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Development of Technology for Manufacture of Bottle Gourd Ice Cream

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Abstract

The present investigation was planned and conducted to develop a technology for the manufacture of a vegetable based "bottle gourd" ice cream. Among three varieties of bottle gourd viz. Pusa Naveen, Anand bottle gourd-1 and Pusa Summer, Pusa Naveen variety was found most suitable for manufacture of bottle gourd ice cream. The most suitable form of bottle gourd for preparation of bottle gourd ice-cream was a combination of processed sugar treated cubes and puree in ice-cream mix formulation consisting of 12.0% milk fat and 11.0% MSNF. Ice cream was prepared using a combination of selected forms viz. cubes and puree using different combination levels using a Response Surface Methodology (RSM) method to choose the best combination of forms of bottle gourd to be added to the ice cream mix. Processed bottle gourd puree was incorporated in ice cream mix and subsequently frozen, while the processed bottle gourd cubes were incorporated into the partly frozen ice cream, when drawn from the ice cream freezer. The optimized process suggested by RSM consisted of addition of cubes @ 6.85% and puree @ 4.71%. The mean score for fat (%), total solids (%), melting rate (%), ash (%) and acidity (% lactic acid) were 10.8, 37.7, 56.93, 0.87 and 0.19 respectively. The bottle gourd ice cream developed by optimized process was found to contain 3.9% protein, 303 cP (at 4°C) viscosity, 1.0962 specific gravity, 128.6 (1/10th mm) hardness, 0.126 mg/ 100 g β-carotene, 0.05% crude fibre, 0.68 mg/ 100 g Vitamin C, 0.15% calcium, 0.5% potassium and 0.16% phosphorus. Cardamom was the most preferred flavor for bottle gourd ice cream by local participants. The acceptability of developed cardamom flavored bottle gourd ice cream was at par (P>0.05) with vanilla ice cream.

Keywords: Bottle gourd; Ice cream, Puree; Vegetable; Cardamom; Pusa naveen

Introduction

Ice cream and frozen desserts are mainly valued for their pleasing flavor, cooling effects and refreshing tastes. The awareness of consumers for healthier and functional food has led to the introduction in ice cream manufacture of certain materials with documented nutritional and physiological properties such as probiotics [1,2], lactic acid bacteria [3], dietary fibers [4], alternative sweeteners [5], natural antioxidants [6] and low glycemic index sweeteners [7]. In today's food industry, a global trend towards the manufacture of healthier and more natural fruit and vegetable food products, such as soups, smoothies and sauces, is ongoing, as well as the incorporation of puréed vegetables in other food products. Currently health is a major concern of customers. Therefore, manufacturers are finding new ways to incorporate natural and innovative ingredients into ice cream for health benefits.

Vegetable plays an important role in daily human diet. Consumption of vegetables has been associated with protection against certain types of cancer, cardiovascular disease and various age related diseases [8]. «Thy food be thy medicine» is one of the laws of nature. WHO and FAO launched [9], a joint initiative to promote fruits and vegetables for health worldwide [10]. The role of vegetables in the human diet has increased since they provide essential carbohydrates, proteins, fiber, vitamins and minerals. They are important sources of vitamins, minerals and salts required for human nutrition. The carbohydrates, proteins and fats are required comparatively in larger quantity than vitamins and minerals. They also supply carbohydrates for energy and proteinous compounds for muscles building. They also contribute to roughage and fiber. Vegetables not only form an essential part of a well-balanced diet, but the flavor, aroma, also make them important in human diet and appetite [11]. WHO [9] recommends a minimum of 400 g of fruits and vegetables per day (excluding potatoes and other starchy tubers) for the prevention of chronic diseases such as heart diseases, cancer, diabetes and obesity as well as for prevention and alleviation of several micronutrient deficiencies, especially in less developed countries. In India more then 20-25% of fruits and vegetables are spoiled before utilization. Despite being the world's second largest producer of fruits and vegetables, only 1.5% of the total fruits and vegetables produced are processed. Incorporation of vegetable for the preparation of dairy products is thought to be a convenient and economical alternative for utilization of these vegetables [12]. Hence, there is a need to develop new functional dairy products to reflect consumer interest in health (e.g. utilizing vegetable source with phytochemicals) and naturalness [13]. Among various vegetables grown in India, bottle gourd (*Langenaria siceraria*) has a high place in diet as it is rich and the cheaper source of nutrients. Bottle gourd has long been an important component of indigenous herbal medicine, particularly in Asia [14]. Bottle gourd was used as an ingredient in ice-cream in this study since it is a highly valued vegetable containing good amounts of nutrients like carbohydrates, Vitamin A, Vitamin C and minerals.

Materials and Methods

Whole milk (5.5 ± 0.13% fat; 8.5 ± 0.16% MSNF; titratable acidity 0.16 ± 0.02% LA) procured from Vidya Dairy, Anand and "Sagar" brand skim milk powder (SMP), marketed by Gujarat Cooperative Milk Marketing Federation Ltd., Anand were used as the base materials for ice cream manufacture. Commercial grade cane sugar (M grade) was obtained from the local market of Anand. Sodium alginate (RM-7494), guar gum (RM-1233) and carrageenan (RM-1576) from Hi-

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media Laboratories Pvt. Ltd., Mumbai were used as a stabilizers 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), cardamom powder (freshly made from commercially available cardamom) and saffron essence (Bush International Flavors and Fragrances India Pvt. Ltd., Mumbai) were used as the flavoring agents in bottle gourd ice cream. Bottle gourd (Pusa Naveen and Pusa Summer variety) were procured from local vegetable market of Anand and Anand Bottle Gourd – 1 variety was procured from the Anand Agricultural University farm located at Anand, Gujarat.

Selection of variety of bottle gourd

Three varieties of bottle gourd viz. Pusa Summer, Pusa Naveen and Anand Bottle gourd-1 were screened for their suitability for preparation of bottle gourd ice-cream. Processed bottle gourd cubes and shreds were prepared using the procedure described by Babar [15] and processed bottle gourd puree was prepared using the procedure described by Agarwal and Prasad [16]. Processing of bottle gourd with peel resulted in bitter taste and off flavor in the final processed bottle gourd form than prepared from without peel bottle gourd. Therefore, peeled bottle gourd was used in the bottle gourd preparations in this study. The products prepared using three varieties were subjected to ranking test for preference using a panel of 25 judges selected from employees and students within department. The summary of ranking results of preference of processed cubes, shreds and puree prepared using three varieties of bottle gourd is presented in Table 1.

There was a significant difference ($P<0.01$) in preferences between the products obtained from the three varieties of bottle gourd studied. Products prepared using Pusa Naveen and Anand Bottle gourd-1 were significantly ($P<0.05$) preferred compared to products prepared using Pusa Summer variety. The products prepared using Pusa Naveen (and/or Anand Bottle gourd-1) were dark green in color, optimum chewiness and firmness and pleasing clean caramelized bottle gourd flavor. On the other hand, products prepared using Pusa Summer were light green in color, hard body, more chewy texture and lacked optimum bottle gourd flavor and were sometimes criticized for being slightly bitter in taste. It can be seen from Table 1 that there was no significant ($P>0.05$) difference in preference of products viz. cubes, shreds and puree prepared from Pusa Naveen and Anand Bottle gourd-1. However, since Pusa Naveen variety is available in the market throughout the year, it was selected and used throughout the study. Firm, tender, uniform, green, nearly straight and cylindrical bottle gourds, at a commercially marketable stage were obtained from a local market in Anand, Gujarat. Bottle gourds having 30 to 40 cm length and 8 to 10 cm thick were selected. Bottle gourds of cylindrical shape and having light green to slight dark greenish but uniform in color were selected. The average weight of selected bottle gourds ranged from 0.5 kg to 1 kg.

Sample	Rank Sum	Significance*
Processed bottle gourd cubes		
Pusa Naveen	41	A
Anand Bottle gourd-1	45	A
Pusa Summer	70	B
Processed bottle gourd shreds		
Pusa Naveen	43	A
Anand Bottle gourd-1	45	A
Pusa Summer	68	B
Processed bottle gourd puree		
Pusa Naveen	44	A
Anand Bottle gourd-1	46	A
Pusa Summer	66	B

Note: *Samples sharing the same letter are not significantly different ($P<0.05$)

Table 1: Summary of ranking results of preference of processed cubes, shreds and puree prepared using three varieties of bottle gourd.

