J Food Sci Technol (July 2015) 52(7):4015–4028
DOI 10.1007/s13197-014-1518-0

ORIGINAL ARTICLE

Development of technology for manufacture of ragi ice cream

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Revised: 17 July 2014 / Accepted: 11 August 2014 / Published online: 15 August 2014

Abstract Ragi (Finger millet) improves the nutritional value of ice cream by enhancing the iron and fibre content. Caramel flavoured medium fat ice cream (6 % fat) was prepared by addition of gelatinized malted ragi flour roasted in butter (MRB) @ 8 %, 9 % and 10 % by weight of mix and compared with control (C) i.e. vanilla ice cream containing 10 % fat. The overall acceptability score of product prepared using 9 % MRB was statistically ($P>0.05$) at par with the C, hence, it was selected. In the next part of the study, ragi ice cream was prepared using 4 different flavours viz. vanilla, mango, chocolate and caramel. Chocolate flavoured ragi ice cream was adjudged as best, followed by mango, caramel and vanilla ice cream. The iron and fibre content of chocolate flavoured ragi ice cream was found to be 12.8 ppm and 1.36 % respectively. vs. 1.5 ppm and 0.18 % respectively in control (C). Heat shock treatment as well as storage up to 30 days had no adverse effect on the sensory quality of the chocolate flavored ragi ice cream. Incorporation of finger millet in ice cream resulted in reduction in the amount of stabilizer used and effectively functioned as fat replacer in ice cream.

Keywords Finger millet · Ragi · Medium fat ice cream · Malting

Introduction

Cereal based milk products are popular all over India. Cereals and milk are blended to compensate for deficiency of lysine (Aneja et al. 2002). Finger millet (Ragi) has both nutritional and medicinal values hence, there is an increased interest in finger millet due to its excellent nutritional value and health benefits. Because of its good thickening properties traditionally in some parts of India it is used for preparation of porridge. The nutritive value of finger millet is better than other cereals (Manay and Shadaksharaswamy 2001). Ragi has best quality protein along with the presence of essential amino acids, vitamin A, vitamin B and phosphorus (Gopalan et al. 2004). According to US National Research Council (1996), finger millet grain is more nutritious than most cereal grains with respect to minerals, dietary fiber and essential amino acids. The interest in finger millet is growing due to its health benefits namely, hypoglycemic characteristics (Lakshmi and Sumathi 2002) and also an antimicrobial and antioxidant activities of its polyphenols (Chethan and Malleshi 2007). Evidence has long shown that patients with diabetes tolerate finger millet better than rice and their blood sugar levels are comparatively lower (Rachie and Peters 2002). Ragi starch is a relatively bland functional starch-based ingredient that has the potential to be utilized in lower fat foods. It has revitalized the interests not only in consumers, but also among researchers to develop formulated products, which are "natural, functional and nutritional" as well. Finger millet grain contains 70–76 % carbohydrates and approximately 61.8 % starch (Obilana and Manyasa 2002). Because of the its good thickening and water binding properties it is hypothesized that incorporation of finger millet in ice cream as a functional ingredient can result in reducing the amount of stabilizer used and effectively function as a fat replacer in ice cream. The total dietary fiber (~22 %) of finger millet grain is relatively higher than that of most of other cereal grains (i.e. 12.6 %, 4.5 %, 13.4 %, and 12.8 % wheat, rice, maize and sorghum, respectively) (Klopfenstein 2000). Dietary fibers can provide a multitude of functional properties. Besides health benefits, dietary fiber supplementations increase the bulk by enhancing water

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binding capabilities and carries great economical advantages for both the consumers and processors (Grigelmo-Miguel et al. 1999). Thus, addition of fibre contributes to the modification and improvement of the texture, sensory characteristics and shelf-life of foods due to their water binding capacity, gel-forming ability, fat mimetic, anti-sticking, anti-clumping, texturizing and thickening effects (Dello et al. 2004; Thebaudin et al. 1997). Incorporation of highly nutritious ingredient like ragi in ice cream will help in improving the nutritional as well as functional properties of ice cream. Ice cream faces a problem of high fat content (i.e. 12–14 %). This offers an opportunity for development and commercially manufacture of reduced fat ice cream that can fit easily into the dietary guidelines for persons suffering from CVDs.

Materials and methods

Fresh, raw mixed (cow and buffalo) milk and skim milk powder of "Sagar" brand, marketed by Gujarat Cooperative Milk Marketing Federation Ltd., Anand was used as the base material for the ice cream manufacture. Commercial grade cane sugar used was of commercial grade was obtained from the local market of Anand. Sodium alginate (S4 Regular) (S. Square & Co., Gwalior, Madhya Pradesh) was used as a stabilizer and commercial grade Glycerol Mono Stearate (GMS) (Brion Fine Chem., Mumbai) was used as emulsifier. Vanilla essence No. 1 (M/s Bush Boake Allen (India) Ltd., Chennai) was used as the flavouring agent in vanilla ice cream. Mango pulp (Kesar variety) (Vadilal Industries Ltd., Ahmedabad) was used for flavouring of mango ice cream. Cocoa powder (Cadbury India Ltd., Mumbai) was used for flavouring chocolate ice cream. Table butter (Amul Dairy, Anand) was used during roasting of ragi flour. Finger millet variety i.e. PRM 9802 (dark colored) (AGMARK Grade I) were procured from a local supermarket at Anand.

Preparation and processing of ragi

Cereals are generally subjected to different types of processing treatment prior to consumption and, as a result, the transformed food products possess acceptable sensory quality and nutritional attributes. During processing, the property changes occurring vary in their significance, e.g. taste and nutritional value, macro- and micro-structure of the product and starch digestibility (Concy 2009). The starch granules undergo physical and chemical changes during processing, and influence the textural and many of the physico-chemical characteristics including digestibility of the food (Tharanathan et al. 1987; Tharanathan 1995). Thus, depending on the type of the processing, the characteristics of ragi would change, owing to complete gelatinization of the starch, or decreased owing to subsequent retrogradation during storage.

During preliminary studies it was observed that addition of gelatinized ragi flour above 2.5 % (w/w of mix) resulted in excessively high viscosity of the mix which were difficult to whip and led to heavy bodied ice cream. It has been reported that malting of finger millet improves its digestibility, sensory and nutritional quality as well as pronounced effect in the lowering the anti nutrients. Malting characteristics of finger millet are superior to other millets and ranks next to barley malt (Malleshi and Desikachar 1986; Pawar and Dhanvijay 2007). This may be attributed to the fact that during malting of ragi, the liberated malt enzymes (amylases) hydrolyze the starch molecules (near the granule periphery) and thereby decrease the slurry viscosity and consistency of mixes containing malted ragi flour in comparison with mixes containing unmalted ragi flour. It is envisaged that because of the decrease in viscosity of mixes, malted ragi flour can be added at a higher rate compared to unmalted ragi flour. This could result in further improvement in the nutritional quality of the product.

