Study the Different Properties of Innovative Cake Blends for Patients with Gluten Sensitivity

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Introduction

Number of patients with celiac disease were increased in recent years **(Catassi *et al*., 2008).** Celiac disease is described by a strong immune response to specific amino acid sequences found in the prolamin bits of wheat, barley and rye. When people with celiac disease have foods containing gluten, their immune system responds by breaking down the intestinal villi leading to the mal absorption of nutrients, so adversely affecting all systems of the body **(Hill *et al.*, 2005).** Whereas, the happening of this disease has been traditionally despised. Nowadays, an occurrence in the range of 1 patient per 130–200 people is known in developed countries **(Sollid, 2002 and Fasano *et al*., 2003).** Celiac disease remains a difficult case due to the steady increase in knowledge dealing with pathophysiology, diagnosis and possible treatment options **(Caio *et al.,* 2019**).The main reasons of celiac disease are the change in people's eating habits and excess in use of fast foods. Consequently, there is an increasing demand for gluten-free high quality products. Therefore, this call cereal technologists to a defy, concerning the low-baking quality of the gluten-free flour resulted from absence of gluten **(Arendt *et al.,*2008)**.However, patients showing nutritional deficiencies could demand supplementation of their food with vitamins, antioxidants, minerals, and proteins to correct deficiencies and return nutrient reserves **(Osella *et al*.,2014 and Bascujonn *et al*.,2016)**. It was found that celiac disease patients suffers from the shortage of gluten free products with the after negative effects on nutritional and health status **(Bourekoua *et al*., 2016)**. Beside this , absence of gluten often makes rather liquid dough and may lead to bakery products with low volume, weak color, dense shape , and other quality defect **(Catassi *et al*., 2008).**

Corn flour is among the best ingredients in the preparation of gluten-free products .Corn starch was used separately in preparing bread used by celiac people in food preparation. Even though corn flour supplies many micro- and macronutrients, amounts of some main nutrients are deficient. Therefore, consumption of these products contributes only small amounts of proteins, minerals and dietary fibers, consequently increasing the danger of nutritional shortage associated with celiac Disease **(Mastromatteo *et al*., 2011 and Schober *et al*., 2008).** In current times, the attention has been concentrated on new application of legume flour or ingredients. The concern in this crop category is mainly due to their functional characteristics, like solubility and water-binding capacity, which play an essential role in gluten-free food formulation and treatment. Their nutritional profile may also counteract the shortage of nutrients commonly highlighted in commercial gluten-free bakery and pasta products giving valuable sources of protein, dietary fiber, vitamins, minerals, and complex carbohydrates, which in turn have a positive impact on human health **(Foschia *et al*., 2017).** Legume flours including fava beans, garbanzo beans, soybeans and chickpeas which good origin of protein and fiber best used in blends with other gluten-free flours to balance taste and texture **(Stone *et al*., 2017)**. Soybean could be an fundamental part of functional foods, as well as it could be used for raising of product quality. Soybean also contains up to 45% protein and as a good source of vitamins and mineral supplies sufficient amount of different amino acids required for repairing the destroyed body tissues **(Ahmad *et al*., 2014 and Islam *et al*., 2007).** Chickpea (Cicer arietinum) is significant source of protein, carbohydrate and minerals, especially to the population groups of developing nations. Chickpea contains 21.1 g protein, 3.1 g fat, 53.4 g carbohydrate, 11.1 g fiber and 5.9 g ash, 360 mg Ca, 315 mg P, 8.2 mg Fe, 5.4 mg Zn, 5.4 mg Mn, 1.1 mg Cu per 100 g **(Dimitrios *et al*., 2006 and Khan *et al*., 2010).**

Presence of high protein content in chickpea is convenient for patients with celiac disease. Furthermore, as proteins can make a network such as gluten, chickpea which could improve gas retention, volume and bread quality in general **(Miñarro *et al*., 2012)**.

Lupine (Lupinus albus spp) as a valuable old legume contains comparatively higher amount of protein than cereals and other legumes except soy. Lysine content of lupine proteins is high while methionine content is low. Lupine is also rich in dietary fiber (30–40%), fat (6-13%), phytochemicals involving antioxidants and phytosterols, vitamin and minerals **(Faluyi *et al*., 2000).**

Cake is one of the most favourite bakery products, consumed worldwide by all ages in large quantities. The quality of cakes relies on many factors, such as the ingredients used for batter preparation, aeration of batter and process conditions. A number of studies are on the formulation of gluten-free baked cakes **(Gularte *et al*., 2012 and Matos *et al*., 2014)**. Beside this , Cake is considered one of the most significant bakery products for Egyptian people it is either home-made or produced on trade scale**(Doweidar, 2006).**

The aim of the present study is to investigate the effect of partial substitution of corn flour by soy flour (SF), chickpea flour (Cp F) and lupine flour (LF) at levels 15% and 30%, on chemical , physical, texture ,color and sensory characteristics of innovative gluten-free cakes.

Materials and Methods

Materials

Yellow corn flour (97% extraction) was obtained from Egyptian Company for corn products 10^{th} of Ramadan City, Egypt. Corn Starch, sugar, eggs, butter, yogurt , baking powder and vanilla were obtained from a local market in Damietta Governorate , Egypt. Soy beans, chick peas and sweet lupine were obtained from a local market in Damietta governorate , Egypt.

Methods

Soy beans, chickpeas and sweet lupine were prepared for milling according to **(Al-Omari,2009)** method. Soy beans, chick peas and sweet lupine were cleaned (discarding small broken, moldy and damaged beans), then washed using distilled water and then sterilized with 0.3% sodium hypochlorite solution for 1 min, after that rewashed more one time with distilled water, then soaked in distilled water for 20 h and lastly dried in a ventilated oven (Vindon, England) at 55°C for 18 h. After that, they were ground by an electrical mill (Braun, Germany) to pass through a 60 mesh sieve (British standard screen). The milled flours were stored in air-tight polyethylene bags at 4°C till required.

Preparing of gluten free cake samples

Seven gluten –free cake flour blends were prepared : control: 100% corn flour (CF), 85% corn flour and 15% chickpea flour (Cp_1F) , 70% corn flour and 30% chickpea flour (Cp_2F), 85% corn flour and 15% soy flour (S_1F) , 70%corn flour and 30% soy flour (S_2F) , 85%corn flour and 15% lupine flour (L_1F), 70%corn flour and 30% lupine flour (L_2F).

