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Development of sugar-free Kajukatli: A traditional Indian sweet

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Abstract
Kajukatli is a very popular traditional Indian sweet that contains high amount of 30-45% added sucrose. The presence of high sucrose in Kajukatli creates health complications for diabetic people and this restricts the consumption of the product by diabetic people. To overcome this problem, the present study was conducted to formulate Kajukatli devoid of added sugar but still having excellent sensory characteristics with permitted high-intensity sweeteners and bulking agents. Two high-intensity sweeteners i.e., saccharine and sucralose, and two bulking agents i.e., polydextrose and isomalt were used as replacers of sucrose. The product was prepared with various levels and combinations of selected ingredients. The prepared Kaju Katri samples were served to the expert judges in a double blindfold manner for sensory evaluation of prepared products. The product containing bulking agent polydextrose was less accepted compared to isomalt added as far as taste of product was concerned. Polydextrose was found unsatisfactory binder material to give the product a good texture compared to isomalt. Overall, the isomalt added product was found better texture and taste compared with the polydextrose added product. Among the high-intensity sweeteners used, sucralose was found more suitable due to its taste profile. Saccharine added Kaju Katri has metallic after taste in product. Sucralose at low addition levels was found more suitable and can replace only around 12% sucrose due to dose-dependent response i.e. more you add sucralose less additional sweetness it confers to the product. Finally, acceptable sugar-free Kaju Katri was prepared using isomalt as bulking agent and sucralose as an intense sweetener.

Keywords: sugar-free, sucralose, isomalt, polydextrose, diabetic, kajukatli

Introduction
Kajukatli is a traditional Indian sweet that is prepared using cashew nuts and sucrose. The sweet contains around 35% w/w sugar [1]. The presence of high sugar can create health-related issues for diabetic people and hence, they cannot enjoy this popular traditional sweet product. High sucrose intake is correlated with diabetes mellitus by many studies [2-4] and thus there is a need to reduce sucrose intake. Cashew (*Anacardium occidentale* L.) nuts contain 49% fat, 36% protein, and 5% carbohydrates [5, 6]. Cashew has a low glycemic index and is protective against diabetes [7, 8] and so sugar-free products containing cashew nuts may be welcomed by diabetic people. The present study was performed with aim of making sugar-free Kajukatli with acceptable sensory attributes.

Legal obligations must be fulfilled by any product in the market. Kajukatli being a traditional Indian product enjoys freedom from most of the legal restrictions but there are restrictions on artificial sweeteners and bulking agents. As per Indian law [9], no one can add more than two artificial sweeteners to the product. Limits of maximum addition are also specified by FSSAI. FSSAI permits the addition of bulking agents i.e., Isomalt, Sorbitol, Mannitol, Xylitol, and Polydextrose in sweets, with maximum limit GMP. These legal limits were taken care of for the product developed under this study.

Materials and Methods
Product Making: Sugar-free Kajukatli was prepared by using a standardized method [10]. Good quality cashew nuts i.e., 300 g were soaked in 600 ml water for one hour. After soaking, water was drained completely. Soaked nuts, 30 ml water, and calculated amount of additives i.e. sucrose, bulking agent, and artificial sweeteners were added into the mixing jar and smooth paste was prepared. The paste was transferred to a cooking pan with having thick bottom to avoid charring during cooking. Cooking was done under medium flame with vigorous stirring to avoid sticking and burning of paste. Cooking was stopped when the consistency of the material was such that one can cut it into cubes. Cooking generally took 20 minutes.

Product was sheeted. Silver foil was applied on top of the product and cut into pieces. The freshly prepared products were served to judges. Control Kaju Katri samples were also prepared by using sucrose (35% of dry nut weight) as sweeteners. Market samples were also obtained from a reputed sweet-making company to compare the acceptability of prepared products.

Sweeteners and Bulking Agents: Two intense sweeteners i.e. sucralose and saccharine and two bulking agents i.e., isomalt and polydextrose were used for the study. Intense sweeteners were used to give sweetness equivalent to 35% sugar on the weight of cashew nut basis. To calculate the quantity of intense sweetener first quantity of sucrose required for a given weight of nuts is calculated i.e. 35% of the weight of nuts. Sucralose was considered 600 times sweeter than sucrose and saccharine was considered 500 times sweeter than sucrose to calculate the equivalent quantity of them for 35% sucrose sweetness. Bulking agents were added at 20%, 35%, and 50% levels to accommodate all possible ranges where optimum level may fall (bulking agent addition range was decided by preliminary trials). Bulking isomalt provides 50% of sucrose sweetness and so the quantity of artificial sweetener is reduced accordingly. No sucrose was added to any sample with artificial sweeteners and bulking agents i.e. replacement of sucrose was always 100%.

