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ORIGINAL ARTICLE

Development of low calorie snack food based on intense sweeteners

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Abstract Intense sweeteners namely Aspartame, Acesulfame K and Sucralose were used in the preparation of sugar substitute sprinklers and these were used in snack food, replacing sugar. Study was conducted with an objective to develop low calorie snack food. The psychometric study showed that the threshold values for Acesulfame K, Aspartame and Sucralose were 0.012, 0.030 and 0.005 g respectively. The time intensity study revealed that among three sweeteners Aspartame had more lingering sweetness (at 60 s). The sensory evaluation of *Shankarpoli* prepared using refined wheat flour revealed that there was no significant difference in typical attributes of the snack; Aspartame and Acesulfame K had same sweetness intensity where as Sucralose had higher intensity of sweetness. Consumer acceptance study revealed that 53 % of the consumers liked the snack with Sucralose, which is highest compared to other two sweeteners namely Aspartame and Acesulfame K (47 %). Thus sweeteners can be used as sweetening agents in traditional food preparations.

Keywords *Shankarpoli* · Sugar sprinklers · Aspartame · Acesulfame K · Sucralose · Maltodextrin

Introduction

Sweets are prepared with high amount of sugar, which adds up to calorie intake of consumer. Additional intake of sweets may predispose to overweight. Hunty et al. (2006) reviewed the effect of aspartame on weight loss, weight maintenance and energy intakes in adults and use of aspartame-sweetened foods and drinks is an effective way to lose weight. Overweight and obesity are well known risk factors for Diabetes and Cardiovascular diseases. Overweight and obesity in youth are also associated with various risk factors for cardiovascular disease (Freedman et al. 1999). People suffering from Diabetes are advised to restrict their use of sugars. Use of alternative sweeteners can help to manage weight and normal blood glucose level (Hunty et al. 2006). Kroger et al. (2006) comprehensively reviewed the low calorie sweeteners and sugar substitutes and reported that low calorie sweeteners enables food manufacturers to formulate a variety of good-tasting sweet foods and beverages that are safe for the teeth and lower in calorie content than sugar-sweetened foods.

People are increasingly concerned about their health and appearance, and have sought feeding alternatives to the main problems that affect world population, such as obesity and diabetes, that share a close relation with high sucrose consumption (Patricia and Helena 2010). In recent days, consumers are aware of the importance of low calorie foods to prevent overweight. Substitution of artificial sweeteners for sucrose may facilitate the maintenance of nutritionally balanced diet by satisfying a diabetic person's desire for sweets and assisting in the control of caloric intake (Chattopadhyay et al. 2011). Therefore there is a need for varieties of sugar substitutes to manage diabetes and also to have low calorie foods. Few studies are conducted to incorporate sugar substitutes like sucralose (Binnis 2003) in traditional foods and other. Arora et al. (2010) replaced the sucrose with aspartame for the preparation of the indigenous dairy product *burfi*. Their storage studies indicated that aspartame-sweetened *burfi* resembled the control *burfi* in retaining the sensory profile, but showed an increase in acidity and microbial load and could not retain the texture. Zoulias et al. (2000) studied the effect of

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sugar replacement by polyols and acesulfame K on the quality aspects of low fat cookie and further reported that supplementation with acesulfame-K increased sweetness and improved perceived flavour and general acceptance of cookies. Acesulfame-K has high degree of stability when exposed to heat; this makes it a versatile sweetener with potential use in a wide range of foods and beverages (Arora et al. 2011).

This investigation was carried out with an objective- to formulate and evaluate sugar substitute sprinklers with Acesulfame K, Aspartame and sucralose on Indian traditional snack known as '*Shankarpoli*'.

Materials and methods

Three sweeteners namely Acesulfame K, Aspartame and Sucralose and Maltodextrin (Bulking agent) were purchased from HiMedia Laboratories Pvt. Ltd, These sweeteners were selected on the fact that Prevention of Food Adulteration Act (2004) has approved as safe for consumption.