Preparation of sugar treated bottle gourd shreds

Bottle gourds were peeled, washed and halved into two parts using clean, dry knife, de-cored and shredded (1.6 ± 0.1 cm length and 0.3 ± 0.1 cm width and thickness) using a shredder attachment (Model-Boss Food Processor, Boss Electrical, Solan and Himachal Pradesh). From 1 kg bottle gourd ~ 15 to 20% of its weight was peel and 20 to 25% was core portion. Therefore, quantity of edible portion bottle gourd obtained after peeling and decoring was 40 to 45% of weight of initial weight of bottle gourd. The shreds were blanched (90°C for 30 s) to prevent enzymatic browning [17] and transferred in pre-washed, sanitized clean pre-weighed stainless steel vessel. After draining, the shreds were mixed with water (obtained during blanching) and sugar at the rate of 70% by weight of raw bottle gourd shreds respectively. Sodium chloride was added at the rate 0.1% by weight of raw bottle gourd shreds and cooked on a medium flame till concentration of sugar syrup reached 60, 65, 70 and 75° Brix. In preliminary studies, it was found that concentration up to 60 and 65° Brix resulted in final shreds having uncooked, predominant raw bottle gourd flavor and less acceptable in terms of sensory characteristic was observed. Concentration to 70° Brix resulted in final quality shreds having very pleasant, clean, caramelized, properly cooked, no raw bottle gourd flavor, good texture was seen but above 70° Brix resulted in excessive increase in caramelized flavor, browning and chances of sticking or burning was more due to excessive concentration. Therefore, 70° Brix was used in preparation of shreds. To prepare 1 kg processed bottle gourd shreds, approximately 1 kg peeled and decored bottle gourd was required.

Preparation of sugar treated bottle gourd cubes

Bottle gourds were peeled, washed, halved into two parts, de-cored and cut in pieces (average length 5.0 ± 1.0 cm slices, breath 2.0 ± 0.5 cm and thickness 2.0 ± 0.5 cm). These raw pieces were blanched (90°C for 2 min) and drained. The pieces were then cut into 0.8 ± 0.2 cm^3 cubes and taken in pre-washed, sanitized, clean, pre-weighed stainless steel vessel. Water and sugar (70% by weight of bottle gourd cubes respectively) and salt (0.1% by weight of cubes) were added to the bottle gourd cubes and concentration was done till different level of degree Brix of sugar syrup (using digital Refractometer) was achieved. Different sugar syrup concentration was studied viz. 60, 65, 70 and 75° Brix by heating on medium flame. It was observed that cooking to final concentration up to 60 and 65° Brix resulted in final cubes having uncooked, unpleasant, predominant raw bottle gourd flavor, less sweet and less acceptable in terms of sensory characteristics. Cooking to concentration up to 70° Brix resulted in final quality cubes having very pleasant, clean, caramelized, sweet flavor and properly cooked firm texture was seen but above 75° Brix resulted in excessive increase in highly cooked, caramelized flavor, browning and chances of sticking or burning was more due to excessive concentration. So, 70° Brix was used in the final preparation of cubes [15]. Hence, 70° Brix sugar syrup concentration was used in the final preparation of cubes. To prepare 1 kg processed bottle gourd cubes 1 kg peeled and decored bottle gourd was required.

It has been reported in literature that treating bottle gourd cubes with calcium chloride solution for preparation of tutti fruity from bottle gourd resulted in improved firmness of cubes [15]. Therefore in this part, effect of treating blanched cubes by addition of calcium chloride on body and texture of processed bottle gourd cubes were evaluated. Control was also prepared without $CaCl_2$ treatment. After blanching the cubes were dipped in 1% calcium chloride solution for 3 h. The cubes were then drained, mixed with equal quantity of 50° Brix sugar syrup and cooked by heating on a direct flame till the concentration of sugar syrup reached 70° Brix. It was observed that $CaCl_2$ treated cubes had slight off flavor. However, the shape and color were acceptable. The control sample had good shape, flavor and color retention, uniform texture and firmness like tutti fruity. No perceptible difference was found in body and firmness of the samples. $CaCl_2$ treatment caused no improvement on texture or firmness of bottle gourd cubes. Hence, $CaCl_2$ treatment was not used during preparation of bottle gourd cubes.

Preparation of processed bottle gourd puree

Bottle gourds were peeled, washed and cut into pieces of average length 5.0 ± 1.0 cm slices, breath 2.0 ± 0.5 cm and thickness 2.0 ± 0.5 cm using a clean sharp, dry stainless steel knife. These pieces were immediately blanched (90°C for 2 min) to prevent enzymatic browning which affects the final quality of puree in terms of color and other sensory aspects [17]. Puree was made from the blanched and drained bottle gourd slices by grinding for 2 to 3 min food processor (Model-Boss Food Processor, Boss Electrical, Solan and Himachal Pradesh). The puree was then transferred in a clean, sanitized pre-weighed stainless steel vessel and sugar was added @ 50% (by weight of puree) and blended. In preliminary investigations it was found that addition of sugar at a higher rate resulted in excessive browning and pronounced caramelized flavor whereas addition of sugar at lower rate resulted in a product with decreased sweetness and unpleasant predominant bottle gourd flavor. The contents in the vessel were then cooked on medium flame. In order to select the concentration ratio (CR) with a view to achieve optimum flavor, color and acceptability of the final puree, three concentration ratios were employed viz. 1.3, 1.5 and 1.7. A properly cooked, clean, pleasing, caramelized bottle gourd flavor with optimum sweetness and dark green in color and having highly acceptable optimum flavor was obtained when a CR of 1.5 was used. Whereas use of lower CR i.e. 1.3 resulted in a puree with predominant raw bottle gourd flavor, lacking desired consistency, lighter in color, is lacking in sweetness. On the other hand, use of higher CR i.e. 1.7 resulted in highly caramelized flavor; excessively sweet, brown color and slight bitterness. Product became sticky therefore chances of browning and burning were more. Hence a CR of 1.5 was selected and used in preparation of bottle gourd puree. To prepare 1 kg processed bottle gourd puree 1.1 kg peeled bottle gourd was required. The prepared bottle gourd puree was bland in taste. Hence, sodium chloride was added at the rate of 0.1% by weight of raw puree to enhance its flavor.

Preparation of ice cream mix

Whole milk, cream and SMP used in the manufacture of ice cream mix were analyzed for their composition. The quantity of milk, cream, SMP, sucrose, sodium alginate, guar gum, carrageenan and GMS required for a batch (i.e. 5.0 kg of ice cream mix to be frozen in a direct expansion type batch freezer) was calculated using serum point method [18]. Cream (40.0 ± 2% milk fat separated from whole milk) was mixed with calculated quantity of whole milk and pre-heated to 45°C. All the dry ingredients viz. SMP, sugar, stabilizers and emulsifiers were dry blended and added to the milk - cream mixture at a temperature of about 50°C. The mix was further heated to 75°C and subjected to homogenization (150 and 50 kg/cm^2 pressure in the first and second stage respectively, M/s. Pal Engineering Ltd., Ahmedabad). The mix was then pasteurized at 80°C for 5 min prior to cooling and aging overnight at 3 ± 1°C. The flavoring ingredients were added just prior to freezing.

Preparation of ice cream

For preparing different batches of ice cream in direct expansion type batch freezer (cylinder capacity 10.0 lit), the aged mixes were frozen in a horizontal batch freezer (M/s. Pal Engineering Pvt. Ltd., Ahmedabad) having an arrangement for air incorporation under pressure. The temperature of the circulating refrigerant was -23.0 to -30.0°C. After freezing the mix to a semi-solid consistency (10.0-15.0 min), as inferred from the load on the ammeter (initial beater load 2.1 amp; final load 2.6 amp), air was whipped in the freezer barrel at a pressure of 10 to 15 psi for about 2 min. Bottle gourd puree was incorporated in ice cream mix prior to freezing while the bottle gourd cubes were incorporated into the partially frozen ice cream before incorporation of air under pressure. 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 tunnel maintained at -25 ± 2°C and hardened for 3 h.

The hardened ice creams were then subjected to compositional analysis, melting quality test and sensory evaluation.

