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The effect of gum tragacanth on the rheological properties of salep based ice cream mix

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ABSTRACT

The influence of concentration (0–0.5%, w/w) of gum tragacanth (GT) on thixotropy, dynamic, and creep-recovery rheological properties of ice cream mixes prepared with milk or water based were investigated. These properties were used to evaluate the viscoelastic behavior and internal structure of ice cream network. The textural properties of ice cream were also evaluated. Thixotropy values of samples were reduced by increasing GT concentration. The dynamic and creep-recovery analyses exhibited that GT addition increased both ice cream elastic and viscous behaviors. The increasing of Burger's model parameters with GT concentration indicated higher resistance network to the stress and more elastic behavior of samples. The applying of Cox–Merz rule is possible by using shift factor (α). GT also led to an increase in Young's modulus and the stickiness of ice creams. The obtained results highlighted the possible application of GT as a valuable member to promote structural properties of ice cream.

1. Introduction

Ice cream is a complex frozen dairy product which is manufactured by freezing a mix and then consumed in frozen state. Processing steps for making ice cream compose of two distinct stages: mix manufacture and freezing operation (Goff, 1997). Stabilizers are the indispensable components which provide a smooth texture by preventing the formation of large ices and lactose crystals in mixes during processing and storage (Tasneem, Siddique, Ahmad, & Farooq, 2014; Varela, Pintor, & Fiszman, 2014). The composition of commercial ice cream has been regulated in Turkey (Number:2004/45, 2005) and one of the type of offering ice cream to the market is Kahramanmaraş which is traditional ice cream consist of milk, sugar and salep. The high sugar content and natural flavor due to salep addition are the characteristic properties and its differences from common ice cream. The local hydrocolloids such as salep glucomannan has been used in ice creams at a concentration of 0.7–1% in Turkey and Iran (Bahramparvar & Tehrani, 2011; Guven, Karaca, & Kacar, 2003). Salep is obtained from roots or tubers of orchids. Glucomannan is the main component of this gum. Salep has been found more applications as stabilizers and traditional beverages. The film forming properties of salep was also reported (Kurt & Kahyaoglu, 2014). The natural plant exudate gum tragacanth (GT) is obtained from stems and branches of *Astragalus* species. It is a very complex heterogeneous anionic branched polysaccharide with a high molecular weight (about 8.4×10^5 Da) and has been widely used as a stabilizer, thickener and emulsifier in the food system for many years (Balaghi, Mohammadifar, Zargaraan, Gavlighi, & Mohammadi, 2011; Karimi & Mohammadifar, 2014).

It is also stated that using mixed combinations of hydrocolloids in ice creams provide more possibilities to control the properties of the ice cream compared to the use of single stabilizer (Bahramparvar & Tehrani, 2011; Haghighimanesh & Farahnaky, 2011). Alternative stabilizers to salep have been searched due to its high retailing prices and the danger posed by the possibility of the extinction of Orchids plants. On the other hand, salep consumption is not given up easily due to its characteristic flavor in ice creams (Guven et al., 2003; Tekinsen & Guner, 2010; Yasar, Kahyaoglu, & Sahan, 2009). Therefore, a better understanding about mixed systems with a reduced usage of salep will be important and a main target of this study. An optimized combination of salep with another adequate hydrocolloid, like tragacanth for example, will open the possibility to establish an ice cream production with ecological and economic benefits. The study replacing salep gum with other hydrocolloids such as Balangu seed gum,

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carboxymethylcellulose, locust bean gum, guar gum, sodium alginate and carrageenan were reported (BahramParvar, Razavi, & Khodaparast, 2010; Guven et al., 2003).

Making ice cream with minimum energy requirement and preserving the structural properties against deformation by using proper hydrocolloid(s) are some of the aims during the ice cream production process. The flow properties and viscosity of the ice cream mix affect the heat transfer in the food system as well as the mixing efficiency. The ice cream mix is also exposed to mechanical deformation during cooling and develops a structure responding to the conditions of this treatment (Marcotte, Hoshahili, & Ramaswamy, 2001; Yang, Irudayaraj, Otgonchimeg, & Walsh, 2004). Thus the information about flow properties of mixes helps to determine the parameters of applied unit operations and gives information about structural properties of the system. Rheological analysis also provides information on the type of interaction between the conformation and functional properties of molecules and biopolymers (Innocente, Biasutti, Venir, Spaziani, & Marchesini, 2009).

The main objective of this study was to evaluate the effect of GT addition on the rheological properties of ice cream mixes. For this aim, thixotropic behaviors, dynamic shear and creep-recovery tests were performed to evaluate viscoelastic behaviors and internal structure of ice cream mixes based on milk or water. Textural properties of ice creams were also investigated to observe structural improvements.

2. Materials and methods

2.1. Materials

Dried and finely grounded salep roots (moisture: 12.49% (w/w), ash: 2.08%, protein: 3.59% determined (AOAC, 1985)) were kindly donated by Özlem Patisserie (Muğla, Turkey). Gum tragacanth (grain thickness: 60 mesh; pH 5–7 (at 1% concentration); ash: 3.7%; moisture: <12%, viscosity: 5000–5500 cP (determined for 2% concentration at 25 °C by using the Brookfield viscometer spindle No: 3 at 20 rpm) as reported by the supplier) was kindly donated by Incom (Mersin, Turkey). Ultra-high-temperature (UHT) milk and sucrose were purchased from a local market in Samsun, Turkey.