Malting of ragi was carried out according to the procedure suggested by Desai et al. (2010). Ragi seeds (1 kg) were washed with water for 5 times and soaked in pasteurized and cooled water (35 °C) for 5 h. Excess water was drained, seeds were tied in a muslin cloth and kept for germination at 27±3 °C for 24 h keeping 5 kg weight on it. The seeds were then spread uniformly on a stainless steel tray and dried in a hot air oven maintained at 60–65 °C for 5 to 6 h. The moisture content of the seeds was less than 14 % after drying. Ragi seeds were ground into flour at commercial flour mills (Make: Milcent flour mill, compression-cum-shearing type (roller) mills, Ahmedabad) adjusted to a fine setting. The flours were sieved using a U.S. standard 20 mesh sieve and stored in air-tight containers. The approximate composition of ragi flour was 7.78 % protein, 1.1 % fat and 88 % total solids. The dried malted flour was stored at 4 °C until use. It was envisaged that roasting of ragi flour in table butter would help in improving the sensory qualities of the product. In the selection of dried and roasted ragi flour to be employed for the present study, the ragi flour was mixed with 15 % table butter (Amul Brand) (by weight of ragi flour) and roasted in an open pan at a temperature of around 125 °C for 10–12 min on a medium flame with a constant stirring till the development of pleasant roasted flavour (Shukla and Srivastava 2011). The quantity of table butter was decided based on preliminary trials.

Ragi flour (roasted in butter) was subjected to gelatinization. Whole milk was used as gelatinization medium for ragi flour, to avoid the problem of dilution which is in the case of water, in preliminary trials and it was found to be a suitable medium for gelatinization. Ragi flour was mixed with whole milk at different rates viz. 10, 15 and 20 % (w/w). These values were decided based on preliminary trials. It was found that when 100 parts whole milk and 15 parts ragi flour were mixed and heated to 90 °C for no hold the mix showed good gel characteristics. Quantity higher than 15 % resulted in too sticky gel, which was difficult to handle and incorporate into mix. Therefore a level of 100 parts whole milk and 15 parts ragi flour (w/w) and heating to 90 °C for no hold was selected for gelatinization. Mohan et al. (2005) reported that the degree of crystallinity of *ragi* starch granules seems to be significantly higher than rice starch granules and this was also reflected by high energy required to gelatinize ragi starch as compared to rice starch. They reported that the swelling power of ragi was maximum at 90 °C gelatinization temperature. On the other hand Mangala et al. (1999) reported that ragi starch showed 100 % gelatinization at a temperature of 71.7 °C. During preliminary investigations it was found that maximum thickening occurred at 90 °C. Hence a temperature of 90 °C for no hold was selected for gelatinization of ragi starch. The product prepared was designated as MRB.

Preparation of caramel flavour Incorporation of ragi resulted in a reddish tinge to the ice cream mix. Since caramel flavour blended well with the cereal flavour of ragi it was used as a flavouring ingredient in all the ice creams to match the colour and flavour of the mix. Caramel flavour was prepared in the laboratory by burning 300 g sugar on direct flame in a clean and dry stainless steel vessel. After caramelization was completed (as indicated by a dark brown colour) heating was stopped and 100 ml water was added and the ingredients were mixed thoroughly. The mixture was cooled and stored in a clean and dry glass bottle until use.

Preparation of ice cream mix The tentative levels of milk fat as well as MSNF were based on FSSAI (2011) requirements for different types of ice creams viz. low-fat, medium-fat and ice cream. In preliminary trials, ice cream mixes were prepared with 2.0, 6.0 and 10.5 % milk fat, which corresponded to requirements for low-fat, medium-fat and regular ice cream respectively. The MSNF content of ice cream varies inversely with the fat content (Marshall et al. 2003). Therefore, the levels of MSNF selected were 11.5, 11.0 and 10.5 % respectively. These levels were based on the minimum requirements for milk protein in ice cream mix according to FSSAI (2011) requirements. Sugar, sodium alginate and glycerol monostearate were added at the rate of 15, 0.25 and 0.2 % respectively in all the mixes. Malted Ragi flour at the rate of 8.0 % by weight of mix was incorporated in all the mixes. The weighed amount of ragi flour was taken and mixed with whole milk (i.e. 100 parts whole milk and 15 parts ragi flour). After mixing thoroughly the mixture was heated to 90 °C for no hold. This temperature was selected since gelatinization temperature of ragi has been reported to be 90 °C (Mohan et al. 2005). The hot gelatinized ragi flour was then incorporated in all the three mixes viz. low-fat, medium-fat and regular ice cream mix. It was found that mixes containing 10.5 % milk fat was very viscous and difficult to handle. Whereas, mixes containing 2.0 % milk fat lacked the desired richness and had powdery, ragi flour taste. Mixes containing 6.0 % fat had the desired consistency, mouthfeel and viscosity. Hence, a level of 6.0 % milk fat and 11.5 % SNF was selected for preparation of mix. Whole milk and cream used in the manufacture of the ice cream were analyzed for their composition, i.e. fat, total solids, MSNF and titratable acidity. The quantity of milk, cream, skim milk powder, sucrose, sodium alginate and GMS required for a batch (i.e. 6 kg of ice cream mix) was calculated by serum point method (Marshall et al. 2003). The composition of the experimental mixes were 6.0 % fat, 11.5 % MSNF, 14.0 % sucrose, 0.1 % sodium alginate and 0.2 % GMS. The composition of control was 10 % fat, 11 % MSNF, 15 % sucrose, 0.25 % sodium alginate and 0.15 % GMS.

The calculated quantities of liquid ingredients viz. whole milk and cream for each treatment were weighed, mixed and blended thoroughly in a stainless steel vessel and heating was initiated. From the total quantity of whole milk, a calculated quantity was used for preparation of gelatinized ragi flour and the remaining milk was mixed at this stage. Skim milk powder and other dry ingredients were mixed with a part of sugar and added to avoid lump formation before the temperature of the mix reached 50 °C. The processed ragi product (MRB) was added to the mix at this point and mixed thoroughly. The mixes were further heated to 75 °C, homogenized in a clean and sanitized double stage homogenizer (Pal Engineering Ltd., Ahmedabad) at 150 kg/cm^2 and 35 kg/cm^2 pressure in the first and second stage respectively and pasteurized by holding the mix at 80 °C for 25 s. The pasteurized mixes were then immediately cooled to about 3–4 °C and aged at this temperature for overnight. Caramel was added as a flavouring agent (@ 7.0 ml per kg mix) immediately before freezing. The malted ragi flour i.e. MRB was added at three levels i.e. 8.0, 9.0 and 10.0 % w/w of ice cream mix (i.e. M1, M2 and M3). Four batches of ice cream were prepared and each part was replicated four times.

