Utilization of Stevia Leaves Powder or Stevia Leaves Aqueous Extract as a Substitute for Sugar to Produce Low Calorie Cake

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ABSTRACT:

The aim of this paper was to study the possibility of using stevia leaves powder and stevia leaves aqueous extract as sugar replacer for producing low calorie cake. Sugar was reduced with the following levels; 10, 20 and 30% and substituted by its equivalent in sweetness from stevia leaves powder or reduced with the following levels 25, 50 and 75 % and substituted by its equivalent in sweetness stevia leaves aqueous extract. The results showed that stevia leaves powder contains %.11.01% protein, 12.37% ash, 15.19% crude fiber, 1845.19 mg calcium, 63.59 mg iron, 4.99 mg zinc and 85.25 mg sodium. Stevia leaves contain also(on dry weight basis) 11.23% stevioside and 6.732% rebaudioside. The average weight of cake produced (g) was gradually increased as the replacement level of sugar with stevia leaves powder or stevia leaves aqueous extract increased when compared to control sample. In contrary, the height and specific volume of cake decreased as the substitution level increased. The sensory evaluation showed that there were no significant differences ($p>0.05$) in all parameters between sample prepared with 25% stevia leaves aqueous extract and control sample. Also cake samples formulated with replacing 20% of sugar with stevia leaves powder or formulated with replacing 50% of sugar with stevia leaves aqueous extract had good organoleptic properties.

Keywords: Cake; low calorie; Natural sweeteners; *Stevia rebaudiana*;Stevioside.

INTRODUCTION

Today, consumers are more cautious about low calorie foods and beverages. Cakes are well accepted all over the world due to their appropriate organoleptic properties (Quatromoni *et al*., 2002). Cakes are tasty baked products that are consumed by people from all over the world. they have various definitions and formulations (Wilderjans *et al*., 2013). Cake is basically a semi-dry foam due to the setting of a liquid medium extended by gas delivered from dissolved chemicals. Cakes usually formulated with relatively high levels of sucrose (Hesso *et al*., 2015). In addition to the sweetening power of sucrose, it acts as a tenderizer and stabilizer by increasing the egg protein denaturation and starch gelatinization temperature (Baeva *et al*., 2003). Also, sucrose helps incorporating air cells into the batter during creaming and contributes good structure, flavor, and texture to the product (Manisha *et al*., 2012). However, high levels of sucrose in cake are associated with health problems such as obesity created as the result of over-consumption (Chung *et al*., 2009). So, global trends in food processing have encouraged producers to use low/noncaloric sweeteners, to a wide extent as a replacer of sugar (Kobus and Gramza., 2015). to avoid the debilitating diseases associated with excessive sugar consumption (Malik *et al*., 2006). Nowadays, the most common high intensity sweeteners in the world market are made of synthetic compounds and exhibit metallic aftertaste which does not provide the realistic taste of sugar as well as some types of synthetic sweeteners such as saccharin that is associated with the potential risk of cancer of bladder when they are used heavily, while aspartame continues to prompt controversy in its reported wide range of negative side effects (Swithers *et al*., 2009). Therefore, researchers nowadays attempt to produce healthier foods by reducing the amount of sucrose or finding other alternative sweeteners especially from natural sources. Stevia is a medical and commercial natural sweetener plant used in a wide range around the world. Stevia's botanical name is *rebaudiana Bertoni*. Stevia leaves have specific glycosides that produce sweeteners but do not have calories value such as stevioside and rebaudioside A. It is estimated that they are 300 times sweeter than sugar. These glycosides can be easily extracted with water (Zahn *et al*., 2013). Biotech companies commercialize the production of different forms of stevia through tissue culture and sale of stevia such as freshly leaves, liquids, and leaves powder (Kumar *et al*., 2015). According to Alaam (2007) the Stevia plant was introduced to Egyptian agriculture, one feddan of Stevia may produce up to 400 kg of Stevia sugar, annually. According to

Kochhar *et al*. (2008) stevia and stevioside are safe when used as sweeteners. Both are suited for diabetics and phenylketonuria patients, as well as for obese persons intending to lose weight by avoiding sugar supplements in the diet the stevioside and steviol, stimulate insulin secretion by direct action on beta cells and these compounds have potential role as anti-hyperglycemic agent in the treatment of type 2 diabetes mellitus. Moreover, the Stevia Sweetener is stable under dry conditions and in aqueous food systems, also it is heat -stable up to 200°C (Giri *et al*., 2014). Currently, steviol glycosides have been approved in the European Union with the E 960 symbol for use in 31 food categories, and it would be beneficial for food industries to develop novel formulations for cakes and biscuits with stevia as sucrose substitute and produce products with good quality and achieve consumer acceptability (Kobus and Gramza., 2015).

