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Original Research Article

Effects of Soymilk and Milk Solid not Fat on Soy Ice Cream Quality

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Abstract:

Soy ice cream is a vegan friendly frozen dessert prepared using soymilk as the major ingredient. Nine formulations of soy ice cream were prepared with varying levels of soymilk (0-100%) and milk solid not fat (MSNF) (10-12%). From sensory evaluation, 50% soymilk and 12% MSNF resulted the best ice cream of all the formulations. From response study, it was found that the overrun was positively affected but melting rate was negatively affected by soymilk whereas both the overrun and melting rate were negatively affected by MSNF and the formulation of 100% soymilk and 10% MSNF was found to be the best optimized. Chemical analysis of the best product (50% soymilk and 12% MSNF) showed 64% moisture, 10% fat, 5.6% protein, 18.9% total sugar and 0.4% ash. Hence, soy ice cream can be prepared by using milk (50%), soymilk (50%) and MSNF (12%) with physical, chemical and sensory qualities similar to that of plain ice cream.

Keywords: Ice cream, soy ice cream, soymilk, milk, milk solid not fat, overrun, melting rate

Introduction

Soy ice cream is a vegan friendly dessert prepared by using soymilk, alone or in combination with milk as a major ingredient. Soybean and soy foods have been acclaimed as health foods due to their high protein content, essential amino acids, omega-3 fatty acids, isoflavones, carotenoids, and fat-soluble vitamins. Soymilk is a stable emulsion prepared by soaking and grinding soybean in water. The composition of soymilk is more or less similar to that of dairy milk. Besides being rich in protein, vitamin and mineral, soymilk is an economical, lactose-free, digestible and nutritious alternative to a dairy-centered diet.

Consumption of soy ice cream instead of regular ice cream causes a decrease in saturated fat intake and an increase in soy protein intake. Although soy ice cream was introduced in the US market in 1976, it has not reached the eastern market yet and no research work has been carried out on this dessert in Nepal. Ice cream consumption is increasing rapidly but due to its high cost poor people cannot afford it. The cost can be reduced by replacing milk with soymilk. Soy ice cream is an inexpensive source of nutrition for milk allergy patients and vegetarians.

Therefore, the main aim of this research was to prepare ice cream from soy milk and to evaluate its quality.

Materials and Methods

Raw materials collection:

Fresh milk was collected from DDC, Dharan having fat and SNF contents of 3.0% and 8.0% respectively. Fresh cream was also bought from DDC, Dharan. It's fat and SNF were found to be 70% and 2.2% respectively. Skim milk powder (94% SNF), mixed stabilizer/emulsifier (containing di-glycerides, gelatin and carrageenan), sugar, vanilla (flavor) and soybean (*Glycine max*) were bought from the local market of Dharan.

Preparation of Soy Milk

Soymilk was prepared by soaking whole soybeans in water for 10 h, dehulling by rubbing and steaming the soybeans at 121 °C for 15 min followed by grinding and filtering. One kg dry soybean gave about 3 kg soy milk using bean to water ratio of 1:2.

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Preparation of soy ice cream

Preparation of mix was done at 50 ^{0}C with cream and soymilk. After addition of sugar, stabilizer, emulsifiers and skim milk powder, the mix was pasteurized at 90 ^{0}C for 1-2 sec. The mix was homogenized, cooled, flavored and aged for 6 h. This was followed by freezing in an ice cream freezer for 15 min and then hardening at -10 to -15 ^{0}C for 10 h.

The experimental data was designed in a Central Composite Face Centered Design (CCFCD) with three levels, two factors and five center points. The independent variables selected were soymilk and milk solid not fat (MSNF) whereas the response variables were overrun and melting rate. Three levels of process variables were coded as -1, 0 and 1.The range of soymilk and MSNF content taken for experiment were 0-100% and 10-12 respectively.

Table 1 Experimental combinations at actual levels for response surface analysis

S.N.	Formulation Varieties	A:Soy milk	B:MSNF
1	A	0	10
2	B	50	10
3	C	100	10
4	D	0	11
5	E	50	11
6	F	100	11
7	G	0	12
8	H	50	12
9	I	100	12

Data Analysis

Physicochemical analysis of milk and soymilk

Total solid content was determined by gravimetric method and fat content by Gerber method (NDDB, 2001). Protein of milk was determined by formal titration method whereas that of soymilk by Kjeldahl method (Rangana, 2000). Acidity (as lactic acid) was determined by titration with standardized alkali solution and total ash content by gravimetric method (Rangana, 2000). Percentage overrun was determined by gravimetric method (NDDB, 2001) and melting rate was determined as per Goff and Hartel (2013).

