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EFFECT OF SUGAR REPLACEMENT WITH JERUSALEM ARTICHOKE FLOUR (*Helianthus tuberoses*) AND STORAGE ON LOW SUGAR BISCUIT QUALITY

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ABSTRACT: *The effect of sugar replacement with different levels(25, 50, 75 and100%) of Jerusalem artichoke flour as well as storing of the produced low sugar biscuits on proximate composition, mineral content, organoleptic properties and microbiological contents were evaluated. The results obtained showed that substitution of sugar with Jerusalem artichoke flour significantly (p≤0.05) increased ash and fiber contents of low sugar biscuits. However, minerals content progressively increased by increasing the levels of Jerusalem artichoke flour (JAF) from 25% to 100%. The increment of K, Ca, Mg and Fe were more obviously noticed when compared with control. Total count, mold and yeast decreased by increasing the levels of JAF. Meanwhile. coliform group was not detected in all treatments. The moisture content was decreased significantly(p≤0.05) with storage for 6 months at room temperature. Protein, fat, fiber, ash, carbohydrate, reducing sugar and non reducing sugar were not affected significantly (p >0.05) after storage. Total count, mold and yeast significantly (p≤0.05) increased by increasing the storage period at room temperature. Evaluation of organoleptic properties revealed that biscuits processed from sugar replaced with 25 and 50% JAF had significantly higher (p≤ 0.05) taste, odor and crust color compared with other biscuit blends,*

Key Words: *Jerusalem artichoke flour, Biscuit, Chemical composition, Storage stability and microbiology.*

INTRODUCTION

The food industry is being challenged to redesign traditional foods for optimal nutritional value, in response to some population sectors with particular nutritional necessities, and making them as tasty or better than the original. One way to achieve a healthy food product is to reduce or to omit some of the calorie-laden ingredients, especially sugar and fat, since, at present, obesity is frequently cited as a serious health problem. At the same time there is a constant demand for dietetic foods suitable for diabetics, that may have the same calorie-value being also sucrose free since this sugar cannot be metabolized without insulin. Sucrose is a principal ingredient in biscuit, and its role extends beyond providing energy and sweetness. In consequence, it cannot be substituted only by intense sweeteners. It acts as a tenderiser by retarding and restricting gluten formation, increasing the temperatures of egg protein denaturation and starch gelatinization, and contributing to bulk and volume (Kulp, *et. al.*, 1991; Ngo and Taranto, 1986; Shukla, 1995; Spies and Hoseney, 1982). Therefore, the reduction of sucrose levels affects structural and sensory properties (Frye & Setser, 1991). It is, thus, necessary to investigate the substitution of traditional and nutritional sweeteners to generate healthier foods but maintaining,at the same time, original colour, texture and flavour Southgate *et al.*, (1990) (Altschul, 1993) Showed that ther are two benefits can be, received upon consuming inulin. Frist the small proportion of glucose in the molecule makes it an alternative carbon source for diabetics. Secondly, their effect on colonic bacterial flora tends to reduce the digestive propels such as constipation. In this respect, it has a similar effect to dietary fibers that have strictly plant cell wall material.

Inulin and oligofructose have been used in many countries to replace fat or sugar to reduce the calories of some foods such as ice cream, dairy products, confections and baked goods. Inulin and oligofructose have caloric values lower than typical carbohydrates. This was attributed to the ß (2-1) bonds linking found in the fructose molecules. These bonds render them non digofructose pass through the mouth, stomach and small intestine without being metabolize (Rumessen *et al.,* 1990). Jerusalem artichoke powder suitable for use in dietetic and therapeutic nutrition. Jerusalem artichoke powder could be added at 7% (flour basis) to formulations containing sugar and at 5% to dietetic formulations containing sorbitol or fructose (Sinyavskaya *et al.*, 2003).

The aim of this research is to evaluate the effect of replacing sugar with Jerusalem artichoke flour on chemical, mineral, microbiological and sensory attributes of the produced biscuits. The changes in chemical composition, sensory attributes and microbiological contents during storage of low sugar biscuit were, also evaluated.

