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INFLUENCE OF STEVIOSIDE AS NATURAL SWEETENER ON THE QUALITY OF BAKED MUFFINS

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ABSTRACT

The effect of substitution of water by four levels of crude hot water stevia (CSWE) extract (5%) i.e (25,50,75 and 100%) contained 41.15 , 82.30,123.45 and 164.62 mg stevioside/100 ml) on the rheological and physical properties of wheat dough was studied using farinograph ,extensograph , viscoamylograph and gasograph instruments.

The results revealed that water absorption and softness decreased, while stability , resistance to extension , extensibility and gas production of dough increased gradually with increasing the substitution level of 5% CSWE to 75% (123.46 mg stevioside).

Sensory evaluation of muffins revealed that free and containing 5%CSWE products could be successfully used by replacing 75% of sucrose solution.

Key words: Stevioside , stevia , muffins

INTRODUCTION

There is a number of plants which can be used as a source of a natural hypocaloric sweetener. Stevia (*Stevia rebaudiana*) is just one of the more popular ones in China ,Korea and Japan (Kolb,*et al.,* 2000).

The leaves of stevia give the sweet essence which is composed of 8 sweet diterpene glycosides (Ikan,1991). The two main sweeteners glycosides are stevioside and rebaudioside , they have 300 and 400 sweeting power as sucrose , respectively (Nishiyama *et al.*,1992 ,Hanson and De Oliver ,1993 and Salem and Becheit ,2002).

Ikan,(1991) mentioned that the stevioside or stevia extract has properties which makes it suitable as noncaloric sweetner for cooked and baked foods .It may also be used in dietetic foods and by diabetes patients in many parts all over the world.

Kienle (1995) mentioned that stevia extract is stable as food additive , so millard reaction does not appear in food containing stevia extract or stevioside as sweetener as shown in food containing sucrose .

Kondou(2000) used stevia instead of sucrose to produce low calorie cocoa and is described as having a pleasant flavor . In Egypt , Hassan (2000) and Salem and Becheit (2002) found that the stevia extract or stevioside ccould be successfully used at 25% replacement of sucrose as sweetener in baked products such as cake and biscuit.

Thus, the aim of this study is to evaluate the crude stevia water extract as sweetener and natural antioxidant. The aim is also extended to assess the possibility of using this extract as sucrose replacer in preparing muffins (high fat ,yeast fermented baked product). Besides ,investigating the effect of this substitution on the physical , rheological properties of muffins .

MATERIALS AND METHODS

Materials:-

Stevia leaves were obtained from Sugar Crops Research Institute , Agriculture Research Center , Giza, Egypt.
Wheat flour (72%) extraction ,yeast ,fresh egg ,butter and sugar were obtained from the local market.

Methods:-

Crude stevia water extract (CSWE)

The crude stevioside was extracted by soaking the stevia leaves (5g) in hot water (almost 100 ml at 95°c) for 24 hrs as described by Salem and Becheit (2002) .The extracted stevioside was subjected to HPLC analysis according to the method described by Kolb *et al.*, (2000). The extracted stevioside was fractionated using stevioside in the HP series 1100 HPLC system(Hewlett-Packaged Avondale,PA) , with BDS C18. Gradient Elution 70:30 v/v , acetonitril/water (pH5). Linear gradient changed over 15 min., flow rate 2m./min , wavelength of UV detector, 210nm.(Figs 1,2).
From the extracted stevioside (5%) which contained 164.60 mg/100 ml three levels of solutions 25%,50%,and 75% were prepared by dilution with water containing 41.15 , 82.30, 123.45 mg/100 ml water , respectively .

Dough properties

Farinograph, extensograph, and viscoamylograph apparatus **(A.A.C.C.,1995)** were used to study the effect of stevioside substitution levels

Determination of gas production

Gas production during fermentation was determined on a 12 channel recording a gaso-graph as described by Fernandes et al.,(1985).

Muffins preparation and properties:

Muffins were prepared and baked as described by Hess and Setser (1983) using 5% CSWE as stock solution and diluted to the following : 0, 25 ,50 ,75 and 100% of stevioside as a substitution of sucrose and water. The ingredients formula used for muffins preparation are shown in Table (1).