Gluten free cakes were prepared according to **(Bennion and Pamford ,1997)** with some modifications which show in table (1). The control corn flour cake was prepared by whipping butter (150 g) and sugar (140 g) to a white cream with using a mixer at high speed then eggs (115 g) , vanilla (5g) and yogurt (125 g) were added and whipped for 5 min, then the other ingredients, corn flour (150 g), corn starch (78g) and baking powder (9 g), were added gradually on the whipped mixture and beaten for three min. using the mixer at low speed . The mixture placed in a preheated oven and baked at 180ºC for 40 min.

The treatments were carried out by substituted corn flour with chickpea flour , soy flour and lupine flour at 15% and 30% levels. The appearances of gluten free cakes are shown in figure (1) and figure (2)

CF Cp_1F Cp_2F S_1F S_2F L_1F L_2F

Figure (1) crust appearance of gluten free cakes

CF: 100% corn flour (control); Cp_1F:85%corn flour and 15% chickpea flour; Cp_2F: 70%corn flour and 30% chickpea flour; S_1F: 85%corn flour and 15% soy flour; S_2F: 70%corn flour and 30% soy flour; L_1F: 85%corn flour and 15% lupine flour; L_2F: 70%corn flour and 30% lupine flour

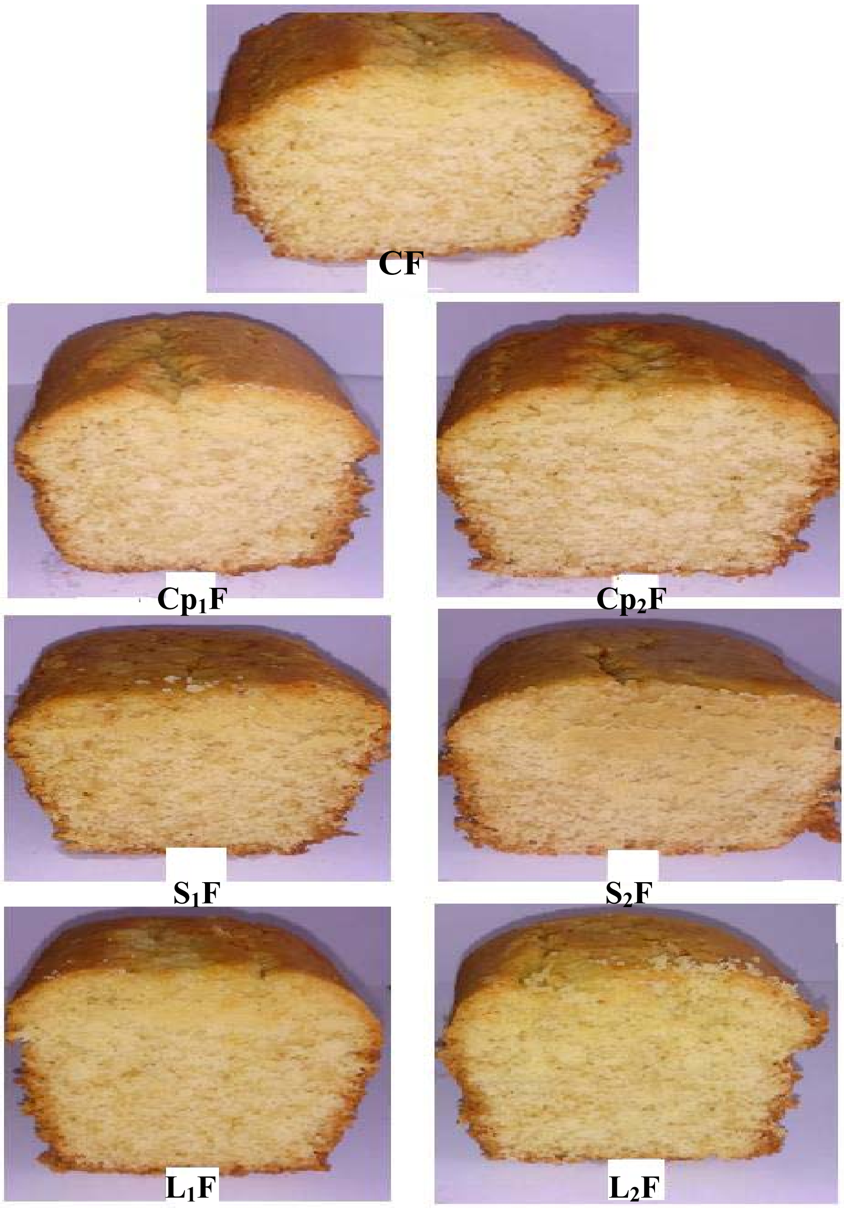

Figure (2) :crumb appearance of gluten free cakes

CF: 100% corn flour (control); Cp_1F:85%corn flour and 15% chickpea flour; Cp_2F: 70%corn flour and 30% chickpea flour; S_1F: 85%corn flour and 15% soy flour; S_2F: 70%corn flour and 30% soy flour; L_1F: 85%corn flour and 15% lupine flour; L_2F: 70%corn flour and 30% lupine flour.

Table (1): Formula of gluten free cakes

Ingredients(gm)	CF cake	Cp_1F cake	Cp_2F cake	S_1F cake	S_2F cake	L_1F cake	L_2F cake
Corn flour	150	127.5	105	127.5	105	127.5	105
Corn starch	78	78	78	78	78	78	78
Sugar	140	140	140	140	140	140	140
Butter	150	150	150	150	150	150	150
Eggs	115	115	115	115	115	115	115
Vanilla	5	5	5	5	5	5	5
Baking powder	9	9	9	9	9	9	9
Yogurt	125	125	125	125	125	125	125
Chickpea flour	-	22.5	45	-	-	-	-
Soy flour	-	-	-	22.5	45	-	-
Lupine flour	-	-	-	-	-	22.5	45

CF: 100% corn flour (control); Cp_1F:85%corn flour and 15% chickpea flour; Cp_2F: 70%corn flour and 30% chickpea flour; S_1F: 85%corn flour and 15% soy flour; S_2F: 70%corn flour and 30% soy flour; L_1F: 85%corn flour and 15% lupine flour; L_2F: 70%corn flour and 30% lupine flour

Chemical analysis

Proximate analysis involving moisture, protein, fat, ash and crude fiber were carried out according to the methods of **AOAC (2005)** .Carbohydrates content was calculated by difference.

