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ABSTRACT

The present study was aimed to evaluate the addition of different levels (10, 15, 20 and 30%) of sweet potato tubers powder to cupcakes. Gluten free rice cupcake samples were prepared by replacing white rice (*Oryza sativa*, L.) flour by sweet potato (*Ipomoea batatas,* L.) flour at different levels. All different cupcakes formula were baked at 200 °C for 5 mintues followed by 180° C for about 45 min then cooled before evaluation, packaged in polyethylene bags and stored at temperature 5ºC. Minerals contents, total phenols, total flavonoids, antioxidant activity, total carotenoids and phenolic compounds of the sweet potato tubers were determined. The chemical compositions, objective, color characteristics and sensory properties of cupcake samples were also evaluated. The results showed that wheat flour contains high amounts of moisture, protein and energy value as compared with rice and sweet potato flour. The mean values were 8.45%, 12.20% and 401.07 kcal/100kg, respectively. While, sweet potato flour contains high amounts of ash and fiber. The mean values were 7.01% and 7.78 %, respectively. Sweet potato tubers contain high amounts of (potassium, calcium and magnesium), total phenols, total flavonoids, antioxidant activity and total carotenoids contents. The highest phenolic compounds in sweet potato tubers recorded for quercetin, rosmarinic acid and chlorogenic acid. The mean values were 327.0, 250.0 and 41.25 mg/g on dry weight basis, respectively. The lowest fat, N-free Extract and energy value contents recorded for cupcake fortified with 20% sweet potato flour except for N-free Extract of cupcake from rice flour with significant differences. Cupcake with 10 % sweet potato flour recorded higher objective properties and color than cupcake with 20 % sweet potato flour. In conclusion, sweet potato flour with white rice flour can improvement the nutritional value, objective and sensory properties of rice cake produced for celiac disease.

Keywords: Bakery products –vegetables tubers -celiac disease **-** bioactive compounds **-** quality.

INTRODUCTION

Food sensitivities are increasing in prevalence within the general population, and wheat-related proteins play a prominent contributing role in this trend **(Sicherer and Sampson, 2014)**. Celiac disease (CD) is an autoimmune condition characterized by a specific serological and histological profile triggered by gluten ingestion in genetically predisposed individuals. CD remains a challenging condition because of a steady increase in knowledge tackling its pathophysiology, diagnosis, management, and possible therapeutic options **(Fasano and Catassi, 2012)**. CD is a chronic entheropathy produced by gluten intolerance, more precisely to certain proteins called prolamines, which causes atrophy of the intestinal villi, mal absorption and clinical symptoms that can appear in both childhood and adulthood that occurs in genetically predisposed people of all ages **(Miñarro *et al.*, 2012; Osella *et al.*, 2014)**. CD is only one aspect of a range of possible manifestations of gluten reactions. Other immunologically mediated gluten-dependent disorders are wheat allergy and non–celiac disease gluten sensitivity. Wheat allergy is an adverse IgE-mediated immunologic reaction to wheat proteins. Depending on the route of allergen exposure and the underlying immunologic mechanisms, wheat allergy can be classified into four categories **(Sapone *et al.*, 2012)**.In addition to a genetic predisposition, the development of CD relies on exposure to dietary gluten, a ubiquitous feature of Western populations. Gluten proteins actually encompass both gliadins, which contain monomeric proteins,and glutenins, which are polymeric aggregated proteins **(Husby *et al.*, 2014)**. A major milestone in the history of celiac disease was the identification of tissue transglutaminase as the autoantigen, thereby confirming the autoimmune nature of this disorder. A genetic background is a mandatory determinant of the development of the disease, which occurs with the contribution of environmental factors (e.g., viral infections and dysbiosis of gut microbiota). Its prevalence in the general population is of approximately 1%, with female predominance. This multifaceted clinical presentation leads to several phenotypes, i.e., gastrointestinal, extra intestinal, subclinical, potential, seronegative, non-responsive, and refractory. Currently, the only treatment for celiac disease is a life-long, strict gluten-free diet leading to improvement in quality of life, ameliorating symptoms, and preventing the occurrence of refractory celiac disease, ulcerative jejunoileitis, and small intestinal adenocarcinoma and lymphoma **(Caio *et al.*, 2019)**.

Gluten is the general term for alcoholsoluble proteins present in various cereals, including wheat, rye, barley, and other closely related cereal grains **(Deora *et al.*, 2015)**.

Flour and starches from rice, corn, cassava, millet, potato; proteins from vegetable sources; and hydrocolloids have been used as gluten replacement ingredients by the food industry **(Mohammadi *et al.*, 2014)**.

There have been significant changes in the diagnosis, pathogenesis, and natural history of this condition, with CD undergoing a true ‘metamorphosis’ due to the steady increase in the number of diagnoses identified, even in geriatric patients. This has been mainly attributed to the greater availability of sensitive and specific screening tests, which allow identification of the risk groups for CD and led to a significant raise in diagnoses worldwide **(Volta *et al.*, 2014)**. Several theories have suggested that the globalization and ubiquitous spread of ‘false’ or ‘extreme’ versions of the Mediterranean diet including the consumption of very high quantities of gluten (up to 20 g/day), has led to an increased prevalence and incidence of CD **(de Lorgeril and Salen, 2014)**. In addition, the quality of gluten itself might also play a contributory role. Indeed, the production of new kinds of grain as a result of technological rather than nutritional reasons may have affected the observed increase in the number of CD diagnoses in recent years **(Van den Broeck *et al.*, 2010)**. The presence of gluten in baking products is a serious health threat to genetically predisposed individuals with HLA haplotyres DQ2. This health condition referred to as celiac disease is a systemic immune-mediated disorder caused by the ingestion of gluten containing grains or products by genetically susceptible individuals **(Lionetti *et al.*, 2015)**.

