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Original article

Optimising the ice cream formulation using basil seed gum (*Ocimum basilicum* L.) as a novel stabiliser to deliver improved processing quality

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Summary Mixture design was used to determine the optimum ratio as well as concentration of basil seed gum (BSG), guar gum (GG) and carboxymethyl cellulose (CMC) in the formulation of ice cream stabilisers. Predicted equations and contour plots of physicochemical responses were also generated. Generally, increasing the ratio of BSG in gums mixture increased the apparent viscosity of ice cream mixes and decreased the melting rate. Increasing the proportion of GG at concentration of 0.35% enhanced overrun of samples. High ratios of BSG at concentration of 0.35% and CMC at concentration of 0.15% increased the fat destabilisation in ice creams. Combination of 84.31% BSG and 15.69% CMC at concentration of 0.35% proposed as optimum formulation which verified in practice. Introducing BSG as a novel source of stabiliser could be promising as alternative and improve the quality and diversity of ice cream and related products.

Keywords Frozen dessert, mixture design, optimisation, response surface methodology, stabiliser.

Introduction

Stabilisers are added to ice cream formulation to gain some purposes such as increase in viscosity, smoothness production in body and texture, reduction in ice and lactose crystal growth during storage, providing some degree of shape retention during melting and enhancement in air entrapment (BahramParvar & Mazaheri Tehrani, 2011).

A variety of substances such as gelatin, guar gum (GG), carboxymethyl cellulose (CMC), locust bean gum, carrageenan, microcrystalline cellulose, xanthan and alginates have been used as ice cream stabiliser. In addition, some local hydrocolloids including Salep or Balangu seed gum have been applied in ice cream (BahramParvar & Mazaheri Tehrani, 2011). Nowadays, commercial stabiliser blends are commonly used by most ice cream manufacturers. Despite these components, attempt to find new sources of hydrocolloids for different applications as well as new combinations of these polysaccharide gums is still continued (Marshall *et al*., 2003).

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Ocimum basilicum L. with vernacular name of basil (Reihan or Reyhan) is one of the endemic plants in Iran and is cultivated and used as an herb plant. Its seed, when soaked in water, swells into a gelatinous mass which has reasonable amounts of gum (Razavi *et al*., 2009). It has been reported that the polysaccharide extracted from basil seed comprise of two major fractions of glucomannan (43%) and (1→4)-linked xylan (24.29%) and a minor fraction of glucan (2.31%). Presence of highly branched arabinogalactan in addition to glucomannan and (1→4)-linked xylan has also been shown (Hosseini-Parvar *et al*., 2010). Suitable functionality of this gum in model systems has been recently proved (Hosseini-Parvar *et al*., 2010; BahramParvar & Razavi, 2012).

Nowadays, multivariate methodologies, such as mixture design, Box–Behnken design and response surface design, are commonly used in optimisation processes (Santos *et al*., 2009). These statistical methods define quantitative relations between variables and responses, covering the entire experimental range tested and including the interactions when they are present (Mastromatteo *et al*., 2009). In addition, these procedures are faster, more economical and efficient, and permit more than one variable to be optimised simultaneously (Santos *et al*., 2009).

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Literature review shows that there are not any published data about the application of simplex-centroid mixture design in optimisation of formulation for ice cream stabilisers. Moreover, there is not any study about the application of Iranian novel sources of hydrocolloid in ice cream stabiliser blends. We have recently studied the rheological interaction between three hydrocolloids that two of them were commercial (GG and CMC) and the other one was novel [basil seed gum (BSG)]. Moreover, effects of addition of some key ice cream constituents, that is, sugar, skim milk and emulsifier, on the rheological properties were determined (BahramParvar & Razavi, 2012). As an extension of our previous work, the aim of this study was to optimise an ice cream stabilisers formulation by means of these hydrocolloids using mixture design method. Moreover, to our knowledge, it is the first time that BSG has been used as ice cream stabiliser.

