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ORGANOLEPTIC ACCEPTABILITY AND GLYCAEMIC RESPONSE OF BISCUITS PREPARED USING STEVIA REBAUDIANA

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Stevia (*Stevia rebaudiana*) is fast becoming a major source of high potency sweetener which produces sweet taste but has no calorific value. Considering its sweetness potential, nutritional and health benefits, the present study was undertaken to develop biscuits by incorporating Stevia powder, artificial sweetener (sucralose) and sugar. Stevia based products were organoleptically evaluated in comparison to sucralose and sugar based products. The developed biscuits were also studied for their glycaemic response in normal (n = 10), obese (n = 10) and diabetic (n = 10) subjects. Mean scores of colour (7.70), appearance (7.80), aroma (7.40), texture (7.30) and taste (7.40) of Stevia powder incorporated biscuits were found at par as sucralose and sugar based biscuits. Overall acceptability scores of all the three types of biscuits were found in the category of 'liked moderately'. Glycaemic response of all the three types of biscuits was assessed in normal, obese and diabetic subjects. Stevia powder and sucralose based biscuits had significantly low glycemic index in normal, obese and diabetic subjects whereas sugar based biscuits had significantly high glycemic index especially in diabetic subjects. Hence, incorporation of Stevia powder as a sweetener in baked recipes instead of sucralose and sugar is a best alternative for obese and diabetic patients.

Keywords: *Stevia* powder, Sucralose, Biscuits, Organoleptic acceptability, Glycaemic response

INTRODUCTION

Stevia (*Stevia rebaudiana*) is a perennial herb that belongs to the Asteracae family. It is widely used in many parts of the world as sweetener and grown commercially in Central America, Korea, Paraguay, Brazil, Thailand and China (Gupta *et al.*, 2014). In India cultivation of *Stevia* as a crop is still restricted to the research level. However, Department of Ayurveda, Yoga and Naturopathy, Unani, Sidha and Homeopathy (AYUSH), (Government of India) has sanctioned proposals for the prospects of *S. rebaudiana* cultivation of various states like West Bengal, Uttranchal, Haryana and Punjab. The leaves of *Stevia* contain a natural complex mixture of eight sweet diterpene glycosides including isosteviol, stevioside, rebaudioside (A, B, C, D, E, F), steviolbioside and dulcoside A. Out of various steviol glycosides, stevioside and rebaudioside A are the major metabolites and these compounds are 250 to 300 times as sweet as sucrose, pH-stable, heat stable, not fermentable and posses healthy promoting potential. Along with sweetness, *Stevia* has some bitter affect due to the presence of some essential oils, tannins and flavonoids (Abdullateef and Osman, 2012). *Stevia* leaves have sensory and functional properties superior to those of many other high-potency sweeteners and is likely to become a major source of natural sweetener for the growing food market. *Stevia* leaves have many medical applications like anti-microbial, anti-viral, anti-fungal, anti-hypertensive, anti-hyperglycaemic, anti-inflammatory, etc. The toxicological studies have shown that secondary metabolites present in *Stevia* does not have teratogenic, mutagenic or carcinogenic effects and no

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allergic reactions have been observed after consuming it as sweetener. The major compounds of *Stevia* as steviol glycosides are metabolized and dominated through similar pathways in both human and animals (Chatsudthipong and Muanprasat, 2009).

There is an alarming increase in the incidence of diabetes in India and with world's largest population being noted, India is labeled as 'Diabetic capital of world'. According to International Diabetes Federations, diabetes currently affects 382 million people worldwide and India has the second largest number of people with diabetes (IDF, 2013; and Gupta *et al.*, 2014). Therefore, substituting sugar with low calorie sweeteners may be efficacious in reducing the weight and its related health problems. So sugar substitutes like saccharin, sucralose and aspartame gained importance in reducing calorie intake. However, these are artificial sweeteners can cause more health problems than they cure (Balaswamy *et al.*, 2014). Globally, scientists have concluded that *Stevia* sweeteners are safe for people of all ages. *Stevia* leaf or extracted forms like stevioside, rebaudioside A and steviol glycosides was approved by US FDA as a dietary supplement considered (Generally recognized as safe). Currently, the joint FAO/WHO Expert Committee on Food Additives reviewed the safety of steviol glycosides and an Acceptable Daily Intake (ADI) for steviol glycosides (expressed as steviol equivalents) of 4 mg/kg body weight/ day was recommended (European Food Safety Authority, 2010).

