

Effect of Sugar Substitution by Stevia Extract on Sensory Acceptance, Color, and Texture Profiles of Brownie

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Abstract:

Currently, consumers pay more attention to health and consumption more healthy foods. Substitution of sugar with natural sweetening agents in sweet products is another interesting option. This research purposed to study the application of stevia extracts to replace sugar in brownies. Stevia leaves were extracted with water at 55°C for 6 h prior to drying using a spray dryer to obtain stevia extract powder. The sugar was replaced by the stevia extract powder with the degree of substitution of 0.125, 0.25, 0.375, and 0.50%. The sensory evaluation of brownies was evaluated by 50 panelists using 9 points hedonic scale. The results indicated that the brownies contained 23.07% of sugar and 0.125% stevia extract powder received the highest liking score which is comparable to those of control brownie sample. For the study on the effect of the addition of stevia extract powder on the color of brownie, it was observed that the brightness value of brownie was affected by the stevia extract added, the more level of the stevia extract powder added, the lower the brightness obtained. For the texture characteristics of the brownie, it was found that the addition of stevia powder significant effect all texture profiles of brownies. Therefore, the application of stevia extract powder to replace sugar is possible. However, further studies on the effect of replacing sugar by stevia extract powder on texture characteristics and nutritional value are needed.

Keywords: Brownies, Stevia, Stevioside, Low sugar, Sugar replacement

Introduction

Excessive sugar intake may negatively affect health, including obesity, diabetes, and high blood sugar. Therefore, varieties of sweeteners have been produced to replace sugar including synthetic artificial and natural sweeteners which are low calories. However, some synthetic sweeteners such as saccharin and aspartame are restricted to be used in food because they may cause adverse effect to humans [1]. Stevioside is a natural sweetener with no calorie obtained from stevia leaves (*Stevia rebaudiana* Bertoni). It is sweeter than sucrose approximately 300 times [2]. The sweetness of glycoside found in stevia relative to sucrose is indicated in Table 1. Since stevioside does not provide calories, makes it interesting in substituting for sugar. Purified stevioside is white, colorless, and odorless. Major active sweetener compounds extracted from stevia leaves are stevioside and rebaudioside A, which accounts for over 90% w/w of all sweeteners in the stevia [3]. The chemical structures of stevioside and rebaudioside A are presented in Fig. 1. Of all sweeteners in the stevia leaves, rebaudioside A gives a good taste without bitter taste [4]. Brownies are one of the most popular sweet bakery products, rich in sugar and chocolate provides a distinctive flavor. Brownies have a semi-cookie texture, consisting of flour, butter, chocolate, sugar [5]. As brownies contain very high sugar and chocolate content in one serving resulting in a sweet and bitter flavor which is associated with the taste of stevia extract that is very sweet and has a bitter after taste in the mouth. Therefore, this research was conducted to find out the suitable amount of stevia extract to replace sugar in brownies and to determine the effect of sugar substitution by stevia extract on texture profile and color of brownies.

Materials and methods

The extraction of stevia and stevia extract powder preparation

Stevia (*Stevia rebaudiana*) (dried leaves) with moisture content approximately 10% was purchased from Chiangmai province, Thailand. The stevia leaves were cleaned and extracted with distilled water (ratio of 100 grams per 550 ml) at 80°C for 6 hours. The extract was filtered using cloth cheese and 0.45 micron filter paper. After that, the filtrate was added with 2% maltodextrin prior to drying using a spray drier. The operation conditions were hot air temperature at 160°C, the flow rate of 12sec/ml. The stevia extract powder was obtained and kept in zip-lock plastic bags and storage at the temperature of 4°C.