Statistical analysis of responses

The responses overrun and melting rate for different experimental combinations were related to the coded variables (x_i, i= 1 and 2), by a second degree polynomial equation as given below:

$$Y = \beta_o + \beta_1 x_1 + \beta_2 x_2 + \beta_{11} x_{12} + \beta_{22} x_{22} + \beta_{12} x_1 x_2 + \varepsilon$$

The coefficients of the polynomial were represented by β_o(constant), β_1, β_2(linear effects), β_{11}, β_{22}(quadratic effects), β_{12}(interaction effect) and ε(random error).

Sensory and physicochemical analysis of soy ice cream

The representative samples of soy ice cream were served to semi-trained panelists and the sensory evaluation was done by using 9 points hedonic rating scale. The parameters for evaluation were aroma, taste, color, body, aftertaste and overall acceptability. The sensory data were analyzed by using analysis of variance (two-way ANOVA) at 5% level of significance using GenSat Release (version12.1) developed by Lawes Agricultural Trust (1995). The best soy ice cream sample was subjected to chemical analysis viz., total solids, overrun, melting rate, acidity, fat, protein, total ash, total sugar and lactose.

Results and Discussion

Soymilk prepared from soybeans and whole milk was used for product preparation. They were analyzed for proximate components which are shown in Table 2.

The obtained values of proximate components of milk were closer to the values given by Acharya (2006).The proximate values of soymilk were closer to values given by Boye et al (2011).

Sensory analysis

Aroma

The statistical analysis showed that there was a significant effect (p<0.05) of soymilk variation on aroma. The samples prepared using the highest soymilk and the lowest MSNF had lower aroma preference scores while those prepared using average soymilk and the highest MSNF had higher aroma preference scores. It was found

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that the bland milk aroma is preferable than the beany soy flavor in ice cream (Figure 1).

Table 2 Proximate composition of milk and soymilk

Components	Milk	Soymilk
Moisture	89.5±1.89	89±0.15
Protein	2.89±0.2	5.19±0.16
Fat	2.49±0.15	1.59±0.15
Ash	0.5±0.3	0.2±0.16
Carbohydrate	4.3±1.42	3.74±0.15

*The values in the table are mean of triplicates ± standard deviation.

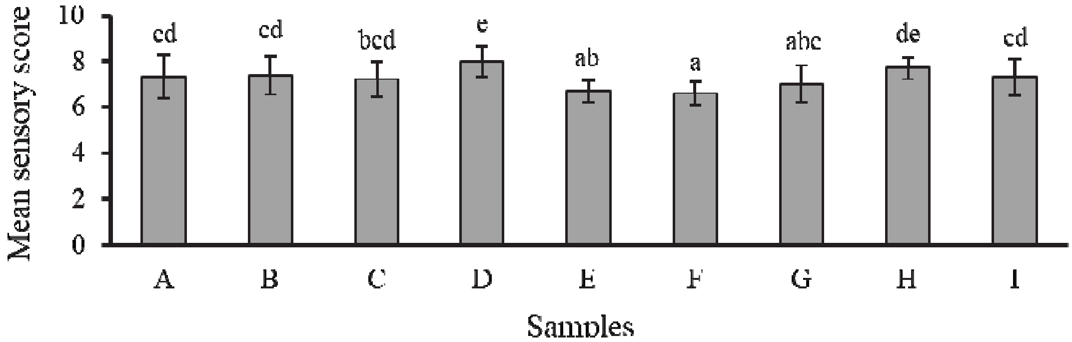

Fig 1: Histogram of mean sensory scores for aroma

(*Note*: Values on top of the bars bearing similar superscript are not significantly different at 5% level of significance.Vertical error bars represent ±standard deviation of scores given by panelists.)

Taste

Sample H had the highest taste score (8.8) which was significantly different from all samples except sample D. Bisla et al. (2012) observed similar result where flavor of ice cream with average soy milk content was preferred over complete soymilk ice cream. It was also found that samples with higher MSNF showed higher values, which indicates that MSNF enhances flavor of ice cream making it more palatable.

