doi: 10.1111/j.1471-0307.2009.00526.x

ORIGINAL RESEARCH

The effect of *Lallemantia royleana* (Balangu) seed, palmate-tuber salep and carboxymethylcellulose gums on the physicochemical and sensory properties of typical soft ice cream

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This study was aimed primarily at determining the suitability of two Iranian sources of hydrocolloid, Balangu seed and palmate-tuber salep (PTS), for the production of ice cream mix. For this purpose, the effect of these gums and carboxymethylcellulose (CMC) on some physicochemical and sensory characteristics of a typical soft ice cream was investigated. In comparison with carboxymethylcellulose, Balangu seed did not make a significant difference ($P > 0.05$) to most characteristics and could be used as a suitable stabiliser. Although products prepared using only the palmate-tuber salep showed more differences from the corresponding ones with carboxymethylcellulose, the variations were not significant.

Keywords *Lallemantia royleana,* Salep, Ice cream, Stabilisers, CMC, Quality attributes.

INTRODUCTION

The quality of ice cream is essentially determined by its structure, density and resistance to melting, in addition to its taste. The superiority of ice cream in terms of these characteristics and its potential to preserve its properties at low temperatures depend on whether the mix contains sufficient levels of stabilisers and emulsifiers (Guven *et al.* 2003). The primary purpose of using stabilisers in ice cream is to produce smoothness in body and texture.

Hydrocolloid stabilisers are commonly used in ice cream mix to prevent the separation of clear serum during meltdown; to produce a stable foam with easy cut-off and stiffness at the barrel freezers for packaging; to slow down the growth of ice and lactose crystals during storage, especially when subjected to temperature fluctuation; to retard moisture migration from the product to the package or to the air; and to prevent shrinkage of the product volume during storage (Goff and Sahagian 1996).

Lallemantia royleana is a member of Labiatae family. This family is one of the largest and most distinctive flowering plants, with about 220 genera and almost 4000 species worldwide. It is well represented in different regions of European and Middle East countries, especially Iran, by 46 genera and 410 species and subspecies (Zargari 1980; Naghibi *et al.* 2005). The vernacular name of *Lallemantia royleana*'s seed is Balangu or Balangu Shirazi (Naghibi *et al.* 2005). Balangu seed is a good source of polysaccharides, fibre, oil and protein and has some medicinal, nutritional and human health properties (Naghibi *et al.* 2005; Razavi and Karazhiyan 2009). This seed adsorbs water quickly when soaked because of a high mucilage content and produces a sticky, turbid and tasteless liquid, which can be used as a novel food hydrocolloid in food formulations (Razavi *et al.* 2008).

Salep is a food ingredient obtained by milling dried tubers of wild orchids (Kaya and Tekin 2001) and used as an essential ingredient for the production of traditional ice cream in Iran (Amin 2005). It primarily contains glucomannose and starch in its structure in addition to water and mineral matters (Kayacier and Dogan 2006). Because it swells in water and milk, glucomannan has stabiliser capacity (Ayar *et al.* 2009). Salep has a generally creamy colour and plays an important role in the flavour of the final product (Kaya and Tekin 2001). Two varieties are grown in Iran, one with branched or palmate tubers, and another with rounded or unbranched tubers (Farhoosh and Riazi 2007). It was found that the salep with palmate tubers produces solutions with more consistency than does rounded-tuber salep, at similar concentrations.

There has been some research into the effect of salep on the properties of ice cream and other desserts (Ayar *et al.* 2009; Kaya and Tekin 2001; Guven *et al.* 2003). Also, there are many valuable studies that used CMC as a stabiliser ingredient in ice cream mix (Glicksman 1982) and in sucrose–lactose solution (Wang *et al.* 1998). However, there are no recorded data available in the literature

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concerning the use of Iranian varieties of Salep and Balangu gums as ice cream stabilisers. Hence, the objectives of this research were: (i) to introduce the Balangu seed gum (BSG) as a novel ice cream stabiliser, (ii) to investigate the effect of palmate-tuber Salep (PTS) and BSG on the properties of soft ice cream, and (iii) to compare the characteristics of ice creams which contain PTS and BSG as stabilisers, with carboxymethylcellulose (CMC) which is a well-known commercial gum used in ice cream formulation.