Table 1 Comparison of the sweet glycosides presented in *S. rebaudiana*

Glycoside name	Content (%)	Sweetness relative to sucrose	Molecular mass (g/mol)	References
Stevioside	5.0-10.0	250-300	804.87	Bridel and Lavieille, 1931[7]
RebaudiosideA	2.0-4.0	350-450	967.01	Wood et al. 1955[8]
RebaudiosideB	<<1	300-350	804.87	Bride land Lavieille,1931[7]
RebaudiosideC	1.0-2.0	50-120	951.01	Sakamoto et al. 1977[9]
RebaudiosideD	<<1.0	200-300	1129.15	Sakamoto et al. 1977[9]
RebaudiosideE	<<1.0	250-300	967.01	Sakamoto et al. 1977[9]
Steviolbioside	<<1.0	Nd	936.99	Sakamoto et al. 1977[9]
Dulcoside A	<<1.0	100-125	642.73	Kohda et al. 1976[10]
	0.4-0.7	50-120	788.87	Wood et al. 1955[8]

Nd=not detected

Source: Geuns 2003 [6]

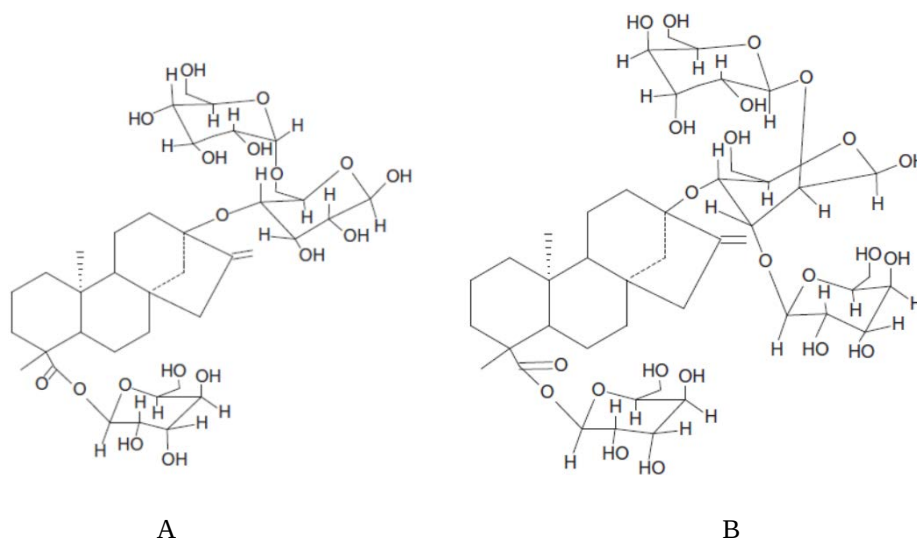


Figure 1 Chemical structure of Stevioside (A) and Rebaudioside A (B) [11]

Experimental design for substitution of stevia extract powder for sugar

A mixture design was applied to investigate the suitable degree of sugar substitution with stevia extract powder. The program Design-Expert Version 7.0 was used to generate the formula of brownies. The amount of sugar used was varied from 0 to 30.76% and stevia extract powder was between 0.2 to 0.5% of the total amount of raw materials [12]. Five formulas of brownies were obtained, namely (1) control formula, (2)

sugar 23.07% and stevia extract powder 0.125%, (3) sugar 15.38% and stevia extract powder 0.25%, (4) sugar 7.69% and stevia extract powder 0.375%, (5) sugar 0% and stevia extract powder 0.50%.

Brownie preparation

Brownies were prepared using the method of Selvakumaran (2017) [13] with some modifications. The ingredients included 75 g of wheat flour, 60 g of cocoa powder, 150 g of unsalted butter, 150 g of chocolate chips, 50 g of eggs, 108 g of sugar, 200 g of baking powder 1.5 g of vanilla, 4 g of salt, and 1.5 g of salt. The chocolate chip and unsalted butter were melt and mixed well, then sugar was added and blended with a high-speed electric mixer until homogeneous with eggs. All-purpose wheat flour was sifted together with baking powder. Then all ingredients and liquid portion were mixed homogeneously. The mixture was baked in an oven at 180°C for 20 minutes. After taken out, the brownies were cooled down to room temperature for 1 hour and the kept in polyethylene bags stored at 4°C for sensory evaluation using the Hedonic 9 scale method.

Sensory evaluation of brownies

The tested samples of 1x1x1 inch brownie (room temperature) were served to 50 test panelists for sensory evaluation using the hedonic test 9 point scale. The evaluation attributes included appearance, color, smell, sweetness, bitter after-taste, overall preference.