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 Hand Book [19] for ice cream mixes using 5 g ice cream mix. The total solids of the ice cream were determined by the standard procedure as described in Laboratory Manual [20] using about 2 g of sample. The titratable acidity of the ice cream was determined by the standard method suggested in ISI Hand Book [19]. The protein content of the ice cream mixes was determined by Semi – Micro kjeldahl method [21], using Kjel-plus Digestion System (Model-KPS 006L, M/s.Pelican Instruments, Chennai) and Kjel-plus Semi-Automatic Distillation System (Model-Distil M, M/s.Pelican Instruments, Chennai). 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. Ash content of ice-cream and ice-cream mixes were determined by procedure described in IS: 1547-1985 [21]. The calcium content of frozen product samples was determined in accordance with the method of Kindstedt and Kosikowski [22]. Potassium and phosphorus concentration were estimated by atomic absorption spectrophotometry (Spectrophotometer-Perkin Elmer Model 3110, λ=766.5 and 214.9 nm respectively) by AOAC [23,24]. The β-carotene content of ice-cream mix was determined by the method described in IS: 15120-2002 [25] and AOAC-2001.13. The crude fibre content of ice-cream mix was determined by the method described in EC No. 152/2009 [26]. The viscosity of ice cream mix was determined by the method of Loweenstein and Haddad [27] 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 [28]. Overrun was determined according to the method given by Marshall [18]. 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 Loweenstein and Haddad [27] 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 inches 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. Total viable count, yeast and mold count and coliform count of ice-cream was determined by following the method described by Messer [29], Frank [30] and Hartman [31] respectively.

Sensory analysis

The ice cream 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 ice cream was subjected to sensory evaluation using 100 point scale based score card suggested by Arbuckle [32].

Statistical analysis

Response Surface Method (RSM) using Design Expert 9.0.2 software was used for the development of bottle gourd ice cream formulation and process standardization. For selecting compatible flavor/s in formulation of bottle gourd ice cream, statistical analysis of the data was carried out as per Steel and Torrie [33] using completely randomized design.

Results and Discussion

Selection of most suitable form of processed bottle gourd for bottle gourd ice cream

To select the most suitable forms of processed bottle gourd for preparing acceptable quality bottle gourd ice-cream, ice cream was prepared in a commercial batch freezer using the various prepared forms viz. puree (4, 6, 8%), shreds (2, 4, 6, 8%), cubes (2, 4, 6, 8%) and combination of the two forms of bottle gourd viz. shreds + puree (2+10, 4+8, 6+6, 8+4%) and cubes + puree (2+10, 4+8, 6+6, 8+4%). Ice cream was prepared according to procedure described above. The various forms of bottle gourd at selected levels were added after aging.

It was found that addition of cube as well as shreds alone resulted in a product which was not acceptable in sensory properties and was less acceptable because addition of shreds or cubes alone resulted in a product with crunchy texture, lacking in flavor and lacking in desired caramelized, pleasant flavor. Addition of puree alone was also not liked well by panelists as it gave unacceptable flavor and faster meltdown. The combination of shreds and puree also had poor acceptability as it gave a similar effect as in case of shreds alone but had a better appearance. Addition of cubes in combination with puree was best in terms of acceptance. It was found that puree contributed to viscosity, richness and cubes contribute good flavor, appearance, texture and increase in palatability of ice cream. Hence, a combination of cubes and puree was selected and used.

Formulation of basic ice-cream mix for manufacture of bottle gourd ice-cream

The tentative levels of milk fat as well as MSNF were based on FSSA [34] 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 12% 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 [18]. Therefore, the levels of MSNF selected were 12.0, 11.5 and 11.0% respectively. These levels were based on the minimum requirements for milk protein in ice cream mix according to FSSA [34] requirements. Sugar, sodium alginate and GMS were added at the rate of 15, 0.2 and 0.2% respectively in all the mixes. Treated bottle gourd puree was blended in mix at 4% level just before freezing whereas treated cubes were added at 8% using fruit feeder after drawing of ice-cream from batch freezer.

Since, it has been reported that bottle gourd contains pectin [35] and the fiber content of peeled bottle gourd was 0.7 ± 0.01% and, it was hypothesized that addition of bottle gourd puree would result in increased viscosity of the mixes and could partly be used as a fat replacer in ice cream. However, it was observed that the low-fat and medium-fat ice cream had very poor acceptability as the ice cream lacked desired richness, consistency, mouth feel, viscosity and had faster melting rate, watery body, ice crystals which could be perceived in mouth. At levels of 12.0% milk fat and 11% MSNF the ice cream was having rich mouth feel, smooth texture, soft body, good meltdown and good color and appearance. Therefore, a milk fat level of 12.0% and 11.0% MSNF was chosen in the formulation.

To select the level of sucrose in the formulation in the preliminary screening sucrose was used at the rate of 13, 14 and 15% (w/w) in the formulation of the frozen product. This sugar which was used for preparation of bottle gourd puree was not deducted from the total sugar required for preparation ice cream mix batch with different levels of sugar viz. 13, 14 and 15%. The sugar used in preparation of cubes was not deducted from the total sugar required for preparation ice cream mix as it did not contribute to overall sweetness of mix since it didn't diffuse out from shreds since the sweetness contributed by cubes was noticed only during chewing. It was found that addition of sugar at higher levels viz. 15% resulted in ice cream which was too sweet and lower level viz. 13% was lacked in optimum sweetness. Hence, a level of 14% sucrose was chosen in the formulation.

It was found that the products prepared using sodium alginate (0.20%) alone as stabilizer had lower melting resistance, weak body and coarse texture. Ice cream manufacturers use blend of several stabilizer ingredients to achieve the desired characteristics which cannot be provided by a single ingredient [36]. Therefore preliminary investigations were carried out using different blend of stabilizers viz. Sodium alginate, guar gum, carboxymethyl cellulose and carrageenan. Addition of blend of sodium alginate, guar gum and carrageenan (0.1:0.05: 0.02%) along with 0.2% GMS as emulsifier resulted in a product having acceptable flavor, body and texture, good meltdown

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and total score. From the experimentation carried out, the formulation chosen was 12% milk fat, 11% MSNF, 14% sucrose, 0.1% sodium alginate, 0.05% guar gum, 0.02% carrageenan and 0.2% GMS, 37.37% total solids.

Optimizing the level of processed bottle gourd forms viz. cubes and puree in bottle gourd ice cream using Response Surface Methodology

Ice cream was made using processed bottle gourd cubes and puree using a Response Surface Methodology (RSM) to optimize the level of processed bottle gourd forms in bottle gourd ice cream. Response surface methodology (RSM) is an effective tool for optimizing a variety of food processes [37-39]. The main advantage of RSM is reduced number of experimental runs that provide sufficient information for statistically valid results. The RSM equations describe effects of the test variables on the observed responses, determine test variables interrelationships, and represent the combined effect of all test variables in the observed responses, enabling the experimenter to make efficient exploration of the process.

Ice cream was prepared by incorporating processed bottle gourd cubes and purees @ 6 to 8% and 2 to 6% (w/w) of mix respectively. The bottle gourd ice-cream prepared with different levels of bottle gourd cube and puree addition as shown in design matrix (Table 2) of two factor CCRD design consisting of 13 experiments were evaluated for various physico-chemical viz. TS, fat, ash and sensory characteristics. Vanilla was used as background flavoring agent in bottle gourd ice-cream throughout RSM experiments. Vanilla essence was added in ice cream mix at the rate of 1.5 ml per kg i.e. around half the rate required for flavoring plain vanilla ice cream.

Effect of different levels of bottle gourd cubes and puree on sensory properties of bottle gourd ice-cream

The sensory parameters chosen to assess the quality of bottle gourd ice-cream are flavor, color and appearance, body and texture, melting quality and total score. The ice cream samples were tempered to -12 ± 2° C for 1 to 2 h before judging. The sensory data along with formulations as per their run order is shown in Table 3. The scores of flavor, body and texture, color and appearance were well fitted in quadratic model. The quadratic model for sensory parameters namely flavor, color and appearance, body and texture, melting quality and total score were obtained through successive regression analysis. The calculated F values more than the Table F values at 5% level of confidence and it indicated the significance of model terms. Furthermore, the coefficient of determination (R^2) that reflects the proportion of variability in data explained or accounted by the model for flavor, color and appearance, body and texture, melting quality and total score were 0.8110, 0.9425, 0.8238, 0.8514 and 0.9182 respectively. A larger R^2 values suggest a better fit of the quadratic model. The adequate precision measures the signal to noise ratio, the value of which should be greater than 4.0. The adequate precision value for flavor, color and appearance, body and texture, melting quality and total score were 6.289, 16.221, 8.290, 9.607 and 11.056 respectively, which were greater than 4, hence supporting the suitability of model to navigate the design.