MATERIALS AND METHODS

Materials

Homogenised and UHT milk (2.5% milk fat) and homogenised and pasteurised cream (30% milk fat) were obtained from Pegah Dairy Industry Co, Mashhad, Iran. Skim milk powder was prepared by Multi Milk Powder Industry Co, Mashhad, Iran. Sugar and vanilla were purchased from the local confectionery market and CMC was supplied by Sunrose Company, Mashhad, Iran. The dried tuber powder of PTS and crude extract powder of BSG were prepared on the basis of the work of Farhoosh and Riazi (2007) and Mohammad Amini and Hadad Khodaparast (2007).

Manufacture of ice cream

The standard ice cream mix formulation consisted of 10% milk fat, 15% sucrose, 11% nonfat milk solids, and 0.3, 0.4 or 0.5% of stabilisers. Liquid ingredients including milk and cream were mixed together and warmed up to 50°C. Dry ingredients were mixed thoroughly then added to the liquid ingredients using a Moulinex mixer (Model R10; Moulinex, France). The mixes were pasteurised at 80°C for 25 s (HTST), cooled immediately to 5°C and then stored overnight at 5°C. After ageing, vanilla extract was added (0.1%) and freezing was done in a domestic soft ice cream maker (Feller ice cream maker, Model IC 100; Feller Technologic GmbH, Düsseldorf, Germany). The required freezing time for different mixes was 25 ± 5 min. Drawing was carried out as per the manufacturer's instructions 'when the direction of blade's rotation changed' and hence varied between formulations. The soft ice cream samples were collected into 50 m lidded plastic containers, coded and placed in a chest freezer (Electrosteel, Model ES. 453; Mashhad, Iran) at a temperature of −18°C for 1 h. Samples were still soft and had the same temperature (around −7°C) for sensory evaluation.

Physicochemical analysis

Total solids

Total solids (TS) was determined by the gravimetric method (AOAC 2005).

pH

pH was tested with a pH meter at 5°C (Metrohm pH meter, Model 691; Herisau, Switzerland). Each sample was mixed thoroughly and the pH was noted (Abdullah *et al.* 2003).

Viscosity

The apparent viscosity of each mix was determined using a rotational viscometer (Bohlin Model Visco 88; Bohlin Instruments, UK) equipped with a heating circulator (Julabo, Model F12-MC; Julabo Labortechnik, Seelbach, Germany). Temperature was controlled at 5 ± 0.5°C using a circulator. Apparent viscosity was reported at a shear rate of 113/s, a typical pumping rate for industrial pumping operations.

Draw temperature

An alcoholic thermometer was placed in an ice cream maker after turning off the equipment to measure draw temperature.

Overrun

This was calculated by comparing the weight of a known volume of ice cream (M_2) to the weight of the same volume of unfrozen ice cream mix (M_1) as follows (Marshall and Arbuckle 1996):

$$OR\% = \frac{M_1 - M_2}{M_2} \times 100 \tag{1}$$

Meltingresistance

A 30 g sample of ice cream was placed in a Buchner funnel on the top of a flask and was allowed to melt at room temperature (24 ± 1°C) for 15 min. After this time, the dipped volume was weighed and melting resistance was obtained using the following equation:

$$\text{Melting resistance} = \frac{A_1 - A_2}{A_1} \times 100$$

where A_1 and A_2 are the weight of initial sample (30 g) and melted sample respectively (Marshall and Arbuckle 1996).