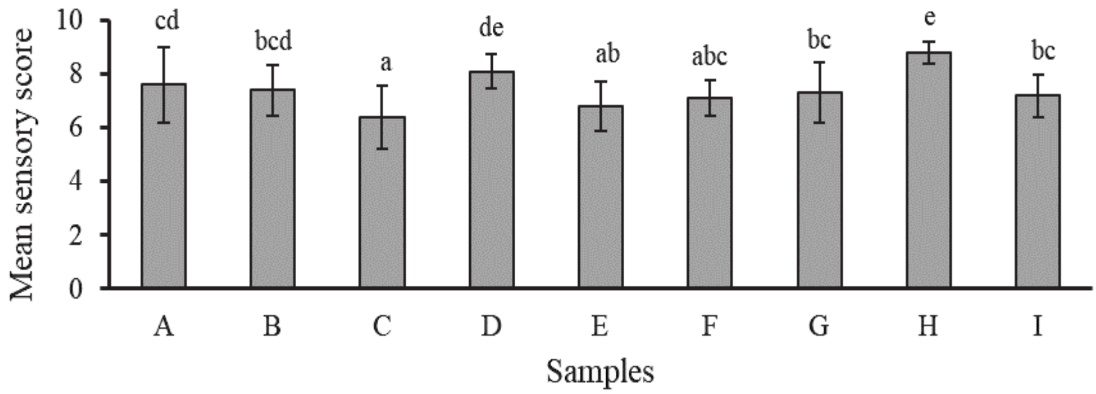

Fig 2: Histogram of mean sensory scores for taste

(Note: Values on top of the bars bearing similar superscript are not significantly different at 5% level of significance.Vertical error bars represent ±standard deviation of scores given by panelists.)

Color

Samples A&H had the highest color score (7.7). Samples A&B, B&I and C&E were found to be significantly different but samples E, F and G had the same mean score (6.4) which indicates that average and complete soymilk content gave the same color effect while samples with same MSNF showed decreasing scores with increasing soymilk content.

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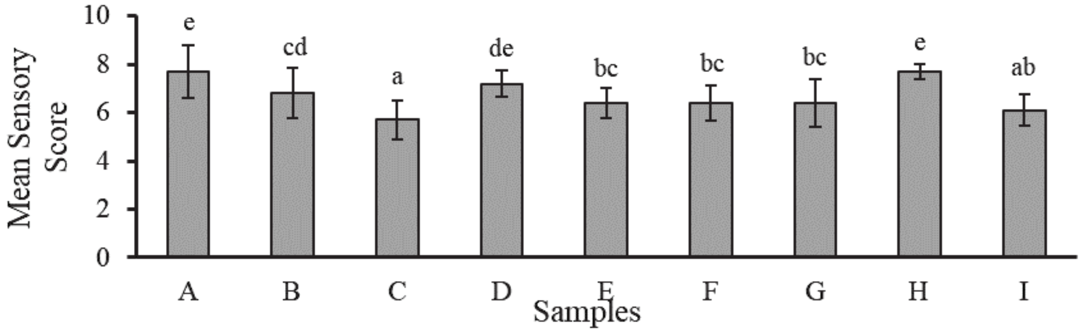

Fig 3: Histogram of mean sensory score for color

(*Note*: Values on top of the bars bearing similar superscript are not significantly different at 5% level of significance. Vertical error bars represent ±standard deviation of scores given by panelists).

Body

The mean score was found to be highest for sample H (7.9) and it was slightly greater than A (7.1). Samples A&C and D&H were significantly different. As such MSNF may not exert much effect on the body of ice cream but average soy content together with high MSNF was found to be preferable. It was found that 50:50 substitution of soymilk in milk creates the highest consistency in ice cream showing a synergistic effect of milk and soymilk resulting in tighter and stronger texture.

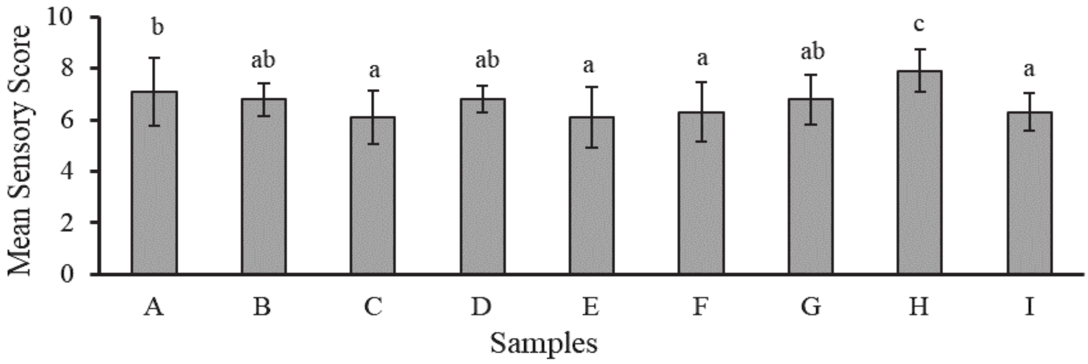

Fig 4. Histogram of mean sensory score for body

(*Note*: Values on top of the bars bearing similar superscript are not significantly different at 5% level of significance. Vertical error bars represent ±standard deviation of scores given by panelists.)