Run	Factor 1:Cube (per cent) (A)	Factor 2:Puree (per cent) (B)
1	7	4
2	6	6
3	8	6
4	7	4
5	7	4
6	7	4
7	7	6.828
8	8.414	4
9	8	2
10	7	1.171
11	5.585	4
12	6	2
13	7	4

Table 2: Experimental Design Matrix (CCRD) for Levels of factors: Bottle gourd Cubes (%) (A) and Bottle gourd Puree (%) (B).

Run	Cube (%) (A)	Puree (%) (B)	Flavor (45)	Colour and appearance(5)	Body and Texture (30)	Melting Quality (5)	Total score (100)
1	7	4	39.000	4.529	26.857	4.214	89.600
2	6	6	37.400	4.643	27.193	4.429	88.664
3	8	6	35.400	4.500	27.264	3.957	86.121
4	7	4	40.386	4.499	26.571	4.357	90.813
5	7	4	40.429	4.459	27.134	4.314	91.336
6	7	4	40.586	4.469	26.714	4.357	91.126
7	7	6.828	38.300	4.664	25.700	4.329	87.993
8	8.414	4	38.857	4.429	26.714	4.226	89.226
9	8	2	38.600	4.271	26.300	4.429	88.600
10	7	1.171	36.500	4.074	24.300	4.500	84.374
11	5.585	4	36.700	4.571	26.143	4.143	86.557
12	6	2	36.560	4.264	24.857	4.214	84.896
13	7	4	39.714	4.594	26.214	4.271	89.794

*The Total sensory score includes full score of 15.0 allotted for bacterial quality for each treatment

Table 3: Experimental Design Matrix and Scores for Sensory Properties of Bottle gourd Ice-cream

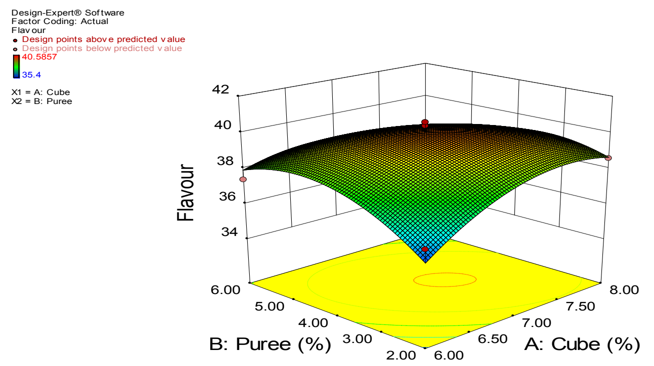

Figure 1: Response surface of flavour as influenced by level of per cent bottle gourd cube and puree.

The ice-cream prepared by using 7% cube and 4% puree addition was rated best for flavor (Table 3 and Figure 1) whereas 8% cube and 6% puree addition was rated lowest score for flavor by the panelists. The coefficient of determination (R^2) is the proportion of variability in the data explained or accounted for the model and high value (0.811) of R^2 indicate a better fit of the model to the data. Also the adequate precision value of 6.289 recommends the use of this response to navigate the design. The P value of% puree (P<0.01) and cube (P<0.05) addition showed its significance at quadratic levels (Table 4). Increase in rate of addition of cube and puree in combination decreases the flavor score significantly (P<0.01) at higher level while at increasing cube and puree levels, flavor score was enhanced at linear level but at higher(quadratic)

Source		Flavour		Colour and appearance		Body and Texture		Melting Quality		Total score	
		P Value	Partial Coefficient	P Value	Partial Coefficient	P Value	Partial Coefficient	P Value	Partial Coefficient	P Value	Partial Coefficient
	Intercept	0.0179	40.02	0.0003	4.51	0.0143	26.70	0.0082	4.30	0.0011	90.53
Linear Level	A	0.2980	0.39	0.0576	-0.042	0.1393	0.29	0.5121	-0.017	0.0821	0.62
	B	0.9481	0.023	< 0.0001*	0.18	0.0068*	0.66	0.0432**	-0.062	0.0337**	0.80
Interaction Level	AB	0.0763	-1.01	0.1973	-0.037	0.2061	-0.34	0.0020*	-0.17	0.0084*	-1.56
Quadratic Level	A^2	0.0107**	-1.27	0.6793	-8.606E-003	0.8466	0.037	0.0370**	-0.070	0.0050*	-1.31
	B^2	0.0054*	-1.46	0.0076*	-0.074	0.0084*	-0.68	0.1403	0.045	0.0003*	-2.17

* Significant at 1 per cent level (P<0.01);

** Significant at 5 per cent level (P<0.05)

Note: A and B refer to the bottle gourdcubes (per cent) and bottle gourd puree (per cent) respectively

Table 4: P Values and Partial Coefficients of Regression Equation of suggested models for sensory properties of Bottle gourd Ice-cream.

level again flavor score decreased. The Multiple Regression equation generated to predict the flavor as affected by different factors in terms of coded factors is as follows:

$$\text{Flavor} = +40.02 + 0.39 * A + 0.023 * B - 1.01 * AB - 1.27 * A^2 - 1.46 * B^2$$

Where, A and B refer to% cube and% puree respectively. A significant negative effect on flavor was found with the higher rate of cube (P<0.05) (A^2) and puree (P<0.01) (B^2) addition in bottle gourd ice-cream. The square of factor indicates that the effect of ingredient at highest (quadratic) level used in the product standardization. A non-significant positive effect on flavor was observed with both rate of cube (A) and puree (B) at linear level. The negative interaction indicates that both the ingredients are negatively correlated and by increasing the level of one ingredient, the level of other ingredient has to be decreased. A non-significant negative interactive effect on flavor was observed with both rate of cube and puree addition (AB).

Color and appearance of the product is the visual perception, which in turn, defines product quality. The color and appearance score of bottle gourd ice-cream ranged from 4.074 to 4.664 and the ice-cream prepared by using rate of 7% cube and 1.1715% puree addition scored lowest color and appearance score (Table 3 and Figure 2). Ice-cream prepared by using rate of 7% cube and 6.828% puree addition score was rated best for color and appearance by the panelists. The P value of% puree addition showed its significance at linear and quadratic levels (Table 4). Ice-cream prepared with higher levels of cube and puree addition content were having dull or non-uniform color and appearance was not liked by panelists. The Multiple Regression equation generated to predict the color and appearance as affected by different two factors in terms of coded factors are as follows:

$$\text{Color and Appearance} = +4.51 - 0.042A + 0.18B - 0.037AB - 8.606E-003A^2 - 0.074B^2$$

Where, A and B refer to% cube and% puree respectively. A significant (P<0.01) positive effect on color and appearance was observed with rate of puree (B) addition in ice-cream at linear level but significant (P<0.01) negative effect was observed at quadratic level (B^2). A non-significant negative effect on color and appearance was observed with rate of cube at linear level (A) and quadratic level (A^2). The negative interaction indicates that both the ingredients are negatively correlated and by increasing the level of one ingredient, the level of other ingredient has to be decreased. A non-significant negative interactive effect on color and appearance was observed with rate of cube and puree addition (AB) in ice-cream.

Body is the standing properties of food. Texture is that property of food which is associated with the sense of feel or touch experienced by fingers or the mouth. Bottle gourd ice-cream prepared by using 8% cube and 6% puree addition was rated best for body and texture by the panelists (Figure 3). The P value of rate of puree addition showed its significance (P<0.01) at linear and quadratic levels (Table 4). The Multiple Regression equation generated to predict the body and texture as affected by different factors in terms of coded factors is as follows:

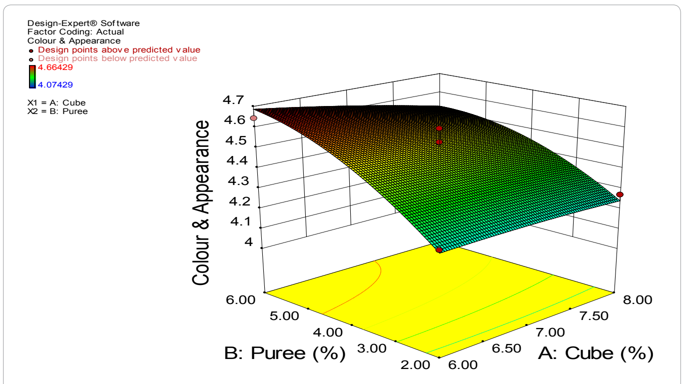

Figure 2: Response surface of colour and appearance as influenced by level of per cent bottle gourd cube and puree.