MATERIALS AND METHODS

Materials:

Dried Stevia Leaves:

Stevia leaves (*Stevia rebaudiana Bertoni*) were obtained from the Institute of Sugar Crops, Agriculture Research Center, Giza, Egypt. The brown and yellow leaves were discarded from the plants which then, washed under tap water and spread on trays covered with cheese-cloth to remove the excess water. The plants were also dried in shadow at temperature ranged from 25 to 30°C for 24 - 48 hrs. The dried leaves were separated from stems and kept in tightly closed plastic bags in the laboratory until used.

Cake ingredients: Wheat flour (72%), sugar, oil, butter, milk, whole eggs, Vanillin and baking powder were obtained from the local market.

Chemicals: were obtained from Sigma Chemical Company, Egypt.

Methods:

Preparation of stevia leaves powder (SLP):

Dried stevia leaves were grinded to powder form with a high-speed blender (Moulinex Model Depose, type DAB1, French) then sieved by using 60 meshes sieve and kept in polyethylene bags and stored in a refrigerator at 4 ±1°C until used. (Elsebaie and Mostafa, 2018).

Preparation of stevia leaves extract (SLE):

The grinded leaves of stevia plant were extracted by water according to (Nishiyama *et al*., 1992) with a slight modification. The grinded leaves were immersed in hot water (65°C) at ratio 1gm leaves powder to 35 ml water for 3 hrs. to achieve mostly stevioside extraction. The crude extract containing stevioside was centrifuged at 4000 rpm for 15 min and filtered through Whatman No. 4 filter paper then purified from suspended particles by addition of 5% $Ca(OH)_2$ (based on weight of dried leaves), The addition of $Ca(OH)_2$ was repeated twice followed by filtration after every addition to obtain clear extract then neutralize the pH with citric acid until 8.5. Then the extract was stored at 5-7°c (Brandle *et al*., 1998 and Abou-Arab *et.al*., 2010).

Determination of sweetening power of stevia leaves powder and its aqueous extract:

After preparation of stevia leaves powder and stevia leaves aqueous extract their sweetening power were sensory evaluated according to (Swaminathan 1995) and Savita *et al*. (2004), since it clear that 1g of stevia leaves powder was equivalent to the sweetness of 20g sugar while 0.9 ml of the aqueous extract was equivalent to the sweetness of 1g sugar. So, in preparation of cake, the sugar was replaced by its equivalent in sweetness from stevia leaves powder or stevia leaves aqueous extract.

Preparation of cupcake samples:

Cupcakes were prepared according to the method described by AACC, (1983) by using the formula showed in table (1). Vegetable oil was beaten thoroughly with sugar and mixed until got smooth like cream, and then a well-blended egg with vanillia were added and mixed together then added fresh milk. Finally, the mix of soft wheat flour (72%) and baking powder were stirred together and added alternately to the egg mixture. The mixture was whipped until got smooth texture. The dough was transferred to a greased pan and was baked for 25 min. in an electrical oven (Vipinho 0448, Prefecta, Curitiba, Brazil) at 200±5ºC then was cooled at room temperature. The samples were packaged in a foam plates, wrapped with poly ethylene film and stored at 5 °C ±1.

Proximate composition

Chemical composition of stevia leaves powder and cake samples (moisture, crude protein, ether extract and ash) were estimated using A.O.A.C. (2005) methods, where total carbohydrates were determined using a method as described by Bamigbola *et al*., (2016). The total value of calories was calculated by the equation stated via FAO/

WHO (1974). Energy (calories) = 4 (carbohydrate + protein) + 9 (fat).

Determination of total chlorophylls and carotenoids of stevia leaves powder:

Both chlorophylls (A and B) and carotenoids were determined in Stevia leaves powder according to (Wettestein, 1959) as follow: Five grams of sample were mixed with 30 ml of 85% acetone in dark bottle and left at room temperature for 15 h, then filtered on glass wool into 100 ml volumetric flask, and made up to volume by 85% acetone solution. The absorbance of the solution was then measured at 440, 664 and 662 nm using spectrophotometer. A blank experiment using acetone (85%) was carried out. The contents of total carotenoids and chlorophylls were calculated using the following equations:

Chlorophyll A (mg/L) = (9.784 × E662) – (0.99 × E664).

Chlorophyll B (mg/L) = (21.426 × E664) – (4.65 × E662).

Total carotenoids (mg/L) = (4.695 × E440) – 0.369 (chl. A + chl. B)

Determination of mineral contents of stevia leaves powder:

Mineral contents, magnesium (Mg), manganese (Mn), iron (Fe) and zinc (Zn) were determined on aliquots of the solutions of the ash and were established according to the method of AOAC (2008) using Atomic Absorption 909 AA, in the Central Labs, Faculty of Agric., Assiut University. The flame photometer was applied for calcium (Ca), potassium(K) and sodium (Na) determination according to the method described by Pearson (1976).