Materials and methods

Materials

Homogenised UHT milk with 3% fat and homogenised–pasteurised cream with 30% fat were obtained from Pegah Dairy Industry Co, Mashhad, Iran. Skim milk powder was purchased from Multi Milk Powder Industry Co, Mashhad, Iran. Sugar and vanilla (vanillin 100%; Polar Bear Brand, Shanghai, China) were prepared from local confectionary market. CMC and GGs and emulsifier E471 (Multec Mono 9402 sfp) were supplied by Sunrose (Mashhad, Iran), Rhodia (Paris, France) and Puratus (Grand-Bigard, Belgium) Companies, respectively. Powder of BSG was prepared according to the work done by Razavi *et al.* (2009).

Methods

Sample preparation

Ice cream formulations consisted of 10% fat, 11% milk solid nonfat (MSNF), 15% sucrose, 0.1% vanilla, 0.15% emulsifier and 0.15% or 0.35% stabiliser. Fluid milk and cream were mixed and warmed up to 50 °C. Then, preblended dry ingredients were added and mixed (Moulinex mixer; Model R10, Moulinex, France) for approximately 3 min prior to pasteurisation (80 °C for 25 s) and homogenisation at required speed (17 000–22 000 rpm) for 1 min (Ultra Turax T-25; IKA Instruments, Konigswinter, Germany). The mixes were cooled and aged overnight at 4 °C before freezing in a batch freezer (Feller ice cream maker, Model IC 100; Feller Technologic GmbH, Dusseldorf, Germany) for 30 min. Ice creams were collected in 50-mL lidded plastic containers and hardened to −18 °C within 24 h after freezing. Physicochemical analyses were done on the hardened samples.

Experimental design

The simplex-centroid mixture design was used to investigate the effect of different ratios of three hydrocolloids including BSG, CMC and GG, at two concentration levels. All the mixtures in the simplex design must have the same final weight (BSG + CMC + GG = 100) (Chen *et al.*, 2010). As shown in Table 1, the experimental design was composed of ten combinations: three pure mixtures, one for each component; three binary blends, one for each possible two-component blend; three complete blends where all three components are included in these blends, but not in equal proportions; one centre point (or centroid) where equal ratios of all three components are included in this mixture. In the case of three components, the factorial space constituted by all the possible fractions of the components is triangle whose vertices correspond to pure components (Santafé-Moros *et al.*, 2005).

Physicochemical analysis

Apparent viscosity

The ice cream mixes after ageing at 4 °C were subjected to shear rates ranging from 14.2 to 512 s^{-1} using a rotational viscometer (Bohlin Model Visco 88; Bohlin Instruments, Worcestershire, UK). Temperature was controlled at 5 ± 0.5 °C using a heating circulator (Julabo, Model F12-MC; Julabo Labortechnik,

Table 1 Different combinations of three component [basil seed gum (BSG), carboxymethyl cellulose (CMC) and guar gum (GG)] mixture design at two concentrations of 0.15% and 0.35%

Formulation number	Stabilisers ratio BSG	CMC	GG	Concentration (%)
1	100	0	0	0.15
2	0	100	0	0.15
3	0	0	100	0.15
4	50	50	0	0.15
5	50	0	50	0.15
6	0	50	50	0.15
7	33.33	33.33	33.33	0.15
8	66.67	16.67	16.67	0.15
9	16.67	66.67	16.67	0.15
10	16.67	16.67	66.67	0.15
11	100	0	0	0.35
12	0	100	0	0.35
13	0	0	100	0.35
14	50	50	0	0.35
15	50	0	50	0.35
16	0	50	50	0.35
17	33.33	33.33	33.33	0.35
18	66.67	16.67	16.67	0.35
19	16.67	66.67	16.67	0.35
20	16.67	16.67	66.67	0.35

Seelbach, Germany). Apparent viscosity at shear rate of 117 s^{-1} was chosen for comparison.

Draw temperature

Draw temperatures (°C) of ice creams were recorded using a digital thermometer, which was placed in the geometrical centre of ice cream maker (French cooking, Biotemp, Alla France, France).