Rice (*Oryza sativa*, L.) is one of the staple foods for more than 3 billion people in more than 100 of the world. Based on the bran color, rice is classified into non-pigmented rice and pigmented rice **(Birla *et al.*, 2017)**. Rice flour is a suitable replacement for wheat flour in the production of gluten free cakes because of the absence of gluten, low amounts of fat, sodium, fiber but high amounts of digestible carbohydrates **(Demirkesen *et al.*, 2010)**. Rice flour is one of the most suitable flours for baking gluten-free products due to its hypoallergenic properties, low sodium content, mild flavour and pale appearance. The particle size of rice flour is also known to be important in gluten-free bread making **(Torbica *et al.*, 2012)**.

Ipomoea batatas L. (Family: *Convolvulaceae*) is commonly known as sweet potato, it is the world's sixth largest food crop, which is widely grown in tropical, subtropical and warm temperate regions. It is an important food crop in many countries **(Truong and Avula, 2010)**. Sweet potatoes are rich in complex carbohydrates, dietary fiber and beta carotene (a precursor of vitamin A), vitamin B6, and vitamin C. Sweet potatoes (SP) can be differentiated into several types based on the color of the tuber, like white, yellow, orange, white striped - purple and purple. In each type of sweet potato has a nutrient content and functionally different. Both sweet- potato roots and leaves are considered to be rich sources of phenolic compounds, high contribute toward the antioxidant activity of sweet potato tissues **(Utami and Rahayn, 2012)**. The major phytochemicals that are generally present in sweet potato are flavonoids, terpenoids, tannins, saponins, glycosides, alkaloids, steroids and phenolic acids. These constituents may vary with varieties depending on flesh and skin colours. Orange varieties are particularly rich in beta-carotene, while purple sweet potato contains higher anthocyanin content than other varieties of sweet potato **(Swamy and Omwenga, 2014)**.

Hence, the purpose of this study was to investgate the quality attributes as chemical composition, objective and sensory properties of gluten free rice cupcakes. Also, effect of fortified with different levels of sweet potato on quality attributes of cupcake.

MATERIALS AND METHODS

Materials

White wheat flour (72% extraction) and white rice flour obtained from (local markets Alexandria government, Egypt). Fresh sweet potato tubers (*Ipomoea batatas*), salt, full fat milk powder, sugar, baking powder, vanilla, eggs and butter were also purchased from local markets Alexandria Governorat, Egypt.

Methods

Preparation of sweet potato flour:

The sweet potato tubers were washed, hand-peeled, shredded and sliced. Sweet potato slices were dried by using an electric oven with an air fan (Deker 3-FM-IN-, France) at 45^{o}C for about 24 hours. The dried sweet potatoes were milled by house mincer (Brown, 351XF Super Blender, Germany). The sweet potato flours were packed in polyethylene bags and kept at 10^{o}C until analysis or for further use in the preparation of cupcakes.

Preparation of Rice Cup Cake Samples:

The ingredients of the cupcakes are tabulated in table (1) according to **A.A.C.C. (2002)**. The control samples were prepared without any sweet potato tubers powder. The sweet potato tubers powder was substitution and addition to rice flour at four levels (10%, 15%, 20% and 30%) the butter and granulated sugar icing were creamed together using the Kenwood mixer for 25minutes until light and fluffy. Vanilla essence was added, and the mixture was creamed a little more. The eggs were added and the liquid content was beaten for a while. This was added to the creamed mixture and beaten together. Then, the flour with or without sweet potato flour and the baking powder were sieved together, and folded alternately with the milk into the creamed mixture. The dough was filled into prepared cupcakes pans to about 2/3 the can volumes. These were baked at oven temperature of 200° C for 5 minutes then of 180° C for about 45 min then cooled on racks for about one hour before evaluation and packaged in polyethylene bags and cold storage stored at 5°C.

Table (1): Ingredients of cupcakes with sweet potato tubers powder

Ingredients (g)	Wheat flour (g)	Rice flour(g)	Experimental samples%			
			10%	15%	20%	30%
Rice flour	0	100	90	85	80	70
Wheat flour	100	0	0	0	0	0
Sweet potato powder	0	0	10	15	20	30
Sugar icing	150	150	150	150	150	150
Egg	125	125	125	125	125	125
Milk	120	120	120	120	120	120
Butter	100	100	100	100	100	100
Vanilla essence	5	5	5	5	5	5
Baking powder	8	8	8	8	8	8
Total	**608**	**608**	**608**	**608**	**608**	**608**

Chemical analysis of wheat, rice and sweet potato tubers flours:

The control of each product and the fortified products (cupcakes with 10% &20%) were subjected to chemical analysis to determine the protein, fat, fiber, ash, and moisture content according to **A.O.A.C. (2000)**. The N-free extract content was obtained by subtracting the percent total of the fat, protein, fiber and ash contents from 100%.Caloric values were calculated from the sum of the percentages of crude protein and total carbohydrates multiplied by a factor of 4 (Kcal.g^{-1}) plus the crude fat content multiplied by a factor of 9(Kcal.g^{-1}) according to **Zambrano *et al.* (2004)**.

