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Studies on Production of Low-Calorie Ice Cream Made with Sucralose and Sorbitol

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Abstract

Low calorie ice cream was developed using artificial sweetener sucralose and sorbitol as bulking agent in complete replacement of sugar. To standardize the sweetness level sucralose sweetener was added at different levels and found that significant (P<0.05) a decrease in score for mouth feel as well for body and texture in addition to the carbohydrate, ash and total solids percentage of ice cream. However, the sweetness of the product 300 ppm containing sucralose found to be nearer to the sweetness of the control ice cream but lacks mouth feel. To achieve the proper mouth, feel and body and texture of the finished product as that of control ice cream a bulking agent (sorbitol) was tried at three different levels and found that 3% sorbitol level was more suitable than compared to the others. Hence low-calorie ice-cream developed with a combination of 300 ppm sucralose and 3% sorbitol was found to best and comparable with that of control ice-cream.

Keywords: Ice Cream, Low Calorie, Physico-Chemical Quality, Sucralose, Sorbitol

Introduction

Ice cream usually composed with fat, protein and carbohydrate which add to its calorific value. On an average the calorific value of ice cream is 200 kcal/100g (Pinto and Dharaiya, 2014). In India alone about 48.14 percentage residents consume high fat diet (Chatterjee, 2007). Survey of Indian Council of Medical Research affirmed that in urban locality 49 percentage of female and 36 percentage of male population suffers from obesity. Obesity can be explained as a store of several other health issues like hyperlipidemia, hypercholesterolemia, diabetes, hypertension, cancer and gallstones. WHO has estimated a world-wide heavy upsurge in the diabetic cases, expected to rise by 57.2 million till 2025 in sharp contrast to the diabetic cases of 19.4 million as in 1995. India has already become the home to diabetes with 69.1 million patients and which is expected to surge by 79.4 million till 2030 (Sonwane and Hembade, 2014; Tripathy *et al.*, 2017). To combat the above health problems, in recent years there is a growing demand of low-calorie dairy products. Ice cream is one of the most served and loved desserts but is high in fat content and sugar, therefore; formulating its sugar free version will serve in good cause for reducing the extra-calorie intake and make it healthier. Removal of sugar to prepare sugar free ice cream counts for some defects like adjustment in total solids and loss in freezing point depression. The prior can be compensated by using bulking agent like polydextrose and later by adding freezing point depressant like sorbitol (Pinto and Dharaiya, 2014; Patil and Banerjee, 2017). Bulking agents impart creaminess, smoothness, improve texture and provide a mouth feel and protection against temperature fluctuation to please customers (Goff and Jordan 1985). Sorbitol or mannitol containing Sugar-free products contain low glycemic index (GI). Hence, present study has been undertaken to develop a low-calorie ice cream with sucralose and sorbitol.

Materials and Methods

Ice cream

In the present study, ice cream (control) was prepared using 10% fat, 11% SNF, 15% sugar, 0.3% stabilizer and emulsifier and 0.2% vanilla flavour the standard method indicated by De (1980) and filled in polystyrene cups of 100ml capacity and kept for hardening at -23°C.

Preparation of Low-Calorie Ice Cream

The low-calorie ice cream was prepared by substituting the cane sugar with low calorie sweetener sucralose and bulking agent sorbitol by adding along with the other ingredients while the sweetener was added to the mix after homogenization as 20% aqueous solution. In order to find out the appropriate level of sweetness, sucralose was added to the mix independently without using bulking agent at the levels of viz. 250, 300, 350 ppm. After obtaining the best suitable level of sucralose, to find out the acceptable mouth feel low calorie ice cream was supplemented with sorbitol at three different levels viz., 2%, 3% and 4%.

Analysis of Ice Cream

The ice cream was evaluated for physico-chemical and sensory characteristics. The fat content of the ice cream were determined by the standard method as suggested in ISI Hand Book (1989). The total nitrogen in the sample was determined by Macro-Kjeldahl method (AOAC, 2000). Ash content of ice cream samples was determined by procedure described in IS: 1547-1985. Total solids content of the ice cream mix was determined by gravimetric method (IS: 2802-1964). The total carbohydrate content in the samples was determined by difference i.e. the sum of moisture, protein, fat and total ash percent was subtracted from 100. The titratable acidity of the ice cream was determined by the standard method suggested in ISI Hand Book (1989). The pH of ice cream mix was determined after ageing using a digital pH meter (Elico Pvt. Ltd., Hyderabad) (AOAC 2000).