Sample preparation

Equal amount (50 g) of semolina and refined flour were taken to which a pinch of salt, one table spoon of hot oil (15 ml) was added and mixed properly to form a dough with 50 ml of water. Dough was rolled into sheets of 1.5–2.0 mm thickness (if needed sprinkle 2–3 g of flour) and cut into diamond shapes. Samples were fried in hot oil at 170–175 °C for 3–4 min. Product was taken out from the pan and sugar powder was sprinkled. The product was puffed and crisp in texture.

Panel training

A group of ten panelists were trained for psychometric tests (threshold, time intensity, dose response test) and Quantitative Descriptive Analysis (QDA). Panel members were scientific staff of the Sensory Science department. In the preliminary session panelists were trained for sensory evaluations; care was taken to avoid physiological errors and bias. Samples were evaluated in a booth room maintained at 22±2 °C under fluorescent lighting equivalent to daylight.

Psychometric studies

Threshold study

Threshold test for the sugar and intense sweeteners were conducted as per the method given in IS: 5126 (1969). Stock solutions of sugar and intense sweeteners were prepared for threshold test (Table 1). From the 1 % stock solution of sucrose, a series of dilutions was made representing increasing concentration of sweetness. Initially geometric series was prepared for deciding the concentration for arithmetic series. The arithmetic series ranging from 0.4 to 2 % for sucrose was prepared and evaluated by trained panelists. The series for other sweeteners were Acesulfame K (0.006 to 0.010 %), Aspartame (0.002 to 0.010 %) and Sucralose (0.001 to 0.005 %). These dilutions of sugar and sugar substitutes had different intensity of sweetness. The panelists were asked to taste the series of solutions arranged in increasing order of concentrations and mark '0' if no stimulus is perceived, '?' if the stimulus was perceived to be different from blank but not recognizable and'X' for Threshold value, i.e., the lowest concentration at which the panel could perceive and recognize the sweetness.

Time intensity study (TI)

A group of ten panelists participated in the evaluation. TI test was carried out to identify the samples having higher intensity of lingering sweetness which serves as an indication of the quality of the sweetener. Concentrations of sugar and sugar substitutes were 2.5, 0.014, 0.037 and 0.006 % of Sucrose, Acesulfame K, Aspartame and Sucralose respectively. The test was performed as per the guidelines given by ASTM manual series (1996) with slight modifications. In the present study panelists were trained to mark the scores on a structured quantitative descriptive analysis scale of 15 cm with anchoring at low (1.25 cm) and high (13.75 cm) thresholds of solutions (Sucrose-0.4, Acesulfame K-0.0023, Aspartame-0.006, Sucralose-0.001 g%). The panelists were asked to mark perceived intensity of sweetness on the scale at regular intervals of 10 s, starting from the onset of sweetness perception up to a total period of 60 s. Each panelist was served 10 ml of the sample and asked to mark the intensity of the perceived sensation on the score card as soon as he/she takes the sample into the mouth, this mark the onset of sweetness perception. The panelists were asked to hold the sample in the mouth for 10 s, after which he was asked to swallow it and mark the intensity. Further markings were done after every 10 s up to 60 s. Time

Table 1 Arithmetic series of sucrose and sweeteners for threshold test

Sucrose (1 %) ml	Sucralose (0.25 %) ml	Acesulfame K (0.25 %) ml	Aspartame (1 %) ml
0.4	0.001	0.006	0.002
0.8	0.002	0.007	0.004
1.2	0.003	0.008	0.006
1.6	0.004	0.009	0.008
2.0	0.005	0.010	0.010

intensity profile was obtained by plotting mean scores of sweetness versus time in seconds.

Dose response study

Dose response relationships reveal the equi-sweetness concentrations of sucrose and sweeteners. A group of ten panelists participated in the evaluation and QDA was used as method of scoring. Dose response relationships were drawn for sucrose ranging from 2 to 32 %, Sucralose 0.006–0.96 %, Aspartame 0.008–0.128 % and Acesulfame K 0.0075–0.12 % (Table 2).