In the next part of the study to select the best flavour compatible in ragi ice cream slight modifications were required in the composition of the mixes for mango and chocolate ice cream. For preparation of mango ice cream the composition of mix was 6.0 % fat, 11.0 % MSNF, 14.0 % sucrose, 0.05 % sodium alginate and 0.2 % GMS and mango pulp was added @ 15.0 % by weight of mix just before freezing. For preparation of chocolate ice cream mix the composition of the mix was 6.0 % fat, 11.0 % MSNF, 16.0 % sucrose, 0.05 % sodium alginate and 0.2 % GMS and cocoa powder was added @ 1.0 % by weight of mix. Four batches of ice cream were prepared and each part was replicated four times.

Preparation of ice cream For preparing different batches of ice creams (control as well as experimental) in direct expansion type batch freezer, the aged mixes were frozen in a horizontal batch freezer (Pal Engg. Pvt. Ltd., Ahmadabad) with an arrangement for incorporation of air under pressure (cylinder capacity 10 lits). The temperature of the circulating refrigerant was −23 to −30 °C. After freezing the mix to a semi-solid consistency (which was 10–12 min), as inferred from the load on the ammeter and the accumulation of ice on the freezer door, air was whipped in the ice cream at a constant pressure i.e. 5–10 psi for about 2 min. The ice cream at the right stage of freezing, as ascertained from the consistency and overrun, was drawn directly into 100 ml High Impact Polystyrene (HIPS) ice cream cups and covered with wax coated paper board lids. The temperature of the ice cream at the drawing stage was recorded. Mixes were frozen to about −4.5 to −5.0 °C and the targeted overrun was set at 90 %. The filled ice cream packs were then transferred immediately to a hardening room maintained at −25±2 °C and hardened for 24 h.

The ice cream was prepared using 4 different flavorings viz. vanilla (VA), chocolate (CH), mango (MG) and caramel (CR). In the manufacture of VA and CR ice creams, the basic mix was prepared having composition as given above. In the manufacture of Vanilla flavored ice cream, vanilla flavour essence (Bush Boakes) was added to the mix @ 3 ml/kg mix. Caramel flavour was prepared according to the procedure given above and was added @ 7.0 ml per kg mix. However, for CH and MG ice creams slight modifications in the composition of the mixes were required. For manufacture of chocolate ice cream, the level of cocoa powder was selected on the basis on preliminary trials from amongst 0.8, 1.0 and 1.2 %. The cocoa powder contributes to the total solids of ice cream mix. Such increase in total solids leads to increase in viscosity of ice cream mix. In order to control the viscosity it was desirable to reduce the quantity of MSNF. Vanilla flavour is reported to enhance the cocoa flavour in chocolate ice cream. Hence, vanilla was used as flavour adjunct (i.e. 1 ml per kg mix). For manufacture of mango ice cream, canned kesar mango pulp was used for flavouring. The canned mango pulp contained: kesar mango pulp (90 %); sugar (6 %); water (4 %) and citric acid (0.1 %). The level of mango pulp required to give optimum flavour in ice cream was decided on the basis of preliminary trials which was found to be 15 % by weight of the mix.

Analysis Physico-chemical analysis of ice cream and ice cream mixes: The fat content of the ice creams were determined by the standard method as suggested in ISI Handbook of Food Analysis (1989) for ice cream mixes using 5 g ice cream mix sample. The total solids of the ice cream were determined by the standard procedure as described for milk using about 2 g of sample. The titratable acidity of the ice cream was determined by the standard method suggested in ISI Handbook of Food Analysis (1989). The pH of the ice cream mixes was determined using a Systronic digital pH meter, Model 335, Systronic Ltd., Ahmedabad, India at 25 °C. The protein content of the ice cream mixes was determined by Kjeldahl method (Menefee and Overman 1940). As per this method the total nitrogen was determined, and the value so obtained was multiplied by a standard factor 6.38 to get the protein content. Iron concentration was estimated by atomic absorption spectrophotometry (Spectrophotometer–Perkin Elmer model 3110, λ=248.3 nm) by AOAC (2005) using dry digestion method. The crude fibre content was determined by the method given IS: 10226 (1982) using 3 g sample. The viscosity of ice cream mix was determined by the method of Lowenstein and Haddad (1972) using a Brookefield Viscometer, Model DV-II+Pro (Brookefield Engineering Laboratories, USA). The viscosity readings were taken at 4 °C after ageing mixes at 3–4 °C for about 24 h. The specific gravity of the ice cream and ice cream mixes was determined at 20 °C using a specific gravity bottle according to the method described by Ling (1963). Overrun was determined according to the method given by Marshall et al. (2003). A known volume of ice cream mix was weighted accurately and then the same volume of ice cream was weighed and the overrun was calculated. The melting characteristics of ice cream were evaluated according to the method given by Lowenstein and Haddad (1972) with slight modifications. A day prior to melting characteristics determination, samples were transferred to a −15±2 °C deep freezer and left overnight. One lit packet of ice cream was taken and a slice weighing 100 g was cut in duplicate. The slices were separately placed over a wire mesh screen (250 pores per sq. inch) and then placed over a long stem glass funnel of 6 in. diameter. The funnel with the wire meshes containing the ice cream slices were placed over a 100 ml glass cylinder. It was then kept in an incubator maintained at 30 °C for 45 min. After 45 min the weight of ice cream melted was noted. The melting characteristics were determined as % of total ice cream melted in 45 min at 30 °C.

The hardness of the hardened frozen product was measured using FPN3 cone penetrometer (Associated Instrument Manufacturers Pvt. Ltd., India). The mass of the dropping assembly (shaft+cone) was 155 g. The hardened samples were subjected to penetration measurements at −15±2 °C. The samples were tested for the hardness by adjusting the cone of penetrometer exactly above the surface of the sample and allowing the cone to freely penetrate the product for 10 s. The depth of penetration was measured in 0.1 mm units on the dial of the instrument. These penetrations were made on each sample at three different points and the closest two readings were averaged.

Heat shock treatment of ice cream

The procedure suggested by Arbuckle (1986) was used to evaluate the freeze–thaw heat shock stability of frozen product samples. After 24 h of hardening, samples were transferred to a temperature controlled area maintained at 22 °C, kept for 1.5 h and then returned to the frozen stage at −18±2 °C. Again after 24 h, the same samples were transferred once again to the same temperature controlled area for another 0.5 h shock and returned back to the frozen storage. The treatment was repeated every day for 6 days. At the end of the heat shock period, the frozen product samples were returned to the frozen storage for 24 h before being evaluated for its sensory attributes. Ice cream samples were also stored for 30 day in a deep freezer at −18±2 °C and tempered to −12±2 °C before being evaluated for sensory characteristics by the panel of judges to study the effect of storage on the quality of ragi ice cream. Each part was replicated six times. The sensory quality of freshly hardened, heat shocked and stored products was adjudged by a panel of 7 judges using the 9-point hedonic scale score card recommended by Stone and Sidel (2004).