Keeping in mind the sweetening property and other medicinal uses of *Stevia rebaudiana*, in the present study, an attempt was made to explore the use of *Stevia rebaudiana* as a sweetener in comparison with artificial sweetener sucralose, so that the diabetic and calorie conscious people can add variety to the diet and relish the food.

MATERIALS AND METHODS

The raw ingredients were procured from local market of Hisar city and *Stevia* powder was procured from IARI, Pusa, New Delhi.

Development and Organoleptic Acceptability of Biscuits

Three types of biscuits were developed by incorporating *Stevia* powder (60 mg), sucralose (30 mg) and sugar (60 g). Sugar based biscuits were served as control. Organoleptic acceptability of biscuits was assessed in terms of colour, appearance, flavour, texture, taste and overall acceptability using a nine point Hedonic Rating Scale.

Glycaemic Response of Biscuits

Selection of Subjects

Glycaemic response of *Stevia* powder, sucralose and sugar based biscuits was assessed in normal (n = 10), obese (n = 10) and diabetic (n = 10) adult subjects in the age group of 35 to 55 yrs. The subjects in each category were selected randomly. None of the subjects were under medication. All the subjects were also informed beforehand about the experiment and their voluntary consents were taken before conducting the experiment.

Meal Tolerance Test

For assessing the glycaemic response of biscuits, the reference food (glucose), control food (sugar) and test foods, i.e., sucralose and Stevia incorporated baked products were fed to each subject. Assessment of glycaemic response was done by Finger prick method by taking the drop of blood on glucose test strip was checked through Glucometer. On first day, fasting blood glucose level was measured. After that, 50 g available carbohydrates in the form of glucose (reference food) dissolved in 250 ml water was given to the subjects. The blood samples were drawn and checked after 30, 60, 90 and 120 min for the postprandial glucose level. On subsequent days, measured portions of the control and test foods containing 50 g available carbohydrate were fed to each subject. The blood samples were drawn and checked after 30, 60, 90 and 120 min for the postprandial glucose level. These blood samples were used to construct a blood glucose response curve for the 2 hr period.

Glycaemic Index of Biscuits

The glycaemic index is a ranking of foods based on the postprandial blood glucose response compared with a reference food. The glycaemic index was calculated by dividing the incremental area under curve for the test food by the incremental area under curve for the reference food and multiplied by 100 (Jenkins *et al.*, 1981). Formula for calculating area under curve is given below:

$$Glycaemic\ index = \frac{Area\ under\ glucose\ curve\ of\ test\ meal}{Area\ under\ glucose\ curve\ of\ reference\ meal} \times 100$$

Statistical Analysis

The data were subjected to statistical analysis for analysis of variance in a complete randomized design using standard methods of Sheoran and Pannu (1999).

RESULTS AND DISCUSSION

Mean score of colour, appearance, aroma, texture, taste and overall acceptability of biscuits prepared using sugar (control), sucralose and *Stevia* powder are presented in Table 1.

Stevia powder incorporated biscuits had mean scores of colour 7.70, appearance 7.90, aroma 7.40, texture 7.40 and taste 7.57. All the scores were found in the category of 'liked moderately' and at par with the scores obtained by sugar based biscuits and sucralose based biscuits. However, mean scores of overall acceptability of three types of biscuits were in the range of 7.14 to 7.85, which differed non-significantly. The results of present study are similar with the results of Salem *et al.* (2009) and Serna *et al.* (2014) who formulated bun, biscuits and cake by 100 per cent replacement of sugar with *Stevia* powder and found good organoleptic characteristics of the products.

Glycaemic Response of Biscuits

Data in respect to area under blood glucose response curve to all the three types of biscuits in normal, obese and diabetic subjects in comparison to glucose load of 50 g are presented in Tables 2 to 4.