Determination of minerals of sweet potato tubers:

Minerals (Fe, Ca, Cu,Mg andS) were determined by using Atomic Absorption Spectrometry according to **Luten *et al.* (1996)**. Total phosphorus was assayed calorimetrically at 630 nm using Carlzeiss Spekol colorimeter according to **A.O.A.C. (2000)**. Na and K were measured using Flame Photometer Model PEP7 as described by the **(A.O.A.C., 2000)**.

Determination of phytochemicals for sweet potato tubers:

Total polyphenol content was carried out according to **Elfalleh *et al.* (2009)**. Flavonoids were extracted and determined according to **Zhuang *et al.* (1992)**. An antioxidant activity (DPPH radical scavenging activity) was estimate according to the method of **Brand-Williams *et al.* (1995)**.

Identifications of phenolic compounds using HPLC for sweet potato tubers:

Extraction, separation and quantification of phenolic compounds were determined according to the method described by **Goupy *et al.* (1999)**. The HPLC system Perkin Elmer PE200 was composed of a binary pump, a column thermostat and an auto sampler. The mass spectrometer used was a 3200QTRAP MS/MS with ESI ionization (Applied Biosystems / MDSSciex, Foster City, California). A bin pump model G1312A, an auto-sampler model G1313A and a RR Zorbax Eclipse Plus C18 column (1.8 µm, 150 mm ×4.6 mm). The mobile phase A was 0.2 % formic acid in water and the mobile phase B was acetonitrile. Elution was performed at 0.95 mL min-1 with the following gradient program of solvent B: 0–20 min, 5–16 %; 20–28 min, 16–40 %; 28–32 min, 40–70 %; 32–36 min, 70–99 %; 36– 45 min, 99 % and 45–46, min. 99–5 %.30. The injection volume was 10 µL. Wave lengths of 280 nm (for flavan-3-ols and benzoic acid derivatives) and 360 nm (for flavonols and cinnamic acid derivatives) were selected for detection. Quantification of the compounds was realized using calibration curves obtained by HPLC of pure standards: gallic acid, caffeic acid, (+)-catechin, (-)-epicatechin, and ellagic acid. Rutin was used as an internal standard. Some compounds were quantified as equivalents of the most similar chemical structures: gallic acid for gallic acid glucoside, gentisic acid glucoside, protocatechuic acid, p-hydroxybenzoic acid and methyl gallate; caftaric acid as caffeic acid; (+)- -catechin for proanthocyanidin dimers and trimers and their monogallates; (–)-

epicatechin for epicatechingallate; ellagic acid for ellagic acid pentoside.

Determination of carotenoids for sweet potato tubers:

Carotenoids were determined according to the methods of **A.O.A.C. (2007).**

Objective measurements of cupcakes fortified with sweet potato tubers flour:

Objective evaluations were done on the products after cooling. The products were removed from the pan and cooled on a wire rack for at least two hours. Weight before and after baking, changes in baked weight was represented as a percentage by using the following equation:

$$\text{cooking loss (\%)} = \frac{\textbf{Weight before baking (g.) - Weight after baking (g.)}}{\textbf{Weight before baking (g.)}} \times \textbf{100}$$

Volume (cm^3) and weight (g) of four cupcake samples of each formation were measured. Estimation of specific volume (g/cm^3) was calculated by dividing of the volume to weight according to the method described in **A.A.C.C. (2000)**.

Color measurement

The color attributes were measured using (Hunter Lab Easy Match QC made in USA). The color parameters (a*, b* and L*) were determined. The a* denotes the red/ green value and b * the yellow / blue value. The L* axis has the following boundaries L= 100 (white or total reflection) and L= 0 (black or total absorption), according to **See *et al*. (2007).**

Sensory evaluation

The sensory characteristics of the samples were analyzed according to **Aljdely and Hemida (2002)** by 25 persons from staff, employees and students of Faculty of Specific Education, Alexandria University, participated in the study. Parameters were taste, color, texture, odor and the overall acceptability which was estimated as the total mean score of all the sensory parameters. A scale of 9-point hedonic scale with ranging from 1(representing extreme dislike) to 9 (representing extreme like) was used to evaluate the sensory attributes.

Statistical analysis:

The data was analyzed using IBM SPSS software package version 20.0. (Armonk, NY: IBM Corp) **(Kirkpatrick and Feeney, 2013)**. Quantitative data were described using mean ± standard deviation. While ANOVA was used for comparing the studied groups and followed by Post Hoc test (LSD) for pairwise comparison. The significance of the obtained results was judged at the 5% level **(Kotz *et al.*, 2006)**.