MATERIALS AND METHODS:

Materials:

1- Jerusalem artichoke tuber (*Helianthus tuberosus*)

The tubers were harvested in December- January 2007 obtaind from the Experimental Station, Agriculture Research Center, El-Kanater El-Khayria, Egypt.

2- Wheat flour (72%), sunflower oil, butter, sugar, salt, baker's yeast, baking powder were purchased from the local market of shebin El-Kom ,Minufiya, Governorate.

Methods:

preparation of Jerusalem artichoke tuber flour:

The tubers of Jerusalem artichoke were washed with tap water to remove dust and undesirable materials. The cleaned tubers were boiled in water for 5 minutes to avoid browning, then cut into small pieces and dried in an air oven at 50 – 55° C for 24 hour. The dried pieces were milled in cereal mechanical mill to pass through 100 mesh screen sieve. The powder was kept in polyethylene bags and stored at 4C°±1 in a refrigerator until used.

Preparation of low sugar biscuits:

Biscuit was processed using manufacturing methods adapted by Hashem, *et al.*, (2004). Palm oil (50gm) and sucrose (100gm) replaced by 25, 50, 75, and 100%of Jerusalem artichoke flour. were firstly creamed by Hobart mixer (model N 50, North York, Ontario, Canada). sodium bicarbonate (2gm) and ammonium bicarbonate (5.5 gm) were dissolved in part of water and added to the prepared creamed mixture. As creaming processing was continued, flour (350gm), 5gm skimmed milk powder and vanillin extract (0.04gm) were added and stirred well together. The full prepared dough was laminated. sheeted, extruded, molded and formed to the required form. The formed biscuit was baked at oven temperature of 230C° for 7 min. After baking, biscuit was cold and packaged manually in cellophane coated with vinyl dichloride. The recipe for biscuit was altered by partially replacing the sugar by 25, 50, 75, and 100%of Jerusalem artichoke flour.

Chemical analysis:

proximate composition

Moisture, crude fat, ash and protein were determined according to AOAC (2003). Reducing sugars were determined in the 70% ethanol extracts by the phenol-sulphuric acid method of Dubois *et al.,* (1956). Total carbohydrate was determined as glucose or fructose after hydrolyzation by HCl fiber were calculated by difference.

Minerals content:

Minerals contents were determined after digestion of the flours in concentrated HNO_3 and $HClO_4$ (1:1, v/v) for 2hr on hot plate. Na, Ca and K were estimated using an emission flame photometer (Model Corning 410, England). Mg, Fe and Zn were determined using an absorption spectrophotometer (Prekin-Elmer Instrument Model 2380, USA).

Sensory evaluation:

Biscuit products were organoleptically evaluated for general appearance, taste, crust color, crumb color, odor, and texture. their organoliptic characteristics by ten panelists from the staff department of food science and technology Faculty of Agriculture, Minufiya University. The scoring scheme was established according to the method of Abdel- lateef, (1995) as follows general appearance (20), taste (20), odor (15), crust color (15), crumb color (15), texture (15) and overall acceptability (100).

Microbiological analysis.

Total aerobic plate count (T.A.P.C):

The total aerobic plate count was determined using a nutrient agar medium. One ml of each dilution was plated with the above medium in duplicates and incubated at 37C° for48 h. The count was then calculated as cfu / g of sample as reported by F.A.O, (1992).

Determination of coliform counts:

Coliforms were counted using MacConkey agar medium (A.P.H.A, 1976).

Determination of mold & yeast

To duplicate sets of Petri-dishes, pipette 1 ml aliquots from 10^{-1}, 10^{-2}, 10^{-3}, 10^{-4}, dilution promptly pour into the Petri-dishes 10-15 ml of sabaroud Dextrose agar, method and tempered to 44-46C°. Immediately mix aliquots with the agar medium by tilting and rotating the Petri-dishes and incubate them at 25C° for 3-5 day to compute the number of mold and yeast per gm of food and multiply by the dilution factor, F.A.O, (1992).