Overrun

Overrun of samples was calculated as follows (Marshall *et al.*, 2003):

$$\%\ \text{overrun} = ((\text{weight of unit volume of mix} - \text{weight of unit volume foam}) / \text{weight of unit volume foam}) \times 100 \quad (1)$$

Fat destabilisation index (turbidity)

The fat destabilisation index in the melted ice cream samples was determined by spectrophotometry, according to the Bolliger *et al.* (2000) method. Mix and ice cream samples (3.00 g) were diluted 1:500 in two steps with distilled water, and absorbance was measured by a spectrophotometer (WPA UV/Visible spectrophotometers, model diode – array S2000, Cambridge, England) at 540 nm against the same distilled water, which had been used for dilution, as a blank. Turbidity as the indicator of fat destabilisation in the sample was calculated by the following equation:

$$\text{Fat destabilisation index} = [(A_{540}\text{diluted mix}) - A_{540}\text{diluted melt}))/(A_{540}\text{diluted mix})] \times 100 \quad (2)$$

Melting rate

A 30-g sample cut carefully as a cube was suspended on a wire mesh and allowed to melt at room temperature (22 ± 1 °C). The weight of drained material through the wire mesh was recorded every 15 min. The weight of passing was plotted as a function of time. Melting rates (g min^{-1}) were calculated from the slope of each melting chart (Soukoulis *et al.*, 2008).

Sensory analysis

After optimisation, sensory evaluation of optimum formulation was done to assess acceptability of the sample for consumers. Fifty-three untrained panellists, twenty-three male and thirty female, with age between 20 and 45 years, were selected among students, faculty and staff at Ferdowsi university of Mashhad, Iran. They used a hedonic scale (i.e. 9 = like extremely, 5 = neither like nor dislike and 1 = dislike extremely) to evaluate the sample on sensory characteristics of appearance, flavour, body and texture, colour and total acceptance. All samples were served in 50-mL lidded plastic containers, and evaluation was done under white lights.

Statistical analysis

Experimental design and statistical analysis were performed using Minitab statistical software (version 13.20; Minitab Inc., State College, PA, USA). Two batches of each ice cream formulation were made, and all experiments except determination of draw temperature were done twice per each batch. Results were recorded as the mean of measurements to decrease in variance of error. Different polynomial models were fitted to the experimental data. The models with the largest values of R^2 and adjusted R^2 were preferred.

The analysis of variance (ANOVA) was performed, and the effect of interaction terms was determined. Statistical significance of the models has been evaluated with P-value. When the P-value is less than 0.05, there is statistically significance at the 95% confidence level.

Results and discussion

Model establishment

Predicted equations for apparent viscosity, draw temperature, overrun, fat destabilisation index and melting rate were developed using mixture design (Table 2). Quadratic models were chosen for analysis the all responses except overrun that was analysed by full cubic model. Generally, polynomial quadratic and full cubic models for mixture designs of q components are given by the following equations, respectively (Santafé-Moros *et al.*, 2005; Chen *et al.*, 2010):

$$Y = \sum_{i=1}^{q} \beta_i x_i + \sum_{i<j}^{q} \beta_{ij} x_i x_j \quad (3)$$

$$Y = \sum_{i=1}^{q} \beta_i x_i + \sum_{i<j} \beta_{ij} x_i x_j + \sum_{i<j<k} \beta_{ijk} x_i x_j x_k \quad (4)$$

The determination coefficients (R^2) of the models exhibited a good correlation between the variables, suggesting that the fitted models could explain about 90% or more of the total variation. Adjusted R^2, which ranged between 76.94% and 91.83%, confirmed the adequacy of models as well. The nonsignificant terms with P-values greater than 0.05 were deleted in final regression equations.