RESULTS AND DISCUSSION

Gross chemical composition of wheat, rice and sweet potato tubers flours:

Data in Table (2) showed the gross chemical composition of wheat, rice and sweet potato tubers flours. It is clear to notice that the wheat flour contains high amounts of moisture, protein and energy value as compared with rice and sweet potato flour with significant difference ($P \leq 0.05$). The mean values were 8.46±0.13, 12.20±0.15 (g/100gDW) and 401.07±0.16 kcal/100kg, respectively. On the other hand, sweet potato flour contains high amounts of fat, ash and fiber with significant difference ($P \leq 0.05$). The mean values were 1.22±0.14, 7.01±0.11 and 7.78 ±0.12(g/100gDW), respectively. Data also indicated that, rice flour recorded the highest NFE contents as compared with wheat and sweet potato flour. The mean values were 90.34±0.13, 85.39±0.12 and 75.32±0.15, respectively. These results are in harmony with **Koua *et al.* (2018)** who reported that the nutritional properties of sweet potatoes were the energy value (363 to 374.08kcal/100 g DW) of whole sweet potato flour, primarily due to its high carbohydrate content (86.75 to 90.87 g/ 100 g DW). Low moisture content (4.50 to 6.30 g/ 100 g DW), and lipids (0.63 to 1.94 g/ 100 g DW) were reported in whole sweet potato flour compared to white corn and white rice flours, the sweet potato flour had the highest ash and fiber content **(Rodrigues *et al.*, 2016)**.

Selected sweet potato varieties are rich in protein and carbohydrates, low in fat, high in polyphenols and carotenoids, and could therefore be a good source of dietary fiber and antioxidants to prevent free radical damage that leads to chronic diseases, as well as to prevent malnutrition with vitamin A **(Alam *et al.*, 2016)**.

Table (2): Gross chemical composition of wheat, rice and sweet potato tubers flours(g/100g DW)

Parameters \ Constitutes	Wheat flour	Rice flour	Sweet potato	LSD
Moisture	8.46[a]±0.13	5.89[c]±0.14	6.35[b]±0.10	0.242
Protein	12.20[a] ±0.15	7.91[c]±0.10	8.67[b]±0.13	0.2489
Fat	1.19[a]±0.10	0.71[b]±0.11	1.22[a] ±0.14	0.2302
Ash	0.63[b]±0.14	0.50[b]±0.12	7.01[a]±0.11	0.2412
Fiber	0.59[b]±0.11	0.54[b]±0.10	7.78[a]±0.12	0.2166
NFE*	85.39[b]±0.12	90.34[a]±0.13	75.32[c]±0.15	0.2659
Energy value(Kcal/100g)	401.1[a]±0.16	399.4[b]±0.15	346.9[c]±0.14	0.301

Values are expressed as mean ± SD. Mean value with different letters in the same raw are significantly different ($P \leq 0.05$)), and vice versa.

* N-free Extract (%) calculated by difference.

Minerals content of sweet potato tubers:

The mineral contents of sweet potato tubers are shown in Table (3). It is obvious that the highest mineral contents of sweet potato tubers recorded for potassium, calcium and magnesium. The values were 850.11±0.60, 182.20±0.40 and 108 mg/100g, respectively. While the lowest values recorded for copper, zinc and iron. The values were 1.01±0.11, 4.01±0.10 and 4.02±0.51, mg/100g, respectively. These results are in agreement with **Koua *et al.* (2018)** registered magnesium (49.37±1.09 to 540.87±0.82 mg/100 g DM), calcium (50.28±1.14 to 110.53±0.79 mg/100g DM), phosphorus (25.12±1.04 to 42.75±0.82 mg/100g DM), potassium (906.25±0.33to 1625±0.61 mg/100g DM) and iron (5.62±0.84to26.89±0.76 mg/100g DM) as the mineral content. **Alloush (2015)** which claimed that certain minerals such as Ca, P, K, Fe, and Zn were high enough of the mineral content of sweet potato varieties and flours. Moreover, sweet potatoes (OSP) had a higher percentage of mean Ca content (111.5-115.4) mg/100g than white-sweet potatoes (WSP). They were also not substantially different in the iron content (OPF and WSP) being the (3.203-

2.096mg/100g). The potassium content of the OSP and WSP respectively was (149.26 - 126.87 mg/100g).

Table (3): Minerals content of sweet potato tubers(mg/100g DW).

Minerals	Concentrations
Phosphorus	60.01±0.12
Potassium	850.11±0.60
Sulfur	78.5±0.10
Calcium	182.20±0.40
Magnesium	108.08±0.31
Iron	4.02 ±0.51
Zinc	4.01±0.10
Copper	1.01±0.11
Sodium	45.61±0.21

Values are expressed in mean ± SD.

Total phenols, total flavonoids, scavenging activity and total carotenoids of sweet potato tubers

Data tabulated in Table (4) showed the total phenols, total flavonoids, scavenging activity and total carotenoids of sweet potato tubers. The obtained data indicated that the total phenols, total flavonoids, scavenging activity and total carotenoids contents of sweet potato roots were 164.17±0.12 mg GAE / 100 g DW, 130.15±0.10 mg CAT/100g DW, 46.50 ±0.14 and 362.22±0.11 mg/g, respectively. These findings are consistent with **Tang *et al.* (2015)** who reported that sweet potato has plenty of phenolic substances and carotenoid material, both contributing to the efficiency of radical scavenging. Phenolics and anthocyanins are the main bioactive substances in the purple sweet potato. Phenolics are antioxidant molecules with one or more hydroxyl groups and at least one aromatic ring.**Shen *et al.* (2015)** stated that phenolics are important mainly because of their role in scavenging the human body's free radicals and helping to maintain a healthy body by scavenging or eliminating the reactive oxygen species (ROS). **Fu *et al.* (2011)** have also stated that carotenoids (such as β-carotene) serve as the primary pigment molecule in yellow or orange sweet potato species, as well as the source of provitamin A, which demonstrates vitamin A production. Because of their conjugated double bonds, carotenoids have a good antioxidant capacity to scavenge free radicals.