Table(1): Ingredients formula of Muffins

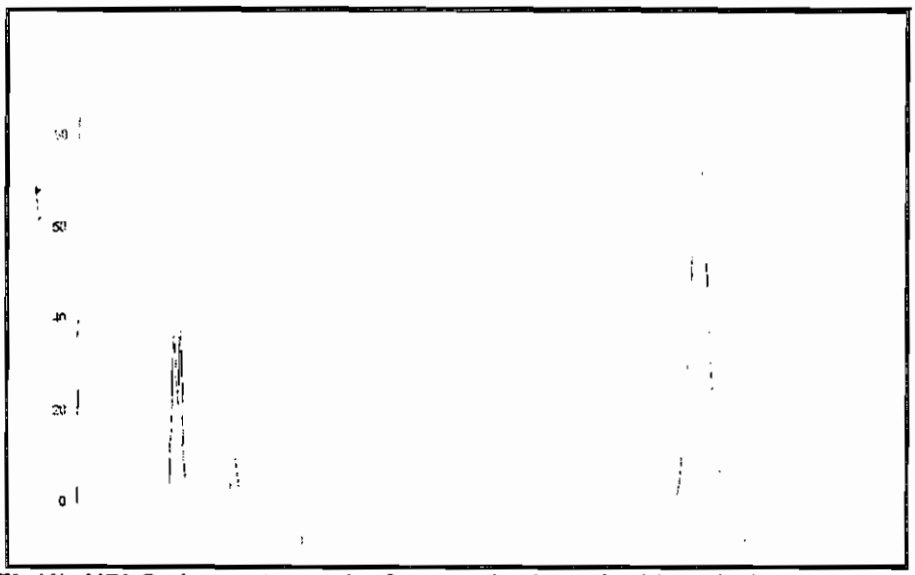
Ingredients	Treatments with 5% CSWE**				
	0.0*	25%	50%	75%	100%
Wheat flour 72% (g)	250	250	250	250	250
Fresh whole egg (g)	120	120	120	120	120
Butter(g)	90	90	90	90	90
Dry skimmed milk(g)	30	30	30	30	30
Yeast(g)	10	10	10	10	10
Water(ml)	325	243.7	162.5	81.3	0.0
5%CSWE(ml)	0.0	81.3 (41.15mg)***	162.6 (82.31 mg)***	243.9 (123.46mg)***	325.2 (164.62mg)***
Sucrose(g)	90	67.5	45	22.5	0.0

* Method of Hess and Setser (1983). **CSWE= Crude stevia hot water extract.
*** amount of stevioside per every treatment.

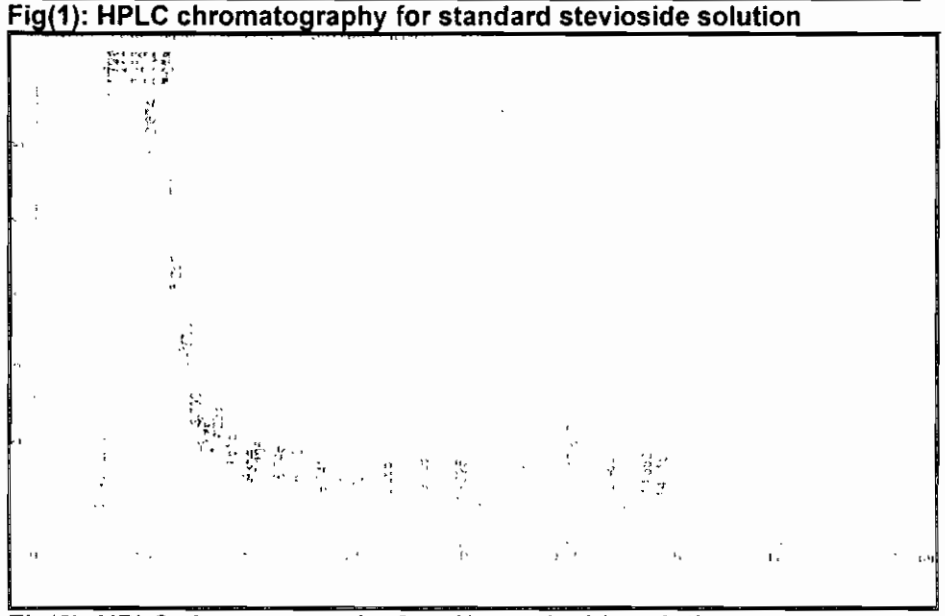
Organileptic properties:

