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The influence of basil seed gum, guar gum and their blend on the rheological, physical and sensory properties of low fat ice cream

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ABSTRACT

In the present paper, the functionality of basil seed gum (BSG), guar gum (GG) & their blend (MGB, 50:50), at the concentration of 0.35, 0.45, 0.50 and 0.55%, related to the rheological, physical and sensory characteristics of low fat ice cream (2.5% fat) was compared with full fat sample (10%) as control. Shear thinning and thixotropic behaviors of all mixes were well described by Herschel–Bulkley and second-order structural kinetic models, respectively. The results showed that BSG and MGB, by producing high consistency coefficient (k), yield stress (τ_0), thixotropy rate constant (k), extent of thixotropy (η_0/η_∞) and low flow behavior index (n) values, provided satisfactory rheological properties in low fat ice cream. Fat reduction resulted in some defects which to some extent compensated by increasing levels of fat replacers. BSG & MGB exhibited a more shear-sensitive thixotropic nature than GG mixes and strongly favored perception of creaminess which was more than full fat mixes in some concentrations. In addition, they depressed the coldness and coarseness perception of low fat mixes. Addition of BSG reduced the meltdown rate and extent of melting at all concentration compared to the GG and MGB mixes, which two latter gum systems showed almost equal value of these properties. Furthermore, significant correlation between the values of melting rate data and rate of breakdown parameters of the mixes was observed. The results presented herein showed that BSG and its blend with GG are very suitable fat replacers/stabilizers for low fat ice cream.

1. Introduction

Recently, health-conscious consumers have focused on low-fat products. Accordingly, the food industry is facing the challenge of probing for new alternatives for fat without any quality loss. Ice cream is a three-component foam system consists of a network of fat globules and ice crystals in a highly viscous aqueous phase (Prentice, 1992). Milk fat has very important functions, such as it melts and crystallizes, is unctuous, depresses the cold sensation, contributes desirable flavor, is a solvent for added flavors, adds structure to ice cream and is the principal explanation for dryness of ice cream at extrusion (Goff, 2008). Ice cream manufacturers have replaced the fat in mixes and the largest numbers of fat replacers are carbohydrate-based, belong to hydrocolloids which are capable of interacting with water and their functionalities such as thickening, gelling, and emulsifying properties allow them to mimic the mouth-feel and flow properties in a manner like to that of fat globules in aqueous systems (Lim, Inglett, & Lee, 2010). Natural gums possess benefits more than synthetic ones because of their lack of toxicity, low cost and availability (Sohail, Huma, Mehmood, Abdullah, & Shah, 2014).

Derived from guar (*Cyamopsis tetragonoloba*) seeds (GG), with linear chains of beta-1,4-D-galactomannans with alpha 1,6-linked D-galactose, is used as a thickener and stabilizer in ice cream and boosts the body, texture, and heat-shock resistance by binding free water (Wielinga, 2000).

Ocimum basilicum L. is a pharmaceutical endemic plant in Iran and grows in different regions of Asia, Africa and Central and South America (Hosseini-Parvar, Mortazavi, Razavi, Matia-Merino, & Goh, 2010). The basil seed gum (BSG) has been optimally extracted and its rheological properties characterized by Razavi et al. (2009) and Hosseini-Parvar et al. (2010), respectively. The major fractions of BSG polysaccharides are glucomannan (43%) and (1–4)-linked xylan (24.29%), and a minor fraction of glucan (2.31%) with a small fraction of protein (1.32% wt/wt). 12.1–19.5% uronic acids in *O. basilicum* species could donate typical polyelectrolyte behavior

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to the extract (Azoma & Sakamoto, 2003). BSG as surface-active polysaccharides can act both as emulsifiers and stabilizers in many cases (Hosseini-Parvar, Matia-Merino, & Golding, 2015). The presence of higher zero-shear viscosity and yield stress than xanthan, konjac and guar gum, high pseudoplastic behavior and heat-resistant nature of BSG could qualify it as a good stabilizer in some food formulations (Hosseini-Parvar, 2009; Hosseini-Parvar et al., 2010). The literature shows that BSG could be an alternative for some of the commercial stabilizers and improve the quality and diversity of ice cream and other food products (BahramParvar & Goff, 2013; BahramParvar, Razavi, & Mazaheri Tehrani, 2012; Hosseini-Parvar et al., 2010). BahramParvar et al. (2012) concluded that satisfactory effects of BSG on apparent viscosity of ice cream mix, draw temperature, meltdown behavior, and total acceptance make it a good stabilizer in a typical fresh ice cream. BSG is able to reduce ice crystal growth and induce changes in the colloidal structure of the ice cream, particularly the fat and air structures (BahramParvar & Goff, 2013).

As it is always difficult to provide all the properties of ice cream using a single stabilizer, combination of two or three hydrocolloids in ice cream mix may result in synergistic effects (Clarke, 2004). The amount and kind of stabilizer required in ice cream formulation depend on the type of stabilizer, strength of the stabilizer, total solids and fat level of the mix, and many other factors (Bahramparvar & Mazaheri Tehrani, 2011). The literature shows there is no report related to the application of BSG as a fat replacer in low fat ice cream, so the objective of the present work was to evaluate the effects of guar gum (as a commercial hydrocolloid), basil seed gum (as a novel hydrocolloid) and their interaction (50:50) at different concentrations on the rheological, textural, physical and sensory properties of vanilla low fat ice cream (2.5% fat) compared to regular ice cream (10% fat).