Table 1: Mean Scores of Organoleptic Characteristics of Biscuits

Types of Biscuits	Colour	Appearance	Aroma	Texture	Taste	Overall Acceptability
Sugar based biscuits (Control)	7.70±0.15	7.80±0.13	7.70±0.15	7.90±0.15	7.98±0.13	7.85±0.09
Sucralose based biscuits	7.30±0.09	7.20±0.14	7.10±0.20	7.20±0.18	7.10±0.11	7.14±0.13
Stevia powder based biscuits	7.70±0.11	7.90±0.12	7.40±0.18	7.40±0.11	7.50±0.15	7.57±0.17
CD (P<0.05)	NS	NS	NS	NS	NS	NS

Note: Values are mean ± SE of ten independent observations, NS = Non-significant, Sucralose based biscuits containing 30 mg sucralose, Stevia powder based biscuits containing 60 mg Stevia powder, Sugar based biscuits containing 60 g sugar which served as control.

Table 2: Area Under Blood Glucose Response Curve (mg/dl) of Biscuits Prepared Using Sugar, Sucralose and *Stevia* Powder in Normal Subjects

S. No.	Glucose (Reference)	Sugar Bbased Biscuits (Control)	GI	Sucralose Based Biscuits	GI	*Stevia* Powder Based Biscuits	GI
1	5468	3793	69.36	2893	52.9	2839	51.62
2	6495	3618	55.71	2766	44.64	2711	43.7
3	6435	4120	64.04	3514	54.61	2848	44.25
4	4995	3645	72.97	2923	58.53	2719	54.43
5	4950	2818	56.94	2669	53.91	2624	53
6	5328	3586	67.3	3179	59.68	2587	48.55
7	5762	4067	70.58	2845	49.69	2913	50.55
8	6349	4577	72.09	3220	50.71	3193	50.37
9	6426	4312	67.1	3163	49.22	2984	46.43
10	5892	3171	53.83	3204	54.37	3886	48.98
Mean	5810	3775	64.99	3100	53.37	2857	49.19

Table 3: Area Under Blood Glucose Response Curve (mg/dl) of Biscuits Prepared Using Sugar, Sucralose and *Stevia* Powder in Obese Subjects

S.No.	Glucose (Reference)	Sugar Based Biscuits (Control)	GI	Sucralose Based Biscuits	GI	*Stevia* Powder Based Biscuits	GI
1	6160	4215	68.42	4018	65.23	3196	51.88
2	4325	2510	58.04	2462	56.92	2457	56.8
3	5942	4163	80.06	2781	46.8	2728	45.91
4	4961	3571	71.98	2576	51.92	2532	57.03
5	5431	3312	60.49	3142	57.82	3119	57.42
6	5679	4091	72.03	3421	60.25	2826	42.76
7	6468	3585	75.43	3759	68.13	3219	49.76
8	6851	3879	66.23	3591	52.41	3525	51.45
9	6743	4859	72.05	3308	49.05	3291	48.8
10	7254	4609	63.35	4400	60.66	3647	50.27
Mean	5981	4072	68.09	3354	56.09	3068	51.31

Table 4: Area Under Blood Glucose Response Curve (mg/dl) of Biscuits Prepared Using Sugar, Sucralose and *Stevia* Powder in Diabetic Subjects

S.No.	Glucose (Reference)	Sugar Based Biscuits (Control)	GI	Sucralose Based Biscuits	GI	*Stevia* Powder Based Biscuits	GI
1	6243	5481	87.81	3320	53.17	3047	48.82
2	6972	5248	75.27	3113	44.66	2938	42.15
3	7195	5042	70.09	4468	62.46	4207	58.48
4	7324	5489	74.95	3942	53.82	3870	52.85
5	6498	5117	78.76	3796	58.41	3734	57.46
6	7742	6918	89.36	40986	52.97	3852	49.7
7	6721	5443	80.98	3308	49.63	3280	48.81
8	6963	4811	69.1	4163	59.78	4166	59.54
9	7542	6012	79.71	4728	62.68	4668	61.9
10	7926	6246	78.8	4271	53.88	3995	50.61
Mean	7112.6	5604	78.8	3974	55.88	3798	53.41