A group of twelve panelists evaluated the muffins according to quality characteristics including : general appearance , crumb color , spongy , odor , taste , and overall palatability as mentioned by Bennion and Bamford (1973).

weight (g) , volume (cc) ,and specific volume (g/cc) of the baked muffins were determined.



Fig(1): HPLC chromatography for standard stevioside solution



Fig(2): HPLC chromatography for 5% stevioside solutions.

Statistical analysis :-The standard deviation (SD) and least significant difference (LSD) were calculated using a package program of Statistical Analysis System , **(SAS,1987).**

RESULTS AND DISCUSSION

Rheological properties :-

Table (2) and Figs (3,4,5,6 and7) show the effect of using 5% CSWE at different levels of substitution on the farinograph characteristics . The obtained data revealed that water absorption and dough softening decreased by increasing the substitution levels of CSWE . On the other hand , arrival time and dough development time decreased with CSWE which increased to 50% , after that level these properties still decreased compared to the control but to constant level (1.0 and 2.3 min ,respectively) . Stability time of dough considerably increased due to using 5% CSWE at 25% (5 to 8.3) and this value was steady at the above levels of substitution . These results may be due to the presence of oxidative minerals in stevia extract such as ferric which converted sulphydryl group "SH" in wheat gluten structure to disulphite group "S-S" leading to an increase in stability time.

Table (3) and Figs (8,9,10,11 and 12) represent the effect of using 5% crude stevia water extract (5%CSWE) at different dilution levels of 25 , 50, 75 , and 100% (w/v) on the extensopraph characteristics of wheat flour dough . The results indicated that there was resistance to extension (RE) and extensibility (E) increased considerably at 25% and 50% substitution levels of water if compared to those "control 75 and 100% levels".

Table (2): Farinograph characteristics of wheat dough free and containing different levels of 5% CSWE.

Farinograph characteristics	Treatment with 5% CSWE*				
	0.0 Control	25% CSWE*	50% CSWE*	75% CSWE*	100% CSWE*
Water or solution absorption (%)	63.4	62.7	61.7	60.6	58.6
Arrival time (min)	2.0	1.3	1.0	1.0	1.0
Development time (min)	3	2	2.3	2.3	2.3
Stability time (min)	5	8.3	8.00	8.00	8.00
Dough weakening (B.U)	90	90	85	80	75

*CSWE = Crude stevia hot water extract.

Table (3): Extensograph characteristics of wheat dough free and containing different diluting levels of 5% CSWE.

Extensograph charactersistics	Treatment with 5% CSWE*				
	0.0	25% CSWE*	50% CSWE*	75% CSWE*	100% CSWE*
Resistance to extension (B.U)	370	460	440	405	395
Extensibility (cm)	115	135	150	140	130
Energy	42	41	36	39	32

*CSWE = Crude stevia hot water extract.