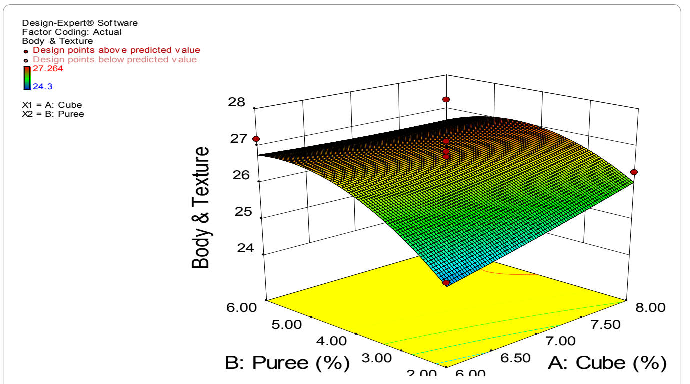

Figure 3: Response surface of body and texture as influenced by level of per cent bottle gourd cube and puree.

$$\text{Body and Texture} = +26.70 + 0.29A + 0.66B - 0.34AB + 0.037A^2 - 0.68B^2$$

Where, A and B refer to% cube and% puree respectively. A significant (P<0.01) positive effect on body and texture was observed with rate of puree at linear level (B) while significant (P<0.01) negative effect on body and texture was observed at quadratic level (B^2). A non-significant positive effect on body and texture was observed with rate of cube addition in ice-cream at linear level (A) and quadratic level

(A^2). The negative interaction indicates that both the ingredients are negatively correlated and by increasing the level of one ingredient, the level of other ingredient has to be decreased. A non-significant negative interactive effect on body and texture was observed with rate of cube and puree addition (AB) in ice-cream.

Meltdown behavior provides insights into key ice cream phenomena, such as protein stability, fat agglomeration and air cell size, which influence body, texture, and other sensory characteristics. Bottle gourd ice-cream prepared by using 7% cube and 1.171% puree addition was rated best for melting quality by the panelists (Figure 4). The P value of rate of puree and cube addition showed its significance (P<0.05) at linear, quadratic levels and quadratic levels respectively (Table 4). Multiple regression equation generated to predict the melting quality as affected by different factors in terms of coded factors is as follows:

$$\text{Melting Quality} = +4.30 - 0.017A - 0.062B - 0.17AB - 0.070A^2 + 0.045B^2$$

Where, A and B refer to% cube and% puree respectively. A significant (P<0.05) negative effect on melting quality was observed with rate of puree at linear level (B) and rate of cubes (P<0.05) at quadratic level (A^2) respectively. A non-significant negative effect on melting quality was observed with cube at linear level (A) while positive effect was observed with puree at quadratic level (B^2). The negative interaction indicates that both the ingredients are negatively correlated and by increasing the level of one ingredient, the level of other ingredient has to be decreased. A significant (P<0.01) negative interactive effect on melting quality was observed with rate of cube and puree addition (AB) in ice-cream.

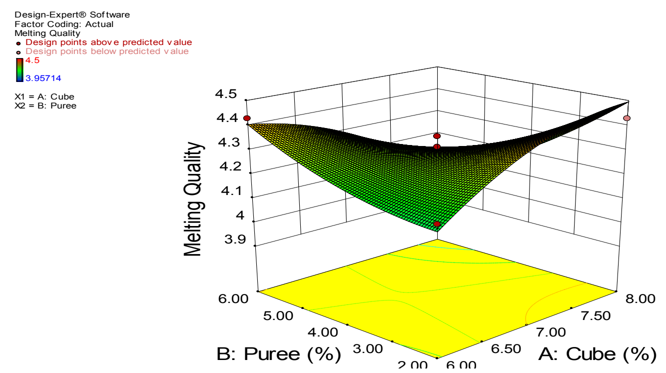

Figure 4: Response surface of melting quality as influenced by level of per cent bottle gourd cube and puree.

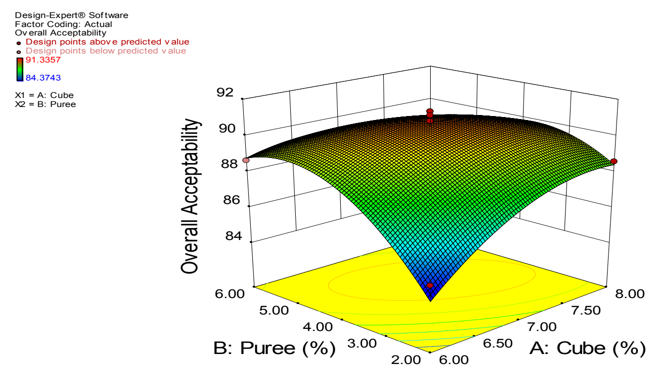

Figure 5: Response surface of flavour as influenced by level of per cent bottle gourd cube and puree.

Response	Suggested Model	Intercept	Model F Value	Adequate Precision	R^2
Flavour	QUADRATIC	40.02	6.01	6.289	0.8110
Colour and appearance	QUADRATIC	4.51	22.93	16.221	0.9425
Body and Texture	QUADRATIC	26.70	6.54	8.290	0.8238
Melting Quality	QUADRATIC	4.30	8.02	9.607	0.8514
Total score	QUADRATIC	90.53	15.71	11.056	0.9182

Table 5: Coefficients of Selected Models for Sensory Attributes of Bottle gourd Ice-cream.

Total score is that property of food which is associated with the acceptance or rejection of product in terms of like. The Total score of bottle gourd ice-cream ranged from 84.374 to 91.336 and the bottle gourd ice-cream prepared by using 7% cube and 1.171% puree addition scored lowest total score (Table 3 and Figure 5). Bottle gourd ice-cream prepared by using 7% cube and 4% puree addition was rated best for total score by the panelists. The coefficient of determination (R^2) is the proportion of variability in the data explained or accounted for the model and high value (0.9182) of R^2 indicate a better fit of the model to the data. Also the adequate precision value of 11.056 recommends the use of this response to navigate the design. The P value of rate of puree and cube addition showed its significance at linear, quadratic level and at quadratic levels respectively (Table 4). Multiple regression equation generated to predict the total score as affected by different factors in terms of coded factors is as follows:

$$\text{Total score} = +90.53 + 0.62A + 0.80B - 1.56AB - 1.31A^2 - 2.17B^2$$

Where, A and B refer to% cube and% puree respectively. A significant (P<0.01) negative effect on total score was observed with rate of puree and cube at quadratic level (B^2 and A^2) respectively. A significant (P<0.05) positive effect on total score was observed with puree at linear level (B). A non-significant positive effect on total score was observed with rate of cube addition in ice-cream at linear level (A). The negative interaction indicates that both the ingredients are negatively correlated and by increasing the level of one ingredient, the level of other ingredient has to be decreased. A significant (P<0.01) negative interactive effect on total score was observed with rate of cube and puree addition (AB) in ice-cream. No data are reported in the literature on effect of addition of processed bottle gourd puree and cubes on acceptability of ice-cream (Table 5).

Effect of different levels of bottle gourd cube and puree addition on physicochemical properties of bottle gourd ice-cream

Physico-chemical attributes play a significant role in deciding the acceptability of the product in new product development process in terms of composition of final product. The physicochemical properties chosen for bottle gourd ice-cream were fat, total solids, melting rate, ash and acidity. The values of these responses along with their factors are given in Table 6. The quadratic model for physico-chemical parameters were obtained through successive regression analysis (Table 7). As seen in Table 8, the calculated F values more than the Table F values at 1% and 5% level of confidence and it indicated the significance of model terms. Furthermore, the coefficient of determination (R^2) that reflects the proportion of variability in data explained or accounted by the model for fat, total solids, melting rate, ash and acidity were 0.9534, 0.9474, 0.8795, 0.9484 and 0.9431 respectively. A larger R^2 values suggest a better fit of the quadratic model. The adequate precision value of all the parameters studied were greater than 4, hence supporting the suitability of model to navigate the design.