Glycaemic Index of Biscuits in Normal Subjects

Mean area under blood glucose curve for glucose was found to 5810 mg/dl followed by control 3775 mg/dl, sucralose based biscuits 3100 mg/dl and *Stevia* powder based biscuits exhibited lowest area under blood glucose curve, i.e., 2857 mg/dl. The area under curve ranged between 2587 to 3886 mg min /100 ml, 2669 to 3514 mg/dl and 2818 to 4577 mg/dl

Table 5: Glycaemic Index of Biscuits in Normal, Obese and Diabetic Subjects

Biscuits	Normal	Obese	Diabetics	CD (P<0.5)
Sugar based biscuits	64.99±1.06	68.09±1.11	78.80±0.89	2.97
Sucralose based biscuits	53.37±1.16	56.09±1.11	55.88±3.18	1.96
Stevia powder based biscuits	49.19±1.12	51.31±1.10	53.41±1.11	3.22
CD (P<0.05)	3.24	3.21	3.83	

Note: Values are mean ± S.E of ten independent determinations, Low GI = 0-55, Medium GI = 56-69, High GI = 70 or above.

for *Stevia* powder based, sucralose based and control biscuits in normal subjects (Table 2).

Glycaemic Index of Biscuits in Obese Subjects

Area under blood glucose response curve in obese subjects ranged between 2510 to 4859, 2462 to 4400 and 2457 to 3647 mg/dl for control, sucralose and *Stevia* powder based biscuits, respectively. The mean values of glycaemic index of control, sucralose and *Stevia* powder based biscuits were observed as 68.09, 56.09 and 51.31, respectively. The glycaemic index of sucralose and *Stevia* powder based biscuits had lower glycaemic index in comparison to control in obese subjects (Table 3).

Glycaemic Index of Biscuits in Diabetic Subjects

The mean area under blood glucose response curve for glucose was 7112.6 mg/dl followed by control biscuits (5604 mg/dl) sucralose based biscuits (3974 mg/dl) and *Stevia* powder based biscuits (3798 mg/dl). The mean values of glycaemic index of control, sucralose and *Stevia* powder based biscuits were found to be 78.80, 55.88 and 53.41 respectively. The glycaemic index value of *Stevia* powder based biscuits was found to be lower than the control and sucralose based biscuits in diabetic subjects. Whereas sucralose based biscuits exhibited higher glycaemic index than *Stevia* powder based biscuits but exhibited lower glycaemic index than control biscuits in diabetic subjects (Table 4).

GI Values of Biscuits in Normal, Obese and Diabetic Subjects

A comparative data regarding glycaemic index of biscuits prepared using sugar (control), sucralose and *Stevia* powder in normal, obese and diabetic subjects are presented in Table 5.

Glycaemic index of biscuits prepared using sugar (control), sucralose and *Stevia* powder in normal subjects were found to be 64.99, 53.37 and 49.19, respectively. Biscuits prepared using sugar and sucralose was found to have a medium GI in normal and obese subjects. However, biscuits prepared using sugar had high GI in diabetic subjects. However, biscuits prepared using sucralose exhibited a medium GI whereas biscuits prepared using *Stevia* powder exhibited low GI. This might be due to the fact that *Stevia* powder contains stevioside and is not absorbed in body by the intestinal tracts. The steviol is excreted in the faeces by the billary way. It was also demonstrated that the steviol remains unabsorbed in the body results in no increase in the blood glucose level (Atteh *et al.*, 2011; and Ali *et al.*, 2013).

These results are in agreement with those reported by Savita *et al*. (2004). They also reported low glycaemic response of sweet buns incorporated *Stevia* powder. Glycaemic index of *Stevia* based buns found to be low category in diabetic subjects. Other workers also reported hypoglycaemic response of *Stevia* based cakes, *chapatti*, *mathi* and *chikki* in obese and diabetic subjects (Parimalavalli and Radhaisri, 2011; and Alizadeh *et al.*, 2014).

CONCLUSION

It may be concluded from the present study that Stevia based bakery products were found equally acceptable in terms of organoleptic characteristics as compared to sugar based products and sucralose based products and had significantly low glycaemic index as compared to sugar based products. Hence, there is need for creating awareness among the people about the nutritional and therapeutic values of natural (herbal) low calorie sweetener (*Stevia*) incorporated food products for those who are suffering from obesity and diabetes.

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