Specific Gravity of Batter and Measurements of Cakes (physical properties)

Specific gravity of cake batter was evaluated according to the method of **(Jyotsna *et al*., 2004)** .Weight (g), volume (cm^3) and specific volume (cm^3 /g) of different cake samples were measured according to the method of **(Bennion and Bamford ,1997).**

Texture profile analysis of gluten free cakes

Samples hardness, resilience, springiness, cohesiveness, gumminess and chewiness was carried out in National Research Center . Dokki, Giza ,Egypt using the TVT Texture Analyzer (Perten instruments) according to TVT Method 10.0. The analyzer was set to carried out two cycle measurements which are used for the determination of the first bite force of a product. The measurement speed of 2 mm/s and a distance of 5 mm were applied. A force–time diagram was taken for each test. The force-time plots were analyzed for peak breaking force (g) and time (s) to reach the peak. Textural elements were measured in three independent samples and the presented values are mean values **(Pongsawatmanit *et al*., 2007)**.

Color determination method

The color was measured by using a Hunter Lab. Model D25 color and color difference Meter **(Francis, 1983)** .This color assessment system is based on the Hunter L*-, a*- and b*- coordinates. L*- representing lightness and darkness, + a*- redness, - a*- greenness, + b*- yellowness and - b*- blueness with white Tile of Hunter Lab color standard: (L= 92.56, a= -0.87 and b= -0.15).

Organoleptic characteristics of gluten free cakes

Organoleptic characteristics were determined according to **(Levent and Bilgic, 2011)** with some modification to evaluate sensory characteristics such as taste (20), odor (20), crumb color (10), crust color (10), texture (10), pore structure (10) and overall acceptability (20) of gluten free cake samples.

Statistical analysis

The current results were analyzed statistically using SPSS statistical package (Version 9.05) according to **(Rattanathanalerk *et al.,* 2005)** analysis of variance (ANOVA), Duncan's multiple range test and least significant difference (LSD) was chosen to determine the significant difference among various treatments. Differences considered significant at $p \leq 0.05$.

Results and Discussion

Chemical composition of gluten free cake flour blends

Chemical composition of gluten free cake flour blends is given in table (2). Data in table (2) demonstrated that the ash content of corn flour CF was lower than the other samples recorded (0.60 $\pm$0.05%), whereas S_2F blend had the highest ash content (1.40$\pm$0.06 %). Beside this the soy flour had the highest protein content and the blend S_2F recorded (15.97$\pm$0.50%) while corn flour had the lowest protein content of(6.95$\pm$ 0.10%) . In this respect , the increase in protein level could be due to the soy fraction of the blended flour because the soy flour has higher protein about (40.2%).Soy bean is an important source of protein and complement to lysine-limited cereal protein.

Adding of soy flour improve the quantity and quality of protein content of the food product, thereby has the great possibility in combating with protein energy malnutrition **Wadsworth (1992).**

The lipid content of the samples ranged from 1.85±0.04 to 5.05±0.10 %. It was observed that the blend S_2F recorded the highest value of lipid . On the other hand , the highest fiber value was for L_2F blend (3.58±0.06%) but the lowest fiber content was for CF blend (0.50±0.01%). These results are in agreement with **Zielinska *et al.*, (2008)** who stated that lupine is an important source of nutrients, like proteins, lipids, dietary fiber.

Finally, the carbohydrate content of corn flour CF was higher than the other samples (80.80±0.80%) these results are in nearly with **Khorshid *et al.*, (1996).** In another study it was found that legumes nutritional profile may also counteract the shortage of nutrients commonly highlighted in commercial gluten-free bakery products, supplying valuable sources of protein, dietary fiber, vitamins, , and minerals, which in turn have a positive effect on human health **Foschia *et al.*, (2017)**. In this concern, **Islam *et al.*, (2007)** showed that adding 15% soy flour to bread blends improved bread quality, and nutritional properties of bread.

It was concluded that replacing corn flour (CF) with soy flour (SF), chickpea flour(Cp F) and lupine flour (LF) at levels 15% and 30% led to significant increase in ash, protein, lipid, fiber but it led to significant decrease in carbohydrate.

Table (2): Chemical composition of different flour types

Flour blends	Moisture %	Ash %	protein %	Lipid %	Fiber %	Carbohydrate %
CF	9.30 ± 0.10^{a}	0.60 ± 0.05^{d}	6.95 ± 0.10^{f}	1.85 ± 0.04^{f}	0.50 ± 0.01^{d}	80.80 ± 0.80^{a}
Cp_1F	9.33 ± 0.01^{a}	0.98 ± 0.02^{b}	9.45 ± 0.15^{e}	2.30 ± 0.08^{e}	1.29 ± 0.03^{c}	76.65 ± 0.05^{b}
Cp_2F	9.33 ± 0.03^{a}	1.35 ± 0.10^{a}	11.96 ± 0.30^{c}	2.77 ± 0.07^{d}	2.08 ± 0.03^{b}	72.51 ± 0.01^{d}
S_1F	9.16 ± 0.02^{b}	1.00 ± 0.10^{b}	11.46 ± 0.30^{cd}	3.45 ± 0.07^{c}	1.30 ± 0.03^{c}	73.63 ± 0.80^{c}
S_2F	9.03 ± 0.03^{c}	1.40 ± 0.06^{a}	15.97 ± 0.50^{a}	5.05 ± 0.10^{a}	2.09 ± 0.05^{b}	66.46 ± 0.70^{f}
L_1F	9.18 ± 0.03^{b}	0.78 ± 0.03^{c}	10.91 ± 0.50^{d}	2.90 ± 0.02^{d}	2.04 ± 0.02^{b}	74.19 ± 0.09^{c}
L_2F	9.04 ± 0.01^{c}	0.97 ± 0.03^{b}	14.86 ± 0.40^{b}	3.96 ± 0.06^{b}	3.58 ± 0.06^{a}	67.59 ± 0.08^{e}

Different superscript letters in the same column indicate a significant ($p\leq0.05$) difference according to Duncan's test; CF: 100% corn flour (control); Cp_1F:85%corn flour and 15% chickpea flour; Cp_2F: 70%corn flour and 30% chickpea flour; S_1F: 85%corn flour and 15% soy flour; S_2F: 70%corn flour and 30% soy flour; L_1F: 85%corn flour and 15% lupine flour; L_2F: 70%corn flour and 30% lupine flour