Sensory analysis The frozen product samples were tempered to −12±2 °C for 1–2 h before judging. Sensory evaluation of the ice cream samples was conducted in isolated booths illuminated with incandescent light and maintained at 23±2 °C. Samples were served in the 100 ml polystyrene cups in which they were frozen. The cups were labeled with three-digit codes. The order of presentation of the samples was randomized across subjects. Subjects judged a maximum of 4 samples in one session. The sensory panel (n=7) was composed of staff members and post graduate students working in the institution. The selection criterion was that subjects had to be regular consumers of typical dairy ice cream as well as their similar behavior between sensory evaluation sessions. Ice cream was analyzed for flavour, body and texture, color and appearance, melting quality and overall acceptability using the 9-point hedonic scale (Stone and Sidel 2004).

Statistical analysis The statistical analysis of the data was carried out as per Steel and Torrie (1980) using completely randomized design.

Results and discussion

Compositional attributes and acidity of ice cream mixes The average compositional values, acidity and pH of control (C) as well as experimental samples (M1, M2 and M3) are presented in Table 1. There was an increase in the total solids content of the mix with increase in level of MRB addition which is from 36.36 in M1 to 37.44 in M3. Incorporation of MRB also tended to increase the fat content and increase protein content of mixes. All the experimental samples had significantly (P>0.05) higher protein content compared to control. The total solids content of C and M1 were at par (P>0.05) with each other. Incorporation of MRB at higher levels tended to increase the acidity and decrease pH of mixes significantly (P<0.05).

Similar observations were also reported by (Desai et al. 2010) while studying the effect of malted ragi flour in cake preparation. There was a decrease in pH and increase in titratable acidity as the quantity of malted ragi flour increased. This change may be due to the hydrolysis of fats, producing fatty acids and production of ascorbic acid during germination process (Sangita and Sarita 2000; Taur et al. 1984).

The increase in total solids with increase in level of MRB could be attributed to the high total solids content i.e. 88 % in ragi flour. An increase in TS with incorporation of rice flour in ice cream was obtained by Cody et al. (2007). The slight increase in acidity of experimental medium-fat ice cream mixes could be ascribed to higher MSNF content compared to control. The values of acidity observed in present study are similar to those reported by Gabriel et al. (1986) and Neshawy et al. (1988). The total solids content of mixes was found to increase in proportion to the amount of ragi flour added. Thus the results corroborates with those reported in literature.

Viscosity of ice cream mixes The viscosity of ice cream mixes tended to increase with increasing level of addition of MRB. The viscosity of control was 295.0 cP. The viscosity of experimental mixes progressively increased with increasing level of addition of MRB and reached a maximum level of 307.8 cP at 10 % level of addition (M3). It is evident from the relevant statistical analysis that incorporation of MRB significantly (P<0.05) increased the viscosity of experimental samples. The viscosity values of control and M2 were statistically at par each other (P>0.05).

Ice cream mixes containing carbohydrate-based fat replacers exhibit a viscous behavior because of the capability for imbibing water, which would increase the viscosity of the system (Cottrell et al. 1980; Schmidt et al. 1993). This was expected, because carbohydrates are known to be good water binding agents, sometimes better than proteins (Clark 1994; Akoh 1998). Incorporation of ragi in various forms tended to increase the viscosity of mixes. Ragi is a good source of starch and fibers. Water absorption property, swelling power and solubility of starch and fibers are temperature dependent; it also depends on the degree of intermolecular bonding while starch depolymerization is caused by the thermal treatment (Alexander 1995). Increasing of temperature exhibits a higher swelling pattern than those shown at low temperature (Kayisu et al. 1981), which was attributed to high thermal treatment that produces a total disruption of the granular structure of the starches (Colonna et al. 1984; Perez 1997). Thus a significant increasing pattern in the viscosity of experimental mixes was associated with progressive increase in the level of MRB was observed. These results are in agreement with Concy (2009) who reported that viscosity decreased in roasted finger millet

Table 1 Influence of varying levels of gelatinized malted ragi flour roasted in butter (MRB) on the chemical composition, pH and viscosity of ice cream mixes

Level of addition of MRB in ice cream mix (% w/w)	Constituents (%)				Physico-chemical properties	
	Fat	Protein	Total solids	Acidity (%L.A)	pH	Viscosity (cp at 4 °C)
C	10.13±0.21[a]	3.99±0.02[a]	36.44±0.14[c]	0.20±0.01[c]	6.30±0.08[a]	295.0±46.54[b]
M1 (8.0)	6.23±0.21[b]	4.33±0.13[b]	36.36±0.63[c]	0.23±0.00[b]	6.28±0.09[a]	238.3±53.77[c]
M2 (9.0)	6.38±0.14[b]	4.34±0.25[b]	36.90±0.94[b]	0.25±0.01[a]	6.20±0.09[a]	287.0±37.74[b]
M3 (10.0)	6.50±0.08[b]	4.39±0.08[b]	37.44±0.93[a]	0.26±0.01[a]	6.05±0.09[b]	307.8±91.46[a]
CD(0.05)	0.46	0.17	0.15	0.012	0.12	10.08

Each observation is mean±SD of 4 replications

[a–c] Superscript letters following numbers in the same column denote significant difference ($P<0.05$)

porridge compared to unroasted millet porridge. Cenkowski et al. (2006) also reported decrease in the peak and final viscosity for micronized oats. They suggested that the loosely packed starch granules with high level of damaged starch in gun puffed cereal grains easily hydrate and swell more rapidly in the presence of heat and consequently produce less peak viscosity (Mariotti et al. 2006a, b). On the contrary, many workers have reported that flours milled from roasted legumes showed increased water retention capacity (D'Appolonia 1978; Han and Khan 1990) and viscosity (Han and Khan 1990). Tonroy and Perry (1974) opined that the more the corn is heated, the greater the degree of swelling which results in decreasing the density, increasing water absorption, and permitting greater accessibility by digestive enzyme. Increase in water absorption capacity after roasting of different cereals and legumes has also been reported by Griffith et al. (1998). The increase was attributed to starch damaged due to gelatinization and formation of porous structure in the endosperm, which imbibes and holds water by capillary action (Mariotti et al. 2006a, b).

Increase in fat and protein may cause increase in viscosity but these components were equal in all experimental samples viz. M1, M2 and M3, so increase in viscosity was only due to differences in type and concentration of gelatinized ragi starch. In this study, M1, M2, and M3 were formulated with increasing levels of MRB. This proved to have a profound effect on viscosity. Gelatinization of ragi starch is the most prominent change taking place during cooking of ragi. It results in uptake of water by the starch granules accompanied by expansion of the network of starch molecule chains. During processing the starch molecule undergoes several physical changes depending on its type and the processing methods employed (Goni and Manas 1996). Viscosity showed an increasing trend with ragi content. A significant increase in viscosity with higher starch content was noted in previous studies (Li et al. 1997; Prindivelle et al. 1999). Gelatinized ragi flour which was added in the experimental mixes contained more than 60 % starch which might be responsible for the change in viscosity. Gelatinized ragi starch has water holding capacity of 10.9 ml/g has been reported for ragi starch (Mohan et al. 2005) and it can influence the rheological properties of ice cream mix (Guinard et al. 1994) so undoubtedly increase in quantity of gelatinized ragi, result in increase in viscosity (Muse and Hartel 2004; Rosalina et al 2004). The swelling power of native ragi starch at 90 °C gelatinization temperature was the highest i.e. 800 %. (Adebowale et al. 2005).