Sensory evaluation

The panel evaluations were conducted at the Dairy Laboratory, Department of Food Science and Technology, Ferdowsi University of Mashhad, Iran. Panel members were selected from the student population. To test panellists in the first ballot, three coded samples were given of which two were alike and one different. Those who could recognise the different samples were chosen for sensory evaluation. Finally, 10 panellists, eight females and two males, all between the ages of 23 and 30 were selected. Sensory evaluations of appearance, flavour, body and texture, and total acceptance were performed in a random order using a 9-point hedonic scale. ‘Dislike extremely’ and ‘Like extremely’ were numbered as 1 and 9 respectively.

Statistical analysis

The experiment was replicated with three mixes made on different days and all analyses were performed in 3–6 replications. Data were analysed with MSTATC statistical software (MSTATC director, Michigan State University, version 1.42). Means were compared using the Least Significant Differences (LSD) test and results were considered significant for $P < 0.05$.

RESULTS AND DISCUSSION

Physicochemical properties

Total Solids

The TS of the mixes differed significantly between 36.4% and 37.8%, with increasing PTS increasing the TS, whereas addition of BSG and CMC did not change the TS.

pH

The pH of ice cream mixes ranged from 6.46 to 6.60. The various gums in different concentrations did not change the pH significantly ($P > 0.05$) but there was a trend to lower pH in mixes with PTS rather than CMC. The ice creams containing BSG and CMC had the lowest and highest pH respectively. The normal pH of ice cream mix containing 11% milk SNF is about 6.31 (Marshall and Arbuckle 1996). According to Guven *et al.* (2003), ice cream produced using only the salep extract had significantly lower pH, which is similar to the findings of our research.

Viscosity

The results showed that the viscosity of ice cream mixes was enhanced by increasing the gum concentration, with mixes containing CMC ranked first followed by mixes including BSG and PTS (Figure 1). Guven *et al.* (2003) also reported that salep extract significantly decreased the viscosity of ice cream mix. There were significant differences among the viscosity of mixes ($P < 0.05$), which varied from 0.037 to 0.745 Pa.s (Figure 1). According to Hagiwara and Hartel (1996), the range of apparent viscosity (shear rate: 115/s, temperature: 5°C) was approximately 0.023–0.058 Pa.s for unstabilised mixes and 0.579–0.687 Pa.s for stabilised mixes. Prindiville *et al.* (1999) obtained the viscosity of 0.102 Pa.s for ice cream mix with 9% milk fat and 0.4% stabiliser. In other research, higher apparent viscosities of ice cream mix were obtained $0.112 \pm 0.0065 \times 10^{-3}$ Pa.s (Alvarez *et al.* 2005). The gums of achi and ogbano seeds, which are commonly found in Nigeria, produced viscosities of 0.035 and 0.025 Pa.s in ice cream mix respectively (Uzmah and Ahiligwo 1999). *Acacia glomerosa*, *Enterolobium cyclocarpum* and *Hymenaea courbaril* are species grown in Venezuela that yield gums. The mixture of the above gums produced a viscosity of 0.040 Pa.s in ice cream mixes, which was higher than the viscosity of a mixture of commercial gums ($0.035 \pm 0.0012 \times 10^{-3}$ Pa.s), while the viscosity of samples without stabiliser was found to be $0.014 \pm 0.0012 \times 10^{-3}$ Pa.s (Rincon *et al.* 2006).

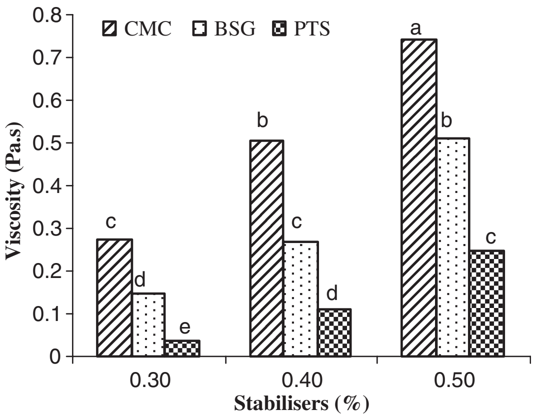

Figure 1 The viscosity of ice cream mixes varying in type and level of stabiliser.