Statistical analysis:

Statistical analysis was done using analysis of variance (ANOVA), Least Significant Difference (LSD) were obtained to compare the means of treatments, using Costat version 6.311 (Copyright 1998-2005, CoHort software. Duncan's multiple range test (Duncan 1955) was used to compare between the treatments means. The mean values within each column followed by same letters are not significantly different at 5% level of probability.

RESULTS AND DISCUSSION

Chemical composition of wheat flour (72 % Ex.) and Jerusalem artichoke flour :

Chemical composition (on dry weight basis) as well as mineral contents of wheat flour (72 %Ex.) as well as Jerusalem artichoke flour are represent in table (1). Wheat flour had a higher protein content (11.7%) than Jerusalem artichoke flour (8.6%). wheat flour (72% extraction) had a higher value of fat content (1.3%) than Jerusalem artichoke flour (0.8%) a higher value of crude fiber was noticed in Jerusalem artichoke flour (7.5%) than wheat flour 72% extraction (1.3 %). Jerusalem artichoke flour had the highest value of ash content (5.3%) wear the wheat flour 72% extraction had a lower ash content (0.8 %).

A higher value of total carbohydrates was found in wheat flour (84.9%) whereas the Jerusalem artichoke flour had a lower carbohydrate content (77.8%). these results are is in harmony with those reported by Ahmed and Barta (2000) and Rizk. (2006).

Table (1): Chemical and minerals composition (on dry weight basis) of wheat flour(72%extraction) and Jerusalem artichoke flour.

Samples		Wheat flour Ex.72%	Jerusalem artichoke flour
Moisture		13.6	6.8
Protein		11.7	8.6
Fat		1.3	0.8
Fiber		1.3	7.5
Ash		0.8	5.3
Total carbohydrates		84.9	77.8
Reducing sugars		8.3	7.6
Non reducing sugars		76.6	70.2
Macro. elements	Na	5	7
	K	13	89
	Ca	210	830
Micro. elements	Mg	161	436
	Fe	1.3	1.4
	Zn	20	18

Jerusalem artichoke flour had a higher value of potassium (89mg/100g), calcium (830mg/100g) and magnesium (436mg/100g) these results agree with Rizk. (2006) for sodium, potassium, calcium and Iron in Jerusalem artichoke flour. while the wheat flour (ext. 72%) contained a lower amount of potassium, calcium, magnesium and Iron (13, 210, 16, and 1.3mg / 100g respectively). this results agree with Hashem, *et al.*,(2004) for sodium and iron in wheat flour.

Chemical composition of low sugar biscuits:

Chemical composition of biscuit containing 25%, 50%, 75% and 100% replacement levels of Jerusalem artichoke flour instead of sugar are represented in Table (2). Replacement of sugar with Jerusalem artichoke flour up to 50% level had no significant ($p > 0.05$) effect on moisture content, while replacing sugar with 100% Jerusalem artichoke flour significantly ($p \leq 0.05$) increased the moisture content compared with control (100%sugar). This may be due to the ability of Jerusalem artichoke flour to hold more water compared with sugar. No significant ($p > 0.05$) effect was observed in protein and fat content of biscuit via replacing of sugar with different levels of Jerusalem artichoke flour. Except for 25% increased significantly($p \leq 0.05$) fiber content of the produced biscuit compared with control.

Table (2): Effect of storage for 6month and replacing sugar with different levels of Jerusalem artichoke flour on chemical composition of low sugar biscuit.