The model equations permitted the evaluation of the factor effects. Typically, positive values in model indicate synergistic effects, while negative values represent antagonism effects (Mastromatteo *et al.*, 2009). As presented in Table 2, main effects of studied variables

Table 2 Predictive regression models describing the relationship between variables and responses*

Attribute	Predicted model	R^2	R^2–adj
Apparent viscosity	$Y = 0.59BSG + 0.27CMC + 0.26GG + 0.45\ (BSG \times X_1) + 0.16\ (CMC \times X_1)$	93.48%	90.48%
Draw temperature	$Y = -4.96BSG - 4.67CMC - 4.24GG + 23.78\ (BSG \times CMC \times GG) + 1.34\ (CMC \times GG \times X_1) + 6.16\ (BSG \times GG \times X_1) + 5.47\ (CMC \times GG \times X_1)$	94.84%	91.83%
Overrun	$Y = 45.9BSG + 54.7CMC + 48.1GG - 70.0\ (BSG \times CMC) + 324.3\ (BSG \times CMC \times GG) + 7.1\ (BSG \times X_1) - 223.8\ (BSG \times CMC \times GG \times X_1)$	91.51%	76.94%
Fat destabilisation index	$Y = 15.3BSG + 18.9CMC + 10.4GG + 17.7\ (BSG \times GG) - 292.4\ (BSG \times CMC \times GG) - 5.3\ (CMC \times X_1) - 25.0\ (CMC \times GG \times X_1) + 261.7\ (BSG \times CMC \times GG \times X_1)$	93.48%	87.60%
Melting rate	$Y = 0.34BSG + 0.68CMC + 0.68GG - 1.03\ (BSG \times CMC) - 0.17\ (BSG \times X_1) + 2.68\ (CMC \times GG \times X_1)$	89.82%	83.88%

*BSG, CMC, GG and X_1 mean BSG, carboxymethyl cellulose, guar gum and gum concentration, respectively.

could be understood using the predicted models. The values of BSG and its concentration demonstrated the main and positive effects of this hydrocolloid on apparent viscosity of ice cream mixes. Individual influence of selected gums on draw temperature was almost the same and interaction among them mainly affect on this factor. This interaction had the most effect on overrun and turbidity as well. The value of CMC > BSG > GG in turbidity model indicated that the linear term influence of CMC was more significant than the other ones. Regression model of melting rate showed the strong role of BSG in decreasing this factor compared to two other stabilizers.

Main variation among samples

To obtain more detailed information, contour plots of responses, which are related to predicted equations mentioned above, are depicted in Figs 1–2.

The viscosity of an ice cream mix is considered a key attribute as it affects the body and texture of the finished product (Stanley *et al.*, 1996). The lowest values of apparent viscosity at concentrations of 0.15% and 0.35% were found in F8 (0.103 Pa.s) and F20 (0.343 Pa.s), respectively, while F3 (0.160 Pa.s) and F11 (1.107 Pa.s) had the highest viscosity at these concentrations, respectively. This range of viscosity is consistent with others researches; for example, BahramParvar *et al.* (2009) showed that apparent viscosity of ice cream mixes containing 0.3–0.5% Balangu seed gum, palmate-tuber salep and CMC varied from 0.037 to 0.745 Pa.s at shear rate of 113 s^{-1}. According to Soukoulis *et al.* (2009) results, apparent viscosity of an ice cream mix containing 6% fat, 11% milk solid not fat, 16% sugar, 0.2% stabiliser (blend of GG and microcrystalline cellulose at 1:1 ratio) and 0.2% emulsifier (mono-diglycerides of fatty acids) was 3.52 ± 1.62 Pa.s at shear rate of 50 s^{-1}. As expected, viscosity of ice cream mixes was enhanced by raising the concentration of stabilisers. Increasing the proportion of GG in mixtures increased the values of apparent viscosity at concentration of 0.15%. Similar trend was observed in the case of CMC. Such ordered behaviour was not observed with increasing the ratio of BSG in mixture at level of 0.15%. Trend of changes in 0.35% was completely ordered, and increasing the proportion of BSG in mixture enhanced the apparent viscosities of ice cream mixes. High ratios of GG and CMC diminished the values of apparent viscosity at level of 0.35%. Therefore, combination of CMC and GG with BSG at this concentration could improve their viscosities (Fig. 1). Efficient functionality of some other hydrocolloids has been proved before. For