Formulation of sugar substitute sprinklers

Based on the results of the threshold tests, sprinkler formulations were prepared. In order to evaluate sugar substitute sprinkler a traditional snack namely *Shankarpoli* was selected.

Sensory profile

A group of ten panelists participated in the evaluation. QDA was selected for sensory analysis as it gives full information of sensory attributes (Stone and Sidel 1998) and was used for profiling of *Shankarpoli*. Panelists were asked to describe the product with descriptors as they found applicable. Following this, an open discussion was held to finalize the descriptors by following guidelines reported earlier (Jellinek 1964). Lexicons used for the study were given with definition in the Table 3. The score card consisted of a 15 cm scale in which 1.25 cm was anchored as low (recognition threshold) and 13.75 cm as high (saturation threshold). Testing was performed in the sensory Booth room built as per ASTM standards (1996).

Consumer acceptance study

For Consumer acceptance study 50 consumers were selected randomly and test was done using seven point hedonic scale ranged from Like very much to Dislike very much with midpoint as Neither like Nor dislike.

Table 2 Instrumental shear force profile of *Shankarpoli* prepared by using different sweeteners

Treatments	Shear force (N)
With sucrose	6.6±0.70[a]
With Acesulfame K	6.7±0.94[a]
With Aspartame	6.1±0.45[a]
With Sucralose	6.3±0.80[a]

Mean scores in a column with different superscripts differ significantly at $p \leq 0.05$ $n=3$

Table 3 Lexicons used in the Quantitative Descriptive Analysis (QDA) of *Shankarpoli*

Lexicon	Description
Buff colour	Buff is a pale yellow-brown colour that got its name from the colour of buff leather.
Puff	Processing the textural property manifested by an expanded and often distorted cellular structure. Sen: touch, sight.
Texture	The attribute of a substance resulting from a combination of physical properties and perceived by the senses of touch (including kinesthesis and mouth feel), sight and hearing. Physical properties may include size, shape, number, nature and conformation of constituent structural elements.
Gritty	Processing the textural property manifested by the presence of small hard particles. Sen: touch, hearing, sight.
Crisp	Processing the textural property manifested by a tendency when subjected to an applied force to yield suddenly with a characteristic sound. Sen: touch, hearing.
Lingering sweetness	Long lasting sweetness in mouth.

Instrumental texture analysis

Shankarpoli sprinkled with Sugar and sugar substitutes were used for analyzing shearing strength using the texture analyzer (model LR5K, LLOYD instruments ltd, UK). Samples used were of 7 cm length and 1 cm thickness. The test was carried out under the following conditions: load cell-50 kg, cross head speed 10 mm/min. The average of three replicates was reported in Newton (N) and results were tabulated in Table 2.

Chemical analysis

Moisture, fat was analyzed for ready *Shankarpoli* according to AOAC (2000) procedures.

Statistical analysis

The data obtained from the tests done were processed by DMRT (Duncan 1955). The mean scores of three replicates were calculated and profilogram was drawn. The data was subjected to Principal Component Analysis (PCA) using Statistica (version–Stasoft, Tulsa, USA)

Result and discussion

Threshold test

Threshold values are spring boards for other data generation and are useful during product development to set sweetness