Sweet potatoes, reported by **Tomlins *et al.* (2012)** are rich in carotenoids and pro-vitamin A. Compounds of carotenoids are commonly present in fruits and vegetables and are responsible for the pigmentation of yellow, orange, and red. Carotenoids are substances with pharmaceutical and medicinal benefits that provide antioxidants. The highest total carotenoid content was found in yellow, purple and white sweet potatoes, followed by orange sweet potatoes. In all sweet potato varieties, β-carotene was available, ranging from 91.95±2.05 µg/g DW in white sweet potato to 376.03±11.05 µg/g DW in orange sweet potato.

Table (4): Total phenols, total flavonoids DPPH, and carotenoids of the sweet potato tubers

Active compounds	Concentration
Total phenols (mg GAE/ 100g DM)	164.17±0.12
Total flavonoids (mg CAT/100 g DM)	130.15 ±0.10
(DPPH) Scavenging capacity(%)	46.50±0.14
Total carotenoids(mg/g)	362.22±0.11

Values are expressed in mean ± SD.DM= Dry matter GAE= Gallic acid equilibrium CAT. = Catechin DPPH = 1, 2- diphenyl picrylhydrazyl**.**

Phenolic compounds of sweet potato roots fractionation by HPLC analysis

Data presented in Table (5) showed the phenolic compounds of sweet potato tubers fractionation by HPLC analysis (mg/kg on dry weight basis). It is clear to mention that the highest phenolics compounds in sweet potato tubers recorded for quercetin, rosmarinic acid and chlorogenic acid. The mean values were 327.0, 250.0 and 41.25 mg/g on dry weight basis, respectively. While, the lowest phenolic compounds in sweet potato tubers recorded for *P*- coumaric acid, ferulic acid, and vanillin. The mean values were 0.35, 0.41 and 0.68 mg/g on dry weight basis, respectively. These findings are consistent with **Wojdyło *et al.* (2007)** which stated that caffeic, p-coumaric, ferulic and neochlorogenic were the key phenolic acids found in analyzed sweet potato root species, while quercetin, luteolin, apigenin, kaempferol and isorhamnetin were the predominant flavonoids.

Sweet potato normally contains phenolic acids such as chlorogenic, isochlorogenic, caffeic, cinnamic, and hydroxycinammic acids. The color, sensory characteristics, nutritional value and antioxidant properties of food have been correlated with phenolic acids **(Robbins, 2003)**.

Table (5): Identified phenolics compounds in dried sweet potato tubers by HPLC

Phenolic compounds	Concentration (mg/g)
Caffeic acid	6.8
Gallic acid	5.48
Rosmarinic acid	250
***P*- coumaric acid**	0.35
***O*-coumaric acid**	12.9
Vanillin	0.68
Quercetin	327
Chlorogenic acid	41.25
Ferulic acid	0.41
4.5-Dicaffeoylquinic acid	16.1
3.5-Dicaffeoylquinic acid	39.1
3.4-Dicaffeoylquinic acid	3.5
Trans-cinnamic acid	3.87

Sensory evaluation of rice cupcake fortified with different levels of sweet potato flour

Data in Table (6) showed the sensory evaluation of rice cupcake fortified with different levels of sweet potato flour. The obtained results indicated that the color of control cupcake from wheat flour and control cupcake from rice flour recorded the highest value compared with other treatments with significant differences, which were 9.65±0.15and 9.50±0.12 score, respectively, while, the cupcake fortified with 20% sweet potato flour recorded the highest color value (9.15±0.14)when compared with other fortified cupcake (30%, 15% and 10%) with significant differences and vice versa with other sensory properties. The mean values were 8.35±0.10, 9.05±0.11, and 7.10±0.13, respectively.

Concerning odor, it is noticeable the control cupcake from wheat flour recorded the higher value compared with control cupcake from rice flour with significant differences, which were 9.40±0.13 and 9.00±0.15 score, respectively. While, the cupcake fortified with 20% sweet potato flour recorded the highest color value (8.50±0.12)when compared with other fortified cupcake (30%, 15% and 10%) with significant differences and vice versa with other sensory properties. The mean values were 7.60±0.11, 7.85±0.11 and 8.10±0.10,respectively.

As to taste and texture,it is obviously the highest values recorded for cupcake made from wheat flour and rice flour compared with others treatments with significant differences, which were 9.50±0.16, 9.36±0.14,9.20±0.11 and 9.0±0.15 score, respectively. While, the cupcake fortified with 10% sweet potato flour recorded the highest taste and texture value (8.50±0.11 and `18.50±0.14)when compared with other fortified cupcake (30%, 15% and 20%) with significant differences and vice versa with other sensory properties. The mean values were (7.80±0.10, 8.05±0.05,8.30±0.14,7.20±0.12, 8.08±0.08 and 8.30±0.10, respectively).