Draw temperature

Draw temperature of different ice cream mixes varied from −4.3 to −6.7°C. The lowest draw temperature was found in the mixes containing 0.3% PTS, while the 0.5% CMC mixes had the highest draw temperature. In most cases, drawing temperature increased with gum concentration. The temperature of the mix at the completion of the freezing process may not be related to the amount of freezing point depression in the mix, because all samples were not frozen for the same amount of time. The time required for freezing of samples was 25 ± 5 min, while mixes with more viscosity took less time for freezing. Therefore, the drawing temperature was probably not a true response variable. The typical draw temperature for an ice cream mix in a batch freezer is between −3.3 and −4.4°C, but in a continuous freezer it is between −5.6 and 6.1°C (Marshall and Arbuckle 1996). It was found that draw temperature of nonfat and low fat ice cream, using the same batch freezer, ranged from −2.98 to −2.82°C and −5.04 to −4.30°C, respectively. In general, as the drawing temperature is reduced, smaller ice crystals are obtained in the product and quality improved (Baer *et al.* 1999). According to Alvarez *et al.* (2005), the drawing temperature of ice cream containing milk protein concentrate varied from −4.7 to −5.4°C. In other research, the values of draw temperatures of ice cream mixes in soft-serve freezers were between

−9.5 and −3.0°C (Miller-livney and Hartel 1997). Hagiwara and Hartel (1996) reported a draw temperature of −9.4 to −3.9°C for unstabilised and −9.1 to −3.5°C for stabilised ice cream mixes.

Melting resistance

The mean values of melting resistance are presented in Figure 2. It can be seen that melting resistances were significantly different ($P < 0.05$), ranging from 40.01% to 98.35%. In all cases, melting resistance was increased as gum concentration increased. Enhanced viscosity improved the resistance to melting; hence, PTS with minimum viscosity had the least melting resistance. These results were similar to those reported by Guven *et al.* (2003). They showed that ice cream produced using only the salep extract had significantly ($P < 0.05$) lower resistance to melting than those produced with the stabiliser combinations. Rincon *et al.* (2006) also found the meltdown of ice creams to be 65 ± 2.11%, 5 ± 1.03% and 40 ± 1.02% for samples without stabilisers, with mixtures of commercial gums and mixture of local gums, respectively. This latter research showed that the mixture of local Venezuela gums provided desirable melting characteristics, as was demonstrated by the tendency to reduce the rate of melting down. As can be seen from Figure 2, no difference ($P < 0.05$) was observed between BSG and CMC in the melting resistance of the ice creams.

Overrun

There was no significant difference ($P > 0.05$) in the overrun of the ice creams, which ranged from 18.8% to 28.6%. The low overrun values in this study could be related to the inefficiency of the ice cream maker in air incorporation and excessive time required for freezing (25 ± 5 min). Marshall and Arbuckle (1996) mentioned that overrun of soft-serve products ranged from 30% to 60%. Akin (1990) pointed out the difficulty in increasing the overrun over 40–45% in soft and semisoft ice creams produced in batch-type freezing machines. In all treatments, ice creams containing PTS and BSG had the maximum and minimum overrun respectively (Figure 3. The effect of salep on the overrun of ice cream in this research was in agreement with the findings of Guven *et al.* (2003), who reported that ice cream containing salep had the lowest viscosity and highest overrun. In their research, overrun varied from 37 ± 4.2% to 42 ± 5.7%. Tekinsen and Karacabey (1984) reported 24–38% overrun in Kahramanmaras-type ice creams, which were prepared through the use of mixtures of ordinary and modified stabilisers.

Sensory evaluation

In this research, panellists found significant differencse ($P < 0.05$) in flavour, appearance, body and texture and total acceptance among samples.