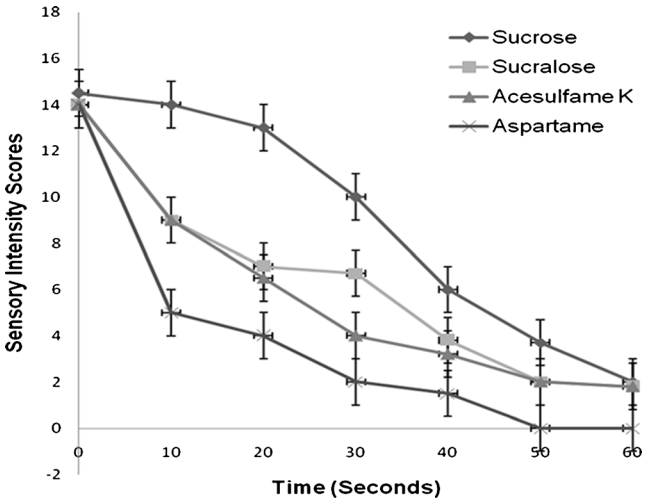

Fig. 1 Variations in sensory intensity profile of different sweeteners with time [n (panelists) =10]

level. Threshold values obtained were 0.4, 0.0023, 0.006, 0.001 g% of sugar, Acesulfame K, Aspartame, Sucralose respectively. Based on the threshold values equi-sweetness between sugar and intense sweeteners could be calculated and the values are 0.4 g, 0.012 g, 0.030 g and 0.005 g of sucrose, Acesulfame K, Aspartame and Sucralose respectively. Maltodextrin which is a bulking agent used in the sprinkler formulation was tested for sweetness. Maltodextrin did not impart sweetness at 20 and 40 % level.

Time intensity (TI) test

Time Intensity study revealed that (Fig. 1), intense sweeteners—Sucralose, Acesulfame K and aspartame had the highest lingering sweetness and this is consistent with the threshold levels also, indicating intense sweeteners have higher intensity of lingering sweetness compared to sucrose. The lingering sweetness intensity for sucrose steadily decreased and after 40 s there was no lingering sweetness for sucrose. Sucralose had slightly higher intensity of 13.1 at 0 s for lingering sweetness and which is reduced to 1.9 after 60 s. Acesulfame K and aspartame fallowed quite similar pattern except that aspartame had a intensity score of 5.8 at 30 s and again decreased to 1.8 after 60 s.

Dose response test for sugar substitute sweeteners

The profile of the selected sweeteners in aqueous solution is quite different from those of sucrose solution. The pattern of sweetness changes with increase in concentrations of different sweeteners, as observed in the dose response study. The artificial sweetener solutions were given with standard sucrose for dose response test based on the result of threshold tests.

Table 4 Dose response of sweeteners

Attributes	Concentration (%)	Sensory attributes*				
		Sweetness	Bitterness	Viscosity	Lingering sweetness	Lingering bitterness
Sucrose	2.0	3.2	0.0	0.5	0.0	0.0
	4.0	4.3	0.0	1.5	0.0	0.0
	8.0	8.0	0.0	4.0	0.0	0.0
	16.0	11.0	0.0	5.0	0.0	0.0
	32.0	14.0	0.0	6.5	5.0	0.0
Sucralose	0.006	0.3	1.0	0.3	0.3	0.0
	0.012	2.4	2.4	0.5	1.5	1.5
	0.024	5.2	4.8	0.5	6.0	3.0
	0.048	7.0	5.9	0.5	8.5	4.0
	0.096	8.3	8.9	0.5	10.0	8.0
Acesulfame K	0.014	0.2	0.0	0.3	0.0	0.0
	0.028	4.3	1.1	0.4	2.0	1.0
	0.056	6.5	3.0	0.4	6.0	3.0
	0.112	10.0	7.0	0.4	9.0	5.0
	0.224	13.0	9.0	0.4	11.0	8.0
Aspartame	0.037	6.5	0.0	0.2	2.0	2.0
	0.074	8.0	4.0	0.3	3.0	3.2
	0.148	10.0	5.0	0.4	5.0	5.1
	0.296	12.0	7.0	0.4	7.5	10.4
	0.592	13.5	8.0	0.4	10.1	12.3