Sensory: The product acceptability was carried out using an overall acceptability score on 9 points hedonic scale according to the method suggested by Wichchukit & O'Mahony [10]. Eight trained judges were chosen as members of the sensory panel and samples were presented to them in a double blindfold manner. The sensory scores were recorded on the scorecard.

Results and Discussion

In the first phase, prepared samples were judged by the expert sensory panel and scored with 100% marks on appearance, flavor, and texture using the scorecard. Sample's final scores for the first phase were calculated using weighed average of appearance (20% weight), flavor and texture (40% weight each) scores.

Score Card *Replication:___ Trial:___ Judge:___*

Attribute	*Max. Score*	*Obtained Score*
Appearance	*100%*	
Flavor	*100%*	
Texture	*100%*	
Comments:		*Sign of Judge*

Fig 1: Scorecard used for the First phase

The sensory scores of selected treatments of first phase are reported in table 1. The scores reported are averages of scoring by eight judges in two replications. One-way ANOVA is used to compare means.

Table 1: Sensory scores of selected treatments

Tukey's HSD = 8.45. This means if two means differ from each other by more than 8.45 units they are really different		**Mean Score**
Treatments	Market Sample	85.86
	Sucralose + 30% Isomalt	84.20
	Control (35% Sucrose + Cashew nuts)	82.50
	Saccharine + 30% Isomalt	82.31
	Saccharine + 35% Isomalt	76.40
	Saccharine + 20% Isomalt	74.19
	Saccharine + 17.5% Isomalt +17.5% Polydextrose	72.04
	Saccharine + 35% Polydextrose	60.68
	Saccharine + 50% Polydextrose	56.56
	Saccharine + 50% Isomalt	56.33
	Saccharine + 20% Polydextrose	52.23

Application of ANOVA data says that the difference between means is significant. Based on the sensory scores and observations of expert sensory judges, among all the combinations of intense sweeteners and bulking agents used for the treatments, the product with 30% isomalt and sucralose was highly acceptable and was comparable to the market sample of kajukatli. The silents observations during the product preparation and during the sensory evaluation of prepared product were as below:

Saccharine is reported to contribute metallic after taste in several studies [11-13]. The same was observed in products prepared with the addition of saccharine. Sucralose added products were giving acceptable results with a good sweetening profile. Similar results were reported [13-16].

Grinding of soaked nuts along with other ingredients should be homogeneous during product making otherwise product becomes chunky. The paste made by grinding was very viscous with peanut butter-like consistency, but any attempt to add water to make grinding easy decreases viscosity were met with oiling out during cooking. The reason may be ascribed to binding of cashew proteins to water and their resistance to leave moisture needing higher temperate to dry out moisture which results in oiling off.

The cooking of Kajukatli is an art. The Kajukatli should be prepared in a thick bottom vessel as the thin walled vessels lead to product burning. The use of nonstick vessels is best for the product cooking. Cooking at a higher temperature for longer time damages cashew cell structure that leads to expelling oil resulting in an oily product. Cooking should be stopped when the product starts leaving the surface of the vessel. The final consistency of the product develops when temperature of product drops to room temperature. The texture improvement was observed within 24 hours of storage.

The sugar-free Kajukatli was prepared without any bulking agent addition, but this leads to a powdery product due to no or poor binding properties. Sugar is crystalline at room temperature and when a product containing sufficient sugar is cooled, sugar again assumes crystalline structure. Sugar acts as cement especially in high sugar, low moisture sweets [13, 17]. In absence of any binding agent, ground cashew nuts cannot reform hard structures after cooking, leading to powdery

structure. This result implies that for sweets in which sugar acts as a binding agent, sugar replacing bulking agent should be crystal forming, and crystal formation rate should be like sugar. Bulking agent polydextrose is not similar in molecular structure to sucrose and so cannot emulate desired hardness of sweet in the given time as suggested by our experiments. Contrary to this isomalt used in this study has a similar molecular weight as sucrose and seems a more suitable binder and used by several studies to replace sugar [18-20]. Isomalt gives a sweetening profile similar to sugar. Though saccharine is not intended to be used in the final product it is important to note that isomalt can mask the metallic taste of saccharine to some extent which is not observed with polydextrose. In addition to this polydextrose is found to be importing slight bitter after taste to the product in presence or absence of saccharine. The unpleasant taste may be specific to a particular supplier or brand of polydextrose but it was not confirmed by comparing products from various suppliers. The unpleasant taste is also reported in the literature in addition to a process to improve taste of polydextrose. Anyone intending to use polydextrose must use Litesse Ultra type of polydextrose as described by Michael, Helen [21].