Color measurement of brownies

Brownie samples were determined for color according to Guajardo Flores [14], using colorimeter (Minolta: Model CR-300). The measuring head was placed in the center of each brownie. Colour values were measured using CIE (Commission Internationale d' Eclairage) $L^*a^*b^*$ scale in triplicate and means were recorded as L^* = lightness (0 = black, 100 = white), a^* (-a = greenness, +a = redness) and b^* (-b = blueness, +b = yellowness).

Texture profile analysis

Texture Profile Analysis was used as a method to evaluate the texture of brownies by following the method used by Guajardo Flores [14]. Brownies were cooled and analyzed after 24 h of baking. Measurements were made using a piece of brownie (3x3x3 cm) for two-cycle compression. The probe used was 50 mm compression plate (P/50) and the settings used for this analysis were strain 50% at a distance of 10 mm with a force of 5.0g. The texture parameters obtained included hardness, adhesiveness, springiness, cohesiveness, gumminess, and chewiness. The texture parameters of each brownie were averaged from 3 replicates.

Results and Discussion

Sensory evaluation of brownies

Sensory evaluation results obtained from 50 panelists were shown in Table 2. The appearance scores ranged from 4.76 to 7.20. The significant highest score was observed in control sample, followed by brownies added with 0.125 and 0.25% of stevia powder and the lowest appearance scores were found with brownies added with 0.375 and 0.5% of stevia powder. The color scores of the sample varied between 5.02 and 7.13. The higher level of stevia powder added, the lower the color score obtained; however, the color score of brownies added with 0.125% of stevia powder was not significant difference from the control sample. The odor scores of the samples ranged from 5.20 to 6.90. The odor of the control sample was not significantly different from the sample added with 0.125% of stevia powder. The sweetness scores were between 5.20 and 7.22. The sweetness of control and brownie mixed with 0.125% of stevia powder had no significant difference in sweetness. The aftertaste scores varied from 3.07 to 6.20 which there was no significant difference between the control and the sample added with 0.125% of stevia powder. The overall liking score of the sample ranged between 3.310 and 7.60 which the liking score of each sample was significantly different from each other. These results were comparable with the study of Saniah's and Samsiah [15] who reported that stevia extract could partially replace sucrose in carbonate drinks, with the highest acceptance of 33.13% sucrose with 0.43% stevia extract. This was also similar to the study of Lenc et

al. [16] who found that consumers revealed the highest acceptance in yogurt samples with a mixture of sweeteners between sugar and stevia extract.

Color determination

The color value of brownies obtained from the CIE (Commission Internationale d'Eclairage) color measurement included brightness (L^*), red (a^*) and yellow (b^*). The results were presented in Table 3. The brownies had L^* values between 19.420 and 27.110. The control sample revealed highest of L^* , a^* , and b^* values. The more the stevia powder added, the lower the values of lightness, a^* , and b^* values. When the amount of stevia extract powder added increased, the brightness of the brownies decreased, this may due to the chlorophyll and porphyrin color of stevia leaves which in accordance with the research of Salazar et al. [17].

Table 2 Sensory evaluation of brownies

Sweeteners (%)		Appearance	Color	Odor	Sweetness	Bitter after-taste	Overall
Sucrose	Stevia						
30.67	-	7.20±1.10 ^a	7.13±1.14 ^a	6.90±1.40 ^a	7.22±1.35 ^a	6.20±1.55 ^a	7.60±0.84 ^a
23.07	0.125	6.42±1.51 ^b	6.78±1.11 ^a	6.27±1.62 ^{bc}	6.80±1.42 ^a	5.89±1.71 ^a	7.02±1.06 ^b
15.38	0.25	6.09±1.69 ^b	5.98±1.60 ^b	6.51±1.06 ^{ab}	5.40±1.96 ^b	4.93±1.72 ^b	6.02±1.22 ^c
7.69	0.375	5.47±1.46 ^c	5.33±1.54 ^c	5.76±1.49 ^c	4.51±1.86 ^c	4.53±1.71 ^b	5.07±1.60 ^d
-	0.50	4.76±1.49 ^d	5.02±1.62 ^c	5.20±1.82 ^d	5.20±1.82 ^b	3.07±1.50 ^c	3.31±1.50 ^e

The results are shown in mean ± sd ($P < 0.05$)