Determination of stevioside by HPLC

The stevioside was analyzed by High-Performance Liquid Chromatography (HPLC) as described by Nishiyama *et al*. (1992). The HPLC system was a HP 1100 chromatograph (Agilent Technologies, Palo Alto, CA, USA) equipped with an auto-sampler, quaternary pump and a diode array detector. The analytical column was Nuclosil 100 C18 column (25 cm × 4.6 mm I.D., 5 µm, Germany). Separation was performed with water and methanol -water (63: 35 v/v) as the elusion solvent at flow rate of 2 ml/min and the detection wavelength was 219 nm.

Physical properties of cake:

Cake mass was weighted after 3 hours of cooling at room temperature. The volume (cm^3) was measured by rapeseed displacement method described in the A.A.C.C. (2000). The specific volume (cm^3/g) was obtained by dividing the volume of cakes by their weights.

Sensory evaluation of cupcake:

Cupcake samples were submitted to sensory evaluation after baking (at zero time), by ten trained panelists were chosen from the staff members of the Department of Food Technology, Faculty of Agriculture, Al-Azhar University, Assiut, Egypt. by assigning scores for various quality parameters namely: crust color (10), crumb color (10), taste (10), odor (10), texture (10), appearance (10), sweet acceptability (10) and overall acceptability (10) according to the method described by (A.A.C.C., 2000) and (DuBois and Stephenson, 1985).

Statistical analysis

All treatments and determinations were carried out in triplicates and the data are presented as means ±SD. They were subjected to analysis of variance (ANOVA) accompanied with Duncan test using SPSS software (version 16.0 for Windows, SPSS Inc., Chicago) to identify the significance ($p< 0.05$) among the treatments Gomez and Gomez (1984)

RESULTS AND DISCUSSIONS

Chemical composition, Chlorophyll (A and B) and carotenoids of dried Stevia leaves (*S. rebaudiana*)

The results obtained by the chemical analysis of dried Stevia plants showed that moisture, protein, fat, crude fiber, ash, and carbohydrates were 5.65, 11.01, 2.15, 15.19,12.37, and 53.64%, respectively in (Table 2). These results are in agreement with those reported by Silva *et al*. (2006), Manish and Rema, (2006) and Savita *et al*. (2004). This data indicated that Stevia leaves could be considered as a good source of carbohydrates, protein, and crude fiber which are the essential factors for maintenance of health. Also, the consumers benefited when the leaves of stevia were used as a substitute for sugar instead of pure stevioside in different food preparations. On the other hand, high ash content marked Stevia leaves as a good source of minerals. However, it is not considered as a good source of oil due to low fat content.

Also, stevia leaves were analyzed for chlorophyll (A and B), carotenoids and total pigments as shown in (Table 2). It was found that the pigments content recorded 39.51, 20.53, 11.49 and 71.53% (on dry basis), respectively. These changes in the structure of these pigments turned the green colour into brown in sun drying. This also would affect the colour changes during extraction and purification of the sweetener. These results are in agreement with Abou-Arab *et al*. (2010).

Minerals content (mg/100 g) of dried Stevia leaves (S. rebudiana)

Data presented in Table (3) showed that concentrations of macro minerals (potassium, calcium, sodium and magnesium) and micro elements, (manganese, iron and zinc) determined in dried Stevia leaves. calcium was detected at the highest content (1845.19 mg/100 g) followed by Potassium (1443.87 mg/100 g) and magnesium (514.05 mg/100 g). On the other hand, the lowest level of major minerals (sodium) was detected at concentration 85.25 mg/100 g dry weight basis. Regarding to heavy metals, the leaves contained lower amount of Mn, Fe and Zn which recorded 8.65, 63.95 and 4.99 mg/100 g, respectively. These results coincide with those reported by Manish and Rema (2006).

Determination and Fractionation of stevioside by (HPLC):

The HPLC analysis of stevioside and related compounds was carried out on reverse phase C18 column by using group specific isocratic methods. The isolated compounds were identified by comparing their retention times (Rt) with standards.

The HPLC analysis of stevia leaves powder and standard had shown in figures 1,2 and 3. The presence of Stevioside and Rebaudioside having the retention time of 4.333 and 8.484 min respectively, which matches to retention time 4.980 and 9.062 min respectively of standard.

Along with this, in fig. 1,2 and 3 respectively from the area under each peak of sample which was 297874 of stevioside and 82864.9 of Rebaudioside, the percentage of Stevioside and Rebaudioside were 11.23 and 6.723% respectively, in stevia leaf powder on dry weight basis according with (Makapugay *et al*., 1984).

Proximate chemical composition and energy content of cake formulated with replacing sugar with stevia leaves powder or stevia leaves aqueous extract.

The effect of replacement sugar with stevia leaves powder (10, 20 and 30%) or aqueous extract (25, 50 and 75%) on the gross chemical composition of the produced cake in compared with the control cake (formulated with sugar) are shown in Table (4). The results indicated that the moisture content of cake was increased with increasing replacing level of sugar with stevia leaves powder or their aqueous extract, since it gradually increased from 31.77 % for control sample to 32.11, 33.84 and 34.66 for the cake formulated with replacing the sugar with 10, 20 and 30 % stevia leaves powder respectively. On the other hand, cake sample formulated with replacing sugar with stevia leaves aqueous extract were have higher moisture content than control and cake samples formulated with stevia leaves powder which were 36.35, 38.75 and 40.55 % for cake samples formulated with replacing sugar with 25, 50 and 75% of stevia leaves aqueous extract respectively.