*Average values of duplicates

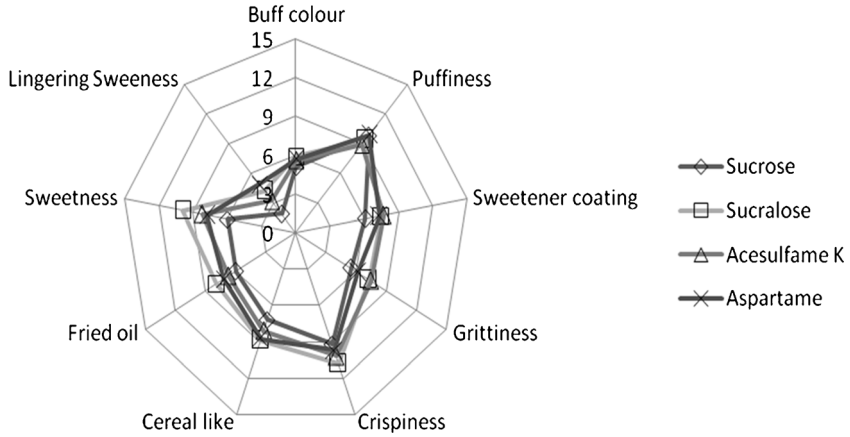

Fig. 2 Sensory profile of *Shankarpoli* prepared by using different sweeteners [n (panelists) =10]

Details of concentration solutions used for dose response test and the findings of the test were given in Table 4. The intensity of Sucralose was slightly higher than sucrose followed by aspartame and Acesulfame K. The lingering sweetness was not observed in sucrose up to 16 %, where as sugar substitutes showed this property at lower concentrations itself and the lingering sweetness increased as the concentration increased.

It is interesting to observe that sucrose even at high concentration of 32 %, did not show any bitterness. As the concentration of sugar substitutes increased the bitterness also increased proportionately. Another aspect of bitterness namely lingering bitterness was not observed in sucrose even at 32 %, where as sugar substitutes showed at 4 % concentration equivalent to sucrose, aspartame registered very high bitterness at high concentration.

Formulation of sugar substitute sprinklers

Based on dose response values, time intensity alternative sweetener sprinkler formulations were formulated. For total weight of 5 g of sugar substitute sprinkler formulation Acesulfame K (0.02 g) and Maltodextrin (4.98 g), Aspartame (0.07 g) and Maltodextrin (4.93 g), Sucralose (0.01 g) and Maltodextrin (4.99 g). This formulation can be used for 50 g of fried snack/per serving.

Evaluation of sugar substitute sprinklers

A traditional sweet namely *Shankarpoli* sprinkled with sugar substitute sprinklers (50 g of pieces was sprinkled with 5 g of sugar substitutes/sugar) then the product was evaluated for attributes, texture and chemical composition (fat and moisture).

Chemical analysis

Moisture and fat estimation of the product was done in duplicates and the result of the analysis showed that the moisture content was 0.025 % and fat content was 18.6 %.

Sensory profile for *Shankarpoli*

Based on the findings of threshold and dose response test, sugar substitute sprinklers were formulated using Maltodextrin

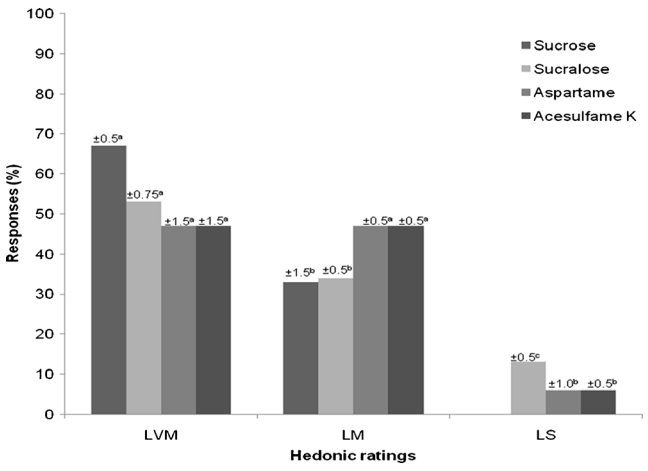

Fig. 3 Consumer acceptance of *Shankarpoli* prepared by using different sweeteners [n (panelists) =10]. *LVM* like very much, *LM* like moderately, *LS* like slightly