Physical properties of gluten free cakes

The physical properties of gluten free cakes prepared from different flour blends are shown in table (3).These results indicated that, the highest value of cake weight (316.50±0.50 g) was observed by the sample S_1F cake with no significant differences with the cake samples produced from CF and L_2F cake 313.00+0.20g and 305.00±0.30g respectively on contrary to the lowest value of weight which investigated by the sample Cp_1F (286±0.30g) with significant differences with all cake samples except Cp_2F cake sample . Concerning the volume of cake samples the control sample CF recorded the highest value of volume (644.73±0.40 cm^3) with significant differences with all samples followed by the cake sample which produced from L_2F (555.71±0.01 cm^3) however, no significant differences was observed between the sample of L_2F, Cp_1F and Cp_2F in terms of the volume while, the lowest value of cake volume (455.25±0.05cm^3) which was obtained by the cake sample produced from S_2F. **Gomez *et al.*, (2008)** reported that with increase the level of chickpea flour, decrease in batter density which was noticed due to the less incorporation of air. It was also expected that lower batter density would lead to higher cake volume. Consequently, the results of specific volume of cake samples were observed as follow: the control sample CF recorded the highest value of specific volume (2.06 ±0.20 cm^3/g) with significant difference with other samples. whilst, no significant difference was found between Cp_1Fcake , Cp_2Fcake and L_2F cake 1.90±0.70, 1.86±0.20 and 1.82±0.30 cm^3/g respectively concerning the specific volume. In this respect ,using chickpea flour resulted in high specific volume and softness **Miñarro *et al.*, (2012)**.

Moreover ,**Bárcenas and Rosell (2005)** reported that the specific volume is increased by several factors such as the amount of protein content, fermentation condition, and using additives .Therefore**, Gomez *et al.*, (2007)** attributed the high specific volumes to the clear increase in batter viscosity. They declared that the high batter viscosity slows down the rate of CO_2 diffusion and consequently, allowed for improved retention through the early stage of baking.

Table (3) Physical properties of gluten free cakes

Cake Samples	Weight (g)	Volume (cm^3)	Specific volume (cm^3/g)
CF	313.00±0.20^{ab}	644.73±0.40^{a}	2.06±0.20 ^{a}
Cp_1F	286.00±0.30^{d}	542.50±0.50 ^{b}	1.90±0.70 ^{b}
Cp_2F	296.00±0.50^{d}	551.25±0.80 ^{b}	1.86±0.20 ^{b}
S_1F	316.50±0.50 ^{a}	515.11±0.90 ^{c}	1.63±0.10^{cd}
S_2F	300.50±0.20^{bc}	455.25±0.05 ^{d}	1.51± 0.20^{d}
L_1F	302.50±0.40^{bc}	511.20±0.20 ^{c}	1.69±0.10 ^{c}
L_2F	305.00±0.30^{ac}	555.71±0.01 ^{b}	1.82±0.30 ^{b}

Different superscript letters in the same column indicate a significant ($p \leq 0.05$) difference according to Duncan's test; CF: 100% corn flour (control); Cp_1F:85%corn flour and 15% chickpea flour; Cp_2F: 70%corn flour and 30% chickpea flour; S_1F: 85%corn flour and 15% soy flour; S_2F: 70%corn flour and 30% soy flour; L_1F: 85%corn flour and 15% lupine flour; L_2F: 70%corn flour and 30% lupine flour

Color measurements of gluten free cakes

Data in table (4) demonstrated the Color measurement of gluten free cakes. Results in table (4) showed the color measurement values (L*, a* and b*) of crust and crumb for gluten free cake samples. From the results presented in the same table it could be noticed that, the highest values of crust lightness (L* values) were recorded by L_2F,Cp_1F and CF cake samples 61.48$\pm$0.50, 60.34$\pm$0.50 and 60.08$\pm$0.50 respectively with no significant difference between them, also, no significant difference between S_1F, S_2F and L_1F cakes in terms of crust (L* values) 53.35+0.40, 56.46$\pm$0.70 and 54.60$\pm$0.60 respectively. While the lowest values of crust lightness 50.31$\pm$0.60 and 53.35$\pm$0.40 were recorded by Cp_2F and S1F respectively. Concerning the redness (a*) of crust color the cake samples L_1F and Cp_2F recorded the highest values 18.63$\pm$0.30 and 18.06$\pm$0.30 respectively with contrast to the cake sample S_2Fwhich recorded the lowest value of redness 10.52$\pm$0.30 with significant differences with other samples whereas, no significant differences between the cake samples Cp_1F, S_1F and L_2F in terms of redness (a* values) of crust cake. As for the yellowness values of crust color (b* values) the cake samples CF and L_2F recorded the highest values 46.23$\pm$0.60 and 44.86$\pm$0.06 respectively with no significant difference, on contrary to the lowest value 34.60$\pm$0.40 which recorded by S_2Fsample. While , no significant differences between Cp_1F and L_1F in terms of yellowness of crust color 43.66$\pm$0.40 and 43.84$\pm$0.04 respectively. Also, no significant differences between $Cp_2F$and S_1F in terms of yellowness of crust color 39.11$\pm$0.50 and 40.47$\pm$0.30 respectively. In this respect , **Singh *et al*., (2003)** reported that the difference in color properties may be attributed to the differences in colored pigments in the flours, which in turn relies on the biological origin of the plant Corn flour had high (b* values) among the others as expected.

From the same table it was observed that the highest values of crumb lightness(L* values) were recorded by CF and L_1F cake samples which recorded 75.02 $\pm$0.70 and 73.29$\pm$0.20 respectively with no significant difference between them, While the lowest values of crumb lightness 66.81$\pm$0.60 and 65.76$\pm$0.80 were recorded by S_1F and S_2F respectively. Such findings are in agreement with **Ramy *et al*., (2002)** who stated that darkness increased as a result of the presence of germ and bran in cakes. In this respect, darkening of products containing chickpea could be attributed to an increased in Maillard reaction happening during baking due to higher lysine content. In the Maillard reaction reducing carbohydrates react by free amino acid side chains of protein mainly lysine and resulted in amino acid–sugar reaction products polymerized protein and brown pigments **Mohammad *et al*., (2012)**.As well as, **Cheftel *et al.*, (1989)** indicated that the higher amount of lupine flour leads to a darker color. The increase in color values could be attributed to interaction of protein and sugar at baking temperatures lead to a higher degree of Maillard reaction. Hence, **Gomez *et al.*, (2008)** stated that Millard reaction fails to happen in cake crumb because it does not reach above 100˚C thus, crumb color reflects of used raw materials colors in their interactions .In this concern ,darkness increased because of the presence of germ and bran in cakes. On the other hand, adding soy flour decreased L* value because of the flour color, and Maillard and caramelization reaction, which are affected by the reaction between amino acids and sugars and water distribution Similar results were obtained by **Zhao *et al.*, (2014)**. Beside this soybean is reported to be rich in lysine which produces darker shades of brown color. Browning color of bakery product such as bread, biscuit may be due to caramelization, dextrinisation of starch or maillard reaction .