Viscosity of ice cream mix increased due to higher dietary fibre content (about 22 %) of Ragi (Klopfenstein 2000). Higher fibre content increases viscosity by increasing total solids content and the formation of networks comprised of hydrated cellulose and hemicelluloses (Soukoulis et al. 2009). Heating of milk in preparation of MRB during gelatinization of ragi denatured proteins in increased viscosity by greater water binding ability (Flack 1988). Blanc and Odet (1981) observed that since the rheological properties of milk are not ideal unlike those of Newtonian liquids, the values published concerning viscosity are not always comparable. Further, the casein aggregates in the mix can be disrupted during the measurement of viscosity and does not always give an accurate picture of consistency. During gelatinization of starch there might be inter and intra molecular reactions of milk constituents and ragi constituents, which may play some role in increasing viscosity of ice cream mixes. In similar studies Patel et al. (2009) reported that addition of sago in gelatinized form increased the viscosity of ice cream mixes. Cody et al. (2007) indicated addition of rice flour increased viscosity of ice cream mix. Cottrell et al. (1980) also reported that polysaccharides such as starch increased the mix viscosity and restricted ice crystal growth during storage of ice cream. Schmidt et al. (1993) found that the use of carbohydrate-based fat replacers in reduced fat ice creams resulted in mixes with higher viscosities. Ice cream mixes with high viscosities are known to have limited whipping ability (Marshall and Arbuckle 1996). These results were in agreement with the data obtained on overrun values (Table 2) where ice cream

Table 2 Influence of varied levels of gelatinized malted ragi flour roasted in butter (MRB) on the average hardness, overrun, weight/volume and melting resistance of ice cream

Level of addition of MRB in ice cream mix (% w/w)	Inverse of hardness (1/10th mm)	Overrun (%)	Weight/volume (g/l)	% ice cream melted at 30 °C after 45 min
C	132.3±6.00[b]	91.83±2.01	578.69±6.20[c]	43.25±2.00[bc]
M1(8.0)	139.5±5.67[a]	89.80±1.04	593.80±3.27[a]	47.25±3.62[a]
M2(9.0)	126.5±4.54[b]	91.50±1.00	589.07±4.61[b]	45.25±2.50[ab]
M3(10.0)	119.0±8.28[c]	90.50±4.24	592.66±13.21[a]	40.25±4.33[c]
CD(0.05)	6.7	NS	6.58	3.59

Each observation is mean±SD of 4 replications

[a–c] Superscript letters following numbers in the same column denote significant difference ($P<0.05$)

mixes containing highest levels of ragi viz. G3 exhibited lower overrun values.

Melting resistance of ice cream Meltdown is an important property of ice cream affecting its sensory quality. Ice cream should melt down to a liquid of smooth consistency, suggestive of a rich ice cream. It is also important that the ice cream is not too hard or should not melt quickly. Table 2 shows the influence of incorporation of MRB at different levels (i.e. 8, 9 and 10 % in M1, M2 and M3 respectively) on the melting resistance of ice cream. The rate of meltdown of ice cream samples containing MRB decreased progressively with increasing rate of addition of MRB.

It can be seen from the statistical analysis that M1 had significantly ($P<0.05$) higher meltdown rate compared to control while M3 had significantly ($P<0.05$) lower meltdown rate compared to M1 and M2. Amongst the experimental samples M1 and M2 were statistically undistinguishable ($P>0.05$) with regard to the melting resistance. The melting resistance of M1 was the lowest followed by M2, C and M3. Thus, it can be seen that increase in rate of addition of MRB was found to cause increased melting resistance of ice cream (i.e. lower melting rate values). The comparatively higher melting resistance evinced in case of samples containing MRB at higher rate (M3) was due to the profound increase in mix viscosity of M3 as is evident on comparing Table 1 with 2. The melt-down rate of ice cream is affected by many factors, including the amount of air incorporated, the nature of the ice crystals, and the network of fat globules formed during freezing. In general as the viscosity increases, the resistance to melting and smoothness increases (Marshall et al. 2003). The increase in melting resistance with increasing level of gelatinized ragi starch addition to ice cream mix is quite evident from this study. The results for melting characteristics suggest that ragi starch may act as a stabilizer due to its high capacity for binding water (Mohan et al. 2005). Slow melting indicates over stabilization and such condition can be corrected by reducing the amount of stabilizer and/or emulsifier. Hydrocolloids present in Ragi might be responsible for increasing the melting resistance of ice cream. The highest level of addition of MRB to ice creams led to a significant decrease in melting rate. Cody et al. (2007) in contradiction reported no significant differences in melting rates between rice flour treatments. Ragi is a good source of fiber. There are little data dealing with the study of the functionality of dietary fibers in ice creams. The use of citrus fiber has led to significant improvement of melting quality of ice cream but failed to improve viscosity, overrun and texture (Dervisoglu and Yazici 2006).

Sakurai et al. (1996) 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 which was attributed to a reduced rate of heat transfer due to a larger volume of air and more tortuous path through which the melting fluid must flow. Rosalina et al. (2004) reported that ice creams with lower overruns were harder than those made with high overrun but melted more rapidly.

Overrun of ice cream Overrun, which is directly related to the amount of air in ice cream, is important because it influences product quality and profits and is involved in meeting legal standards. Too high overrun produces a fluffy ice cream and too little produces a soggy, heavy product. Table 2 represents the average values of overrun in ice cream samples expressed as % overrun, as influenced by the level of addition of MRG. The average overrun was found to be maximum in C (91.83 %). The average overrun values of all the experimental samples ranged from 89.8 % in M1 to 91.5 % in M2. The statistical values determined on the basis of these data depicted in Table 2 indicate no significant ($P>0.05$) effect of addition of MRB on the overrun of ice creams.

In all the samples, increase in concentration of MRB and therefore increase in viscosity improved overrun slightly, however, this effect was not found to be significant. The most likely reason why overrun did not appear to be significant in this study was the low range of overruns obtained during batch freezing. All ice creams had overruns between 89.8 and 91.8 %. The use of a batch freezer in this study did not allow for sufficient differences in overruns. A wider range in overrun is needed to see an effect on melting rate (Muse and Hartel 2004). The overrun in ice cream also affects hardness. Ice creams with high overruns are softer (Wilbey et al. 1998).