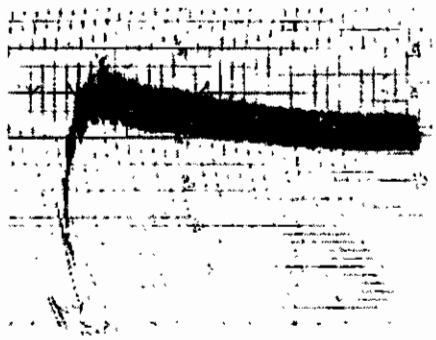


FIG (3): Control

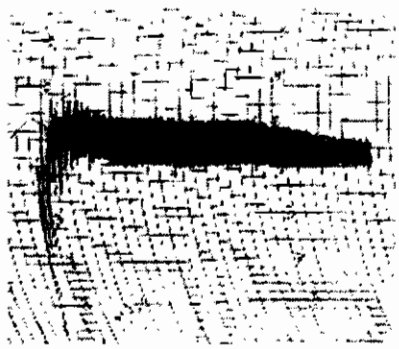


FIG (4): 25% CSWE*

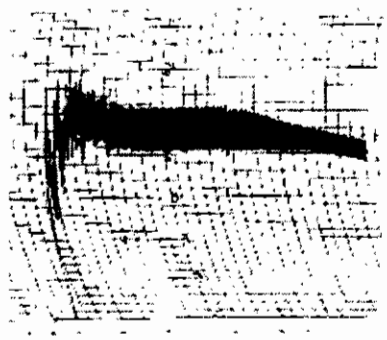


FIG (5):50%CSWE*

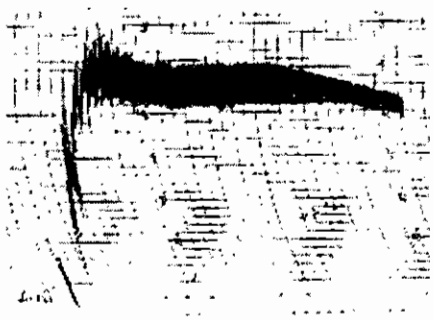


FIG (6): 75%CSWE*

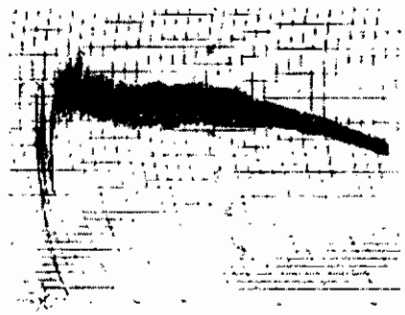


FIG (7): 100%CSWE*.

FIGS (3-7) : Farinograph characteristics of wheat dough free and containing different levels of 5% CSWE.

*CSWE = Crude stevia hot water extract.

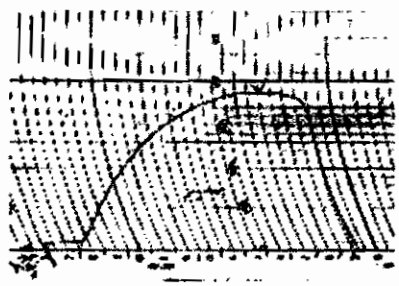


FIG (8): Control

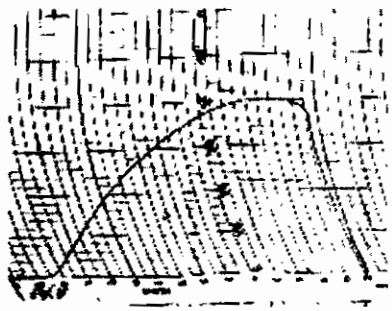


FIG (9):25%CSWE*

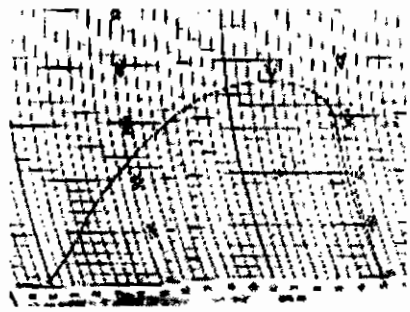


FIG (10):50%CSWE*

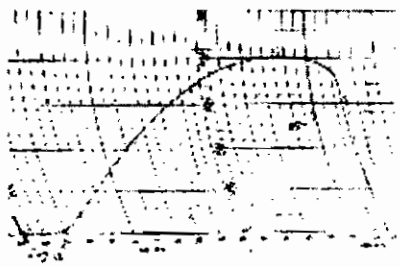


FIG (11):75%CSWE*

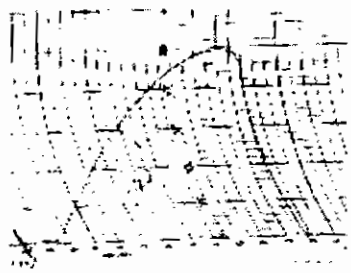


FIG (12):100%CSWE*

CSWE = Crude stevia hot water extract.