Concerning the redness (a*) of crumb color the cake samples S_1F and L_2F recorded the highest values which recorded 7.15+0.20 and 6.85+0.10 respectively with no significant difference between them, while the cake sample L_1F recorded the lowest value of redness 5.21+0.10. Over there , the reason of an increasing redness could be due to a high amount of proteins leading to increased interactions between reducing sugars and amino acids **Claughton and Pearce, (1989).**

Regarding the yellowness values of crumb color (b* values) it was observed that the cake sample L_2F recorded the highest value 44.48±0.04, on contrary to the lowest value 33.92±0.02 which recorded by S_2F sample. While, no significant differences between Cp_1F, Cp_2F and L_1F in terms of yellowness of crumb color which recorded 38.78±0.08 , 37.99±0.01 and 37.38±0.10 respectively. Also, there is no significant differences between CF and S_1F in terms of yellowness of crumb color they recorded 41.06±0.30 and 40.45±0.05 respectively. In this respect **Sandhu *et al.*, (2007)** reported that higher b* value of corn flour may be give out to its higher carotenoid content.

As well as, **Gadallah (2017)** declared that substituted rice flour with germinated chickpea flour in gluten-free cakes demonstrated significant ($p \leq 0.05$) increase in redness (a*), yellowness (b*) followed by substituted levels 30 and 20% compared with other treatments, wheat and rice cake samples. These results may be due to the different pigments in germinated chickpea flour which had a positive influence on yellowness of prepared gluten-free cakes.

Table (4) : Color measurements of gluten free cake samples

Cake samples	Crust color			Crumb color		
	L	a	b	L	a	b
CF	60.08$\pm$0.50^{a}	16.29$\pm$ 0.20^{b}	46.23$\pm$0.60^{a}	75.02$\pm$0.70^{a}	5.37$\pm$0.10^{d}	41.06$\pm$0.30^{b}
Cp$_1$F	60.34$\pm$0.50^{a}	14.28$\pm$0.10^{c}	43.66$\pm$0.40^{b}	70.29$\pm$0.60^{bc}	6.19$\pm$0.10^{c}	38.78$\pm$0.08^{cd}
Cp$_2$F	50.31$\pm$0.60^{c}	18.06$\pm$0.30^{a}	39.11$\pm$0.50^{c}	70.07$\pm$0.80^{bc}	5.97$\pm$0.10^{c}	37.99$\pm$0.01^{d}
S$_1$F	53.35$\pm$0.40^{bc}	13.52$\pm$0.20^{c}	40.47$\pm$0.30^{c}	66.81$\pm$0.60^{d}	7.15$\pm$0.20^{a}	40.45$\pm$0.05^{bc}
S$_2$F	56.46$\pm$0.70^{b}	10.52$\pm$0.30^{d}	34.60$\pm$0.40^{d}	65.76$\pm$0.80^{d}	6.63$\pm$0.20^{b}	33.92$\pm$0.02^{e}
L$_1$F	54.60$\pm$0.60^{b}	18.63$\pm$0.30^{a}	43.84$\pm$0.04^{b}	73.29$\pm$0.20^{ab}	5.21$\pm$0.10^{d}	37.38$\pm$0.10^{d}
L$_2$F	61.48$\pm$0.50^{a}	14.56$\pm$0.30^{c}	44.86$\pm$0.06^{ab}	69.63$\pm$0.03^{c}	6.85$\pm$0.10^{ab}	44.48$\pm$0.04^{a}

Different superscript letters in the same column indicate a significant ($p\leq 0.05$) difference according to Duncan's test; CF: 100% corn flour (control); Cp$_1$F:85%corn flour and 15% chickpea flour; Cp$_2$F: 70%corn flour and 30% chickpea flour; S$_1$F: 85%corn flour and 15% soy flour; S$_2$F: 70%corn flour and 30% soy flour; L$_1$F: 85%corn flour and 15% lupine flour; L$_2$F: 70%corn flour and 30% lupine flour

Texture profile analysis of gluten free cakes samples (TPA)

Results presented in table (5) revealed the texture profile analysis of gluten free cake samples. Texture profile analysis is very important technique for investigating food products. The texture profile analyzer was used for the estimation of hardness (HRD), resilience (RES), Springiness (SPR), Gumminess (GUM) and Chewiness (CHW). Hardness is the peak force measured through the first compression cycle (*i.e.,* first bite) **Bourne (2002)** . From the results presented in table (5) it could be observed that, the highest value of hardness was observed by the cake sample which produced from Cp$_2$F cake (36.04$\pm$0.04 N) with significant differences with other groups with contrast to the lowest value (21.46$\pm$0.06 N) recorded by the cake sample which produced from S$_1$F cake with significant differences with other groups. This means that the cake become harder with increasing level of chickpea flour.

In this concern, chickpea addition brought a clear increase in hardness probably as a result of the thickening of the crumb walls surrounding the air cells and the strengthening of the crumb construction by the protein particles **Mohammad *et al*.,(2012)**. As well as, hardness and factorability are the most main criteria for textural properties of bakery products . It was noticed that products prepared with flour containing a higher protein content resulted in a harder structure **Moiraghi *et al*., (2011).** Several researchers have shown that protein content in flours is an important factor in the rate of hardening and staling **Pateras *et al.*, (2007)**. For resilience (RES) the cake sample L_2F recorded the highest value (0.22±0.07), on contrary to the lowest value (0.11±0.01) which recorded by S_2F sample cake. In addition that , Cohesiveness quantifies the internal resistance of food structure **Ronda *et al.*,(2009)**Cohesiveness determined from the area of work through second compression divided by the area of work during the first compression **Chaiya and pongsawatmanit (2011).** According to the results in the same table cohesiveness of the cake sample Cp_2F recorded the highest values (0.43±0.03) with no significant differences with the cake sample L_2F (0.41±0.02) with contrast to the cake sample CF (0.27±0.07) which recorded the lowest value of cohesiveness.