Similarly, the protein content of cake samples was increased significantly by increasing the replacing level of sugar with stevia leaves powder or stevia leaves aqueous extract, since the protein content increased from 9.08 % for control sample to 9.70, 10.33 and 11.05 % for cake sample prepared by replacing sugar with 10, 20 and 30 % of stevia leaves powder respectively. On the other hand, the protein contents for cake samples formulated with replacing sugar with the aqueous extract of stevia leaves with the levels 25, 50 and 75% were 11.26, 11.52 and 12.40% respectively.

As shown in Table (4), there was significantly alteration in the fat content of all cake samples formulated with stevia leaves powder or their aqueous extract, since the fat content increased from 12.89 % for control sample to 13.24, 13.56 and 14.26 % for cake sample prepared by replacing sugar with 10, 20 and 30 % of stevia leaves powder respectively. On the other hand, the protein contents for cake samples formulated with replacing sugar with the aqueous extract of stevia leaves with the levels 25, 50 and 75% were 15.27, 16.85 and 18.09% respectively.

From the same table, there was a slight alteration in the ash contents of all cake made with replacing of sugar with stevia leave powder or their aqueous extract, which is increased with increasing the level of substituting. Ash content gradually increased from 1.89 % for control sample to 1.99, 2.10 and 2.33 % for cake sample prepared by replacing sugar with 10, 20 and 30 % of stevia leaves powder respectively. On the other hand, the ash contents for cake samples formulated with replacing sugar with the aqueous extract of stevia leaves with the levels 25, 50 and 75% were 2.00, 2.33 and 2.52 % respectively.

The same behavior was also observed for the crude fiber content which was increased from 0.75 % for control sample to 1.03, 1.39 and 1.77 % for cake sample prepared by replacing sugar with 10, 20 and 30 % of stevia leaves powder respectively. On the other hand, the crude fiber contents for cake samples formulated with replacing sugar with the aqueous extract of stevia leaves with the levels 25, 50 and 75% were 1.07, 1.54 and 2.05 % respectively.

On the other hand, the carbohydrates content significantly decrease with increasing the level of substituting sugar with stevia leaves powder and their aqueous extract. The carbohydrates content cake samples decreased from 43.62 % for control sample to 41.93, 38.78 and 35.93 % for cake sample prepared by replacing sugar with 10, 20 and 30 % of stevia leaves powder respectively. On the other hand, the carbohydrates contents for cake samples formulated with replacing sugar with the aqueous extract of stevia leaves with the levels 25, 50 and 75% were 34.06, 29.01 and 24.39 % respectively.

As illustrated in Table (4), there was decrement in the energy value of all cake samples formulated with replacing sugar with stevia leaves powder or their aqueous extract, since it decreased from 326.80 Kcal/100 gm for control sample to 325.76, 318.46 and 316.24 Kcal/100 gm for cake samples prepared by replacing sugar with 10, 20 and 30% stevia leaves powder respectively. On the other side, energy contents of cake samples prepared by replacing sugar with 25, 50 and 75% stevia leaves aqueous extract were 318.67, 313.78 and 309.98 Kcal/100 gm, respectively.

The increments in all components of cake samples may be due to the decrement of sugar content in cake formulation which resulted in decreasing of batch weight and the proportion increasing of the other ingredients.

These results agreed with those of Martinez-Cervera *et al*., (2012); Zahn *et al.,* (2013); Ruiz *et al.,* (2015) and Elsebaie and Mostafa (2018).

Physical characteristics of cake formulated with replacing sugar with stevia leaves powder or stevia leaves aqueous extract.

The physical properties i.e. weight, volume and specific volume of the produced cakes as affected by replacement sugar with different levels of stevia leaf powder and aqueous extract are presented in Table (5). From these data, it could be observed that, the average weight of cake produced (gm) was gradually increased as the replacement level of sugar with stevia leaves powder increased, whereas it was increase from 99.00g for control sample to 100.62, 101.75 and 102.31 g for cake samples formulated with replacing sugar with 10, 20 and 30 % stevia leaves powder respectively. Similarly, the weight of cake sample formulated by replacing sugar with 25, 50 and 75 % stevia leaves powder (101.85, 102.56 and 102.86 g)

From the same table it could be noticed that, the volume of cake was decreased as the replacing of sugar with stevia leaves powder or stevia leaves aqueous extract, since it decreased from 254.00 cm^3 to 252, 250.67 and 248.33 for cake samples containing 10, 20 and 30 % stevia leaves powder respectively. The decreasing of volume was obviously noticed with replacing sugar with stevia leaves aqueous extract, since the lowest volume was recorded for cake sample formulated with replacing sugar by stevia leaves aqueous extract with replacing level 75 % (206.83 cm^3).

