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Preparation and Evaluation of Gluten-Free Foods for Celiac People

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Abstract: This study was performed to prepare gluten-free cakes and crackers produced with different flours of rice, corn, and sweet lupin for celiac people and evaluate the effect of flours on chemical, physical and sensory cakes and crackers properties compare with control cakes and crackers made with wheat flour. Six cakes and crackers formulations were followed as: RF_1 (cake with 100% rice flour), CF_2 (cake with 100% corn flour), LF_3 (cake with 100% sweet lupin flour), RF_4 (crackers with 100% rice flour), CF_5 (crackers with 100% corn flour) and LF_6 (crackers with 100% sweet lupin flour). Control cake and crackers were used with 100% wheat flour. The cakes and crackers were characterized with chemical, physical, and sensory analysis. The results of the chemical composition of cake and crackers ingredients showed that the RF_1 and RF_4 the highest percentage of moisture, copper, and iron compare with other samples. While LF_3 and LF_6 contain maximum value of protein, fiber, fat, ash, phosphorus and potassium. The CF_2 and CF_5 showed the maximum of calcium and sodium. Cakes and crackers formulated with LF and RF displayed improved quality characteristics such as increased weight and volume but decreased the specific volume. The hedonic scale showed that the panelists preferred the LF cake and RF crackers (8.7 and 8.8 respectively) after WF cake and crackers. The overall assessment pointed that WF cake and crackers a greater acceptance by panelists, while gluten-free cakes and crackers are considered nice in the opinion of the panelists. Also, the sensory evaluation showed that using the corn flour in cakes and crackers caused lower acceptance by the panelists.

Keywords: Gluten-free foods, celiac, rice flour, corn flour, sweet lupin flour, cakes, crackers.

Introduction

Celiac disease (CD) is known as gluten sensitive enteropathy, is an autoimmune chronic disease causing inflammation of the upper small intestine in genetically predisposed individuals. It is triggered by ingestion of wheat gliadin and prolamins of rye and barley (Heredia *et al.,* 2007) which release these peptides during digestion and cause flattening of the intestinal mucosa (Miñarro *et al.,* 2012) due to loss of normal villi and inflammation leading to mal-absorption of nutrients like iron, folic acid, calcium and fat-soluble vitamins (Albanell *et al.,* 2012).

In Middle Eastern (ME) and North African (NA) countries, the literature regarding CD has expanded significantly (Akbari et al., 2006). Until the 1990s, the prevalence of CD in ME and NA countries was considered low. However, with the introduction of anti-endomysial antibodies (AEA) and antigliadin antibodies (AGA) testing, CD has been more readily reported from developing countries, and its prevalence seems similar to that of Western countries (Kassem *et al.,* 2010).

Untreated CD is associated with an increased risk of developing other diseases, such as osteoporosis (Corazza *et al.,* 2005), reproductive problems in both women and men (Ludvigsson, 2001) and cancer (Smedby *et al.,* 2005). The cornerstone treatment of celiac disease is a lifelong strict withdrawal of wheat, rye, barley and an adherence to a gluten free diet. Many of the gluten-free products are not enriched, and therefore do not provide the same levels of thiamin, riboflavin, niacin iron and folate found in enriched and fortified wheat products (Londono *et al.,* 2013). Recent studies have consequently shown nutritional inadequacy of these nutrients associated with the gluten-free diet (Tess *et al.,* 2015).

A few years ago, gluten-free products were virtually unheard of except in specialty health-food stores. Nowadays an increasing demand for gluten-free products is seen in market trends. The increasing interest has promoted the launching of hundreds of gluten-free foodstuffs, being a niche market with a steadily growing share (Maria and Cristina, 2015).

Gluten-free foods are of low quality, more expensive, not widely available and lack variety with lower palatability. Most of the gluten-free products are on starch basis with the addition of different types of hydrocolloids. However, the gluten-free formulations containing gums as the gluten replacements lack in fibers and nutrients (Lerner, 2012).

Therefore it is very important to develop gluten-free foodstuffs with high nutritional quality ingredients. A large number of flours and starches (rice, corn, soybean and peanut), soybean proteins, dairy products, egg white and prebiotics have been used to mimic viscoelastic properties of gluten in gluten-free cereal products in order to improve nutritional quality, structure, mouth feel, acceptability and shelf life (Torbica *et al.,* 2010).