During the freezing of ice cream, the whipping action and ice crystallization destabilizes the fat emulsion in the mix. The destabilized fat acts as a cementing agent and provides support to the air bubbles primarily lined by proteins. The combination of milk proteins and partially coalesced fat provides strength and structure to the ice cream (Goff and Jordan 1989; Hegenbart 1990; Marshall and Arbuckle 1996). Thus, creating and stabilizing the desired structure in low-fat frozen dessert products is difficult, because the coalesced fat fraction is lowered, whereas the protein fraction may be increased (Adapa et al. 2000). However, in this study even though the fat content of experimental mixes (i.e. 6 %) were lower than control (10 %) there was no effect on the overrun of ice cream. Addition of malted ragi could have helped in providing additional strength and structure to the ice cream.

Hardness of ice cream Hardness of ice cream is measured as the resistance of the ice cream to deformation when an external force is applied. The hardness of ice cream is affected by factors such as the overrun, ice crystal size, ice phase volume, and extent of fat destabilization. Sakurai et al. (1996) found that ice creams with larger ice crystals were harder. The hardness of ice cream was exponentially related to the ice phase volume. Incorporation of ragi in the form of MRB could have had an effect on these properties. An inverse relationship between hardness and overrun has been observed (Tanaka et al. 1972; Wilbey et al. 1998). However no such relationship was observed in this study. The average values of hardness of C, M1, M2 and M3 is presented in Table 2. It can be interpreted from the Table that there was an increase in hardness of ice creams with increase in the extent of MRB. The statistical analysis reveals that there M3 was significantly harder and M1 was significantly less firm than all the other samples. There was no significant difference ($P>0.05$) in the hardness values of the C and M2.

The increase in hardness with addition of gelatinized ragi flour may be due to the good water binding properties of gelatinized ragi starch which would have made the product more firm than the control. There are little data dealing with the study of the functionality of dietary fibers in ice creams. The use of citrus fiber has led to significant improvement of melting quality of ice cream but failed to improve viscosity, overrun and texture (Dervisoglu and Yazici 2006). Addition of rice starch was found to be a satisfactory fat replacer, though it imparted a powdery mouthfeel. Significant differences ($P<0.05$) were observed among all the rice flour concentration levels (2, 4, and 6 %) for hardness, chewiness, gumminess, and flour flavor, which showed a continuous increase with elevated rice flour concentrations (Cody et al. 2007).

Sensory attributes To select the preferred level of MRB in ice cream from the three levels tested, the sensory quality was assessed by a panel of 7 experienced judges. It can be observed from Table 3 that among the experimental samples, M2 (9 % MRB) was preferred the most with respect to flavour scoring 8.11 followed by C, M1 and M3. It can also be seen from the table that the flavour scores of C and M2 were at par ($P>0.05$) with each other. The flavour scores of M3 were significantly ($P<0.05$) lower than control and M2. Even though the fat level in M2 was significantly lower than control (10.13 % vs. 6.38 % fat), judges could not differentiate the creaminess/richness between both the samples. Roasting of malted ragi flour in butter enhanced the richness and taste of the product. Thus, MRB can effectively used as a fat replacer in ice cream. Body and texture score was at par ($P>0.05$) for C and M2. The body and texture score of M3 and M1 were significantly ($P<0.05$) lower than C and M2. The body and texture of M2 and control was firm, velvety smooth and creamy. On the other hand, M1 lacked the desired smoothness, whereas M3 had a slightly gummy body owing to excess quantum of MRB which led to more chewy and gummy product. The mean colour and appearance scores of ice cream samples varied within a very narrow range of 8.16 (C) and 7.86 (M3) and were in the order C>M2>M1>M3. No significant difference in colour and appearance scores amongst control and samples was observed ($P>0.05$). Addition of MRB did not have any adverse effect on colour and appearance scores of ice cream. The melting quality score of control was maximum being 8.23. The scores of the melting quality of experimental samples ranged from 8.01 (M2) to 7.54 (M1). The melting quality scores of control were statistically at par with M2. However the melting quality scores of M1 and M3 were significantly ($P<0.05$) lower than control. M1 (8 % MRB) scored minimum marks. The sample was criticized for its faster meltdown compared to rest of the samples by some of the judges.

The overall acceptability score of C was the highest (8.15) followed very closely by M2 (8.04), followed by M3 (7.77) and M1 (7.67) scoring minimum marks. The overall acceptability scores of M2 were found to be at par with that of control ($P>0.05$). The medium fat product prepared using 9.0 % MRB was found to have a pleasant, delicate flavour with a creamy and rich aftertaste. As can be seen from the flavour, body and texture and melting quality scores, the sensory characteristics of M2 were not noticeably different from control. Whereas, M1 was found to have a slightly higher melt down, coarse texture, weak body and M3 had a flat flavour and gummy body. It is evident that amongst all the levels tried, M2 (9.0 % MRB) resulted in a product having superior flavour score and overall acceptability score.

Table 3 Influence of varied levels of gelatinized malted ragi flour roasted in butter (MRG) on the 9-point hedonic scores of ice cream

Level of addition of MRB in ice cream mix (% w/w)	Flavour	Body and texture	Melting quality	Colour and appearance	Overall acceptability
C	8.04±0.32[ab]	8.16±0.15[a]	8.23±0.11[a]	8.16±0.07	8.15±0.08[a]
M1(8)	7.73±0.12[bc]	7.61±0.12[c]	7.54±0.12[c]	7.98±0.07	7.67±0.12[b]
M2(9)	8.11±0.12[a]	8.02±0.18[a]	8.01±0.06[ab]	8.02±0.15	8.04±0.05[a]
M3(10)	7.57±0.18[c]	7.86±0.10[b]	7.80±0.24[b]	7.86±0.13	7.77±0.14[b]
CD(0.05)	0.31	0.22	0.23	NS	0.16

Each observation is mean±SD of 4 replications

[a–c] Superscript letters following numbers in the same column denote significant difference ($P<0.05$)

Preference of flavouring agents in ragi based ice cream

To select the best form of flavouring compatible in ragi ice cream, ragi ice cram was prepared using 4 different flavorings viz. vanilla (VA), cocoa (CH), mango (MG) and caramel (CB). The formulation of VA, CH, MG and CB is presented in Table 4.

Physical properties The average compositional values, acidity and pH of ragi ice creams prepared using different flavoring materials viz. vanilla (VA), caramel (CR), mango (MG) and chocolate (CH) are presented in Table 5. There was an increase in the total solids content of the mix when cocoa was used as a flavoring agents whereas addition of mango as flavoring agents resulted in a decrease in total solid and protein content. Incorporation of mango also resulted in increase in acidity and decrease in pH of the mixes. Addition of vanilla and caramel flavour had no effect on total solids of the mix. The protein content of CH, CR and VA were at par with each other ($P>0.05$). The protein and total solids content of MG was significantly lower than all the other samples. Addition of mango pulp resulted in significantly lowering the fat and total solids content of the mixes. Patel et al. (2009) reported acidity of mango ice cream mix to be in range from 0.5 to 0.52 % LA. However, they added mango pulp at a higher rate i.e. 20 %. In this study the acidity of mango ice cream mix was found to be 0.39 % LA. The iron content of VA, CR, MG and CH was found to be 8.25, 8.25, 7.37 and 12.8 ppm respectively vs. 1.5 ppm in control (C). The total crude fibre content of VA, CR, MG and CH was 1.28 %, 1.28 %, 1.25 % and 1.36 % respectively vs 0.18 % in control (C).