Table 3 effect of stevia on the color of brownies

Sweeteners		L^*	a^*	b^*
Sucrose (%)	Stevia extract (%)			
30.67	-	27.110±1.060 ^a	3.240±0.180 ^a	5.800±0.190 ^a
23.07	0.125	24.430±0.730 ^b	2.460±0.180 ^b	4.960±0.290 ^b
15.38	0.25	21.590±1.340 ^c	-0.250±0.140 ^c	2.120±0.090 ^d
7.69	0.375	21.110±0.710 ^c	0.130±0.020 ^d	2.210±0.030 ^d
-	0.50	19.420±0.470 ^d	1.370±0.180 ^c	3.060±0.880 ^c

The results are presented in mean ± sd ($P < 0.05$)

Texture profile analysis

Texture characteristics of brownies using a texture profile analysis (TPA) as shown in Table 4. Hardness values of brownies were between 22.54 and 147.31 N. Brownies added with stevia alone were significantly different in hardness from those added with some sugar, however, it was not significantly different from the control sample. Moreover, reducing sugar and increasing the proportion of sweetener from stevia leaf extract increased the adhesiveness value of the brownie (-0.05 to -0.46 N/s). When the proportion of sweetener from stevia leaf extract was increased and the sugar added was reduced, the brownies adhered to the teeth was less. The sample's springiness values ranged between 4.35 and 7.80. The brownie with the addition of sugar only has the highest springiness value (7.80) whereas the brownies with stevia extract alone had the springiness value of 4.35. The brownies that less springiness, the more hardness. The cohesiveness value of the sample ranged between 0.22 and 0.42. The cohesiveness of the brownies varied from 0.22 to 0.42. Brownies with only sugar addition had the least cohesive value (0.22). When the sugar content was reduced and the addition of stevia leaf extract powder was increased, the cohesiveness of brownies increased. The gumminess of the brownies was between 0.22 and 60.70. The brownies that add

sweeteners from the stevia extract powder alone had highest gumminess (60.70), while the brownies that add sugar alone was lowest gumminess. Lowest Chewiness values of brownies are between 38.17-263.47. Brownies added with stevia extract alone revealed the highest chewiness value (263.47) while the chewiness values of brownies with sugar of 23.07:0.125% stevia extract and sugar 30% were not significantly different ($p < 0.05$).

Table 4 Texture analysis profiles of brownies

Sweeteners		Texture profiles					
Sucrose %	Stevia %	Hardness (N)	Adhesiveness (N/s.)	Springiness	Cohesiveness	Gumminess	Chewiness
30.67	0	22.54±1.72 ^b	-0.05±0.02 ^a	7.80±0.39 ^a	0.22±0.01 ^c	0.22±0.01 ^c	38.17±2.64 ^b
23.07	0.125	35.36±17.81 ^b	-0.33±0.17 ^{bc}	7.08±1.29 ^{ab}	0.35±0.07 ^{ab}	0.35±0.07 ^{ab}	79.46±20.08 ^b
15.38	0.25	23.38±5.24 ^b	-0.10±0.35 ^a	6.40±0.46 ^b	0.36±0.02 ^{ab}	8.46±1.39 ^{bc}	54.15±8.45 ^b
7.69	0.375	79.95±16.16 ^b	-0.24±0.04 ^b	6.55±0.17 ^b	0.34±0.00 ^b	27.74±5.90 ^b	182.37±42.98 ^a
0	0.50	147.31±70.48 ^a	-0.46±0.12 ^c	4.35±0.23 ^c	0.42±0.03 ^a	60.70±25.00 ^a	263.47±10.37 ^a

Values within a column represent mean ± standard deviation of replicate experiments (n = 3) with different letters indicating a significant difference ($P < 0.05$)

Conclusions

Based on the results of sensory evaluation, color values, and texture profiles, brownies which were replaced sugar by stevia extract powder of 0.125% was the suitable substitution degree. When increasing the amount of stevia extract powder, it significantly affected the sensory evaluation, color values, and texture profile of the brownies. Therefore, this research showed that the amount of sugar could be reduced from normal formulas by replacing by stevia extract powder.

Acknowledgements

This research has been funded by Mahasarakham University and the company Kidtueng bakery Co., Ltd.

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