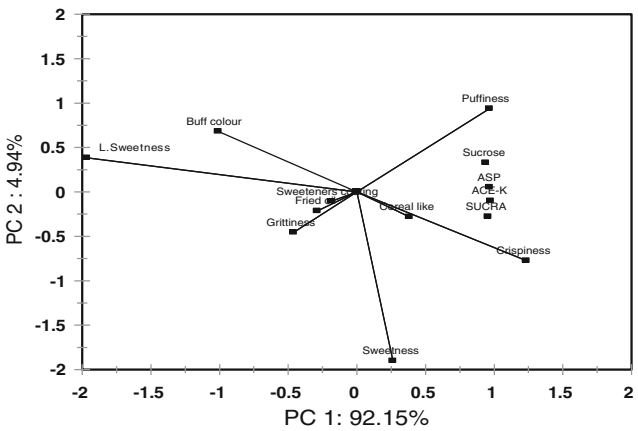

Fig. 4 Principal component analysis (PCA) biplot of *Shankarpoli* with descriptive sensory attributes. *PC* principal component

as bulking agent, the concentration of sugar substitutes for 5 g were Acesulfame K (0.02+4.98 g), Aspartame (0.078+ 4.922 g), Sucralose (0.019+4.98 g). These sprinkler formulations were sprinkled on the product and evaluated for sensory quality attributes. The results of the same were depicted in the Fig. 2.

There was no significant difference in the buff colour, puffiness, sweetener coating, grittiness, crispiness, cereal taste, of the product with all the sweeteners. Sweetness of Acesulfame K and Aspartame were of same intensity, sucrose was less and Sucralose was higher. Lingering sweetness was more in sugar substitutes and less in case of sucrose.

Instrumental texture analysis

The texture analysis of *Shankarpoli* with control (sucrose) and other sugar substitutes were analyzed using texture analyzer. The peak force (N) did not differ between the samples significantly ($p \leq 0.05$).

Consumer acceptance study

A population of 67 % rated "LVM" (Like Very Much) for *Shankarpoli* with Sucrose, 53 % for Sucralose, 47 % for Aspartame and Acesulfame K. Population of 33 % rated "LM" (Like Moderately) for the snack with Sucrose, 34 % for Sucralose, 47 % for Aspartame and Acesulfame K. Another 13 % of the population rated "LS" (Like Slightly) for Sucralose and 6 % for other two intense sweeteners. However since all the samples have fallen on the 'LIKE' category the samples found to have good consumer acceptability (Fig. 3).

Principal component analysis (PCA) analysis

Sensory descriptors along with *Shankarpoli* prepared with four different sweeteners are depicted in Fig. 4. It is clear from the PCA biplot that more than 92 % of the variance explained by PC 1 axis while remaining around 5 % data by the PC2, accounting nearly 97 % of the total variance in the data matrix. Sensory descriptors like lingering sweetness, crispness, sweetness puffiness were the discriminating sensory attributes while all the four samples were closely associated each other indicating their sensory attributes are comparables irrespective of the sweeteners used. The samples were also associated closely with crispness, puffiness and cereal like. Similar PCA analysis was carried out for *Halubai*—an Indian traditional sweet by Asha et al. (2011).

Conclusion

Three intense sweeteners were evaluated for acceptance, lingering sweetness by threshold test, time intensity and dose response test. Based on the results obtained sweetener formulations were developed and incorporated in the fried sweet *Shankarpoli*. By the above results it may be concluded that these sugar substitute sprinklers especially Sucralose and Acesulfame K can be used as a sweetening agent in traditional product. This can also be tried in drinks, beverages as a quick source of sweetening agent or as table top dispensers.

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