Properties	Control (100sugar)	% of Jerusalem artichoke flour				L.S.D	Storage periods (month)							L.S.D
		25%	50%	75%	100%		*Zero time	*1	*2	*3	*4	*5	*6	
moisture	21^{b}	22^{b}	23^{ab}	24^{a}	26^{a}	2.33	23.7^{a}	6.9^{b}	6.6^{b}	6.4^{b}	6.3^{b}	6.2^{b}	6^{b}	1.32
protein	10.6^{a}	10.7^{a}	10.8^{a}	10.9^{a}	11.2^{a}	1.54	10.5^{a}	10.5^{a}	10.5^{a}	10.5^{a}	10.4^{a}	10.4^{a}	10.4^{a}	1.59
fat	12.6^{a}	13.1^{a}	13.2^{a}	13.4^{a}	13.6^{a}	1.36	13.2^{a}	13.1^{a}	13.1^{a}	13^{a}	13^{a}	13^{a}	13^{a}	1.37
fiber	1.2^{b}	2.3^{ab}	2.8^{a}	3.3^{a}	3.7^{a}	1.22	2.9^{a}	2.9^{a}	2.9^{a}	2.9^{a}	2.9^{a}	2.9^{a}	2.8^{a}	1.11
Ash	2.3^{b}	2.7^{ab}	3.1^{a}	3.2^{a}	3.5^{a}	0.60	3.2^{a}	2.9^{a}	2.9^{a}	2.9^{a}	2.9^{a}	2.9^{a}	2.9^{a}	0.60
Total carbohydrates	73.3^{a}	71.2^{b}	70.1^{bc}	69.4^{cd}	68^{d}	1.21	70.2^{a}	70.6^{a}	70.6^{a}	70.7^{a}	70.8^{a}	70.8^{a}	70.9^{a}	1.21
Reducing sugars	9.4^{a}	9.1^{a}	9^{ab}	8.8^{ab}	8.5^{b}	0.63	8.9^{a}	8.8^{a}	8.8^{a}	8.7^{a}	8.6^{a}	8.5^{a}	8.2^{a}	0.73
Non Reducing sugars	63.9^{a}	62.1^{b}	61.1^{bc}	60.4^{cd}	59.5^{d}	1.47	61.3^{a}	61.8^{a}	61.8^{a}	62^{a}	62.2^{a}	62.3^{a}	62.7^{a}	1.57

*Mean of replacement at levels (25, 50, 75 and 100%) Jerusalem artichoke flour.
Mean in the same row with different letters are significantly different at ($p \leq 0.05$).

Significant increase ($p \leq 0.05$) in ash content of the produced biscuit by increased replacing sugar with (50, 75,and100%) Jerusalem artichoke flour compared with control, while no significant difference($p > 0.05$)were noticed between biscuit produced by replacement sugar with 25% Jerusalem artichoke flour and control but no significant difference ($p > 0.05$)were noticed among all replacement levels. Significant decrease ($p \leq 0.05$) was observed in total carbohydrate and non reducing sugars as well as up to(100% replacement level) in all replacement level compared with control, while a significant decrease ($p \leq 0.05$) was noticed in reducing sugars content in all replacement levels of Jerusalem artichoke flour. These are in the same line with Mazza (1985) and Abd EL-Lateef (2000) they found that increasing the replacement levels of Jerusalem artichoke flour was associated with an increase in each of ash, fiber and moisture in biscuit product. The effect of storage (at room temperature) for 6 month of low sugar biscuit produced by replacing sugar with Jerusalem artichoke flour at levels 25%, 50%, 75% and 100% on chemical composition are represented in Table (2). The moisture content was decreased significantly ($p \leq 0.05$) with storage. Protein, fat, fiber, ash, carbohydrate, reducing sugars and non reducing sugars did not affect significant $p > 0.05$ after storage. In general, the chemical composition of low sugar biscuit could be modified using Jerusalem artichoke flour, because these attributes were significantly ($p \leq 0.05$) from each other among the low sugar biscuit and from the control biscuit without Jerusalem artichoke flour. These increased in fiber and ash may be due to Jerusalem artichoke contain more fiber and ash than sugar.