The viscosity of ice cream mix was determined by the method of Loweenstein and Haddad (1972) using a Brookfield Viscometer, Model LTD2T, (Brookfield Engineering Laboratories, Chennai). The overrun in ice cream was determined as per the method of Marshall *et al.* (2003). The penetration value of the hardened frozen product was measured using cone penetrometer. The melting rate was determined as per the procedure given below by Specter and Setser (1994). The acceptability of low calorie ice cream was studied by conducting sensory evaluation with the help of panel of trained judges were assessed by using 9 point hedonic scale.

Statistical Analysis

The results obtained during the course of investigation were subjected to statistical analysis using the software OPSTAT, as proposed by Sheoran *et al*.,1998.

Results and Discussion

Selection of Sucralose Sweetener Level for Preparation of Low-Calorie Ice Cream

Compositional and Physico-Chemical Analysis

On perusal of the data presented in Table 1 reveals that the mean fat percentage values for control and low-calorie ice cream were in range of 9.96 to 10.12 with sucralose added at levels of 250 ppm, 300 ppm and 350 ppm, respectively. The corresponding protein percentage values were found to be 3.54 to 4.046 and there were no significant differences ($P \geq 0.05$) among four treatments for both fat and protein contents. These findings are in agreement with the observations made by (Manuka *et al.,* 2013). Addition of sucralose sweetener in ice cream resulted in a significant ($P < 0.05$) decrease in carbohydrate content as compared to control. Similar trend was observed even in ash content and total solids content resulted due to the lack of sugar in treatment which is completely replaced with artificial sweetener. These results in comparable with findings made by Asghar *et al.* (2013) reported that there was a significant decrease in ash content by incorporation of non-nutritive sweeteners in ice cream as compared to the control ice cream.

Further, on perusal of the mean pH and acidity values observed that there were no significant differences ($P \geq 0.05$) among control and treatment samples in pH and acidity. Since the sucralose is a chlorinated disaccharide are not contributors of acidity and pH of mix (George *et al.,* 2006 and Natraj Kumar, 2008).

Table 1: Average composition and physico–chemical analysis for low calorie ice cream with different levels of sucralose

Treatments	Fat (%)	Protein (%)	CHO* (%)	Ash (%)	Total solids (%)	pH	Acidity (% LA)
Control	10.12 ± 0.12	4.04± 0.31	21.94^{a}± 0.49	0.91^{a}± 0.01	36.88^{a}± 0.29	6.39± 0.03	0.22± 0.01
T_4	9.98± 0.01	3.64± 0.09	8.21^{b}± 0.11	0.72^{bc}± 0.01	22.71^{b}± 0.08	6.41± 0.02	0.2± 0.01
T_5	9.99± 0.01	3.54± 0.09	8.55^{b}± 0.11	0.76^{b}± 0.01	22.86^{b}± 0.15	6.39± 0.03	0.2± 0.01
T_6	9.96± 0.01	3.57± 0.11	8.64^{b}± 0.44	0.71^{c}± 0.02	22.90^{b}± 0.45	6.38± 0.04	0.21± 0.01
CD ($P \leq 0.05$)	NS	NS	1.02	0.04	0.54	NS	NS

Values mentioned above are mean ± SE; (n=5); abcd: means in the same column with different superscripts differ significantly ($P \leq 0.05$)

Sensory Evaluation

On perusal of the data presented in Table 2 revealed that the mean flavour, body and texture score and colour and appearance scores values are more or less stable between the three levels of sucralose added ice cream. However, there is a significant difference when compared to control. The decrease in body and texture score mainly due to absence of bulking agent as not only body and texture but also acceptable mouth feel. The addition of sugar in control ice cream increases the total solids and gives good body and texture when compared to the sucralose added ice cream. The observations are in conformity with the findings of Arora *et al.* (2008) reported the insufficient water binding capacity of artificial sweetener which resulted in a product with lower score for body and texture. The mean sweetness scores for ice cream prepared using 250 ppm of sucralose showed significantly lower ($P \leq 0.05$) sweetness (score 7.63) in comparison with control ice cream sweetness (8.54). On the other hand, 350 ppm of sucralose had mean intensity score of 8.142, which was significantly ($p \leq 0.05$) lower than control due to an increase level of sucralose gives a bitter taste, while the score of 300 ppm sucralose was close to that of control. Optimum sweetness in 300 ppm added sucralose was observed by the panelist which is equal to the perceptiveness of the ice cream made with sugar without any after taste. It is observed from the mean sweetness scores of ice cream prepared using sucralose that there is a significant difference ($P \leq 0.05$) between the levels and control. The mean mouth feel

and overall acceptability scores of ice cream had significantly higher (P≤0.05) in control than in other treatments. The control ice cream showed good mouth feel, in between treatment levels there is a weak body and lacking sufficient mouth feel. Based on this analysis, it can be concluded that 300 ppm of sucralose imparted the sweetness taste quite close to that of sucrose in frozen dessert and was selected.