Fat content of ice-cream greatly influences the physico-chemical and sensory properties of ice-cream. Fat imparts rich flavor, soft body and smooth texture and also important in acceptance of ice-cream in terms of consumer's sensory perception. The values of fat in bottle gourd ice-cream ranged from 10.536 to 11.117% of bottle gourd ice-cream. Bottle gourd ice-cream prepared by using 6% cube and 2% puree addition was having highest% fat (11.12%) content (Table 6 and Figure 6). The P values of rate of puree and cube addition showed its significance at linear level (Table 7). Multiple regression equation generated to predict the% fat content in bottle gourd ice-cream affected by different factors in terms of coded factors is as follows:

$$Fat = +10.86 - 0.084A - 0.19B + 0.028AB - 0.033A^2 - 4.999E - 003B^2$$

Where, A and B refer to% cube and% puree respectively. A significant (P<0.01) negative effect on fat was observed with rate of puree (B) and cube (A) at linear while non-significant negative effect on fat was observed with rate of puree (B^2) and cube (A^2) at quadratic level respectively. A non-significant positive interactive effect on fat was observed with rate of cube and puree addition (AB) in ice-cream. The dilution effect of puree in ice-cream was found to exercise significant influence (P<0.01) on the fat content. There was a progressive decrease in fat content of experimental samples with increase in level of addition of bottle gourd puree and cubes. However, the average values of fat in all the experimental ice-creams were well above the minimum values specified for ice-cream either legally [34] or as recommended by Bureau of Indian Standards [40] for India.

The values of total solid content ranged from 36.601 to 38.202% of bottle gourd ice-cream mix. Bottle gourd ice-cream prepared by using 6% cube and 2% puree addition was having lowest% total solid content

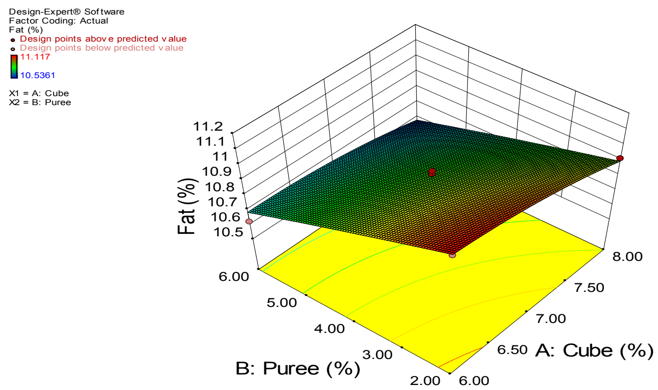

Figure 6: Response surface of fat content as influenced by level of per cent bottle gourd cube and puree.

Run Order	A: Cube (%)	B:Puree (%)	Fat (%)	Total Solids (%)	Melting Rate (%)	Ash (%)	Acidity (% LA)
1	7	4	10.819	37.584	57.045	0.873	0.1928
2	6	6	10.623	37.838	54.085	0.869	0.1913
3	8	6	10.536	38.202	53.693	0.857	0.1902
4	7	4	10.879	37.754	57.602	0.864	0.1920
5	7	4	10.849	37.674	56.364	0.877	0.1918
6	7	4	10.859	37.604	57.784	0.874	0.1925
7	7	6.828427	10.652	38.021	55.142	0.858	0.1904
8	8.414214	4	10.684	37.942	54.205	0.863	0.1910
9	8	2	10.916	37.407	54.602	0.881	0.1923
10	7	1.171573	11.100	37.049	56.250	0.892	0.1932
11	5.585786	4	10.957	37.336	57.046	0.884	0.1925
12	6	2	11.117	36.601	57.415	0.897	0.1933
13	7	4	10.899	37.504	57.330	0.873	0.1921

Table 6: Experimental Design Matrix and Scores for Physico-chemical Properties of **Bottle** gourd Ice-cream

Source		Fat (%)		Total Solids (%)		Melting Rate (%)		Ash (%)		Acidity (% L.A.)	
		P Value	Partial Coefficient	P Value	Partial Coefficient	P Value	Partial Coefficient	P Value	Partial Coefficient	P Value	Partial Coefficient
Intercept		0.0002	10.86	0.0002	37.62	0.0041	57.23	0.0002	0.87	0.0003	0.19
Linear level	**A**	0.0019*	-0.084	0.0008*	0.25	0.0071*	-0.90	0.0009*	-6.971E-003	0.0020*	-5.242E-004
	B	< 0.0001*	-0.19	< 0.0001*	0.43	0.0193**	-0.73	< 0.0001*	-0.013	< 0.0001*	-1.018E-003
Interactive level	**AB**	0.2882	0.028	0.1262	-0.11	0.1179	0.61	0.6082	9.687E-004	0.9671	-6.598E-006
Quadratic level	**A^2**	0.1263	-0.033	0.8256	-0.011	0.0067*	-0.98	0.4278	1.152E-003	0.0923	-2.279E-004
	B^2	0.7979	-4.999E-003	0.2325	-0.063	0.0081*	-0.94	0.1842	2.017E-003	0.1496	-1.892E-004

* Significant at 1 per cent level (P<0.01); ** Significant at 5 per cent level (P<0.05)

Note: A and B refer to the bottle gourdcubes (per cent) and bottle gourd puree (per cent) respectively

Table 7: P Values and Partial Coefficients of Regression Equation of Suggested Models for Physico-chemical Properties of Bottle gourdIce-cream.

Response	Suggested Model	Intercept	Model F Value	Adequate Precision	R^2
Fat (%)	QUADRATIC	10.86	28.62	16.200	0.9534
Total Solids (%)	QUADRATIC	37.62	25.22	15.718	0.9474
Melting Rate (%)	QUADRATIC	57.23	10.21	7.686	0.8795
Ash (%)	QUADRATIC	0.87	25.71	15.874	0.9484
Acidity (% L.A.)	QUADRATIC	0.19	23.20	14.722	0.9431

Table 8: Coefficients of Selected Models for Physico-chemical Attributes of Bottle gourd Ice-cream.

(Table 6 and Figure 7). Bottle gourd ice-cream prepared by using 8% cube and 6% puree addition was having highest% total solid content. The P values of rate of puree and cube addition showed its significance at linear level (Table 7). Multiple regression equation generated to predict the total solid content in bottle gourd ice-cream affected by different factors in terms of coded factors is as follows:

$$\text{Total Solids} = +37.62 + 0.25A + 0.43B - 0.11AB - 0.011A^2 - 0.063B^2$$

Where, A and B refer to% cube and% puree respectively. A significant ($P<0.01$) positive effect on% total solid content was observed with both rate of cube (A) and puree (B) at linear level. The negative sign in interaction indicates that both the ingredients are negatively correlated and by increasing the level of one ingredient, the level of other ingredient has to be decreased. A non-significant negative interaction effect on% total solid content was observed with rate of cube and puree addition (AB). The square of factor indicates that the effect of ingredient at highest (quadratic) level used in the product standardization. A non-significant negative effect on% total solid content was observed with both rate of cube (A^2) and puree (B^2) at quadratic level in bottle gourd ice-cream.

The addition of sugar treated processed bottle gourd puree and cubes was found to exercise significant influence ($P<0.01$) on the total solids content of experimental ice-cream. There was a progressive increase in total solids content of experimental ice-cream with increase in level of addition of bottle gourd puree and cubes. This effect could be attributed to the higher total solid content of bottle gourd puree (57.32%) and bottle gourd cubes (78.86%) compared to total solids content of basic ice-cream mix i.e. 37.37%. The average values of total solids content all the experimental samples were well above the minimum values specified for ice-cream either legally [34] or as recommended by Bureau of Indian Standards [40] for India.

A desirable melting quality in a frozen product means the melted product should have the appearance and consistency similar to original mix. Furthermore, meltdown is an important part of any consumer's perception of product quality. Meltdown behavior provides insights into key ice cream phenomena, such as protein stability, fat agglomeration and air cell size, which influence body, texture, and other sensory characteristics. The values of melting quality ranged from 53.693 to 57.784% of bottle gourd ice-cream (Figure 8). The P values of rate of puree and cube addition showed its significance at linear level (Table 7). Multiple regression equation generated to predict the melting rate in bottle gourd ice-cream affected by different factors in terms of coded factors is as follows:

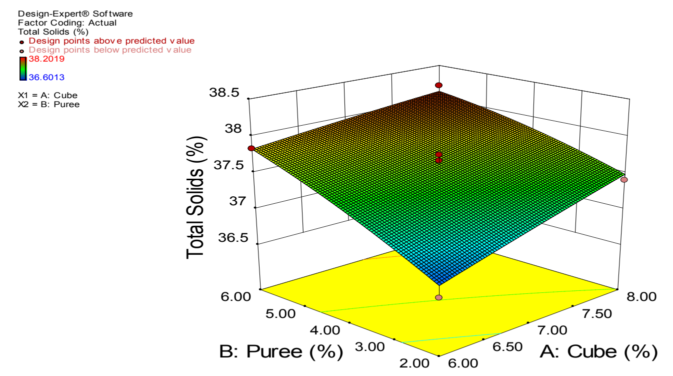

Figure 7: Response surface of total solids content as influenced by level of per cent bottle gourd cube and puree.