The viscosity of ice cream mixes ranged from 272 cP in CR to 355 cP in MG. The statistical analysis reveal that the viscosity of MG was significantly ($P<0.05$) higher than all the other samples. The viscosity of VA and CR ice cream mixes were also at par ($P>0.05$) with each other. Incorporation of mango and chocolate as flavoring components in ice cream mixes tended to increase the viscosity of mixes. Cocoa contains a high amount of starch (5.30–7.00 %)

Table 4 Formulation for mango, chocolate, vanilla and caramel ice cream

A. Composition of the base mix					
Sr. No.	Constituents	% level of addition			
		Vanilla ice cream	Caramel ice cream	Mango ice cream	Chocolate ice cream
1.	Milk fat	6	6	6	6
2.	MSNF	11.5	11.5	11	11
3.	Sucrose	15	15	14	16
4.	Stabilizer	0.1	0.1	0.05	0.05
5.	Emulsifier	0.2	0.2	0.2	0.2
	Total solids	32.8	32.8	31.25	33.25
B. Rate of addition of ragi and flavoring agents in the base mix:					
1	Rate of addition of MRB	9	9	9	9
2.	Cocoa				1 kg/100 kg mix
3.	Kesar mango pulp			15 kg/100 kg mix	
4.	Vanilla essence	3 ml per kg mix			1 ml/kg mix
5.	Caramel		7 ml per kg mix		

Table 5 Influence of different flavouring ingredients on the chemical composition, acidity and pH of ragi ice cream mixes

Type of ice cream	Constituents (%)				Physico-chemical properties	
	Fat	Protein	Total solids	Acidity (%L.A)	pH	Viscosity (in cp at 4 °C)
Vanilla	6.50±0.06[a]	4.36±0.04[a]	37.95±0.02[b]	0.23±0.01[b]	6.23±0.04[a]	287.00±5.72[c]
Caramel	6.50±0.04[a]	4.36±0.04[a]	37.95±0.02[b]	0.24±0.01[b]	6.21±0.02[a]	272.74±21.78[c]
Mango	5.84±0.03[b]	3.69±0.08[b]	35.12±0.02[c]	0.39±0.01[a]	5.80±0.08[b]	355.49±13.77[a]
Chocolate	6.54±0.02[a]	4.34±0.01[a]	38.74±0.14[a]	0.23±0.00[b]	6.29±0.04[a]	314.26±12.28[b]
CD(0.05)	0.064	0.08	0.112	0.01	0.08	22.44

Each observation is mean±SD of 4 replications

[a–c] Superscript letters following numbers in the same column denote significant difference (P<0.05)

which would have resulted in increased viscosity of mix. Pectin present in mango pulp could have resulted in increased viscosity of mango ice cream mixes. The acidity of MG was also higher than all the other samples. The higher acidity of the mix might have been responsible for the increased viscosity of the mix. The inter- and intra-molecular reactions of the milk solids, ragi solids and mango solids might be playing some role in increasing the viscosity which needs further investigations.

The experimental samples (CH, MG, CR and VA) were evaluated for their melting resistance in terms of % ice cream melted after 45 min at 30 °C. The melting resistance of ice cream samples varied from 39.25 % in mango to 46.50 % in caramel (Table 6). MG had the highest melting resistance whereas CR had the lowest melting resistance. The melting rate of caramel and vanilla were at par (P>0.05) with each other. The results indicate that addition of mango significantly increased the melting resistance of ice creams (P<0.05). The higher melting resistance of MG could be due to the higher viscosity resulting from incorporation of mango pulp at higher amounts. The viscosity of MG mix was also found to be higher than all the other samples.

The average overrun was maximum in caramel (94.5 %) and minimum in chocolate (82.8 %). The CR had significantly (P≤0.05) higher overrun than all the other samples. CR and VA being at par with each other (P>0.05). The overrun of MG and CH were significantly lower than all the other samples, being at par with each other. The lower overrun encountered in the experimental samples may be ascribed to the relatively higher viscosity associated with such samples.

The experimental samples have shown a penetration depth of 116.75 (chocolate), 120 (mango), 126.5 (vanilla) to 128 (caramel). The hardness of CH was significantly (P<0.05) higher than VA and CR. The hardness value of CH and MG were at par with each other (P>0.05). The increase in hardness with addition of cocoa and mango pulp may be due to the higher viscosities of these mixes which would have made the product more firm than the other samples.

Sensory properties The objective of this section was to identify and quantify the flavour, mouth feel appearance of ice cream by incorporation of various flavoring agents in ice cream incorporated with malted gelatinized ragi at varying levels. Chocolate was most preferred flavor among all followed by mango, caramel and vanilla (Table 7). The flavour score of CH was found to be significantly higher than all the other samples. From the body and texture score point view, CH (8.39) obtained the highest score of followed very closely by MG (8.32), CR (8.04) and VA (8.00). The body and texture scores of chocolate and mango were undistinguishable

Table 6 Influence of different flavoring agents on the average hardness, overrun, weight by volume and melting resistance of ragi ice cream

Type of ice cream	Inverse of hardness (1/10th of mm)	Overrun (%)	Weight/volume (g/lit)	% ice cream melted at 30 °C after 45 min
Vanilla	126.5±2.65[a]	93.0±1.41[a]	585.52±4.26[b]	44.75±2.06[ab]
Caramel	128.0±2.83[a]	94.5±3.00[a]	581.08±8.93[b]	46.50±4.43[a]
Mango	120.0±3.27[b]	83.3±2.06[b]	616.70±6.93[a]	39.25±0.96[c]
Chocolate	116.8±2.06[b]	82.8±2.99[b]	618.50±10.14[a]	42.00±0.82[bc]
CD(0.05)	4.21	3.79	12.16	3.89

Each observation is mean±SD of 4 replications

[a–c] Superscript letters following numbers in the same column denote significant difference (P<0.05)

Table 7 Influence of various flavoring ingredients on the 9 point hedonic scale scores of ragi ice cream

Type of ice cream	Sensory attributes				
	Flavour score	Body and texture score	Melting quality score	Colour and appearance score	Overall acceptability score
Vanilla	7.89±0.09^{c}	8.00±0.08^{b}	8.11±0.24^{b}	8.09±0.0^{b}	8.00±0.07^{c}
Caramel	7.93±0.00^{c}	8.04±0.07^{b}	8.20±0.07^{b}	8.11±0.1^{b}	8.05±0.04^{c}
Mango	8.38±0.04^{b}	8.32±0.04^{a}	8.57±0.12^{a}	8.16±0.1^{b}	8.42±0.04^{b}
Chocolate	8.79±0.06^{a}	8.39±0.09^{a}	8.66±0.36^{a}	8.57±0.1^{a}	8.61±0.05^{a}
CD(0.05)	0.09	0.12	0.21	0.14	0.08