Table (4) and Figs (13,14,15,16 and 17) show pasta characteristics of the starch fraction of wheat dough (free and containing 5% CSWE) .From the obtained data , it could be concluded that using 5% CSWE led to an increase in transition temperature, but the highest transistion temperature was observed at the addition of 50%. This means that the starch granules of flour were restricted in swelling compared to the control . Maximum viscosity of the granules starch increased gradually as the level of substitution increased. Generally, it could be concluded that stevia had no great effects on dough characteristics such as dough constituents meanwhile undesirable starch fraction was greatly affected by stevia leading to alternation in granules swelling as it increased especially at high levels of substitution .Concerning protein , phospholipids and fiber constituents of dough , water absorption took place within the formation of hydrogen bonds with polar groups of these constituents such as OH^-, NH_3 and PO_4^-.

Therefore water absorption decreased because stevia solution aggregates with water molecules preventing it considerably to form hydrogen bonds formation, thus water absorption decreased comparing to control (free from stevia extract) , this increasing represented about 1.53 , 11.45 , 33.59 , and 71.76 % at 25 , 50, 75 , and 100% substitution level stevia material withdraw water molecule to penetrate starch granules without forming hydrogen bonds but aggregate around stevia solution , thus prevent water molecules from going out the granules . This behavior increases swelling .

Wong and Lelievre(1982) mentioned that gelatinization process causes the melting of crystallites in the starch granule and resulting gel structure that is amorphous. Also , the presence of fats and oil affected the rheological properties when oil is added in the continues phase where a decrease in pasting properties were observed in the study of Osman and Dix (1960) .

ElSokkary (2000) found that addition of stevia (dry powder form) resulted in no significant differences in water absorption while an increase in dough development time was observed after the addition of 0.07 g stevioside powder . The same investigator found that dough stability was decreased as the stevia powder increased.

Table (4): Viscoamylograph characteristics of wheat dough free and containing 5% CSWE at different levels.

Viscoamylograph characteristics	Treatment with 5% CSWE*				
	0.0	25%CSWE*	50%CSWE*	75%CSWE*	100%CSWE*
Transition temp. (°C)	63	64.5	66.5	64.5	64.5
Maxixmum Viscosity (B.U)**	655	655	730	875	1125
Temp. of maximum viscosity (°C)	88.5	87.5	88.5	88.5	84.0

*CSWE= Crude stevia hot water extract.
** Brabender Units.