Springiness was defined as the distance to which the sample get better in height through the time that elapsed between the end of the first compression cycle and the start of the second pressure cycle **.** According springiness the cake sample Cp_2F recorded the highest value (7.29±0.09) with significant differences with other cake samples groups, on contrary to the lowest value (6.03±0.03) which recorded by CF sample cake with significant differences with other cake samples groups . Gumminess was calculated by multiplying hardness and cohesiveness, therefore, chewiness was acquired from the product of hardness, cohesiveness and springiness **.** For Gumminess values the cake sample Cp_2F recorded the highest value (15.53±0.03) with significant differences with other cake samples groups, on contrary to the lowest value (6.30±0.20) which recorded by CF sample cake with significant differences with other cake samples groups. **Chaiya and Pongsawatmanit (2011)** reported that chewiness was gained from the product of hardness, cohesiveness and springiness.

These results are in agreement with obtained by **Mohammad *et al.*, (2012)** who stated that chickpea addition brought a noticeable increase in crumb hardness probably as a result of the thickening of the crumb walls framing the air cells and the strengthening of the crumb structure by the protein particles .

Therefore, chewiness defined as the energy is demand to masticate solid food to a state of readiness for swallowing **Karaoglu and Kotancilar(2009)**. Whilst ,chewiness of the cake sample Cp_2F recorded the highest value (113.20±0.20) with significant differences with other cake samples groups , on contrary to the lowest value (38.00±0.01) which recorded by CF sample cake with significant differences with other cake samples groups . As well as**, Ronda *et al.*,(2009)** reported that cohesiveness quantifies the internal resistance of food structure.

Gumminess was calculated by the product of that is by multiplying hardness and cohesiveness, thus chewiness, defined as the energy required to run down solid food to a state of readiness for swallowing was obtained from the product of hardness, cohesiveness and springiness **Karaoglu and Kotancilar (2009)** .In this concern ,using additional ingredient like corn starch decreased crumb firmness, chewiness and increased cohesiveness, springiness, resilience **Onyango *et al*.,(2011).**

The results of texture profile concluded that the highest values of hardness, cohesiveness, springiness, gumminess and chewiness was observed by the cake sample which produced from CP_2F cake. This means that the cake become more harder, more cohesiveness, more springiness ,more gumminess and more chewiness by increasing chickpea flour.

Table (5) :Texture profile analysis of cake samples

Cake samples	TPA Parameters					
	Hardness (N)	Resilience	Cohesiveness	Springiness (mm)	Gumminess (N)	Chewiness (mJ)
CF	23.11 ± 0.01^{f}	0.14 ± 0.02^{b}	0.27 ± 0.07^{g}	6.03 ± 0.03^{f}	6.30 ± 0.20^{g}	38.00 ± 0.01^{f}
Cp_1F	29.88 ± 0.04^{c}	0.16 ± 0.01^{ab}	0.36 ± 0.03^{bde}	6.98 ± 0.01^{bc}	10.69 ± 0.04^{b}	74.60 ± 0.20^{b}
Cp_2F	36.04 ± 0.04^{a}	0.17 ± 0.03^{ab}	0.43 ± 0.03^{a}	7.29 ± 0.09^{a}	15.53 ± 0.03^{a}	113.20 ± 0.20^{a}
S_1F	21.46 ± 0.06^{g}	0.14 ± 0.04^{b}	0.37 ± 0.02^{bc}	6.90 ± 0.20^{c}	8.01 ± 0.01^{f}	55.30 ± 0.20^{e}
S_2F	32.02 ± 0.02^{b}	0.11 ± 0.01^{b}	0.31 ± 0.01^{eg}	7.13 ± 0.03^{b}	9.94 ± 0.04^{d}	70.90 ± 0.02^{c}
L_1F	24.04 ± 0.02^{e}	0.16 ± 0.06^{ab}	0.36 ± 0.02^{bef}	6.43 ± 0.03^{d}	8.73 ± 0.01^{e}	55.20 ± 0.20^{e}
L_2F	24.50 ± 0.50^{d}	0.22 ± 0.07^{a}	0.41 ± 0.02^{acdf}	6.23 ± 0.03^{e}	10.12 ± 0.02^{c}	63.10 ± 0.10^{d}

Different superscript letters in the same column indicate a significant ($p\leq0.05$) difference according to Duncan's test; CF: 100% corn flour (control); Cp_1F:85%corn flour and 15% chickpea flour; Cp_2F: 70%corn flour and 30% chickpea flour; S_1F: 85%corn flour and 15% soy flour; S_2F: 70%corn flour and 30% soy flour; L_1F: 85%corn flour and 15% lupine flour; L_2F: 70%corn flour and 30% lupine flour

Organoleptic characteristics of gluten free cakes

Data in table (6) demonstrated the organoleptic characteristics of gluten free cakes .Sensory analysis is carried out by using experienced panelists to measure sensory characteristics like taste, odor , crumb color, crust color, texture, Pore structure and overall acceptability.

From table(6) it was observed that control gluten free cake (CF) was classified significantly with the highest scores for taste, odor , crumb color, crust color ,texture , Pore structure and overall acceptability.

Taste is the most main factor which affects the acceptability of an edible product **Farzana and Mohajan (2015)**. The best taste was for (CF) cake and the lowest taste was for L2F cake. These evaluation attributes decreased with the addition of soy flour, chickpea flour and lupine flour at different levels 15% and 30% .In addition that, the lowest evaluation of odor and crumb color was obtained for L_2F cake . It was found that there is no significant differences between control gluten free cake CF, Cp_1F and Cp_2F cakes in taste, odor , crumb color, crust color these results are in harmonization with **Gadallah (2017)** who stated that using germinated chickpea flour at 20% as substitution levels of rice flour produced good gluten-free cakes with acceptable freshness and sensory properties for celiac people . Regarding texture, there is no statistical difference with control gluten-free cake(CF) and cake with 15% chickpea flour Cp_1F cake .Concerning Pore structure the lowest score for sensory attributes were obtained for cake with 30% soy bean S_2F(5.28$\pm$0.01) ,while the highest score for Pore structure were obtained for CF cake (8.64$\pm$0.02).Results of overall acceptability showed that the highest value was found for CF cake (16.68$\pm$0.01) and Cp_1F cake(16.06$\pm$0.01), whereas the lowest value of overall acceptability was found for S_2F cake (12.64$\pm$0.02). Beside this, another studies have found that soy could improve the crumb, volume, and absorption properties of the bakery products **Sanchez *et al.*, (2004).**

In this respect **Miñarro *et al.*, (2012)** stated that using soy flour gave good sensory appearance. Therefore , **Farzana and Mohajan, (2015)** declared that adding 10% or 15% soy flour to other flours gave acceptable products. whereas ,other studies declared that incorporation of soy flour more than 15% did not produce acceptable products. Furthermore**, Bunde *et al.*, (2010)** reported that nutritional and functional characteristics of soy flour efficiently used to prepare bakery products like bread, muffins, etc .