Aftertaste

Sample D had slightly higher aftertaste score (7.8) than samples H and A (7.6). Samples A&D, B&C, C&G and D&F were found to be significantly different while samples C, F and I were almost similar with least mean scores showing less preference for high soy concentration.

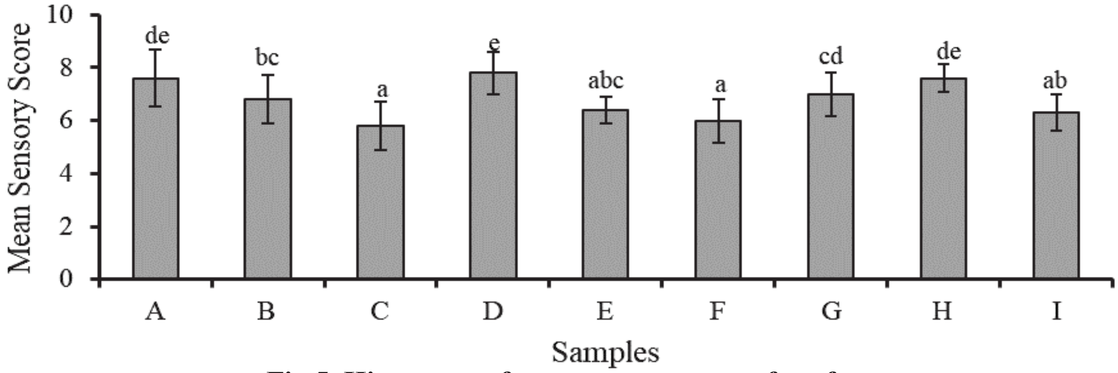

Fig 5. Histogram of mean sensory score for aftertaste

(*Note*: Values on top of the bars bearing similar superscript are not significantly different at 5% level of significance. Vertical error bars represent ±standard deviation of scores given by panelists.)

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Overall acceptance

The mean sensory score was found to be the highest for sample H (8.1). Samples A&C, C&D and E&H were significantly different whereas samples A&D, C&E and F&I were not significantly different. The samples with same MSNF content showed decreasing mean scores with increasing soy content. Bisla et al. (2012) and Pourahmed and Ahanian (2015) also observed lower scores for samples with high soy content in terms of acceptability of ice cream and higher scores for samples with average soy content.

Therefore, sample H was found to be the best in most of the parameters and overall acceptability. The formulation with 50% soymilk and 12% MSNF was chosen to be the best product by sensory evaluation.

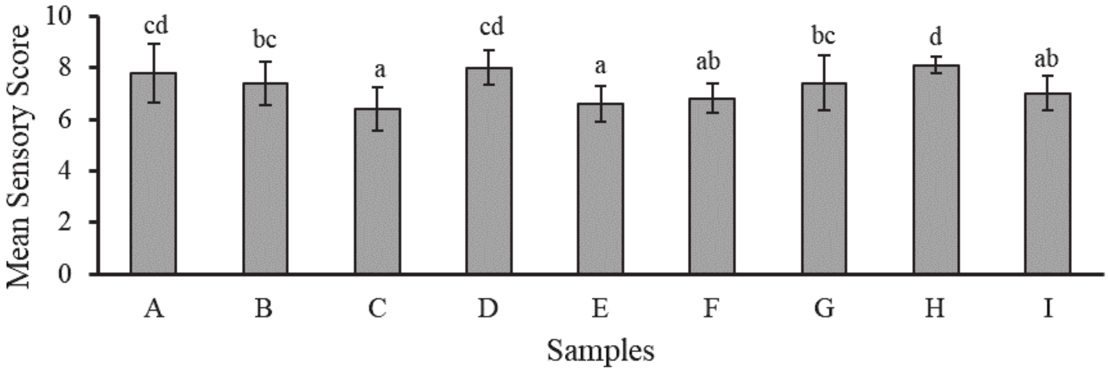

Fig 6: Histogram of mean sensory score for overall acceptance

(*Note*: Values on top of the bars bearing similar superscript are not significantly different at 5% level of significance. Vertical error bars represent ±standard deviation of scores given by panelists.)