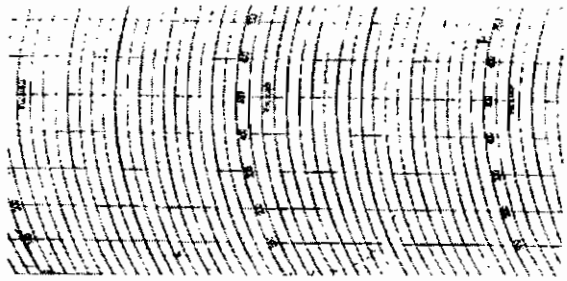


FIG (13): Control

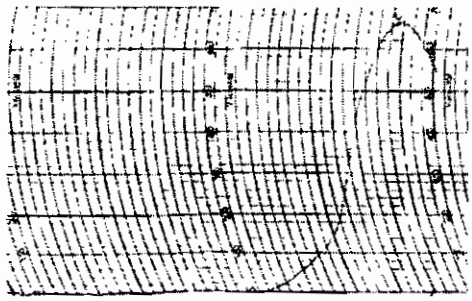


FIG (14): 25%CSWE*

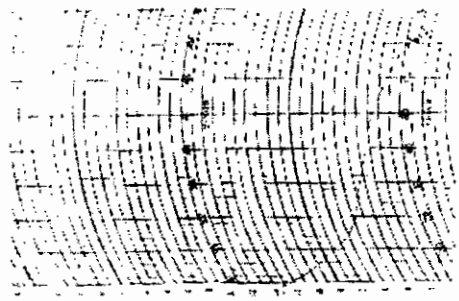


FIG (15):50%CSWE*

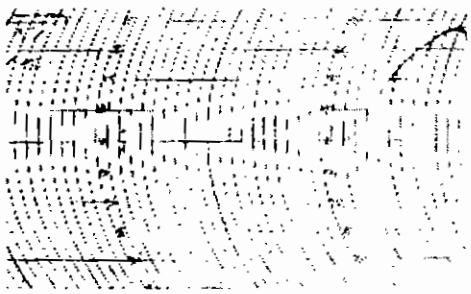
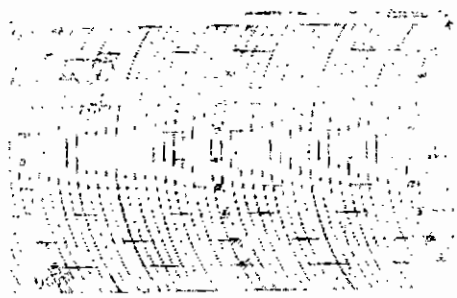


FIG (16): 75%CSWE*



8FIG (17):100%CSWE*

Figs (13-17): Viscoamylograph charadteristics of wheat dough free and containing 5% CSWE at different levels.

***CWSE = Crude stevia hot water extract.**

To confirm the obtained data about the effect of stevia on the viscosity of dough , stevia extracted solutions (concentrated and diluted) were examined using a computerized spindle viscometer . The obtained data are shown in Table (5). From this Table , it is clear that the concentrated solutions of stevia required nine folds of the revolving power compared to the diluted one in the lowest RPM(50), while both 100 and 150 RPM showed no considerable variations . Concerning viscosity , at 50 RPM gave 21.6 cP in concentrated solution, but in diluted one , there was no viscosity shear stress of concentrated solution 50 RPM was 3.05 , but of diluted one it was no considerable difference between concentrated and diluted solutions.
Concerning shear rate, there was no difference between the two solutions, at the same RPM .

Table (5): Viscosity characteristics of stevia solution

Solution Spindle Speed (RPM*)	Viscosity Characteristics				
	Torque %	Viscosity cP**	Shear Stress D/cm	Shear rate 1/sec	T***
Concentrated					
50	1.8	21.6	3.02	14.0	32.9°C
100	0.1	0.6	0.17	28.0	
150	0.3	1.2	0.50	42.0	
Diluted					
50	0.2	0 0	0.00	14.0	
100	0.1	0.6	0.17	28.0	
150	0.2	0 6	0.34	42.0	

***RPM= Revolution Per Minute.**
**** cP=Centipois**
*****T= Temperature.**

From the above results , it could be concluded that stevia solution was distinguished with high viscosity in concentrated solution , while its viscosity diminished at low concentration .Therefore the most suitable concentration to be used in baked products should be at 50 to 75 % .

The effect of 5% CSWE substitution of dough water at different levels on the production of gas was also studied using gasograph and the results are given in Table (6).

Table (6): Gasograph characteristics of wheat dough free and containing 5% CSWE*.

Period (min)	Treatment with 5% CSWE				
	0(control)	25%CSWE*	50%CSWE*	75%CSWE*	100%CSWE*
30	147	148.07	147.82	177.16	146.62
60	169	173.80	178.76	204.16	165.50
90	170	185 72	204.16	206.25	165.51
120	170	186.40	191.80	217.39	173.80

Average of duplicate as percentage of gas production
***CSWE = Crude stevia hot water extract.**

those revealed that , replacing water with 5% CSWE led to an increase in gas production until 75% replacing at the same fermentation period. At 75% replacing gave the highest increase , ranges between 20.5% after 30 min to 27.8 % after 120 min, but using CSWE at 100% replacing led to reduction in gas production comparing to control. This effect may be due to the presence of sugars (accelerator entation) and other components (depress fermentation process) in the crude extract of stevia. Generally, replacing water with 5% CSWE at 75% led to an increase in gas production and more leavening after baking.