Regarding the specific volume, it also decreased with increasing sugar replacing level with stevia leaves powder or stevia leaves aqueous extract. Since specific volume values of cake sample formulated with replacing sugar with 10, 20 and 30 % stevia leaves powder were 2.50, 2.46 and 2.43 cm3 respectively as compared to 2.57 for control sample. The decreasing of specific volume was clear in cake samples formulated by replacing sugar with 25, 50 and 75 % stevia leaves aqueous extract. The lowest specific volume was recorded for cake sample formulated with replacing sugar with stevia leaves aqueous extract at level of 75 % (2.01 cm3). The obtained results were in the same trend with those recorded by Choi *et al*. (2013) and Elsebaie and Mostafa (2018).

Organoleptic quality of cake formulated with replacing sugar with stevia leaves powder or stevia leaves aqueous extract.

The effect of partial replacement sugar with different levels of stevia leaves powder (10, 20 and 30%) or stevia leaves aqueous extract (25, 50 and 75%) on the organoleptic quality characteristics of produced cake is presented in Table (6).

From this data it could be showed that, in general, stevia leaves aqueous extract shows no significant differences in all parameters, up to 25% replacement of sucrose. These results are in agreement with those of Khalil *et al*., (2015).

From the sensory evaluation results, it could be seen that with increased levels of stevia leaf powder and aqueous extract, there were significant differences (p>0.05) in crust color between control sample and other cake samples except cake prepared with 25% aqueous extract which was non-significant differences (p.<0.05) in crust color compared to control. The crust color score of all cake sample ranged between 7.25 to 8.75 compared with control cake sample (9.25). Also, the highest score of crumb color recorded for control sample (9.25) followed by cake prepared by 25% aqueous extract (9.13), cake prepared with 10% stevia leaf powder and 50% aqueous extract (8) while the lowest score of crumb color recorded for cake prepared by 30% stevia leaf powder (6.38).

On the other hand, odor scores were 8.13, 7.88 and 7.63 for cake prepared by 10, 20 and 30% stevia leaf powder; respectively, and 8.75, 8 and 7.83 for cake prepared by 25, 50 and 75% stevia aqueous extract; respectively, compared with control sample which was (8.63).

From these table it could be observed that, there were no significant differences (p>0.05) in taste score between control sample and cake prepared by 10 and 20% stevia leaf powder and 25 and 50% stevia aqueous extract compared with other samples. The highest taste score (8.88) was recorded for cake prepared by 25% aqueous extract and control followed by cake prepared by 10% stevia leaf powder (8.38), while the lowest value (7.13) was recorded for cake prepared by 75% aqueous extract.

From the same table, texture scores ranged between 7.50 to 8.13 in cake treated by stevia leaf powder and 7.13 to 8.88 in cake treated by aqueous extract compared with control cake sample (8.88).

Also, there were no significant differences (p>0.05) in sweet acceptability scores between the control sample and other cake samples with increased levels of stevia leaf powder and aqueous extract except cake prepared with 75% aqueous extract. Sweet acceptability scores ranged between 6.75 to 9.13 in all samples.

On the other hand, there were no significant differences (p>0.05) in Overall acceptability score between control sample and cake prepared by 25% stevia aqueous extract and no significant differences (p>0.05) between all other cake samples except cake prepared with 75% stevia aqueous extract. Overall acceptability score (9.50) recorded with the control sample, while, the cake samples prepared with stevia leaf powder 10, 20 and 30% were 8.25, 7.88 and 7.38, respectively, and the cake samples prepared with aqueous extract 25, 50 and 75% were 9.25, 8 and 6.88, respectively. These results are in agreement with those of Khalil *et al*., (2015) and Elsebaie and Mostafa (2018).

CONCLUSION

Finally, it could be concluded that cake can be produced with replacing 20 % of sugar with its equivalent in sweetness from stevia leaves powder or by replacing 50 % of sugar with its equivalent in sweetness from stevia leaves aqueous extract without any detrimental effects on its physical, chemical and sensory characteristics.

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Table 1: Formula of cake

Ingredients	control	Stevia leaves powder (SLP)			Stevia leaves aqueous extract (SLAE)		
		10%	20%	30%	25%	50%	75%
Wheat flour 72%(g)	200	200	200	200	200	200	200
Fresh egg (g)	180	180	180	180	180	180	180
Sugar(g)	160	144	128	112	120	80	40
SLP (g)*	-	0.8	1.6	2.4	-	-	-
SLAE (ml)**	-	-	-	-	36	72	108
Vegetable oil (ml)	100	100	100	100	100	100	100
Fresh milk (ml)	240	240	240	240	204	168	132
Baking powder (g)	9	9	9	9	9	9	9
Vanilla(g)	2	2	2	2	2	2	2

* SLP and SLAE added as equivalent to sugar sweetening power, ** SLAE the volume of the added extract was subtracted from added fresh milk.