Each observation is mean±SD of 4 replications

$^{a–c}$ Superscript letters following numbers in the same column denote significant difference (P<0.05)

statistically (P>0.05) while caramel and vanilla had significantly lower scores than all the other ice creams (P<0.05). The colour and appearance scores indicate that chocolate scored the highest (8.57) followed by mango (8.16), caramel (8.11) and vanilla (8.09). The colour and appearance scores of CH was significantly (P<0.05) higher than all the other samples. The colour and appearance scores of VA, CR and MG were at par (P>0.05) with each other. The presence of fine dark coloured specks in chocolate ice cream due to ragi fines were not objected by the judges in chocolate flavoured ice cream whereas in ice creams flavoured with caramel, mango and vanilla, the judges objected to the presence of the reddish dark coloured particles. A very marginal variation was observed in the melting quality score ranging from chocolate (8.66) to vanilla (8.11). The melting quality scores of CR and VA were significantly (P<0.05) lower than all the other samples. Incorporation of mango and cocoa as flavoring ingredients resulted in increasing the melting resistance of ice creams. This could have in part been responsible for the improved melting quality scores of these products. The overall acceptability score of CH was the highest (8.61) followed by mango (8.42), caramel (8.05) and vanilla (8.00). The overall acceptability score of CH was significantly (P<0.05) higher than all the other samples. The overall acceptability score of VA and CR was significantly lower than the other samples (P<0.05). Thus, it can be concluded that Chocolate flavoured ragi ice cream was preferred most followed by mango, caramel and vanilla flavored ragi ice cream.

Assessing the effect of heat shock and storage on sensory properties of chocolate flavoured ragi ice cream

Ice cream is a high cost-value dairy product. Costs are mostly related to ingredients and energy required for frozen storage, distribution, and retail sale. Consumer acceptance of ice cream depends largely on its textural quality and flavor. However, any temperature fluctuation or abuse between manufacture and consumption can cause detrimental effects on ice cream quality (Alvarez et al. 2005). During storage, frozen desserts, like any other dairy products undergo physical and biochemical changes that on set the deterioration in organoleptic quality of the product making them unacceptable. It is hypothesized that incorporation of ragi will influence physical properties of the ice cream, thus slowing development of icy texture over time and after heat shock. Chocolate flavoured ice cream containing malted gelatinized and roasted ragi flour (CH) was found to be superior to the other samples with respect to flavour and overall acceptability score. Hence it was used in this part of the study. The freshly hardened ice cream (−18±2 °C for 24 h) was evaluated along with hardened ice cream melted out with heat shock treatment and stored product (i.e. at −18±2 °C for 30 day). The average sensory scores for the freshly hardened; heat shocked and stored dietetic frozen dessert for the various attributes are collated in Table 8. The difference in the score of either fresh, heat shocked or stored product was found to be very small in magnitude. In case of heat shocked and stored product there

Table 8 Influence of heat shock and storage on the sensory on 9-point hedonic scale scores of ragi ice cream

Attribute	Freshly hardened ragi ice cream	Heat shocked ragi ice cream	Stored ragi ice cream	CD(0.05)
Flavour	8.45±0.17	8.33±0.21	8.21±0.18	NS
Body and texture	8.25±0.09	8.14±0.12	8.23±0.06	NS
Colour and appearance	8.40±0.07	8.41±0.04	8.35±0.07	NS
Melting quality	8.36±0.24	8.25±0.27	8.31±0.21	NS
Overall acceptability	8.40±0.06	8.34±0.08	8.29±0.08	NS

Each observation is mean±SD of 6 replications was a very slight decrease in the flavour score. From the statistical point of view, the heat shock treatment or storage did not exert any influence on the flavour score of the product ($P>0.05$).

Normally, the stabilizer content of ice cream ranges from 0.2 to 0.3 % to avoid coarseness during storage (Marshall et al. 2003). Since the rate of addition of stabilizer in MRB was lower than normal, i.e. 0.05 % only, a very close attention was given to examine the body and texture scores. As seen in Table 8, in case of heat shocked product, there was a slight decline in body and texture score 8.14 compared to the fresh product i.e. 8.25. The average body and texture score of stored sample was 8.23 out of 10. It can be seen from the table that though there was a decline in body and texture scores of heat shocked and stored products, the decrease was found non significant ($P>0.05$). The total dietary fiber of ragi is very high (Klopfenstein 2000). This could have helped in increasing the viscosity of mixes. Soukoulis et al. (2009) reported that the content of fiber in insoluble compounds increased significantly the viscosity and the shear thinning behavior of ice creams, due to the increase of total solids and the formation of networks comprised of hydrated cellulose and hemicelluloses. Soukoulis et al. (2009) suggested the potential use of dietary fibers (oat, wheat, apple and insulin) as crystallization and recrystallization phenomena controllers in frozen dairy products. These results are not consistent with those reported by Cody et al. (2007) who reported that heat-shocked ice creams containing rice flour were significantly more icy and less cold than the control (stored but not heat-shocked) samples. Thus, compared to rice solids ragi solids have potential to control crystallization and recrystallization phenomena in ice cream which occurs during storage. Heat shock treatment or storage did not have any adverse effect on the colour scores of medium fat ragi ice creams.

The melting quality score decreased during heat shock treatment. The melting quality of stored sample was the highest i.e. 4.36 followed by stored i.e. 4.31 and heat shocked product 8.25. However, no significant differences in the melting quality scores of fresh, heat shocked or stored samples could be observed ($P>0.05$). Heat shock treatment or storage did not have any adverse effect on the melting quality scores of MRB.

The average overall acceptability scores decreased very slightly in magnitude with storage from 8.40 in fresh product to 8.29 in stored product. The overall acceptability score of heat shocked sample was lowest i.e. 8.34. Although the total score of heat shocked sample was slightly lower than fresh samples, no significant ($P>0.05$) difference in the overall acceptability of the sample was observed.

It can be concluded that acceptable quality medium fat (6 % milk fat) ragi ice cream can be prepared using pretreated malted ragi flour. The acceptability of this product was ice cream was comparable with vanilla ice cream containing 10 % milk fat. Among different flavours, Chocolate flavoured ragi ice cram was preferred most followed by mango, caramel and vanilla flavoured ragi ice cream. Incorporation of finger millet in chocolate ice cream as a functional ingredient resulted in reducing the amount of stabilizer used and effectively functioned as a fat replacer in ice cream. Heat shock treatment as well as storage up to 30 days had no adverse effect on the quality of the chocolate flavored ragi ice cream on the basis of the overall acceptability score.

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