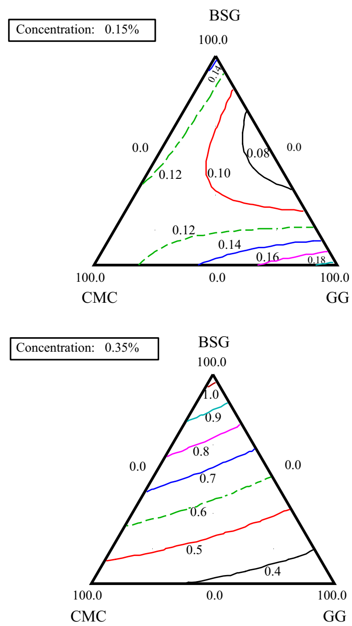

Figure 1 Contour plot for the effect of selected hydrocolloids on apparent viscosity of ice cream mixes (Pa.s) at two stabiliser concentrations of 0.15% and 0.35%.

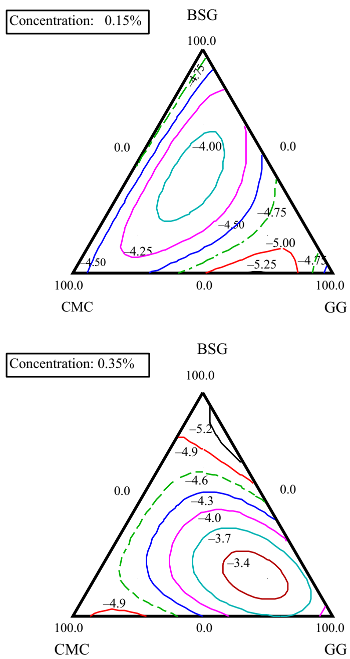

Figure 2 Contour plot for the effect of selected hydrocolloids on draw temperature of ice creams (°C) at two stabiliser concentrations of 0.15% and 0.35%.

instance, Rincon *et al.* (2006) reported that mixture of *Acacia glomerosa*, *Enterolobium cyclocarpum* and *Hymenaea courbaril* (2:1:2), at optimum concentration of 0.3%, produced high viscosity values. The backbone gum structures of *Acacia glomerosa* and *Enterolobium cyclocarpum* correspond to a β-D-(1→3) galactan, while polysaccharides of *Hymenaea courbaril* seeds correspond to a xyloglucogalactan. Enhanced viscosity of ice cream mixes containing gum of another Iranian endemic plant, that is, Balangu seed gum, has also been shown by BahramParvar *et al.* (2009, 2010).

Characteristics of ice cream mix influence the draw temperature of ice cream as a measure of heat removal in the freezer (Hartel, 1996). This response varied between −5.05 and −3.15 °C. Draw temperatures in this research were low enough, because typically values of −3.3 to −4.4 °C have been reported for batch freezer (Baer *et al.*, 1999). Giving an overall curvilinear effect, there was not arranged behaviour in draw temperatures with variation of GG and BSG ratios in mixtures at concentration of 0.15%. In contrast, high ratios of CMC at concentration of 0.15% decreased the draw temperature. Combinations of about 67% GG and 33% CMC produced the lowest draw temperature at 0.15% concentration (Fig. 2). Increased proportion of BSG in concentration of 0.35% decreased the draw temperature value that is considered as a suitable property in practice, because smaller ice crystals are produced in the product with lower draw temperature (Hartel, 1996).