Table 2: Chemical composition, Chlorophyll (A and B) and carotenoids of dried Stevia leaves (*S. rebaudiana*)

Chemical composition (% on dry weight basis)	Moisture	5.65
	Protein	11.01
	Fat	2.15
	Crude fiber	15.19
	Ash	12.37
	*Carbohydrates	53.64
pigments (mg/100 g)	Chlorophyll A	39.51
	Chlorophyll B	20.53
	Carotenoids	11.49
	Total pigments	71.53

* Calculated by difference

Table 3: Minerals content (mg/100 g) of dried Stevia leaves (*S. rebudiana*)

Elements	Mineral content (mg/100 g weight basis)	Elements	Mineral content (mg/100 g weight basis)
Macro minerals		Micro (heavy metals)	
Potassium (K)	1443.87	Manganese (Mn)	8.65
Calcium (Ca)	1845.19	Iron (Fe)	63.95
Sodium (Na)	85.25	Zinc (Zn)	4.99
Magnesium (Mg)	514.05		

Table 4: Proximate chemical composition and energy content of cake formulated with replacing sugar with stevia leaves powder or stevia leaves aqueous extract.

Component %	Treatments						
	Control (100 % Sugar)	Stevia leaves powder			Stevia leaves aqueous extract		
		10%	20%	30%	25%	50%	75%
Moisture	31.77±0.590[e]	32.11±0.220[e]	33.84±0.365[d]	34.66±0.450[d]	36.35±0.065[c]	38.75±0.330[b]	40.55±0.586[a]
Protein	9.08±0.170[f]	9.70±0.235[e]	10.33±0.306[d]	11.05±0.250[c]	11.26±0.035[bc]	11.52±0.197[b]	12.40±0.343[a]
Fat	12.89±0.316[f]	13.24±0.223[ef]	13.56±0.386[e]	14.26±0.165[d]	15.27±0.217[c]	16.85±0.348[b]	18.09±0.080[a]
Ash	1.89±0.025[d]	1.99±0.030[cd]	2.10±0.020[c]	2.33±0.010[b]	2.00±0.040[cd]	2.33±0.010[b]	2.52±0.010[a]
Fiber	0.75±0.050[e]	1.03±0.119[de]	1.39±0.152[c]	1.77±0.021[ab]	1.07±0.025[d]	1.54±0.398[bc]	2.05±0.040[a]
Carbohydrates*	43.62±0.685[a]	41.93±0.454[b]	38.78±0.485[c]	35.93±0.564[d]	34.06±0.195[e]	29.01±0.910[f]	24.39±0.985[g]
Energy	326.80±1.700[a]	325.67±1.048[a]	318.46±2.754[b]	316.24±2.030[bc]	318.67±1.381[b]	313.78±2.349[cd]	309.98±1.988[d]

* Calculated by difference Means with different letter in the same row indicate significant differences between treatments ($p < 0.05$)

Table 6: Sensory evaluation of cake formulated with replacing sugar with stevia leaves powder or stevia leaves aqueous extract.

Criteria / Treatments		Crust color	Crumb color	Oder	Taste	Texture	Sweet acceptability	Overall acceptability
Control		9.25±0.46[a]	9.25±0.70[a]	8.63±1.060[ab]	8.88±0.640[a]	8.88 ±0.640[a]	9.13 ±0.640[a]	9.50 ±0.534[a]
Stevia leaves powder	10%	8.13±0.64 [b]	8.00±0.75 [b]	8.13±0.353 [abc]	8.38±0.517 [ab]	8.13 ±0.834 [ab]	8.75 ±0.707 [a]	8.25 ±0.707 [b]
	20%	8.25±0.461 [b]	7.13±0.92 [bc]	7.88 ±0.353 [bc]	8.25±1.035 [ab]	7.88 ±0.353 [bc]	8.38 ±0.744 [a]	7.88 ±0.991 [b]
	30%	7.38±0.51[c]	6.38±0.98 [c]	7.63 ±0.916 [c]	7.63±0.744 [bc]	7.50 ±0.755 [bc]	8.38 ±1.187 [a]	7.38 ±0.916 [bc]
Stevia leaves aqueous extract	25%	8.75±0.46 [a]	9.13±0.64 [a]	8.75 ±0.886 [a]	8.88 ±0.991 [a]	8.88 ±0.991 [a]	8.63±0.744 [a]	9.25 ±0.707 [a]
	50%	8.13±0.99 [b]	8.00±0.92 [b]	8.00±0.534 [abc]	8.25 ±0.707 [ab]	7.50 ±0.925 [bc]	8.25±1.035 [a]	8.00 ±1.195 [b]
	75%	7.25±0.70 [c]	7.25±0.53 [bc]	7.38 ±0.744 [c]	7.13 ±0.640 [c]	7.13 ±0.834 [c]	6.75 ±1.035 [b]	6.88 ±0.991 [c]

Control = cake from 100% sugar Means with different letter in the same column indicate significant differences between treatments ($p < 0.05$).