Polydextrose has more water-binding capacity [22] and is found to be giving sticky wet product rather than dry crispy product, the latter is desired.

Polydextrose being a long filamentous molecule absorbs and retains a lot of moisture. Similar observations were also reported in studies [23-25]. Due to this retained moisture it was not possible to remove sufficient moisture from product by cooking, making product soft, rubbery and sticky instead of dried and brittle. From the first phase, isomalt was selected as bulking agent and sucralose as an artificial sweetener for further study.

In the second phase of study, two levels of isomalt were tired before goal of parity with market sample in sensory score was achieved. The first combination was 30% isomalt and sucralose. Second combination was 25% isomalt and sucralose. Sucralose was added in high concentration i.e. 750 ppm by weight of nuts in both trials i.e. 25% and 30% trials. For the second phase paired comparison sensory taste was done. Nine points hedonic scale was used for this purpose. The scorecard used for the second round of treatments is given below.

Trial	*Name*								*Signature*
Sample Code	*Like Extremely*	*Like Very Much*	*Like Moderately*	*Like Slightly*	*Neither Like Nor Dislike*	*Dislike Slightly*	*Disike Moderately*	*Dislike Very Much*	*Dislike Extremely*
Sample Code	*Like Extremely*	*Like Very Much*	*Like Moderately*	*Like Slightly*	*Neither Like Nor Dislike*	*Dislike Slightly*	*Disike Moderately*	*Dislike Very Much*	*Dislike Extremely*

Fig 2: Scorecard used in the Second phase Treatments

The observation data of second phase of experiments are reported in table 2. Each result is an average of eight replications.

Table 2: Sensory score for 30% isomalt and sucralose

		1	2	3	4	5	6	7	8	Mean
Treatments	Sugar Free	8.5	7.625	7.125	7.625	7.875	6.875	7.625	8.5	7.72
	Market	7.75	7.875	7.75	8.125	8.25	7.625	8.125	8	7.93

Student's t test was used to compare means of prepared sugar-free product and market samples of kajukatli. The sugarfree product was not significantly different at 5% level of significance compated to the market sample of kajukatli. Developed sugar free kajukatli product was at par with market sample of kajukatli in sensory attributes. But still the score of sugar free product was lower than market sample. Some judges suggested that score can be further improved by reducing hardness. Reduction of hardness was possible but it was clear that too low bulking agent will give an unsatisfactory product. 20% level was already proved unsatisfactory so 25% isomalt with sucralose was chosen. Authors believe that going beyond 5% resolution is not possible because of the human factor involved in product preparation as well as judging. In Table 3, results of 25% isomalt with sucralose as intense sweetener are shown. Mean is the average of six replications.

Table 3: Sensory score for 25% isomalt and sucralose

		1	2	3	4	5	6	Mean
Treatments	Sugar Free	8.125	8.25	7.875	7.875	7.875	8	8.00
	Market	8.375	8.125	7.875	7.875	7.75	7.75	7.96

The statistical data showed that the developed sugar free product was not significantly different than the market sample of kajukatli. This indicates that the developed products was acceptable by the judges.

The other observation during the product preparation is highlighted: The reported potency of sucralose is in the order of 600 times that of sucrose. As high potency sweeteners, this factor varies depending on the level of sucralose being used. The dose-response curve of sucralose showed that after 12% sucrose equivalent concentration, sucralose was unable to provide much sweetness, no matter in what concentration it was added [26]. In the present study, we have added maximum sucralose permitted by Indian law to increase sweetness. Sweetness providing bulking agents should be preferred over non-sweet bulking agents like polydextrose to replace a high amount of sugar.

Conclusion

The sugar-free Kajukatli with highly acceptable sensory properties can be prepared using 25% isomalt as a bulking agent and 700 ppm sucralose as an artificial sweetener. The developed sugar free kajukatli product was at par with the market sample of kajukatli.

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