Ice cream composition (fat, emulsifier and stabiliser contents) and processing conditions (whipping temperature and freezing power) can influence air cell development during batch freezing of sample (Chang & Hartel, 2002). Values of overrun in samples ranged between 25.45 (F4) – 57.72% (F2) and 39.42 (F14) – 58.28% (F20) at concentrations of 0.15% and 0.35%, respectively. As shown in Fig. S1, increasing the ratios of BSG at concentration of 0.15% led to increase in overrun values form 36% to 56% then decrease from 56% to 36%. Similar trend was observed in the case of GG. There was a positive relationship between elevation in proportions of GG as well as CMC in mixture and overrun at concentration of 0.35% (Fig. S1). Increase in ratios of BSG in level of 0.35% did not make an ordered trend and decreased overrun in some cases that could be related to incapability of ice cream maker in entrapment of air at high viscosity. Multiple stabilisers containing locust bean gum, CMC, GG and sodium alginate produced overrun values ranged from 37 ± 4.2% to 39 ± 3.7% in Kahramanmaras ice creams, which made by a batch freezer (Guven *et al.*, 2003).

Destabilisation (or partial coalescence) of the fat emulsion, which happens during the freezing process, is one of the critical steps in the production of a high-quality ice cream (Marshall *et al.*, 2003). Change in turbidity of diluted ice cream in comparison with diluted mix is measured as a way of quantification of extent of fat destabilisation (Goff & Hartel, 2004). The turbidity values of samples that varied between 2.57% and 25.70% was related to formulations containing equal ratios of selected gums at concentration of 0.15% (F7) and combination of 50% GG and 50% CMC at concentration of 0.15% (F6), respectively. This range of turbidity was relatively narrow, and higher degrees of fat destabilisation did not produced despite the use of emulsifier. The most likely reason was the insufficient shear forces of the scraper blades during batch freezing. This is in agreement with Marshall *et al.* (2003) who reported that generally greater fat destabilisation occurs in continuous freezers than in batch freezers because of the higher shearing action of the scraper blades in the former. High ratios of CMC in mixture at concentration of 0.15% produced the high turbidity that could be related to emulsification ability of this gum (Marshall & Arbuckle, 1996). It has been reported that emulsifiers enhance the fat destabilisation (Goff & Hartel, 2004). Variations trends at concentration of 0.35% were more ordered than 0.15%. Increasing ratios of BSG and GG in mixture at concentration of 0.35% increased and decreased the turbidity values, respectively (Fig. S2). Increased levels of destabilised fat increase fat network thereby decrease the melting rate of ice cream and promote shape retention (Muse & Hartel, 2004). In addition, partially coalesced fat globules are responsible for surrounding and stabilizing the air cells in ice cream (Goff & Hartel, 2004). Therefore, functionality of BSG in elevation of turbidity at concentration of 0.35% could be of practical importance.

Formulations with 66.67% BSG, 16.67% CMC and 16.67% GG at concentration of 0.35% (F11) and 100% GG at concentration of 0.15% (F3) gained the lowest and the highest values of melting rate, respectively. Melting rate values range between 0.053 and 0.763 g min^{-1}. This is in agreement with results of other researchers. For instance, melting rate of ice creams containing different levels and types of emulsifier varied between 0.1% and 1.0% min^{-1} (Bolliger *et al.*, 2000). Generally, melting rate values increased with increasing ratios of CMC and GG in the mixture; in contrast, BSG reduced the melting rate (Fig. S3) that is useful especially in cone ice creams. Intense melting resistance in samples containing high ratios of BSG is attributable to high viscosity of them and functions of viscosity in reduction in melting rate (Marshall *et al.*, 2003). As expected, the increase in hydrocolloid content led to the decrease in melting rate of ice creams. A reason is that the greater hydrocolloids content is related to the increase in serum (unfrozen phase) microviscosity, and thus, more time is needed for the water to be diffused into the concentrated serum phase before it begins to flow from the interior to the ice cream exterior (Muse & Hartel, 2004; Soukoulis *et al.*, 2008).