Mineral content of low sugar biscuits:

Mineral content of biscuit containing 25%, 50%, 75% and 100% of Jerusalem artichoke flour instead of sugar are showed in Table (3). Replacement of sugar with Jerusalem artichoke flour 25%, 50%, 75% and 100% progressively increased the mineral content with increasing the replacement level of Jerusalem artichoke flour. Sodium content was increased by 7.6% with 25% Jerusalem artichoke flour and by 25%with replacement by 50% Jerusalem artichoke flour and by 58% with replacement 75% Jerusalem artichoke flour and by 91% with 100% replacement level.

Potassium content was increased by 53.8% with 25% Jerusalem artichoke flour, and by 130.7%with 50% replacement and by 161.5% with 75% replacement and by 246.2% with 100% replacement level. Calcium, magnesium and iron contents were increased by 27.3, 11.9 and 11.4% with 25% replacement level and by 50, 72.6 and 15.2%with replacement by 50% of Jerusalem artichoke flour and by 77.3, 80.9 and 25.7% with replacement by 75% Jerusalem artichoke flour and by 104.5, 138 and 35.2% with 100% replacement level.

Table (3): Effect of replacing sugar with Jerusalem artichoke flour on minerals content of biscuit (mg/100g) .

Samples	Macro elements			Micro elements		
	Na	K	Ca	Mg	Fe	Zn
100% sugar	12	13	220	84	2.10	23
75% sugar + 25%Jerusalem artichoke flour	13	20	280	94	2.34	22
50% sugar + 50%Jerusalem artichoke flour	15	30	330	145	2.42	21
25% sugar + 75%Jerusalem artichoke flour	19	34	390	152	2.64	21
100% Jerusalem artichoke flour	23	45	450	200	2.84	20

On the other hand, Zinc contents slightly decreased by increasing the level of Jerusalem artichoke flour (from 25 to 100 %) compared with control. Generally the minerals content in biscuit made from wheat flour with different concentrations of Jerusalem artichoke flour was found to be higher than that in biscuit made of wheat flour. From the above discussed data, it could be concluded that the addition of Jerusalem artichoke flour to low sugar biscuit could be improve the mineral content of such biscuit and may be take part in partial providing children and adults consuming biscuit with their daily requirements of K, Ca, Mg and Fe. This increase in mineral content may be due to Jerusalem artichoke is rich in minerals (Table 3) than wheat flour. These results agree with Hashem *et al.*, (2004)who reported that the replacement of wheat flour with Jerusalem artichoke flour 5%, 10% and 15% progressively increased the minerals content.

Microbiological analysis of low sugar biscuits.

Effect of replacing sugar with different levels (25%, 50%, 75% and 100%) of Jerusalem artichoke flour on the microbiological content of the produced low sugar biscuits are presented in Table (4). It could be seen that replacement of sugar by Jerusalem artichoke flour resulted in a significant decrease ($p \leq 0.05$) in *total count* of at levels 25, 50, 75 and 100% were (5×10^3, 3×10^3, $5\times10^2$and 3×10^2). Significant ($p \leq 0.05$) decrease by increasing the levels of Jerusalem artichoke flour on *total count* compared with control. *Mold &yeast* of microbiological quality at levels 25, 50, 75 and 100% were (3×10^3, 2×10^3, $3\times10^2$and 2×10^2) respectively. Significant ($p \leq 0.05$) decrease by increasing the levels of Jerusalem artichoke flour on *mold &yeast* compared with control. The *Coliform group* was not detected in all treatments. On the other hand effect of storage at room temperature (for 6month) and replacing sugar with different levels of Jerusalem artichoke flour on microbiological analysis of low sugar biscuit are presented in Table (4). Significant ($p \leq 0.05$) increase by increase the storage period on *total count* compared with zero time.

Table (4): Effect of storage for 6month and replacing sugar with different levels of Jerusalem artichoke flour on microbiological analysis of low sugar biscuit.