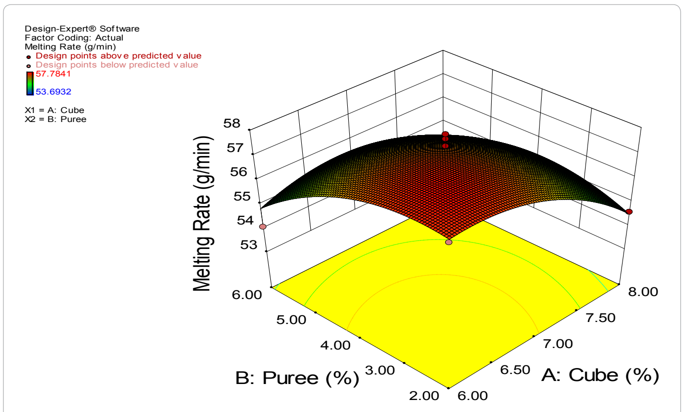

Figure 8: Response surface of melting rate as influenced by level of per cent bottle gourd cube and puree.

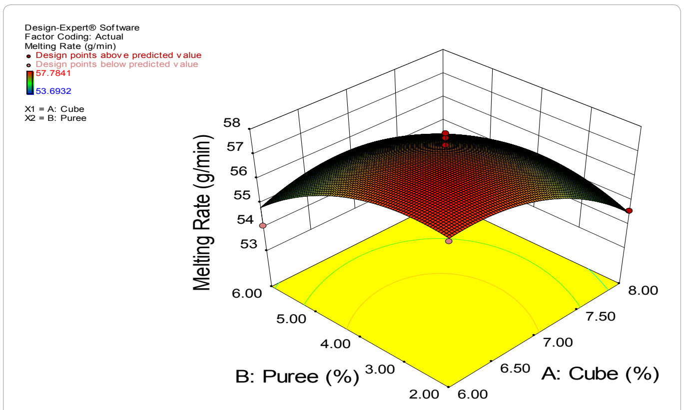

Figure 9: Response surface of ash content as influenced by level of per cent bottle gourd cube and puree.

$$\text{Melting Rate} = +57.23 - 0.90*A - 0.73*B + 0.61*AB - 0.98*A^2 - 0.94*B^2$$

Where, A and B refer to% cube and% puree respectively. A significant negative effect on melting rate was observed with both rate of cube (A) ($P<0.01$) and puree (B) ($P<0.05$) at linear level. The positive sign in interaction indicates that both the ingredients are positively correlated and by increasing the level of both ingredients at linear level, it positively influence melting rate means melting rate increases. A non-significant positive interaction effect on melting rate was observed with rate of cube and puree addition (AB). The square of factor indicates that the effect of ingredient at highest (quadratic) level used in the product standardization. A significant ($P<0.01$) negative effect on melting rate was observed with both the rate of cube (A^2) and puree (B^2) at quadratic level in bottle gourd ice-cream. It means at both linear and quadratic level of both the form of bottle gourd addition decreases melting rate of bottle gourd ice-cream.

The values of ash content ranged from 0.857 to 0.897% of bottle gourd ice-cream. Bottle gourd ice-cream prepared by using 6% cube and 2% puree addition was having highest% ash content (Table 6 and Figure 9). Bottle gourd ice-cream prepared by using 8% cube and 6% puree addition was having lowest% ash content. The P values of rate of puree and cube addition showed its significance at linear level (Table 7). Multiple regression equation generated to predict the ash content in bottle gourd ice-cream affected by different factors in terms of coded factors is as follows:

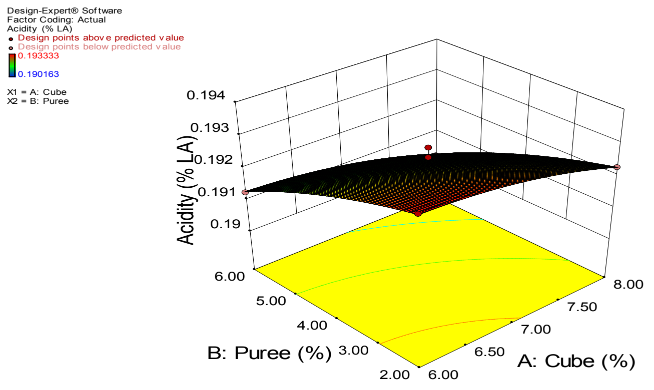

Figure 10: Response surface of acidity (% l.a.) as influenced by level of per cent bottle gourd cube and puree.

Sr. No	Constraints	Units	Goal	Lower Limit	Upper Limit	Level of Significance
1	Flavour	-	maximize	35.4	40.5857	5
2	Colour and Appearance	-	maximize	4.07429	4.66429	4
3	Body and Texture	-	maximize	24.3	27.264	4
4	Melting Quality	-	maximize	3.95714	4.5	4
5	Total score	-	maximize	84.3743	91.3357	5
6	Fat	%	in range	10.5361	11.117	3
7	Total Solids	%	in range	36.6013	38.2019	3
8	Melting Rate	%	in range	53.6932	57.7841	3
9	Ash	%	in range	0.857179	0.896637	3
10	Acidity	% L.A.	in range	0.190163	0.193333	3

Table 9: Criteria Chosen For Optimization Process.

Solution No.	Solutions					Desirability
	Fat	Total Solids	Melting Rate	Ash	Acidity	
1	10.804	37.734	56.930	0.869	0.192	0.810

Table 10: Suggested Solution from RSM Analysis for Bottle gourd Ice-cream.

$$Ash = +0.87 - 6.971E-003*A - 0.013*B + 9.687E-004*AB + 1.152E-003*A^2 + 2.017E-003*B^2$$

Where, A and B refer to% cube and% puree respectively. A significant (P<0.01) negative effect on ash was observed with both rate of cube (A) and puree (B) at linear level. The positive sign in interaction indicates that both the ingredients are positively correlated and by increasing the level of both ingredients at linear level, it positively influences ash content. A non-significant positive interaction effect on ash was observed with rate of cube and puree addition (AB). The square of factor indicates that the effect of ingredient at highest (quadratic) level used in the product standardization. A non-significant positive effect on ash was observed with both the rate of cube (A^2) and puree (B^2) at quadratic level in bottle gourd ice-cream.

The values of acidity ranged from 0.1902 to 0.1933% lactic acid of bottle gourd ice-cream. Bottle gourd ice-cream prepared by using 6% cube and 2% puree addition was having highest% acidity content. Bottle gourd ice-cream prepared by using 8% cube and 6% puree addition was having lowest% acidity content (Table 6 and Figure 10). The P values of rate of puree and cube addition showed its significance at linear level (Table 7). The negative sign indicates that increase in level of cube and puree addition at linear level decreases analyzed% acidity content of ice-cream. Negative sign in interaction of rate of cube and puree addition in ice-cream decreases% acidity content. Multiple regression equation generated to predict the acidity in bottle gourd ice-cream affected by different factors in terms of coded factors is as follows:

$$Acidity = +0.19 - 5.242E-004*A - 1.018E-003*B - 6.598E-006*AB - 2.279E-004*A^2 - 1.892E-004*B^2$$

Where, A and B refer to% cube and% puree respectively. A significant (P<0.01) negative effect on% acidity content was observed with both rate of cube (A) and puree (B) at linear level. The negative sign in interaction indicates that both the ingredients are negatively correlated and by increasing the level of one ingredient, the level of other ingredient has to be decreased. A non-significant negative interaction effect on% acidity content was observed with rate of cube and puree addition (AB). The square of factor indicates that the effect of ingredient at highest (quadratic) level used in the product standardization. A non-significant negative effect on% acidity content was observed with both rate of cube (A^2) and puree (B^2) at quadratic level in bottle gourd ice-cream (Table 8).

No data are reported in the literature on effect of addition of processed bottle gourd cubes and puree on fat, total solids, melting rate, ash and acidity of ice-cream for comparison

Optimization of Product Formulations

Optimization was done to achieve the best possible combination of% rate of bottle gourd cube and puree addition in ice-cream that would lead to the most acceptable product in terms of sensory scores and physico-chemical attributes. The specified selected range was used for obtaining the best optimized combination is illustrated in Tables 9 and 10. The data were analyzed in Design Expert Package 9.0.2. Considering the constraints and their limits, the RSM suggested the one most suited solution. The final product was made with this formulation and compared with that of predicted values (Table 11). The calculated values of 't' for all the parameters being less than the table values, there was no significant difference between the predicted and actual values of responses (Table 12). It is, therefore, confirmed that the selected combination is the best one in terms of the sensory, compositional and physicochemical responses delineated at the beginning of the study.