Appearance

Appearance scores were significantly different, between 6.2 and 8 (Figure 4). Ice creams containing CMC ranked first, followed by PTS and then

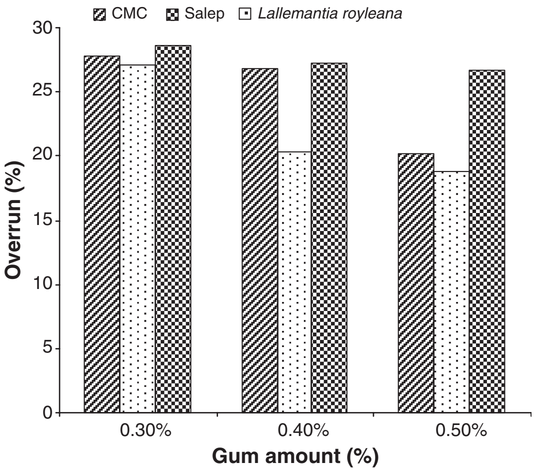

Figure 3 The overrun of ice creams varying in type and level of stabiliser.

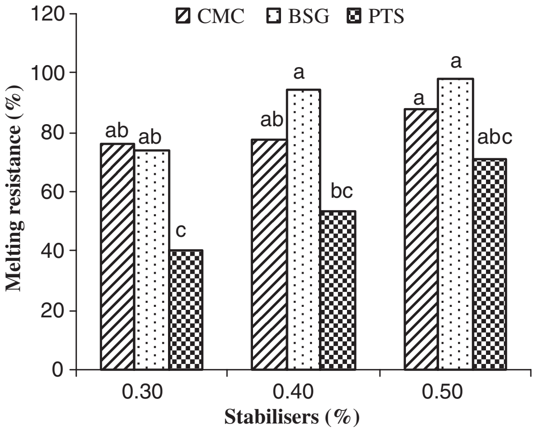

Figure 2 The melting resistance of ice creams varying in type and level of stabiliser.

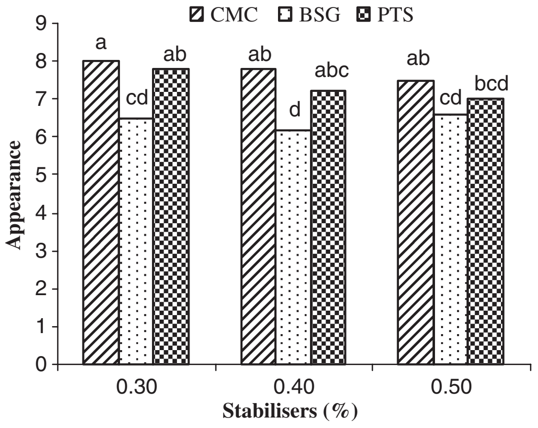

Figure 4 The appearance of ice creams varying in type and level of stabiliser.

BSG samples. Balangu seed gum gave a light coffee-like colour to ice cream that was not desirable for some panellists because they expected a creamy colour for vanilla ice cream. For this reason, the application of BSG in cocoa, coffee and chocolate ice creams may be more acceptable. Salep did not change the appearance significantly ($P > 0.05$) compared with CMC.

Flavour

Flavour (taste and smell) is the most important factor in acceptance of frozen desserts (Abdullah *et al.* 2003). In our research, ice creams containing salep gum obtained the lowest acceptance in terms of taste and smell (Figure 5), which is in agreement with the results of Guven *et al.* (2003), who found that salep caused the lowest flavour acceptability in ice cream. Reduction in the flavour scores of PTS at all concentrations was significant ($P < 0.05$).

Body and texture

Samples with 0.4% and 0.5% BSG received the best texture scores (Figure 6). The difference between PTS and CMC was significant ($P < 0.05$) only at 0.4% and between PTS and BSG was significant ($P < 0.05$) at 0.4% and 0.5%. Texture values ranged from 6.4 to 8.2. In all levels of stabilisers, PTS showed the lowest texture quality in ice cream. This can be related to low viscosity of the ice cream containing salep.