On the other hand, **Levent and Bilgiçli (2011)** revealed that gluten-free cake could be produced with satisfactory results by adding lupine flour up to 30% respectively.

It was concluded that gluten-free cake could be produced with satisfactory results by replacing corn flour with soy flour (SF), chickpea flour (CPF) and lupine flour (LF) at 15% and 30%, respectively. In addition that , Cp_1F and Cp_2F cakes showed higher overall acceptability values after CF where they recorded 16.06$\pm$0.01 and 15.60$\pm$0.03 respectively.

Table (6) : Organoleptic characteristics of gluten free cake samples

Samples	Taste (20)	Odor (20)	Crumb color (10)	Crust color (10)	Texture (10)	Pore structure (10)	Overall acceptability (20)
CF	18.36±0.01[a]	19.50±0.02[a]	9.48±0.01[a]	9.34±0.03[a]	8.54±0.01[a]	8.64±0.02[a]	16.68±0.01[a]
Cp_1F	17.95±0.03[ab]	18.64±0.01[a]	9.40±0.01[a]	9.12±0.01[ab]	8.21±0.02[a]	8.00±0.01[b]	16.06±0.01[ab]
Cp_2F	17.54±0.02[ab]	18.43±0.01[ab]	9.00±0.03[a]	9.05±0.01[ab]	7.31±0.01[b]	7.01±0.03[c]	15.60±0.03[b]
S_1F	17.13±0.01[bc]	17.40±0.06[b]	8.83±0.05[ab]	8.63±0.02[bc]	6.85±0.03[c]	6.13±0.05[d]	14.62±0.01[c]
S_2F	16.22±0.01[cd]	14.58±0.05[cd]	7.75±0.05[bc]	6.98±0.02[d]	5.11±0.01[d]	5.28±0.01[e]	12.64±0.02[d]
L_1F	15.34±0.04[d]	15.64±0.03[c]	7.60±0.02[c]	8.25±0.05[c]	7.23±0.02[bc]	7.61±0.02[b]	14.00±0.01[c]
L_2F	14.22±0.05[e]	13.84±0.01[d]	7.24±0.02[c]	7.46±0.06[d]	7.15±0.04[bc]	7.64±0.01[b]	12.90±0.01[d]

Different superscript letters in the same column indicate a significant ($p \leq 0.05$) difference according to Duncan's test; CF: 100% corn flour (control); Cp_1F:85%corn flour and 15% chickpea flour; Cp_2F: 70%corn flour and 30% chickpea flour; S_1F: 85%corn flour and 15% soy flour; S_2F: 70%corn flour and 30% soy flour; L_1F: 85%corn flour and 15% lupine flour; L_2F: 70%corn flour and 30% lupine flour

Conclusion

The aim of this study was to assess the effect of replacing corn flour (CF) with soy flour (SF), chickpea flour (Cp F) and lupine flour (LF) on chemical, physical, texture ,color and sensory characteristics of innovated gluten-free (GF) cakes. Regarding chemical properties, the main results concluded that replacing corn flour with soy flour, chickpea flour and lupine flour at levels 15% and 30% led to significant increase in ash, protein ,lipid, fiber but it led to significant decrease in carbohydrate. Concerning physical properties ,it was found that these replacement processes decreased the values of volume and specific volume. Furthermore, the results of color measurements revealed that there is no significant differences between CF cake, Cp_1F cake and L_2F cake in crust (L^*) values. Over there , there is no significant differences between CF cake, L_1F cake in crumb (L^*) values. Concerning texture profile the highest values of hardness, Cohesiveness, Springiness, gumminess and chewiness was observed by the cake sample which produced from CP_2F cake. This means that the cake become more harder, more cohesiveness, more springiness , more gumminess and more chewiness by increasing chickpea flour. For sensory evaluation it was observed that innovative gluten-free cakes could be produced by replacing corn flour with soy flour, chickpea flour and lupine flour at level 15% and 30% respectively and CF cake was distributing significantly with the highest scores for taste, odor , crumb color, crust color ,texture , Pore structure and overall acceptability. In addition that , Cp_1F and Cp_2F cakes showed higher overall acceptability after CF cake . The study recommended that entering soy flour, chickpea flour and lupine flour in making products for celiac people.

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Abstract

Study the Different Properties of Innovative Cake Blends for Patients with Gluten Sensitivity

The aim of this study was to assess the effect of soy flour (SF), chickpea flour (Cp F) and lupine flour (LF) on chemical , physical, texture , color and sensory characteristics of innovative gluten-free cakes . In this study corn flour was replaced with soy flour, chickpea flour and lupine flour at different levels 15% and 30% to produce more nutritionally balanced gluten-free cakes. Chemical , physical, color , texture and sensory properties were measured in gluten free cake samples .Seven gluten –free cake flour blends were prepared : control: 100% corn flour (CF), 85% corn flour and 15% chickpea flour (Cp_1F) , 70% corn flour and 30% chickpea flour (Cp_2F), 85% corn flour and 15% soy flour (S_1F) , 70%corn flour and 30% soy flour (S_2F) , 85%corn flour and 15% lupine flour (L_1F), 70%corn flour and 30% lupine flour (L_2F).Regarding chemical properties, the main results concluded that replacing corn flour with soy flour, chickpea flour and lupine flour at levels 15% and 30% led to significant increase($P \leq 0.05$) in ash, protein ,lipid, fiber but it led to significant decrease($P \leq 0.05$) in carbohydrate. Concerning physical properties the highest value of cake weight (316.50$\pm$0.50 g) was observed by the sample S_1F cake but the lowest value of weight which investigated by the sample Cp_1F (286.00$\pm$0.30 g).Therefore, the control sample CF recorded the highest value of volume and specific volume with significant difference with other samples. Furthermore, the results of color measurement (L*, a* and b*) revealed that there is no significant differences between CF cake, Cp_1F cake and L_2F cake in crust (L*) values. Over there ,there is no significant differences between CF cake, L_1F cake in crumb (L*) values. Whereas ,the highest value of crust (a*) was for L1F cake which recorded (18.63$\pm$0.30) and for crumb color was for S1F cake which recorded (7.15$\pm$0.20).In addition that ,the highest value for crust (b*) was for CF cake (46.23$\pm$0.60) and the highest value for crumb (b*) was for L_2F cake which recorded (44.48$\pm$0.04).Whereas, the results also declared that the texture profile affect by replacement processes, the results of hardness, resilience, cohesiveness and chewiness ranged From 21.46$\pm$ 0.06 :36.04$\pm$0.04 , 0.11$\pm$ 0.01:0.22$\pm$0.07 , 0.27$\pm$0.07:0.43$\pm$ 0.03 , 38.00$\pm$ 0.01: 113.20$\pm$ 0.20 .The results of the sensory evaluation judged by panelists indicated that CF cake was distributing significantly with the highest scores for taste, odor , crumb color, crust color ,texture , Pore structure and overall acceptability. These results also revealed that there is no significant differences between control gluten free cake CF, Cp_1F and Cp_2F cakes in taste, odor , crumb color, crust color. In addition that , Cp_1F and Cp_2F cakes showed higher overall acceptability values after CF where they record 16.06±0.01 and 15.60±0.03 respectively. It was concluded that innovative gluten-free cakes could be produced with satisfactory results by replacing corn flour with soy flour, chickpea flour and lupine flour at level 15% and 30% respectively. The study recommended entering of soy flour, chickpea flour and lupine flour in making products for celiac people.