Table 5: Physical characteristics of cake formulated with replacing sugar with stevia leaves powder or stevia leaves aqueous extract.

Physical characteristics / Treatments		Weight (g)	Volume (cm3)	Specific volume (cm3/g)
Control		99.00±1.000[d]	254.00±1.732[a]	2.57±0.042[a]
Stevia leaves powder	10%	100.62±0.544[c]	252.00±2.646[a]	2.50±0.035[b]
	20%	101.75±0.137[b]	250.67±1.528[c]	2.46±0.012[c]
	30%	102.31±0.537[ab]	248.33±1.155[b]	2.43±0.021[c]
Stevia leaves aqueous extract	25%	101.85±0.437[ab]	253.17±0.764[a]	2.49±0.015[b]
	50%	102.56±0.441[ab]	224.20±0.721[d]	2.19±0.012[d]
	75%	102.86±0.430[a]	206.83±1.258[e]	2.01±0.020[e]

Control = cake from 100% sugar Means with different letter in the same column indicate significant differences between treatments ($p < 0.05$).

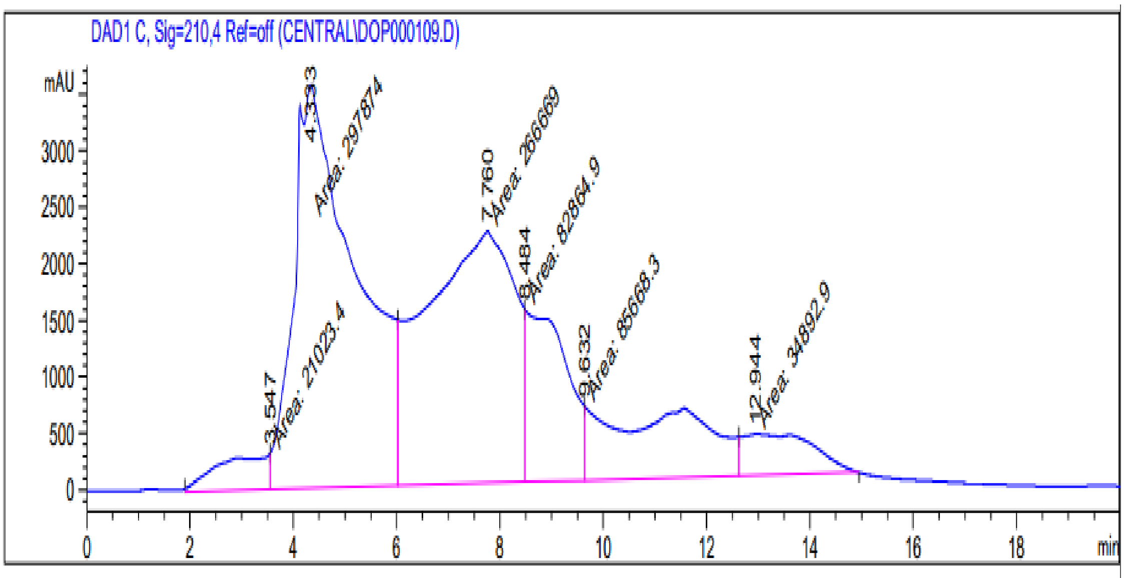

Figure 1: HPLC Chromatogram of sample

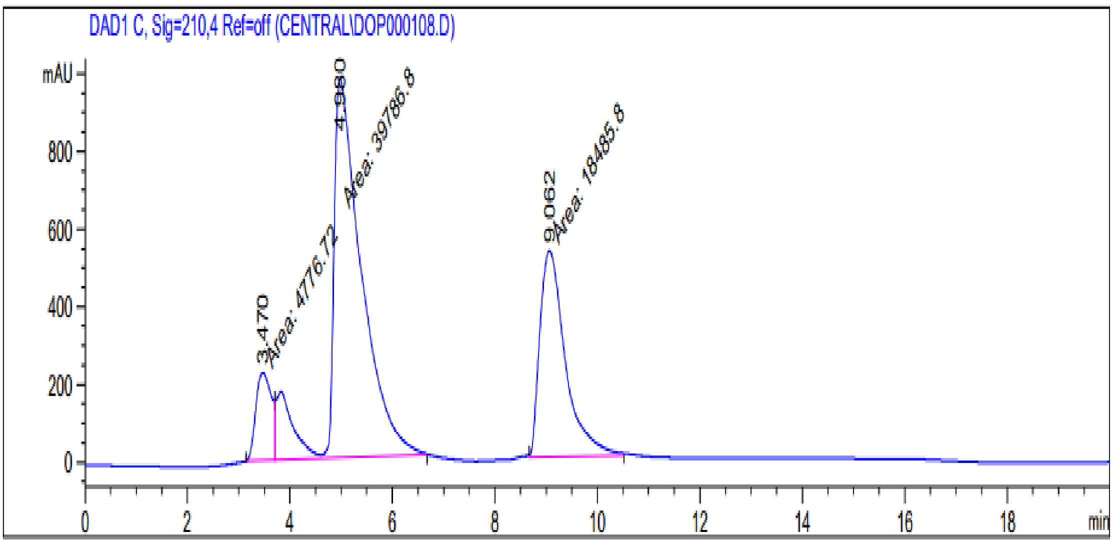

Figure 2: HPLC Chromatogram of stevioside standard

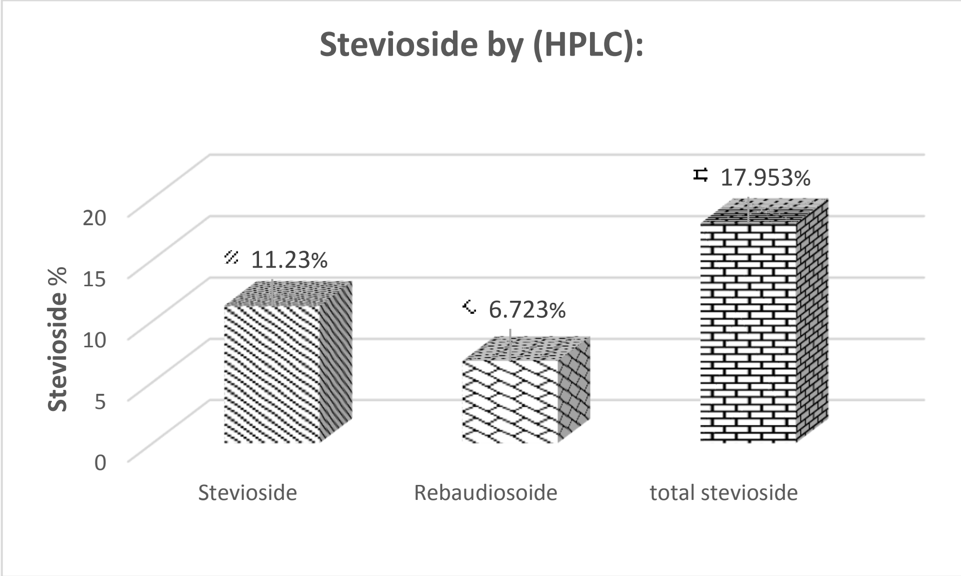

Figure 3: percentage of total steviosides compound in stevia leaf powder

استخدام مسحوق أوراق الاستيفيا أو المستخلص المائي لأوراق الاستيفيا كبديل للسكر لإنتاج كيك منخفض السعرات الحرارية

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الملخص العربي:

تهدف هذه الدراسة الى إمكانية استخدام مسحوق أوراق الاستيفيا و المستخلص المائي لها بديلا للسكر لإنتاج كيك منخفض السعرات الحرارية، حيث تم خفض نسبة السكر بالمستويات التالية ١٠ و ٢٠ و ٣٠٪ واستبدالها بما يكافئها في الحلاوة من مسحوق أوراق الاستيفيا أو خفضه بمستويات ٢٥ و ٥٠ و ٧٥٪ واستبدالها بما يعادلها في الحلاوة من المستخلص المائي لها.حيث أظهرت النتائج أن مسحوق أوراق الاستيفيا يحتوي على١١,٠١٪ بروتين ، ١٢,٣٧٪ رماد ، ١٥,١٩٪ ألياف خام ، ١٨٤٥,١٩ مجم كالسيوم ، ٦٣,٥٩ مجم حديد ، ٤,٩٩ مجم زنك ، ٨٥,٢٥ مجم صوديوم. كما تحتوي أيضًا على ١١,٢٣٪ ستيفيوسيد و ٦,٧٣٢٪ ريبوديوسيد(على أساس الوزن الجاف).وكانت هناك زيادة تدريجية فى متوسط وزن الكيك الناتج بزيادة مستويات استبدال السكر مع مسحوق اوراق الاستيفيا او المستخلص المائى لها مقارنة بالكنترول و على العكس من ذلك فإن الحجم والحجم النوعى للكيك الناتج ينخفض مع زيادة نسبة الاستبدال. كما أظهر التقييم الحسي عدم وجود فروق معنوية ($p > 0.05$) في كل الصفات بين الكيك المعد بنسبة استبدال ٢٥٪ من المستخلص المائي لأوراق الستيفيا والكنترول. كما أن عينات الكيك المعدة باستبدال ٢٠٪ من السكر بمسحوق أوراق الاستيفيا أو باستبدال ٥٠٪ من السكر بمستخلص المائي لأوراق الاستيفيا كانت لها خصائص حسية مقبولة

الكلمات الاسترشادية: كيك منخفض السعرات الحرارية، نبات الاستيفيا، المحليات الطبيعية، الاستفيوسيد