Properties	Control (100sugar)	% of Jerusalem artichoke flour				L.S.D	Storage periods (month)							L.S.D
		25%	50%	75%	100%		*Zero time	*1	*2	*3	*4	*5	*6	
Total Count	8×10^{3a}	5×10^{3b}	3×10^{3b}	5×10^{2b}	3×10^{2b}	23.65	3×10^{3c}	6×10^{3bc}	4×10^{4b}	5.2×10^{3b}	1.3×10^{5a}	2.4×10^{5a}	6×10^{5a}	22.25
Coliform group	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mold& yeast	5×10^{3a}	3×10^{3b}	2×10^{3b}	3×10^{2b}	2×10^{2b}	20.74	1×10^{3c}	4×10^{3bc}	3×10^{4b}	4.1×10^{4b}	8×10^{4bc}	2×10^{5a}	5×10^{5a}	20.14

*Mean of replacement at levels (25, 50, 75 and 100%) Jerusalem artichoke flour.
Mean in the same row with different letters are significantly different ($p\leq0.05$).

While significant ($p \leq 0.05$) increase by increasing the storage period on *mold & yeast* compared to zero time. These result agree with Abd El-Hady, (2003) who found that replacement of wheat flour with Jerusalem artichoke flour on bread discourage the growth of *total count, mold* and *yeast* bacteria compared with control after storage at room temperature for 1 week.

Sensory attributed of low sugar biscuits.

Effect of replacing sugar with different levels (25%, 50%, 75% and 100%) of Jerusalem artichoke flour on sensory attributes of the produced low sugar biscuits are represented in Table (5). It could be seen that replacement of sugar by JAF resulted in an increase in average of overall acceptability (90.9, 94.7 and 88.2) of organoleptic quality at levels 25, 50 and 75% led to low score values, compared with (88) in the control sample. In addition, it should be noted from the statistical analysis of the abovementioned data that no significant ($p > 0.05$) differences between control and replacement of sugar up to 75% Jerusalem artichoke flour on low sugar biscuit for appearance, taste, odor, crust color, crumb color and texture. While replacement of 25% and 50% Jerusalem artichoke flour on low sugar biscuit significantly ($p \leq 0.05$) increased appearance, odor, crust color, crumb color and texture of the produced low sugar biscuit compared with control. On the other hand, replacement all sugar with Jerusalem artichoke flour significantly ($p \leq 0.05$) decreased the appearance, odor, crust color, crumb color and texture of the produced low sugar biscuit (compared with control).The effect of storage (for 6month) on organoliptic evaluation of low sugar biscuit is represented in Table (5). No significant ($p > 0.05$) differences after storage for 5 month in all treatments on appearance, odor, crust color, crumb color, texture and overall acceptability of the produced low sugar biscuit. While significant ($p \leq 0.05$) decrease in appearance, odor, crust color, crumb color, texture and overall acceptability of the produced low sugar biscuit were noticed after storage at room temperature for 6month. The replacement of wheat flour with JAF in hard sweet biscuit resulted in an increase in the average at total score of organoliptic quality at levels 5 and 10% of JAF replacement but decrease at level 15%JAF (Rizk, 2006 & Hashem *et al.*, 2004).

Table (5): Effect of storage for 6month and replacing sugar with different levels of Jerusalem artichoke flour on organoliptic evaluation of low sugar biscuit.

