^{A}
GG_1	48.53±3.50^{BC}	3.02±0.07^{AB}
GG_2	40.33±1.75^{C}	2.62±0.17^{BC}
CSM_1	53.30±2.62^{AB}	3.05±0.13^{AB}
CSM_2	49.33±2.25^{B}	2.92±0.21^{ABC}
CSM_3	51.50±2.73^{B}	2.42±0.16^{C}
FSM_1	60.63±2.40^{A}	2.72±0.21^{ABC}
FSM_2	51.00±1.95^{B}	2.57±0.20^{BC}
FSM_3	50.00±3.00^{B}	2.60±0.11^{BC}

Means±SE, (n = 3) with the same capital letters in the same column are not significantly different at $p \leq 0.05$, C: Ice cream mix without polysaccharides, GG_1: Ice cream containing 0.025% guar gum, GG_2: Ice cream containing 0.05% guar gum, CSM_1: Ice cream containing 0.025% cress seed mucilage, CSM_2: Ice cream containing 0.05% cress seed mucilage, CSM_3: Ice cream containing 0.10% cress seed mucilage, FSM_1: Ice cream containing 0.025% flaxseed mucilage, FSM_2: Ice cream containing 0.05% flaxseed mucilage, FSM_3: Ice cream containing 0.10% flaxseed mucilage

CMC with LCG (presented higher viscosity) than those containing LBG and CMC with ICG at same proportions (Pintor and Totosaus, 2012) and in ice milk containing modified starch or waxy maize (Abd El-Aziz *et al*., 2004). The decreasing in the hardness may be negatively correlated with both mix viscosity and overrun percentage. The increase in viscosity may inhibit the development of iciness in frozen dairy dessert. This owing to the concentration of the unfrozen phase in the lamellae may increase sufficiently to decrease the movement of water molecules and thus, limit ice crystal growth (Schmidt and Smith, 1992). Flores and Goff (1999) demonstrated that milk proteins had a large impact on texture by limiting ice crystal size and enhancing their stability when in the presence of polysaccharides. In addition, the increase in overrun percentage retards growth of ice crystals. Hartel (1996) observed coarser ice crystals in ice cream at low overrun percentage than in the same ice cream made at high overrun. Moeenfard and Tehrani (2008) found that ice creams with lower overruns were harder than those made with high overrun but melted more rapidly. Microscopy, the initial ice crystal size and the rate of growth after 24 weeks of storage at abusive temperatures were smaller in stabilized ice creams than in un-stabilized ice creams (Goff *et al*., 1993).

Meltdown of frozen ice cream: The slow meltdown, slow serum drainage, good shape retention and slower foam collapse are some of the desired important quality parameters of ice cream (Goff *et al*., 1993). Table 4 shows the meltdown of frozen ice cream (g/100 g) containing CSM or FSM compared with that containing GG or control ice cream. After 10 min, addition of CSM, FSM and GG had no significant effect on the amount of melted ice cream compared with control ice cream except that containing 0.025 CSM, which had the lowest melted ice cream ($p<0.05$). After 20 min onward, the amount of melted ice cream was lower significantly in that containing 0.025% CSM, 0.05% GG or 0.05% FSM compared with control ice cream ($p<0.05$). These results are agreement with those found by other researchers as well (Moeenfard and Tehrani, 2008; Alakali *et al*., 2009). Melting resistant increased as mix viscosity, fat destabilization, ice crystal size and overrun increased (Muse and Hartel, 2004; Badawi *et al.,* 2002). Sofjan and Hartel (2004) found that ice creams with low overruns melted quickly, whereas ice creams with high overruns began to melt slowly and had a good melting resistance. This slower melting rate in the ice creams with high overruns was attributed to a reduced rate of heat transfer due to a larger volume of air.

Table 4: Meltdown of frozen ice cream containing guar gum, cress seed mucilage or flaxseed mucilage

	Meltdown of frozen ice cream (g/100 g)			
Ice cream-base treatments	10 min	20 min	30 min	40 min
C	3.5±0.73^{A}	15.3±0.75^{A}	24.3±2.01^{AB}	29.5±3.01^{AB}
GG_1	4.1±0.59^{A}	13.1±0.71^{AB}	23.2±1.47^{AB}	31.1±1.08^{A}
GG_2	3.1±0.69^{A}	9.2±0.69^{C}	17.2±0.59^{C}	24.3±1.22^{B}
CSM_1	0.7±0.12^{B}	03.3±0.48^{D}	08.0±0.91^{E}	12.3±0.75^{C}
CSM_2	4.1±0.61^{A}	13.7±0.31^{AB}	22.1±1.18^{B}	28.6±0.22^{AB}
CSM_3	3.7±0.83^{A}	12.2±1.61^{B}	19.5±1.25^{BC}	25.2±3.02^{AB}
FSM_1	3.5 ±0.66^{A}	12.7±1.50^{AB}	22.2±1.54^{B}	28.5±1.65^{AB}
FSM_2	4.0±0.50^{A}	15.1±0.85^{A}	26.7±1.71^{A}	29.7±1.65^{AB}
FSM_3	2.3±0.70^{AB}	7.5±1.19^{C}	11.8±1.37^{D}	14.8±1.08^{C}