Solution No.	Flavour	Colour and appearance	Body and texture	Melting Quality	Total score
1	39.812	4.573	26.822	4.297	90.504

Table 11: Predicted Sensory Scores of Optimized Bottle gourd Ice-cream from RSM.

Response	P Value	Predicted Value *	Cal. t-Value#	Actual Value @	
Flavour	0.4603	39.813	0.8161	40.13	NS
Colour and appearance	0.1822	4.573	1.6125	4.39	NS
Body and texture	0.1641	26.823	1.7046	27.33	NS
Melting Quality	0.4252	4.297	0.8870	4.496	NS
Total score	0.2909	90.505	1.2158	91.426	NS
Fat	0.5345	10.804	0.6789	10.95	NS
Total Solids	0.0808	37.734	2.3239	38.6001	NS
Melting Rate	0.6997	56.930	0.4146	57.14	NS
Ash	0.6558	0.869	0.4808	0.873	NS
Acidity	0.3098	0.192	1.1621	0.189	NS

*Predicted values of Design Expert 9.0.2 package
@ Actual values (average of five trials) optimized product
# t-values found non-significant at 5 per cent level of significance
NS = Non-Significant
Tabulated t-value = 4.303 (cal. t-value less than tabulated value)

Table 12: Comparison of Predicted V/S Actual Values of Responses.

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Physico-chemical, sensory and microbiological analysis of bottle gourd ice-cream manufactured by optimized combination of bottle gourd cubes and puree

The approximate composition, physicochemical, rheological, sensory and microbiological quality of the optimized product is presented in Table 13. It was envisaged that the developed bottle gourd ice cream would be high in fibre content since it has been reported that the fibre content of bottle gourd (Pusa Naveen) is 0.7% [34]. However, the crude fibre content of developed bottle gourd ice cream was found to be only 0.05%. This could be attributed to use of peeled and de-cored bottle gourd for preparation of bottle gourd puree and bottle gourd cubes. It has been reported that most of fibre content in bottle gourd is in peel and core portion [34]. Since vegetables are a good source of β-carotene, the β-carotene content was analyzed and was found to be 0.126 mg per 100 g. The β-carotene content of control vanilla ice-cream was found to be 0.115 mg per 100 g. Addition of bottle gourd did not result in increasing β-carotene content of bottle gourd ice-cream. The Vitamin C content of peeled raw bottle gourd was 12 mg per 100 g. Processed bottle gourd was added in bottle gourd ice-cream at the rate of 10.36%. The Vitamin C content was found to be only 0.68 mg per 100 g. Hence, there was about 50% loss of Vitamin C during processing of bottle gourd. The calcium, potassium and phosphorus content of raw peeled bottle-gourd were found to be 0.03, 3.35 and 0.5 mg/100 g edible portion respectively. The calcium potassium and phosphorus content of bottle gourd ice cream was 0.14, 0.5 and 0.16 g/100 g respectively.

Selecting compatible flavor/s in formulation of bottle gourd ice cream and assessing the cost effectiveness of the formulated bottle gourd ice cream against vanilla ice cream

To select the most preferred flavor in bottle gourd ice cream, three flavors viz. cardamom (fresh powder), vanilla and saffron were selected. Vanilla and saffron were added at the rate of 1.5 ml and cardamom powder was added at the rate of 0.15 g per kg of ice-cream mix. Bottle gourd ice cream prepared using above three flavors was compared with sample of vanilla ice cream. For preparation of bottle gourd ice cream the composition of basic mix was 12.0% fat, 11.0% MSNF, 14.0% sucrose, 0.10% sodium alginate, 0.05% guar gum, 0.02% carrageenan and 0.20% GMS. The optimized rate of bottle gourd forms viz. puree and cubes was added at the rate of 4.71 and 6.85% by weight of mix. The effect of use of different flavoring ingredients on sensory attributes of bottle gourd ice cream and vanilla ice cream is presented in Table 14.

It can be seen from Table 14 that there was no significant (P>0.05) difference in color and appearance and melting quality scores of all the experimental samples. The flavor score of bottle gourd ice cream flavored with cardamom and vanilla was at par (P>0.05) with vanilla ice cream whereas the flavor score of saffron flavored bottle gourd ice cream was significantly (P<0.05) lower than all the experimental samples. The body and texture scored of all the three bottle gourd ice creams were significantly (P< 0.05) lower than sample of vanilla ice cream. This could be attributed to lower fat content in bottle gourd ice cream viz. 10.95% versus 12.0% in sample of vanilla ice cream. However, the total score of bottle gourd ice cream flavored with cardamom was at par (P>0.05) with sample of vanilla ice cream.

ATTRIBUTES	BOTTLE GOURD ICE-CREAM	ATTRIBUTES	BOTTLE GOURD ICE-CREAM
Compositional Attributes		**Minerals**	
Total Solids(%)	38.6 ± 0.833	Calcium (%)	0.14
Fat(%)	10.95 ± 0.481	Potassium (%)	0.51
Protein (%)	3.9012 ± 0.049	Phosphorus (%)	0.16
Ash(%)	0.873 ± 0.016	**Microbiological Count**	
Acidity (% L.A.)	0.1892 ± 0.006	Standard Plate count(cfu/g, log transformed)	18625 ± 1342.403
β-carotene(mg/ 100 g)	0.126	Yeast and Mold count(cfu/g, logtransformed)	Nil
Crude Fibre (%)	0.05	Coliform Count (cfu/g, log transformed)	Nil
Vitamin C (mg/100g)	0.68		
Physical properties		**Sensory Attributes**	
Melting Resistance (%)	57.14 ± 1.132	Flavour	40.13 ± 0.869
Hardness ($1/10^{th}$ mm)	128 ± 4.320	Colourand Appearance	4.39 ± 0.256
Overrun (per cent)	71.71 ± 10.960	Bodyand Texture	27.33 ± 0.667
Viscosity (cP at 4°C)	303 ± 4.535	Melting Quality	4.5 ± 0.500
Specific Gravity (at 16°C)	1.0962 ± 0.013	Total score	91.42 ± 1.695

Table 13: Average proximate chemical composition, physicochemical properties and microbiological quality of Bottle gourd Ice-cream manufactured by standardized process.

Flavour Used	Flavour	Colour and Appearance	Body and Texture	Melting Quality	Total score
Vanilla flavoured bottle gourd ice-cream	41.75 ± 0.96[a]	4.25 ± 0.29	27.13 ± 0.25[b]	4.19 ± 0.24	92.31 ± 0.90[b]
Saffron flavoured bottle gourd ice-cream	38.88 ± 0.85[b]	4.38 ± 0.25	26.33 ± 0.48[c]	4.38 ± 0.29	89.13 ± 1.10[c]
Cardamom flavoured bottle gourd ice-cream	42.63 ± 0.48[a]	4.13 ± 0.25	27.63 ± 0.48[b]	4.13 ± 0.38	93.69 ± 0.74[a]
Vanilla flavoured ice-cream	42.50 ± 0.4[a]	4.50 ± 0.00	28.25 ± 0.29[a]	4.50 ± 0.25	94.63 ± 0.63[a]
S.Em	0.35	0.19	0.11	0.15	0.43
CD (0.05)	1.10	NS	0.60	NS	1.33
CV %	1.72	1.412	5.29	6.85	0.93

*The Total sensory score includes full score of 15.0 allotted for bacterial quality for each treatment.
Each observation is a mean ± SD of 4 replicate experiments (n=4); Different superscripts in the same column indicate significant differences at $P \leq 0.05$

Table 14: Effect of different flavouring on sensory attributes of bottle gourd ice-cream and regular vanilla ice-cream.

Thus, it can be concluded on the basis of this study that among three varieties of bottle gourd available in market Pusa Naveen is most suitable for manufacture of bottle gourd ice cream. A combination of sugar treated bottle gourd puree and bottle gourd cubes added at the rate of 4.71% and 6.85% resulted in most acceptable bottle gourd ice cream. Cardamom was the most preferred flavor for bottle gourd ice cream. The acceptability of developed cardamom flavored bottle gourd ice cream was at par (P>0.05) with vanilla ice cream.

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