2.2. Preparation of ice cream mixes

Ice cream model mixes were prepared in accordance with the traditional ice cream mixture including just sugar, salep and milk (Kaya & Tekin, 2001; Kus, Altan, & Kaya, 2005). The mixes were also prepared with water instead of milk to observe the effects on flow behavior. Since the aim of this study was to research the effect of gum tragacanth on the rheological properties of ice cream mixes, the concentration of sugar was kept constant at 22% (w/w). Gum tragacanth (GT) and salep glucomannan (SG) ratio 0:1, 0.25:0.75 and 0.5:0.5% was adjusted to get a constant concentration 1% (w/w). Due to the taste deficiency (observed with preliminary tests) the more GT concentrations has not been considered to preserve the effect of salep glucomannan on the taste of end product. The required amount of dry GT and SG was mixed with 3.2% of the total amount of sugar in the final mix before adding it to the mother mix not to allow the forming of lumps in the mixes. The rest of sugar was dissolved in 60% (w/w) of the total amount of milk or water, and the mixture was heated to 50 °C followed by the addition of the prepared gum-sugar mixes. After adjusting the final volume (400 mL) by adding the rest of milk or water, the mixtures were pasteurized at 85 °C for 1 min with constant vigorous stirring. Then, the mixes were rapidly cooled down to +4 °C and stored at this temperature for 24 h until the rheological experiments. Textural experiments were done for ice creams which were obtained from whipped and frozen mixes (400 g) by using a batch ice cream-maker machine (Delonghi, ICK 5000, China) of 700 g capacity and without any additional aeration source for a fixed time of 20 min. The temperature of soft ice creams was −7 ± 1 °C at the end of freezing via refrigerant R134a. Ice cream samples were produced in triplicate.

2.3. Physicochemical analyses of ice creams

Total solid content of samples was determined by drying at 105 ± 2 °C for 4 h using an air oven. Milk fat content of the ice cream was determined using the Gerber method. pH values of ice cream mixes were measured with pH meter (Eutech Instruments, pH 700, Singapore) at −8 °C. Titratable acidity was determined by titrating melted ice cream samples with 0.1 N sodium hydroxide (NaOH) using phenolphthalein as indicator and expressed as percent of lactic acid. Overruns were measured according to the proportion of ice cream to the volume of mix (Karaca, Guven, Yasar, Kaya, & Kahyaoglu, 2009). To determine first dripping (second) and melting rate (g/min) 25 g of ice creams samples were left to melt (at room temperature, 20 °C) on a 0.14-mm wire mesh screen above a preweighed beaker and the beaker was recorded at 10-min time intervals for 60-min. Ice cream samples were subjected to color measurement using a Colorflex, EZ (Hunter associates laboratory, USA). The color of the samples was expressed as L^*-value (lightness), a^*-value (redness/greenness) and b^*-value (yellowness/blueness). Three measurements were taken per single sample and the average was calculated.

2.4. Rheological properties of ice cream mixes

The rheological measurements of the ice cream mixes were made with a rheometer (HAAKE Mars III; Thermo Scientific, Germany) with a cone and plate geometry (diameter: 35 mm, cone angle: 2°). All the time dependent and viscoelastic (dynamic) and creep-recovery properties were determined at +4 °C in triplicate for each sample.

2.4.1. Time-dependent rheological behavior

The flow curves were obtained by registering shear stress at shear rates from 1 to 100 s^{-1} (forward) in 150 s and down in 150 s from 100 to 1 s^{-1} (backward). Thixotropic areas, A_t were obtained using data acquisitions software. The A_t values were calculated using the equation as (Karasu, Toker, Yilmaz, Karaman, & Dertli, 2015)

$$A_t = \frac{(A_{\text{up}} - A_{\text{down}})}{A_{\text{up}}} \times 100 \tag{1}$$

where A_{up} and A_{down} are the areas (Pa/s) under ascending and descending flow curves (by fitting the Ostwald–de Waele model), respectively.

2.4.2. Dynamic rheological analysis

Oscillatory (dynamic) tests were conducted for all samples from 0.1 to 10 Hz at 0.2 Pa (in the linear viscoelastic range assessed by the stress sweep test). The samples were allowed to rest for 2 min after loading. In these tests, the storage (G'), loss (G'') modulus (Pa), and tan $\delta(G''/G')$ were computed from raw data.

Correlations between the values of dynamic and steady shear parameters were evaluated by using the Cox–Merz rule. Cox–Merz rule implies that the apparent viscosity (η) at a specific shear rate ($\dot{\gamma}$) is equal to the complex viscosity (η^*) at a specific angular velocity(ω), when $\gamma = \omega$ (Eq. (2))

$$\eta * (\omega) = \eta(\dot{\gamma})_{|\omega=\dot{\gamma}} \tag{2}$$