In case of Dist. Pores and overall acceptability, control cupcake from wheat flour recorded the higher value being, 9.70±0.15 and 9.20±0.13, respectively when compared with other fortified cupcake (20%, 15% and 10%) with significant differences and vice versa with other sensory properties.The mean values were (8.30±0.11, 7.98±0.01,8.60±0.14, 8. 30±0.13, 7.80±0.14 and 8.60±0.12,respectively). While the lowest value recorded for cupcake fortified with 30% sweet potato flour with significant differences, being, 7. 0±0.13 and 7.60±0.14 score. Finally, it could be noticed that the best sensory properties recorded for cupcake fortified with 10% and 2 sweet potato flour. These findings are in line with **Dansby and Bovell-Benjamin (2003)** that no major variations ($P \leq 0.05$) were recorded in color substitution levels of up to 20 percent were generally appropriate in cake samples. It has been stated that the amounts of ingredients in the preparation of cake. The statistical analysis displayed the superior sensory evaluation from various ratios of sweet potato recorded for 10 and 20%, respectively, and its ratios applied in the research plan.

Table (6): Sensory evaluation of rice cupcake fortified with different levels of sweet potato flour

Treatments / Parameters	Wheat cupcake	Rice cupcake/2	Cupcake SP 10%	Cupcake SP 15%	Cupcake SP 20%	Cupcake SP 30%	LSD
Color	$9.65^{a}\pm0.15$	$9.50^{a}\pm0.12$	$9.05^{b}\pm0.11$	$7.10^{d}\pm0.13$	$9.15^{b}\pm0.14$	$8.35^{c}\pm0.10$	**0.2214**
Odor	$9.40^{a}\pm0.13$	$9.0^{b}\pm0.15$	$8.10^{d}\pm0.10$	$7.85^{e}\pm0.11$	$8.50^{c}\pm0.12$	$7.60^{f}\pm0.11$	**0.2134**
Taste	$9.50^{a}\pm0.16$	$9.36^{a}\pm0.14$	$8.50^{b}\pm0.11$	$8.05^{c} \pm 0.05$	$8.30^{b}\pm0.14$	$7.80^{d}\pm0.10$	**0.2061**
Texture	$9.20^{a}\pm0.11$	$9.0^{a}\pm0.15$	$8.50^{b}\pm0.14$	$8.08^{c}\pm0.08$	$8.30^{b}\pm0.10$	$7.20^{d}\pm0.12$	**0.2127**
Dist. pores	$9.70^{a}\pm0.15$	$8.87^{b}\pm0.12$	$8.60^{c}\pm0.12$	$7.98^{e}\pm0.01$	$8.30^{d}\pm0.11$	$7.0^{f}\pm0.13$	**0.2159**
Overall Accept	$9.20^{a}\pm0.13$	$8.91^{b}\pm0.10$	$8.60^{c}\pm0.12$	$7.80^{e}\pm0.14$	$8.30^{d}\pm0.13$	$7.60^{e}\pm0.14$	**0.2203**

Values are expressed as mean ± SD. Mean value with different letters in the same raw are significantly different ($P \leq 0.05$), and vice versa. SP= Sweet potato Dist. Pores =Distributed pores Overall accept. = Overall acceptability.

Gross chemical composition of rice cupcake fortified with different levels of sweet potato flour (g/100g DW)

The gross chemical compositions of rice cupcake fortified with different levels of sweet potato flour (g/100gDW) are shown in Table (7). It is clear to notice that the highest moisture, protein and ash contents recorded for control cupcake from rice flour. While, the lowest contents recorded for control cupcake from wheat flour with significant differences. The mean values were (30.16±0.13, 12.47±0.10 & 4.01±0.13g/100g DW) and (25.50±0.11, 9.69 ±0.13& 0.88±0.14 g/100g), respectively.

On the other hand, the highest fat, NFE and energy value contents recorded for control cupcake from wheat flour. While, the lowest contents recorded for cupcake fortified with 20% sweet potato flour except for NFE (cupcake from rice flour the lowest) with significant differences. The mean values were (15.47±0.10, 47.34±0.15 g/100g DW & 369.15±0.16 kcal/100g) and (11.99±0.11, 30.74±0.10 g/100g DW & 276.95±0.13 kcal/100g), respectively. These results are in accordance with **Alloush (2015)** who reported that the protein, ether extract, moisture content and crude fiber content of the composite flour decreased as the level of potato flour substitution increased. The sweet potato flour had less oil content and increased ash and carbohydrate content, as the level of substitution also increased the composition of the sweet potato flour. These findings were also supported by those of **Guy (2012)** who stated that proteins and carbohydrates are the key chemical compositions that enhance the water absorption capacities of flours since these components contain hydrophilic parts such as polar or charged side chains.

Table (7): Gross chemical composition of rice cupcake fortified with different levels of sweet potato flour (g/100gDW)

Constitutes / Parameters	Control (A)	Control (B)	Cupcake + SP 10%	Cupcake + SP 20%	LSD
Moisture	25.50^{d}±0.11	30.16^{a}±0.13	26.53^{c}±0.14	27.92^{b}±0.12	**0.2299**
Protein	9.69^{d}±0.13	12.47^{a}±0.10	11.13^{c}±0.11	11.52^{b}±0.15	**0.2324**
Fat	15.67^{a}±0.10	12.21^{c}±0.11	13.46^{b}±0.12	11.99^{d}±0.13	**0.213**
Ash	0.88^{c}±0.14	4.01^{a}±0.13	3.01^{b}±0.15	3.91^{a}±0.12	**0.2516**
Fiber	0.60^{c}±0.12	11.02^{b}±0.11	11.22^{b}±0.13	13.92^{a}±0.15	**0.2397**
NFX	47.34^{a}±0.15	30.13^{d}±0.14	34.65^{b}±0.11	30.74^{c}±0.10	**0.2368**
Energy value (Kcal/100g)	369.15^{a}±0.16	280.29^{c}±0.10	304.26^{b}±0.12	276.95^{d}±0.13	**0.2415**