Deriving the optimum formulation and its validation

The general target of any optimisation is to discover the conditions that produce the best output. Applying the Minitab software, the optimisation calculations were performed to find an optimum gums mixture proportions and concentration. This was carried out by establishing desirability specifications of acceptable quality for each factor (Table 3). The optimum ratios were 84.31% BSG and 15.69% CMC at level of 0.35%. This promising result confirmed the capability of BSG as ice cream stabiliser, because the most portion of optimised formulation consisted of this gum and it could meet almost all expectations of the responses. The predicted responses for apparent viscosity, draw temperature, overrun, turbidity and melting rate were 0.944 Pa.s, −4.91 °C, 46.18%, 15.00% and 0.056 g min^{-1}, respectively, with a high composite desirability of 76.55%.

For validation of predicted optimum formula, an experiment with the optimised stabiliser formulation was conducted in two replications. Mean observed values for apparent viscosity, draw temperature, overrun, turbidity and melting rate were 1.053 ± 0.066 Pa.s, −4.90 ± 0 °C, 48.91 ± 4.71%, 17.14 ± 1.61% and 0.059 ± 0.009 g min^{-1}, respectively. It was found that there was no significant difference ($P > 0.05$) among observed responses and the predicted ones that indicate the adequacy of optimisation process.

Hedonic sensory scores of appearance, flavour, body and texture, colour and total acceptance of ice cream containing optimum stabilisers blend were 6.66, 7.28, 7.01, 6.91 and 7.43 respectively. These results showed that all characteristics scored good or excellent and were acceptable for consumers. This means that optimum stabiliser formulation not only produce desirable physical properties in ice cream, but also help to create pleasing sensory attributes in the product.

Suitable functionality of some multiple stabilisers has been proved before. For example, Guven *et al.* (2003) concluded that the use of 0.3–0.4% locust bean gum in combination with CMC, GG and sodium alginate at total usage level of 1% provided the most suitable properties for the Kahramanmaras-type ice creams that are traditional in Turkey. A commercial blend of ice cream stabilisers (C-196) has been consisted of 12% carrageenan, 33% GG and 55% CMC (Chang & Hartel, 2002). Rincon *et al.* (2006) proved the capability of mixture of gums from *Acacia glomerosa*, *Enterolobium cyclocarpum* and *Hymenaea courbaril* (species grown in Venezuela) compared to a commercial blend of gums including k-carrageenan, locust been gum and CMC (Grindsted Products A/S, Danisco, Denmark) as ice cream stabilisers.

Table 3 The desirable ranges for each response

Parameters	Goal	Lower	Target	Upper	Weight	Importance
Apparent viscosity	Maximum	0.10	1.11	1.11	1	1
Draw temperature	Minimum	−5.05	−5.05	−3.15	1	1
Overrun	Maximum	25.45	58.28	58.28	1	1
Turbidity	Maximum	2.57	25.70	25.70	1	1
Melting rate	Minimum	0.053	0.053	0.76	1	1

Conclusion

Simplex-centroid mixture design was successfully used for predicting the optimum formulation of BSG, GG and CMC as ice cream stabilisers. The statistical study showed that the fitted models were adequate to describe the responses. Optimum formulation consisted of 84.31% BSG and 15.69% CMC proved the suitable functionality of BSG as a novel source of hydrocolloid in the stabilization of ice cream. Furthermore, basil seed has been used as a pharmaceutical plant in Iran for many years. As a result, its application could have health benefits in addition to functional profits. The optimum formulation produced and it was found that observed responses were not significantly different ($P > 0.05$) from the predicted ones, indicating the adequacy of optimisation process. Supplementary studies on other characteristics of ice cream containing optimum formulation or BSG by itself as well as application of this gum as stabiliser in other frozen dessert could be helpful.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Figure S1. Contour plot for the effect of selected hydrocolloids on overrun of ice creams (%) at two stabiliser concentrations of 0.15% and 0.35%.

Figure S2. Contour plot for the effect of selected hydrocolloids on fat destabilisation index of ice creams (%) at two stabiliser concentrations of 0.15% and 0.35%.

Figure S3. Contour plot for the effect of selected hydrocolloids on melting rate of ice creams (g min^{-1}) at two stabiliser concentrations of 0.15% and 0.35%.

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