Keywords: celiac disease , corn flour , soy flour, chickpea flour , lupine flour, chemical properties, physical properties, texture profile ,color measurements and sensory properties- gluten free cakes.

ملخص البحث

دراسة الخصائص المختلفة لخلطات مبتكرة من الكيك
تصلح لمرضي حساسية الجلوتين

هدفت الدراسة الحالية إلي معرفة تأثير استبدال دقيق الذرة في الكيك الخالي من الجلوتين بكل من دقيق الصويا ،دقيق الحمص ودقيق الترمس بنسبة (١٥% ، ٣٠%) لكل منهم علي التركيب الكيميائي ، الخواص الفيزيائية ، الخواص الحسية ، خواص الملمس والخواص اللونية للكيك المنتج . ولهذا الغرض تم إعداد كيك بخلطات مختلفة (١٠٠% دقيق ذرة ، ٨٥% دقيق ذرة + ١٥% دقيق صويا ، ٧٠% دقيق ذرة + ٣٠% دقيق صويا، ٨٥% دقيق ذرة + ١٥% دقيق حمص ، ٧٠% دقيق ذرة + ٣٠% دقيق حمص، ٨٥% دقيق ذرة + ١٥% دقيق ترمس و٧٠% دقيق ذرة + ٣٠% دقيق ترمس). وقد أشارت النتائج إلي أن الاستبدال قد أدي إلي زيادة معنوية ($P \leq 0.05$) في محتوي الكيك من الرماد والبروتين والدهون والألياف بينما حدث انخفاض معنوى فى نسبة الكربوهيدرات. كما أظهرت نتائج الخواص الفيزيائية أن أعلي وزن للكيك (٣١٦,٥٠± ٠,٥٠جم) سجل مع ١٥% دقيق صويا، بينما أقل وزن (٢٨٦,٠٠± ٠,٣٠جم) كان مع ١٥% دقيق حمص ،كما سجل كيك العينة الضابطة أعلي قيمة بالنسبة للحجم (٦٤٤,٧٣± ٠,٤٠جم) وكذلك أعلي قيمة بالنسبة للحجم النوعي (٢,٠٦±

٠,٢٠ سم^٣ / جم) وبفروق معنويـة (P ≤0.05) مع باقي خلطـات الكيـك . وأظهرت نتائـج قيـاس اللون (L*, a* and b*) عدم وجود فروق ذات دلالة معنوية(P ≤0.05) بين كيك العينة الضابطة ، كيك(١٥% دقيق حمص) ، وكيك (٣٠ % دقيق ترمس) في قيم (L*) للون القشرة ، وكذلك عدم وجود فروق ذات دلالة معنوية بين كيك العينة الضابطة وكيك (١٥% دقيق ترمس) في قيم (L*) للون اللب، أما أعلي قيمة لـ (a*) للون القشرة فكانت لكيك (١٥% دقيق ترمس) حيث سجلت (١٨,٦٣± ٠,٣٠جم) وللون اللب كانت لكيك (١٥% دقيق صويا) حيث سجلت (٧,١٥± ٠,٢٠جم) ، كما كانت أعلي قيمة لـ (b*) للون القشرة لكيك العينة الضابطة (٤٦,٢٣± ٠,٦٠) وللون اللب لكيك (٣٠% دقيق ترمس) حيث سجلت (٤٤,٤٨± ٠,٠٤). هذا وقد أسفرت النتائج عن تأثر خواص الملمس بعمليات الاستبدال حيث تراوحت نتائج كل من الصلابة ، المرونة ، التماسك والمضغية ٢١,٤٦± ٠,٠٦ : ٣٦,٠٤± ٠,٠٤ ، ٠,١١± ٠,٠١ : ٠,٢٢± ٠,٠٧ ، ٠,٢٧± ٠,٠٧ : ٠,٤٣± ٠,٠٣ ، ٣٨,٠٠± ٠,٠١ : ١١٣,٢٠± ٠,٢٠ علي التوالي . و أظهرت نتائج تقييم الخواص الحسية أن كيك العينة الضابطة حقق أعلى القيم في المذاق ، الرائحة ، لون اللب ، لون القشرة ،الملمس والتقبل العام ، كما لوحظ عدم وجود فروق ذات دلالة معنوية (P ≤0.05) بين كيك العينة الضابطة وكل من كيك (١٥% دقيق حمص) وكيك (٣٠% دقيق حمص) في المذاق ، الرائحة ، لون اللب ولون القشرة ، كما أظهر كل من كيك (١٥% دقيق حمص) وكيك (٣٠% دقيق حمص) أعلي درجة تقبل عام بعد العينة الضابطة حيث سجلا ١٦,٠٦± ٠,٠١ ، ١٥,٦٠± ٠,٠٣ علي التوالي . ولقد أوصت الدراسة بإدخال كل من دقيق الحمص ، دقيق الصويا ودقيق الترمس فى عمل منتجات تصلح لمرضى حساسية الجلوتين.

الكلمات المفتاحية: مرض حساسية الجلوتين ، دقيق الذرة ، دقيق الصويا ، دقيق الحمص ، دقيق الترمس ، التركيب الكيميائي ، الخصائص الفيزيائية ، الخواص اللونية، خواص الملمس ،الخواص الحسية، الكيك الخالي من الجلوتين.