Effect of formulation on overrun

The overrun of soy ice cream varied from 21.1% to 50.68%. Regression model fitted to experimental results of overrun shows the Model F-value of 89.91, which implies the model is significant ($p<0.05$) relative to the pure error. The chance of large model F-value due to noise was only 0.01% .The lack of fit was not significant.

Equation 1 represents variation of overrun.

$$\text{Overrun} = 32.06 - 3.63A - 3.89B - 4.71AB + 15.42A^2 - 5.24B^2 \quad \text{......} 1$$

where A and B are the coded values of soymilk (%) and MSNF (%) respectively.

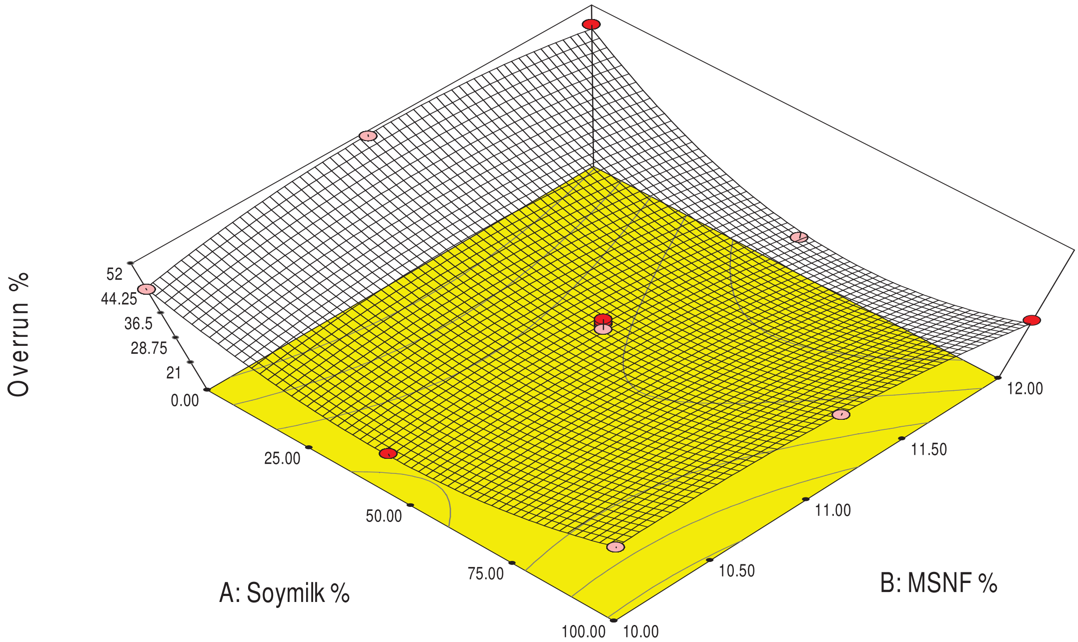

Fig 7: Response surface plot for Overrun as a function of Soymilk and MSNF content in soy ice cream

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The equation (1) of overrun had significant ($p<0.001$) negative effect of (A) soymilk at 95% confidence level. The linear term of MSNF (B) had linear negative effect on overrun of soy ice cream. Quadratic term of soymilk (A^2) and MSNF (B^2) had significant ($p<0.001$) positive and negative quadratic effect respectively, indicating the convex shaped variation on the overrun. The interaction term of soymilk and MSNF (AB) had a negative effect on overrun. Findings of Pourahmed and Ahanian (2015) were also parallel with this results as the overrun of soy ice cream was positively affected by higher concentrations of soymilk due to interaction effect which can be attributed to increased total solids content in samples with high amount of soymilk.

Effect of formulation on melting rate

The melting rate of soy ice cream varied from 0.5 g to 1.27 g per 5 minutes. Regression model fitted to experimental results of melting rate shows the model F-value of 4.17 which implies the model is significant ($p<0.05$) whereas, lack-of-fit F-value of 0.5299 was not significant ($p>0.05$) relative to the pure error. There is 4.45% chance that a 'Model F-value' this large could occur due to noise. Equation 2 represents variation of melting rate.

$$\text{Melting rate} = 1.04 - 0.17A - 0.063B - 0.14AB - 0.10A^2 - 0.15B^2 \qquad (2)$$

where A and B are the coded values of soymilk (%) and MSNF (%) respectively.