Values are expressed as mean ± SD. Mean value with different letters in the same raw are significantly different ($P \leq 0.05$), and vice versa. A= 100% wheat flour B= 100% rice flour SP= Sweet potato

Objective properties of rice cupcake fortified with different levels of sweet potato flour

Data tabulated in Table (8) showed the Objective properties of rice cupcake fortified with different levels of sweet potato flour. It is obvious that all tested physical properties (specific gravities, baking loss, volume, weight and specific volume) of control A (cupcake from wheat flour) recorded the higher values compared with control B (cupcake from rice flour) with significant differences. The mean values were (1.35±0.11g/cm^3, 9.55%±0.15, 108.30±0.14 cm^3, 54.10±0.12g & 2.52±0.10 cm^3/g) and (1.12±0.15g/cm^3, 9.07%±0.10, 90.30±0.13cm^3, 45.40±0.14g & 2.35±0.12cm^3/g), respectively. Data also indicated that all tested objective properties decreased with increasing level of sweet potato flour. Cupcake with 10 % sweet potato flour recorded higher objective properties than cupcake with 20 % sweet potato flour. The mean values were (1.27b±0.10g/cm^3, 8.61c±0.13%, 104.50b±0.10cm^3, 52.50b±0.12 g & 2.30b±

0.11cm^3/g) and (1.22c±0.14g/cm^3, 8.01d±0.11 %, 101.04c ±0.14 cm^3, 52.61b±0.13g & 2.15c±0.15cm^3/g) for specific gravities, baking loss, volume, weight and specific volume, respectively. Also, the volume values were decreased so, the specific volume values of cupcake samples were deceased. These findings may be attributed to the low viscosity of sweet potato flour, because the bubbles in the butter can quickly rise to the surface and are lost to the atmosphere during baking, causing the cake's structure to collapse **(Turabi *et al.*, 2010)**. The loss values for baking were reduced, so the weight values were increased. The high fiber content that increased the water absorption ability of sweet potato flour could be due to these findings.

These findings were in line with those obtained by **Alloush (2015)** who discovered that the increasing sweet potato flour supplementation to wheat flour decreased the volume of the loaf, while the weight of the loaf was increased, so that the basic volume values were deceased. These findings may be due to sugars found in sweet potatoes that are known to delay the gelatinization of starch by reducing the system's water activity and stabilizing the starch granule's amorphous regions by interacting with starch chains. Thus, the gas bubbles that lead to lower volume and harder structure can not be trapped by cake **(Milde *et al.*, 2012)**.

Table (8): Objective properties of rice cupcake fortified with different levels of sweet potato flour

Treatment / Parameters	Control (A)	Control (B)	Cupcake + SP 10%	Cupcake + SP 20%	LSD
Specific gravities(g/cm3)	1.35^a±0.11	1.12^a±0.15	1.27^a±0.10	1.22^a±0.14	**0.2368**
Baking loss %	9.55^a±0.15	9.07^b±0.10	8.61^c±0.13	8.01^d±0.11	**0.2324**
Volume (cm3)	108.30^a±0.14	90.30^d±0.13	104.50^b±0.10	101.04^c±0.14	**0.235**
Weight (g)	54.10^a±0.12	45.40^c±0.14	52.50^b±0.12	52.61^b±0.13	**0.2338**
Specific (Volume)	2.52^a±0.10	2.35^{ab}±0.12	2.30^{ab} ±0.11	2.15^b±0.15	**0.2282**

Values are expressed as mean ± SD.Mean value with different letters in the same raw are significantly different (P≤0.05), and vice versa
A= 100% wheat flour B= 100% rice flour SP= Sweet potato

Color of rice cupcake fortified with different levels of sweet potato flour

The color of rice cupcake fortified with different levels of sweet potato flour were measured in crust and crumb by luminosity, red intensity and yellow intensity values and they are presented in Table (9). It is clear to mention that the luminosity, and red intensity values of control A (cupcake from rice flour) recorded the higher values compared with control B (cupcake from wheat flour) with significant differences. The mean values were $59.02^{a}\pm0.11$ and $22.91^{a}\pm0.13$, respectively. While, the vice versa recorded for yellow intensity value being $42.30^{a}\pm0.15$. The obtained results indicated that all tested color properties decreased with increasing level of sweet potato flour. Cupcake with 10 % sweet potato flour recorded higher color than cupcake with 20 % sweet potato flour. The mean values were ($56.98^{a}\pm0.13$, $19.37^{b}\pm0.10$ & $39.50^{b}\pm0.11$) and ($51.47^{b}\pm0.12$, $18.24^{b}\pm0.14$ & $38.12^{b}\pm0.14$) for luminosity, red intensity and yellow intensity values, respectively. These findings are in agreement with the findings of **Olatunde *et al.* (2016)** who reported that only sweet potato flour ($P\leq0.05$) was affected by drying and the interaction between pretreatment and drying. The consequence of these interactive effects is that, for the functional properties of flour, and of the key factors as well as the combinations are very important and should therefore be properly selected during the processing of sweet potato flour.