Effect of CSWE on organoleptic properties of muffins:-

The effect of replacements 25,50,75 and 100% of sucrose with 5% CSWE on the organoleptic properties of muffins was studied. Table (7) shows the results of sensory evaluation and physical properties of muffins. The results indicated that replacing of sucrose solution with 5% CSWE reduced all characteristics and this reduction increased gradually with replacement increasing, but still good at levels 75% especially spongy, taste and overall palatability .

A general trend of non significantly ($p<0.05$) difference of all properties at levels 25,50,and 75 % but significantly ($p<0.05$) different at the 100% level substitution.

On the other hand slight increase in muffins weight but high in muffins volume gradually with substitution levels of 5% CSWE which increased to 75% and approximately was not affected at 100% comparing with muffins control.

Therefore , the obtained specific volume increased until 75% substitution level.

Finally it cab be concluded that a 5%CSWE can be used successfully to replace up to 75% of sugars in the preparation of muffins with good sensory characteristics.

Table (7):Effect of addition of CSWE on organoleptic properties and nature characteristics of muffins.

Samples	Organoleptic properties						Nature characteristics		
	Appearance	Spongy	Taste	Color	Odor	Overall acceptability	Weight (g)	Volume	Density
Control	9.2±0.32	9.5±0.37	9.0±0.42	9.4±0.36	8.92±0.41	9.4±0.38	168±3.12	34.30±2.25	4.89±0.62
25%CSWE*	8.25±0.21	8.75±0 27	8.62±0.33	8.72±0.38	8.78±0.28	8.15±0.43	184±2.55	42.92±1.29	4.28±0.71
50%CSWE*	8.53±0.17	9.32±0.40	8.11±0.45	8.58±0.28	8.23±0.18	9.2±0.34	240±4.43	47.16±2.16	5.08±0.48
75%CSWE*	7.8±0.22	8.82±0.26	6.85±0.19	7.54±0.35	7.24±0.22	8.12±0.28	228±5.66	44.48±3.02	5.12±0.65
100%CSWE*	4.95±0.25	5 72±0.18	4 39±0.27	6.22±0.33	6.32±0.28	6.00±0.31	165±4.37	47.23±3.55	3.49±0.34
L.S.D.	0.88	1.12	1.3	0.94	1.03	1.22	1.88	1.23	0.28

*CSWE = Crude stevia hot water extract

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تأثير استخدام الأستيفيوسيد كمحلى طبيعى على جودة المافن

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معهد بحوث تكنولوجيا الأغذية – مركز البحوث الزراعية – الجيزة – مصر

تمت دراسة تأثير استبدال الماء باربع مستويات مختلفة باستخدام محلول مستخلص الأستيفيا الساخن الخام (٥%) و هى٢٥ ،٥٠ ،٧٥ ، ١٠٠% و التى تحتوى على ٤١,١٥ ،٨٢,٣١ ، ١٢٣,٤٦ ، ١٦٤,٦٢ مجم ستيفيوسيد/١٠٠ملل و ذلك على الخصائص الريولوجية و الطبيعية لعجائن الدقيق باستخدام اجهزة الفارينوجراف والأكستنسوجراف و الفسكواميلوجراف و الجازوجراف .

و قد اوضحت النتائج حدوث نقص فى امتصاص الماء و النعومة فى حين ازدادت فترة الثبات و المقاومة للمطاطية و المرونة و كذلك انتاج الغاز و ذلك بصورة تدريجية مع زيادة معدل الأستبدال بمستخلص الأستيفيا ٥% حتى الوصول الى نسبة ٧٥% (١٢٣,٦٤ مجم ستيفيوسيد) كما اظهرت نتائج التقييم الحسى لعينات المافن المرجعية و المحتوية على مستخلص الأستيفيوسيد انه يمكن انتاج عينات جيدة حتى الوصول الى نسبة ٧٥% استبدال للسكر.