Table 2: Average sensory scores for low calorie ice cream prepared with different levels of Sucralose

Treatments	Flavour	Body and texture	Colour and appearance	Sweetness	Mouth feel	Overall acceptability	Comments
Control	8.44^{a}± 0.02	8.60^{a}± 0.01	8.40^{a}± 0.04	8.54^{a}± 0.01	8.54^{a}± 0.01	8.50^{a}± 0.03	Acceptable sweetness, optimum body with good mouth feel
T_4	8.29^{b}± 0.02	7.70^{c}± 0.02	8.25^{b}± 0.01	7.63^{d}± 0.02	7.37^{c}± 0.10	7.85^{b}± 0.18	Less sweetness, weak body
T_5	8.36^{b}± 0.02	7.79^{b}± 0.03	8.32^{b}± 0.01	8.44^{b}± 0.02	7.91^{b}± 0.11	8.16^{ab}± 0.13	Optimum sweetness, weak body
T_6	8.32^{b}± 0.02	7.764^{bc}± 0.02	8.38^{b}± 0.01	8.14^{c}± 0.01	7.20^{c}± 0.08	7.94^{b}± 0.21	Too high sweetness, weak body
CD (P≤0.05)	0.07	0.07	0.07	0.05	0.26	0.46	-

Values mentioned above are mean ± SE; (n=5); abcd: means in the same column with different superscripts differ significantly (P≤0.05)

Selection of Sorbitol Levels to the Standardized Sucralose Level Low Calorie Ice Cream

Sorbitol is less sweet as well as low calorie sugar replacer used to feel up the bulk that provided by sugar. In the present investigation an attempt was made to study the feasibility of using sorbitol as bulking agent in the preparation of low-calorie ice cream as to improve the mouth feel as well body and texture. A separate trail was conducted by adding three levels of sorbitol viz. 2 (S_1), 3 (S_2) and 4 (S_3) percent.

Composition and Physico-Chemical Analysis for Low Ice Cream Prepared with Different Levels of Sorbitol

On perusal of the presented in Table 3 it was observed that the mean fat percentage values were in range of 10.16 to 8.98 in control and treatments respectively and is significantly different (P≤0.05) between control and sorbitol levels. A similar trend also observed in protein percentage. The carbohydrate and ash percent in low calorie ice cream was observed to increasing with increasing levels of sorbitol and are significantly different from one another. The addition of different levels of sorbitol significantly affects the total solids of ice cream. The differences observed were statistically significant among all treatments; this may be due to increasing the level of sorbitol the total solids content also increases, but not as equal to the control.

Table 3: Average composition and physico–chemical analysis for low calorie ice cream prepared with different levels of sorbitol

Treatments	Fat (%)	Protein (%)	CHO* (%)	Ash (%)	Total solids (%)	pH	Acidity (%LA)
Control	10.16^{a}± 0.03	3.81^{a}± 0.03	22.15^{a}± 0.26	0.91^{a}± 0.02	37.04^{a}± 0.24	6.58^{a}± 0.03	0.22^{ab}± 0.01
S_1	9.83^{b}± 0.01	3.67^{ab}± 0.07	11.08^{d}± 0.19	0.81^{b}± 0.02	25.44^{d}± 0.14	6.39^{b}± 0.05	0.23^{a}± 0.01
S_2	9.69^{c}± 0.02	3.579^{b}± 0.04	12.62^{c}± 0.06	0.82^{b}± 0.03	26.75^{c}± 0.06	6.34^{bc}± 0.05	0.21^{bc}± 0.01
S_3	8.98^{d}± 0.02	3.54^{b}± 0.03	14.02^{b}± 0.38	0.93^{a}± 0.02	27.63^{b}± 0.33	6.20^{c}± 0.03	0.20^{c}± 0.01
CD (P≤0.05)	0.07	0.18	0.76	0.08	0.66	0.14	0.01