Properties	Control (100sugar)	% of Jerusalem artichoke flour				L.S.D	Storage periods (month)							L.S.D
		25%	50%	75%	100%		*Zero time	*1	*2	*3	*4	*5	*6	
General appearance 20	16.5 ^{ab}	17.1 ^{a}	18.6 ^{a}	16.6^{ab}	14.6 ^{b}	2.47	16.7^{a}	16.4^{a}	15.6^{a}	15.2^{a}	14.6^{a}	14^{a}	12.6^{b}	2.42
Taste 20	16.5 ^{ab}	17.3 ^{a}	18.5 ^{a}	16.7^{ab}	13.5 ^{b}	2.83	16.5^{a}	15.2^{a}	15.2 ^{a}	14.6 ^{a}	13.9 ^{a}	13.4^{a}	12.4^{b}	2.75
Odor 15	13.8 ^{a}	14.1 ^{a}	14.3 ^{a}	13.8 ^{a}	10.8 ^{b}	2.21	13.3^{a}	12.6^{a}	12.2^{a}	11.3^{a}	10.9^{a}	10.2^{a}	10.2^{b}	2.17
Crust color 15	13.8 ^{a}	14.1 ^{a}	14.4 ^{a}	13.8 ^{a}	10.8 ^{b}	2.32	13.3^{a}	12.5^{a}	12.3^{a}	11.3^{a}	11.1^{a}	10.4^{a}	10.1^{a}	2.31
Crumb color 15	13.5 ^{a}	14 ^{a}	14.3 ^{a}	13.5 ^{a}	9.8 ^{b}	2.13	12.9^{a}	12.1^{a}	11.9^{a}	10.9^{a}	10.8^{a}	10.6^{a}	10^{b}	2.04
Texture 15	13.9 ^{a}	14.3 ^{a}	14.6 ^{a}	13.8 ^{a}	9.8 ^{b}	2.37	13.2^{a}	12.5^{a}	12.3^{a}	11.9^{a}	11.1^{a}	10.4^{a}	10.1^{b}	2.41
Overall acceptability 100	88 ^{a}	90.9 ^{a}	94.7 ^{a}	88.2^{a}	65.3 ^{b}	14.23	84.7^{a}	81.6^{a}	78.1^{ab}	76.4^{ab}	75.1^{ab}	69^{ab}	65.4^{b}	14.16

*Mean of replacement at levels (25, 50, 75 and 100%) Jerusalem artichoke flour.
Mean in the same row with different letters are significantly different at ($p \leq 0.05$).

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تأثير استبدال السكر بدقيق درنات الطرطوفه والتخزين على جودة البسكويت منخفض السكر.

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الملخص العربى

تم استبدال سكر السكروز فى البسكويت بنسب مختلفة (٢٥، ٥٠، ٧٥، ١٠٠%) من دقيق درنات الطرطوفه وقياس تأثير ذلك على التركيب الكيماوى والمحتوى الميكروبى والخصائص الحسية . وكذلك تم دراسة تأثير التخزين للبسكويت منخفض السكرعلى درجة حرارة الغرفة لمدة ٦ اشهر على نفس الخواص. وقد أظهرت النتائج ارتفاع معنوى لكل من الرماد والألياف بزيادة نسبة الاستبدال. محتوى البسكويت المنتج من المعادن المختلفة زاد بصورة مطردة مع زيادة نسب استبدال السكر بدقيق درنات الطرطوفة وكانت هذه الزيادة أكثر وضوحا فى محتوى البسكويت من السبوتاسيوم،الكالسيوم، الماغنسيوم، الحديد. بينما انخفض المحتوى الميكروبى للعدد الكلى للبكتريا والفطريات والخمائر مع زيادة نسبة استبدال السكر أما مجموعة بكتريا القولون لم يظهر لها اى نموات فى جميع العينات. من الجانب الأخر كان هناك انخفاض معنوى فى نسبة الرطوبة للبسكويت منخفض السكر أما بالنسبة للبروتين، والدهون، والألياف، والرماد، والكربوهيدرات الكلية، والسكريات المختزلة والغير مختزلة لم يحدث لها انخفاض معنوى أثناء التخزين على درجة حرارة الغرفه لمدة ستة اشهر.وأظهرت نتائج التخزين على درجة حرارة الغرفة لمدة ٦ اشهر للبسكويت منخفض السكر زيادة معنوية فى محتواه من العدد الكلى للبكتريا والخمائر والفطريات وخلوها من بكتريا مجموعة القولون. أما بالنسبه للخواص الحسية للبسكويت المصنع فقد أوضحت النتائج حدوث تحسن ملحوظ فى الطعم والرائحة واللون الخارجى حتى مستوى استبدال ٥٠% من دقيق درنات الطرطوفة بالمقارنة بباقى الاستبدالات.