Means±SE, (n = 3) with the same letters in the same column are not significantly different at $p \leq 0.05$, C: Ice cream mix without polysaccharides, GG_1: Ice cream containing 0.025% guar gum, GG_2: Ice cream containing 0.05% guar gum; CSM_1: Ice cream containing 0.025% cress seed mucilage, CSM_2: Ice cream containing 0.05% cress seed mucilage, CSM_3: Ice cream containing 0.10% cress seed mucilage, FSM_1: Ice cream containing 0.025% flaxseed mucilage, FSM_2: Ice cream containing 0.05% flaxseed mucilage, FSM_3: Ice cream containing 0.10% flaxseed mucilage

Table 5: Sensory properties of frozen ice cream containing guar gum, cress seed mucilage or flaxseed mucilage

	Sensory properties of frozen ice milk				
Ice cream-base treatments	Appearance (10)	Melting quality (10)	Body and texture (30)	Flavour (50)	Total scores (100)
C	8.0±0.33^{A}	6.9±0.67^{A}	23.4±1.42^{A}	45.0±0.92^{A}	83.3±1.58^{A}
GG_1	8.0±0.53^{A}	7.0±0.46^{A}	25.5±0.95^{A}	45.0±1.00^{A}	85.5±1.47^{A}
GG_2	8.1±0.26^{A}	7.8±0.53^{A}	26.0±1.13^{A}	45.6±0.84^{A}	87.5±1.84^{A}
CSM_1	8.5±0.38^{A}	7.5±0.42^{A}	26.1±1.02^{A}	45.8±1.25^{A}	87.9±1.43^{A}
CSM_2	8.4±0.32^{A}	7.6±0.32^{A}	25.6±0.80^{A}	45.9±0.93^{A}	87.5±2.03^{A}
CSM_3	8.4±0.37^{A}	7.5±0.38^{A}	24.8±1.00^{A}	45.4±1.35^{A}	86.0±2.04^{A}
FSM_1	8.5±0.5^{A}	7.4±0.75^{A}	25.0±1.10^{A}	46.8±0.84^{A}	87.6±2.98^{A}
FSM_2	7.9±0.48^{A}	7.4±0.60^{A}	25.1±1.52^{A}	46.1±0.98^{A}	86.5±2.07^{A}
FSM_3	7.5±0.57^{A}	7.5±0.63^{A}	24.9±1.32^{A}	45.6±1.34^{A}	85.5±1.49^{A}

Means±SE, (n = 3) with the same letters in the same column are not significantly different at $p \leq 0.05$, C: Ice cream mix without polysaccharides, GG_1: Ice cream containing 0.025% guar gum, GG_2: Ice cream containing 0.05% guar gum, CSM_1: Ice cream containing 0.025% cress seed mucilage, CSM_2: Ice cream containing 0.05% cress seed mucilage, CSM_3: Ice cream containing 0.10% cress seed mucilage, FSM_1: Ice cream containing 0.025% flaxseed mucilage, FSM_2: Ice cream containing 0.05% flaxseed mucilage, FSM_3: Ice cream containing 0.10% flaxseed mucilage

Sensory properties of frozen ice cream: The sensory properties of ice cream containing GG, CSM or FSM are presented in Table 5. In general, addition of different levels of GG, CSM or FSM had no significant effect on all sensory parameters of resultant ice cream ($p<0.05$) compared control ice cream. However, slight improvement in both melting quality and body and texture of all frozen ice cream containing GG, CSM or FSM was observed. Also, frozen ice cream containing 0.05% GG or 0.025% CSM gained the highest score, which characterized with more smoothness and creaminess compared with other treatments. These results are agreement with those reported by Rincon *et al*. (2006) and BahramParvar *et al*. (2010). The improvement in melting quality and body and texture could be attributed to the increase in viscosity and/or overrun, which inhibits the development of iciness in frozen ice cream (Schmidt and Smith, 1992) and melted relatively slowly in the mouth (Ohmes *et al*., 1998; Baer *et al*., 1999). Donhowe *et al*. (1991) reported that stabilizers decrease the icy sensation via their influence on re-crystallization and sensory perception of ice crystals.

CONCLUSION

The functional properties of polysaccharides in the in ice cream depend on the source of polysaccharides and polysaccharides concentrations. For example, ice cream mix containing 0.025%

CSM exhibited the higher apparent viscosity compared with that containing GG or FSM while that containing 0.05% GG exhibited the higher apparent viscosity compared with that containing CSM or FSM at the same potion. All ice cream mixes exhibited shear-thinning behavior, which increased by increasing the proportion of GG, CSM and FSM Addition of 0.025% FSM, CSM or commercial GG was the best percentage to improve the physical and sensorial properties of resultant ice cream.

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