CHO - Carbohydrate; Values mentioned above are mean ± SE; (n=5); abcd: Means in the same column with different superscripts differ significantly (P≤0.05)*

Pawar (2011) and Dere (2012) also noted that use of ingredients added in ice cream affects the total solids content of ice cream. The mean pH of low calorie ice cream prepared with different levels of sorbitol was ranged from 6.39 to 6.20, whereas ice cream prepared with sugar as pH of 6.58 and acidity in the control sample is 0.22 where as in ice cream prepared with different levels of sorbitol was 0.23, 0.21 and 0.20 respectively. Sorbitol significantly decreased (P≤0.05) the acidity of low-calorie ice cream as compared to control. The observations are in conformity

with the findings of (Frye and Sester 1993) reported the sorbitol are non-fermentable by yeast and fairly resistant to bacterial growth.

Physical Characteristics of Low-Calorie Ice Cream Prepared with Different Levels of Sorbitol

Viscosity

Perusal of the data presented in Table 4 reveals that the mean viscosity (Cp) of mix before ageing at 37°C the values are 151.15, 88.20, 96.92, 106.56 and after ageing the mix at 4°C the values are 381.01, 276.90, 284.20, 296.00 in treatments control to S_3 respectively which was significantly higher ($P \leq 0.05$) in control than in other treatments. Verma (2002) reported that viscosity of artificially sweetened frozen dessert increased when maltodextrin and sorbitol were used in combination.

Overrun

It is evident from Table 4 that the overrun of control was 85.04 percent. The overrun of S_3 was lower than control and that of S_1 and S_2 higher than S_3. This may be due to an increase in viscosity with increase in the level of sorbitol was observed in the decreasing overrun.

Penetration Value

The mean penetration value (mm/5s) observed that there was a very slight decrease in penetrometer reading. Among treated low-calorie ice cream as the level of sorbitol addition to substitute sugar was increased there was significant increase in penetration value indicating decrease in hardness.

Table 4: Physical characteristics of the low-calorie ice cream prepared with different levels of Sorbitol

Treatments	Viscosity before ageing at 37°C	Viscosity after ageing at 4°C	Overrun (%)	Penetration value (mm/5s)
Control	151.15^{a}± 3.21	381.01^{a}± 7.99	85.04^{a}± 0.50	63.50^{c}± 0.13
S_1	88.20^{c}± 2.39	276.90^{c}± 0.87	83.20^{b}±0.20	75.52^{a}± 0.18
S_2	96.92^{bc}± 3.32	284.20^{bc}± 0.40	80.40^{c}± 0.24	67.10^{b}± 0.36
S_3	106.56^{b}± 4.63	296.00^{b}± 1.38	78.20^{d}± 0.58	61.08^{d}± 0.30
CD ($P \leq 0.05$)	10.45	12.25	1.25	0.79

Values mentioned above are mean ± SE; (n=5); abcd: Means in the same column with different superscripts differ significantly ($P \leq 0.05$)

Effect on First Drip Time and Melting Rate for Low Calorie Ice Cream Prepared with Different Levels of Sorbitol

The values given in the Table 5 indicates that there was significantly higher in S_3 than in other treatments for first dripping time, in case of melting rate showed that there was significantly higher in S_1 than in other treatments. It was observed from the table that the first dripping time increased and melting rate decreased with increasing amount of sorbitol because it contains some hydrocolloids, which caused increase in viscosity and thus enhanced the melting resistance. However, the S_2 is comparable with that of the control ice cream.

Table 5: Effect on first drip time and melting rate of low-calorie ice cream prepared with different levels of Sorbitol