2. Materials and methods

2.1. Samples preparation

The ice cream mixes were prepared based on the following formulations: 2.5% (low fat) or 10% (full fat) milk fat (provided as homogenized/pasteurized cream-25% fat by Pegah Dairy industry Co., Mashhad, Iran), 11% non-fat milk powder (Zarrin Shad Food Industries Co., Esfahan, Iran); 15% sugar and 0.1% vanilla (purchased from local markets), 0.15% emulsifier (E_{471} mono and diglyceride, Beldem Food Industries Co., Dilbeek, Belgium) and 0.35%, 0.45%, 0.50% & 0.55% selected gums (guar gum (Rhodia Co, Germany)), basil seed gum (obtained at the optimized conditions suggested by Razavi et al. (2009) and their mixture (MGB) in the ratio of 50:50). Full fat sample (10%) with 0.35% selected gums was considered as control. Firstly, to impede the lumps in the mix, the selected fat replacers were mixed with sugar prior to their addition to the mother mix. After that, liquid materials including milk and cream were mixed and warmed up to 50 °C, then dry ingredients were mixed thoroughly, dispersed under agitation into the liquid materials using a lab mixer (Model SM-65, Sunny, Germany), pasteurized at 80 °C for 25 s (HTST), homogenized at 23,000 rpm for 2 min (Ultra Turrax T25D IKA, Germany), cooled rapidly to 5 °C and then aged at constant temperature overnight (12 h) at 5 °C. The aged mixes were gently blended with vanilla extract and the freezing was carried out in a batch soft ice cream maker (Model IC 100, Feller Technologic GmbH, Dusseldorf, Germany). Required freezing time for the different mixes was 30 ± 5 min. After drawing, soft ice creams were collected into lidded plastic containers, coded and stored in a chest freezer (−18 °C) for about 24 h.

2.2. Rheological measurement

The steady shear flow behavior of the ice cream mixes were determined using a rotational viscometer (Bohlin Model Visco88; Bohlin Instruments, UK) equipped with a heating circulator (Julabo, Model F12-MC; JulaboLabortechnik, Seelbach, Germany) at 5 ± 0.1 °C.

2.2.1. Time-dependent properties

Samples were sheared at a constant shear rate (150 s^{-1}) and the shear stress (τ, Pa) was recorded as a function of shearing time (t, min) until shear stress reached to steady state. The time dependency of mixes was investigated using structural kinetic model (Abu-Jdayil, 2003):

$$\left[\frac{\eta-\eta_\infty}{\eta_0-\eta_\infty}\right]^{1-n} = (n-1)\times kt + 1 \qquad (1)$$

where, η_0 (Pa.s) is the initial apparent viscosity at t = 0 (structured state), and η_∞ (Pa.s) is the steady state apparent viscosity at $t\rightarrow\infty$ (nonstructured state). n and k are the order of the structure breakdown order and the breakdown rate constant, respectively. In this paper, the second-order ($n = 2$) was used to describe the structural breakdown kinetic of samples.

2.2.2. Time-independent properties

To eliminate the time dependency, prior to measurement, the adequate samples were placed into C14 cup/bob geometry and allowed to equilibrate at 5 °C and 150 s^{-1} for 120 s. The apparent viscosity of ice cream mixes were calculated at a shear rate of 50 s^{-1} which is an effective oral shear rate (BahramParvar & Goff, 2013) and sheared at a logarithmically increasing scale from 14.4 to 600 s^{-1} during 17.5 min and the viscous flow behavior data was described by Herschel–Bulkley model (Steffe, 1996):

$$\tau = \tau_0 + k\dot{\gamma}^n \qquad (2)$$

where, τ_0 is the Herschel–Bulkley (H–B) yield stress (Pa), k is the H–B consistency coefficient ($Pa.s^n$), and n is the H–B flow behavior index (dimensionless).

2.2.3. Concentration dependency

The concentration dependency of the apparent viscosity and Herschel–Bulkley model parameters of ice cream mixes were evaluated by using power model (Eqn. (3)) (Rao, 1999):

$$y = a_1 C^{b1} \qquad (3)$$

where, a_1 and b_1 are constants.

2.3. Instrumental texture analysis

Mechanical properties were evaluated on hardened ice creams (−18 °C for 24 h). Penetration test with the penetration depth (deformation as target value) of 15 mm at the test speed of 2 mm s^{-1} was conducted at room temperature using a texture analyzer (CNS Farnell Co, UK) equipped with a 6-mm diameter stainless steel cylindrical probe, based on the modified method recommended by BahramParvar, Mazaheri Tehrani, and Razavi (2013). Two parameters including hardness (the peak compression force (N) during the penetration of the sample), adhesiveness (the negative surface area (N.s) during withdrawal) were determined from the force-deformation data.