Table (9): Color of rice cupcake fortified with different levels of sweet potato flour

Parameters \ Treatments		Control (A)	Control (B)	Cupcake + SP 10%	Cupcake + SP 20%	LSD
Crust	L*	$50.0^{d}\pm0.15$	$59.02^{a}\pm0.11$	$56.98^{b}\pm0.13$	$51.47^{c}\pm0.12$	**0.2397**
	A*	$18.12^{c}\pm0.11$	$22.91^{a}\pm0.13$	$19.37^{b}\pm0.10$	$18.24^{c}\pm0.14$	**0.2223**
	B*	$42.30^{a}\pm0.15$	$22.30^{d}\pm0.10$	$39.50^{b}\pm0.11$	$38.12^{c}\pm0.14$	**0.2368**
Crumb	L*	$74.62^{a}\pm0.14$	$61.02^{c}\pm0.12$	$71.32^{b}\pm0.16$	$71.40^{b}\pm0.11$	**0.2491**
	A*	$4.62^{c}\pm0.13$	$2.80^{d}\pm0.14$	$6.21^{b}\pm0.10$	$7.35^{a}\pm0.11$	**0.2223**
	B*	$31.01^{c}\pm0.12$	$19.24^{d}\pm0.11$	$33.24^{b}\pm0.15$	$34.79^{a}\pm0.13$	**0.2397**

Values are expressed as mean ± SD. Mean value with different letters in the same raw are significantly different ($P\leq0.05$), and vice versa.
A= 100% wheat flour B= 100% rice flour SP= Sweet potato
L*(luminosity),a*(red intensity), and b*(yellow intensity).

CONCLUSION

Fortified white rice flour with sweet potato flour at levels 10 and 20% in gluten free rice cupcake samples can improve nutritional value, objective, sensory properties and quality attributes of the rice cupcake samples due to the presence of natural antioxidant, carotenoids and phenolic compounds.

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الاستفادة من درنات البطاطا لتحضير الكب كيك الخالي من الجلوتين لمرضى الاضطرابات الهضمية (سيلياك)

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تهدف الدراسة الحاليه الي تقييم إضافة تركيزات مختلفة ١٠ ، ٢٠٪ من مسحوق درنات البطاطا الحلوة إلى الكب كيك. تم تحضير عينات الكب كيك الأرز الخالي من الجلوتين باستبدال دقيق الأرز الأبيض بدقيق البطاطا الحلوة بتركيزات مختلفة. تم تسوية جميع أنواع الكب كيك المختلفة عند ٢٠٠ م° لمدة ٥ق ثم على ١٨٠ م° لمدة حوالى ٤٥ دقيقة ثم تبريدها قبل التقييم ، وتعبئتها في أكياس بولي إيثيلين وتخزينها عند درجة حرارة ٥ م°. تم تقدير الأملاح المعدنية ، الفينولات الكلية ، الفلافونويدات الكلية ، النشاط المضاد للأكسدة ، الكاروتينات الكلية والمركبات الفينولية لدرنات البطاطا الحلوة. كما تم تقدير التركيب الكيميائي والخواص الطبيعية وخصائص اللون والصفات الحسية لعينات الكب كيك. أظهرت النتائج أن دقيق القمح يحتوي على نسبة عالية من الرطوبة والبروتين وقيم الطاقة مقارنة بالأرز ودقيق البطاطس. كان متوسط القيم ٤٥،٨٪ ، ٢٠،١٢٪ ، ٤٠١،٠٧ كيلو كالوري / ١٠٠ كجم على التوالي. بينما يحتوي دقيق البطاطا الحلوة على كميات عالية من الدهون والرماد والألياف. كان متوسط القيم ٢٢،١٪ ، ٠١،٧٪ ، ٧٨،٧٪ على التوالي. تحتوي جذور البطاطا الحلوة على كميات عالية من الأملاح المعدنية (البوتاسيوم والكالسيوم والمغنيسيوم) والفينولات الكلية والفلافونيدات الكلية ومضادات الأكسدة والكاروتينات الكلية. سجلت أعلى قيم للمركبات الفينولية في درنات البطاطا الحلوة لمركب الكيرسيتين وحمض روزمارينيك وحمض الكلوروجينيك. كان متوسط القيم ٠،٣٢٧ ، ٠،٢٥٠ ، ٢٥،٤١ مجم / جم على أساس الوزن الجاف على التوالي. سجلت أقل محتويات قيمة الدهون والكربوهيدرات والطاقة للكب كيك المدعم بـ ٢٠٪ دقيق البطاطا الحلوة باستثناء كربوهيدرات الكب كيك من دقيق الأرز مع وجود فروق معنوية. سجل الكب كيك المحتوي على ١٠٪ من دقيق

البطاطا الحلوة خواص فيزيائية ولون أعلى من الكب كيك الذي يحتوي على ٢٠٪ دقيق البطاطا. في الختام ، يمكن لدقيق البطاطا الحلوة مع دقيق الأرز الأبيض تحسين القيمة الغذائية والخصائص الفيزيائية والحسية لكب كيك الأرز المنتج لمرض الاضطرابات الهضمية(سيلياك) .

الكلمات الرئيسية: منتجات المخابز – درنات االبطاطاِ– مرض سيلياك – المركبات الفعالة – الجودة.