Treatments	FDT (min)	Melting rate % (Time in minutes)									
		10	20	30	40	50	60	70	80	90	100
Control	10.6^{b}± 0.53	10.60^{c}± 0.37	17.55^{c}± 0.73	30.95^{c}± 1.21	45.58^{b}± 2.03	56.27^{b}± 2.39	62.10^{b}± 62.10	67.07^{b}± 1.00	66.53^{b}± 1.82	67.66^{c}± 1.44	68.82^{c}± 1.35
S_1	5.8^{c}± 0.33	9.49^{a}± 0.53	23.93^{a}± 0.43	37.07^{a}± 0.44	52.45^{a}± 0.74	62.11^{a}± 0.47	68.57^{a}± 68.57	72.20^{a}± 0.62	73.95^{a}± 0.48	74.84^{a}± 0.49	75.91^{a}± 0.45
S_2	9.0^{b}± 0.40	8.24^{b}± 0.35	20.79^{b}± 0.38	35.42^{ab} ± 0.56	49.48^{a}± 0.29	59.90^{ab}± 0.81	68.13^{a}± 68.13	70.55^{a}± 0.52	71.43^{a}± 0.46	72.32^{b}± 0.33	73.11^{b}± 0.20
S_3	11.8^{a}± 0.33	6.37^{c}± 0.29	20.07^{c}± 0.44	33.57^{b}± 0.31	45.38^{b}± 0.48	56.67^{b}± 1.20	62.90^{b}± 62.90	65.26^{b}± 0.79	68.43^{b}± 0.45	69.79^{c}± 0.50	71.08^{b}± 0.34
CD (P≤0.05)	1.37	1.2	1.56	2.17	3.35	4.26	4.39	2.27	2.99	2.46	2.22

Values mentioned above are mean ± SE; (n=5); abcd: Means in the same column with different superscripts differ significantly (P≤0.05)

Sensory Evaluation for Selection of Low-Calorie Ice Cream Made with Different Levels of Sorbitol

On perusal of results presented in Table 6 reveals that the mean flavour scores were 8.62, 8.396, 8.50 and 8.28 in treatments control to S_3 respectively, which was significantly higher (P≤0.05) in control than in other treatments. The average flavour score for 3% addition of sorbitol was 8.50 which were higher than 2 and 4% level. The treatments were statistically different and are significant this may be due to increasing the level of sorbitol the flavour score decreased. The mean body and texture, colour and appearance, mouth feel and sweetness scores are significantly different between the sorbitol levels and control. The statistical analysis revealed that S_2 significantly higher (P≤0.05) scores than in other treatments, this may be due to increasing the level of sorbitol there is a decreasing the scores. The body and texture for 3% sorbitol is selected by panel of judges which is slightly lower than the control than the remaining levels. Addition of sorbitol levels gives smooth body and texture as well mouth feel, improves the colour and appearance. Similar findings were noticed by Morley and Ashton (1982) suggested that 10.8% sorbitol is optimum to produce softness in soft scoop ice cream. On the other hand, Finney and Dea (1978) obtained the soft scoop ice cream with 3% sorbitol. The 3% level incorporation sorbitol treatment was found to be having optimum sweetness and over acceptability score and was selected by the judges than that of control. Based on the sensory attributes of the above study confirming that 3% sorbitol with 300 ppm sucralose added low calorie ice cream is found to be optimum sweetness with good mouth feel.

Table 6: Average sensory scores for low calorie ice cream prepared with different levels of Sorbitol

Treatments	Flavour	Body and texture	Colour and appearance	Sweetness	Mouth feel	Overall acceptability	Comments
Control	8.62^{a}± 0.01	8.54^{a}± 0.01	8.51^{a}± 0.02	8.51^{a}± 0.03	8.44^{a}± 0.01	8.53^{a}± 0.02	Acceptable sweetness with good mouth feel
S_1	8.39^{c}± 0.02	8.12^{c}± 0.03	8.31^{c}± 0.01	8.20^{d}± 0.01	8.19^{c}± 0.01	8.26^{bc}± 0.05	Lower degree sweetness
S_2	8.50^{b}± 0.02	8.41^{b}± 0.01	8.43^{b}± 0.02	8.43^{b}± 0.01	8.33^{b}± 0.02	8.43^{ab}± 0.03	Optimum sweetness with good mouth feel
S_3	8.28^{d}± 0.02	7.76^{d}± 0.02	8.21^{d}± 0.02	8.31^{c}± 0.02	8.11^{d}± 0.02	8.14^{c}± 0.10	Higher degree sweetness
CD (P≤0.05)	0.06	0.06	0.07	0.07	0.06	0.18	-

Values mentioned above are mean ± SE; (n=5); abcd: Means in the same column with different subscripts differ significantly (P≤0.05)

Conclusion

From the investigation, the replacement of sugar with sucralose and sorbitol has significantly affected the sensory attributes of ice cream. On the basis of compositional, physico-chemical and sensory evaluation found that ice cream prepared with 300 ppm sucralose plus 2 percent sorbitol was highly acceptable as compared to control by the consumers. The calorific value of low-calorie ice cream was efficiently reduced to 60.71 Kcal/100g due to addition

of low-calorie sugar substitute and sorbitol.

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Conflict of Interests

There is no conflict of interest.

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