Total acceptance

The total acceptance scores of the soft ice creams were between 6.0 and 7.7, with the most acceptable ice cream being the sample containing 0.3% CMC (Figure 7). In this research, the total acceptance scores of all ice creams were higher than the average score. Panellists found no differences ($P > 0.05$) between CMC and BSG in terms of total acceptance. However, Salep decreased the overall acceptability of ice cream in all concentrations studied, significantly against CMC at all concentrations, and at 0.4 and 0.5% for BSG and PTS. The decrease in overall acceptability in ice cream containing PTS was similar to that reported by Guven *et al.* (2003).

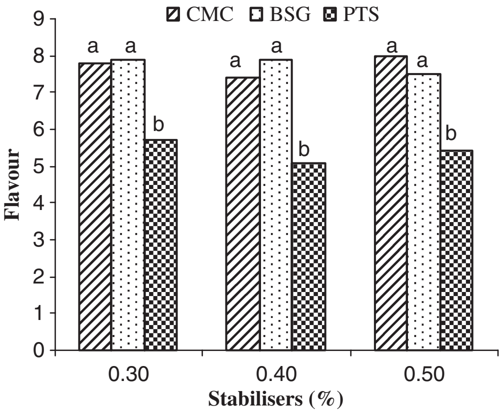

Figure 5 The flavour of ice creams varying in type and level of stabiliser.

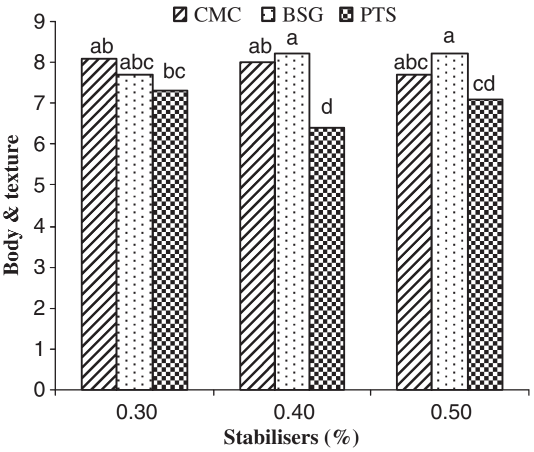

Figure 6 The texture of ice creams varying in type and level of stabiliser.

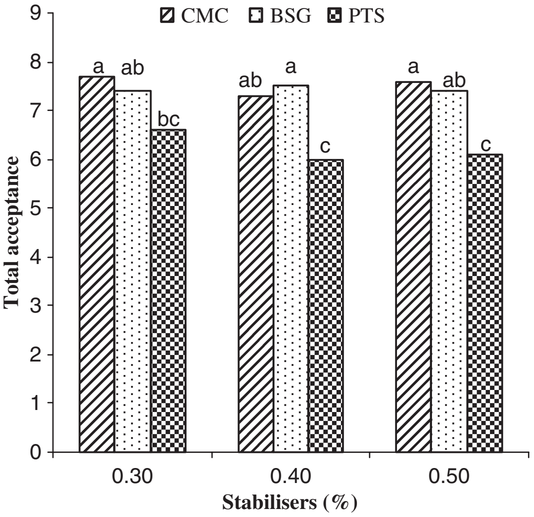

Figure 7 The total acceptance scores of ice creams varying in type and level of stabiliser.

CONCLUSION

This work studied the behaviour of two new Iranian sources of hydrocolloid, BSG and PTS, with corresponding CMC as a commercial stabiliser in ice cream preparation. Overall evaluation of the results led to the conclusion that BSG acts as a suitable stabiliser in ice cream formulation. Palmate-tuber salep imparted some useful characteristics in ice cream, but some quality attributes sored lower than CMC. The properties of this variety of Iranian salep in ice cream were comparable with other kinds of this extract. Because of the lower viscosity of ice creams containing salep, higher levels of this gum are proposed. Furthermore, ice creams containing salep would be more suitable for use in chocolate, fruit, coffee and other flavoured ice creams which may mask its flavour.

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