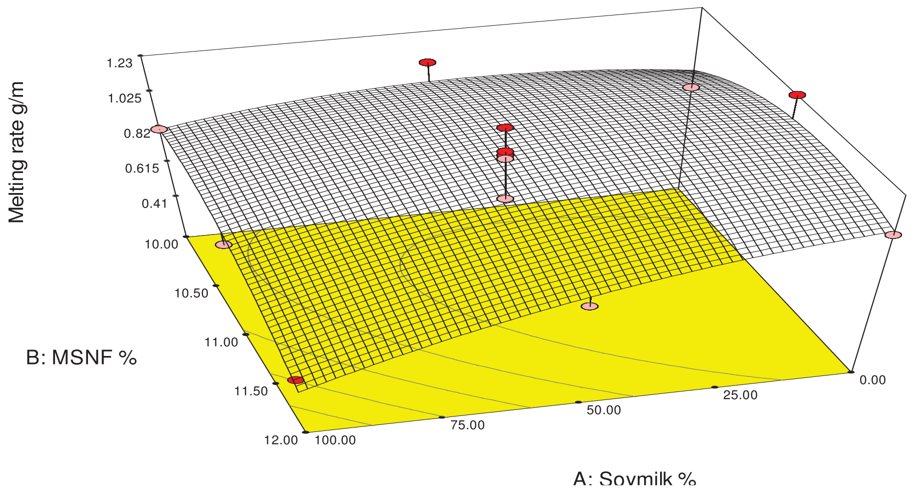

Fig 8: Response surface plot for melting rate as a function of soymilk and MSNF content in soy ice cream

The equation 2 of melting rate had a highly significant negative effect of soymilk (A) ($p<0.05$) at 95% confidence level. The linear term of MSNF (B) had linear negative effect on melting rate of soy ice cream. Quadratic term of soymilk (A^2) and MSNF (B^2) had a negative effect. Santos and Silva (2012) reported similar results. The interaction term of soymilk and MSNF (AB) had a negative effect on melting rate, indicating a concave shaped variation with the change in value of variables.

Optimization study

A numerical multi-response optimization technique was applied to determine the optimum combination of soymilk and MSNF in soy ice cream. The assumptions were to develop a product with maximum overrun and minimum melting rate. These parameters were attempted to be maintained whereas other parameters were kept in range. Under these assumptions by Design expert, the uncoded optimum proportions of milk and solids for soy ice cream preparation were 100% soymilk and 10% MSNF with a desirability of 70.3%. The response predicted by the software for these optimum proportions of constituents were overrun of 47.207% and melting rate of 0.82 g per 5 minutes.

Table 3: Multi response optimization constraints of soy ice cream

Name	Goal	Lower limit	Upper limit	Lower weight	Upper weight	Importance
Soymilk	Is in range	0	100	1	1	3
MSNF	Is in range	10	12	1	1	3
Overrun	Maximize	21.1	50.68	1	1	3
Melting rate	Minimize	0.5	1.23	1	1	3

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Analysis of the best product

The optimized sample given by Design expert was sample C (100% soymilk, 10% MSNF) but from sensory analysis, sample H (50% soymilk, 12% MSNF) was found to be the best. Physical analysis and sensory evaluation are different techniques used to optimize the product and these are hard to correlate. Giving first priority to sensory evaluation, sample H was selected as the best one.

Table 4: Proximate analysis of the best soy ice cream sample (50% soymilk and 12% MSNF)

Parameter	Result
Moisture content (%)	64±1.57
Fat (%)	10±0.06
Lactose (%)	6.4±0.1
Protein (%)	5.6±0.52
Total sugar (%)	18.9±0.26
Ash content (%)	0.4±0.05

Conclusions

It was concluded that soy ice cream was nutritionally equivalent to plain ice cream. It was found to be slightly yellowish in color and had a mild soy flavor. Soy ice cream had higher overrun and significantly reduced melting rate than that of plain ice cream. Production cost of the prepared soy ice cream was reasonable within the reach of general population and much lower than dairy ice cream so its commercialization could be done. From sensory analysis sample with 50% soymilk and 12% MSNF was found to be the best whereas from physical analysis 100% soymilk and 10% MSNF was found to be the optimized sample respective of overrun and melting rate.

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