Rice flour does not contain gluten, and contains low levels of sodium, protein, fat and fiber, and has a high amount of easily digested carbohydrates, whereas it is frequently used as a wheat substitute in gluten free food products (Korus *et al.,* 2009). Rice, on the contrary, seems to be very well tolerated by CD patients. Hence, rice is one of the most used cereals in these specialty food elaborations. However, replacement of wheat flour by rice flour usually leads to a noticeable decrease in the quality of elaborated products. Therefore, an optimization of rice flour formulae is essential (Nuno *et al.,* 2011).

Corn flour, like rice, does not contain gluten, and, therefore, corn flour based dough does not demonstrate rheological properties comparable to those of a wheat flour based dough (Pite *et al.,* 2008). Both corn and rice flour can be used in the formula of gluten free cakes. Corn flour provides a natural yellow colour and a characteristic flavour. Rice flour has very little flavour on its own, yet when it is mixed with corn flour, the flavour of the cake can be increased without the need for flavour and colour additives. However, both corn and rice flour a batter with lower viscosity and stability when compared to wheat flour (Oliete *et al.,* 2010).

Lupin (*Lupinus albus* L.) is a species in the family *Leguminosae*. Lupin flour contains comparatively higher protein (about 40 % by weight) and dietary fiber (30%) contents (both soluble and insoluble) than wheat flour. The high lysine, low methionine content complements that of wheat flour proteins which are poor in lysine and relatively higher in the sulphur containing amino acids. LF also found to provide a wide range of phytochemicals including antioxidants and phytosterols which are beneficial to health (Erbas *et al.,* 2005).

Considering its nutritional and functional properties, it has a high potential to be used in different foods such as fermented foods, pasta, crisps, bread, biscuits and cakes. LF is lower in cost compared with

other similar legume flours such as soybean. Therefore, with the substitution of LF, it can be produced products with improved nutritional and functional quality at a comparatively lower cost (Levent and Bilgiçli, 2011).

Some studies have demonstrated that obtaining these specialty foods is difficult for some patients. Therefore, the development and study of new GF foods of high quality suitable for CD patients is obviously necessary (Ronda *et al.*, 2009).

Cakes and crackers are popular bakery product which contains basically wheat flour, sugar, egg, shortening, dairy products, emulsifiers, leavening and flavoring agents (Levent and Bilgiçli, 2011). Many studies have been performed in gluten free bread but studies on the other gluten-free bakery products such as cakes and crackers are limited. Therefore, the objective of this study was to prepare gluten-free cakes and crackers produced with flours of rice, corn and sweet lupin for celiac people and evaluate the effect of flours on physical, textural and sensory cakes and crackers properties compare with control cakes and crackers were made with wheat flour.

Materials and Methods

Materials

Commercial wheat flour (72% extraction rate), rice seeds, corn seeds, sweet lupin seeds, crystal white sugar, salt, sunflower oil, baking powder, baking powder free gluten, dry milk and fresh whole eggs were purchased from local markets, Assiut, Egypt.

Methods

Seeds flour preparation

The cleaning of rice, corn and sweet lupin seeds was performed manually to remove damaged seeds, dust particles. Rice, corn and sweet lupin seeds were ground into powder in the hammermill and sieved with a mesh of size 0.50 mm to obtain lupin flour. The seeds used to produce the flour to be consumed in the experimental design were subjected to heat treatment in a conventional oven at 150 ^{o}C for 30 min as previously described by Carvalho, (2009). After the heat treatment, the grains were ground in a food processor (Walita brand) and then cooled.

Cakes and crackers formulations

Cakes and crackers formulations were followed as: RF_1 (cake with 100% rice flour), CF_2 (cake with 100% corn flour), LF_3 (cake with 100%

sweet lupin flour), RF_4 (crackers with 100% rice flour), CF_5 (crackers with 100% corn flour) and LF_6 (crackers with 100% sweet lupin flour). Control cakes and crackers were used with 100% wheat flour.

Gluten-free cakes preparation

Gluten-free cakes were prepared according to the method described by Levent and Bilgicli, (2011). Ingredients and pictures of cakes are given in table1 and figure1. Firstly fat and sugar were mixed in a mixer to a white cream. Then egg was added and mixed for 5 min then the other ingredients were added and the batter was mixed for additional 1 minute. Cake batter (900 g) was placed in rectangular shape cake molds (30 cm length, 20 cm wide and 3.5 cm height) baked at 160° C for 50 min in an electric oven. Upon completion of baking, the cakes were removed from the pan and left for 1 h at room temperature for cooling. After weighing, the cakes were packaged in polyethylene bags at room temperature (22° C) until their measurements and analyses.

Gluten-free crackers preparation

Crackers were produced according to the modified recipes published by Fenster (2004). Ingredients and photos of crackers are shown in Table (1) and Figure (1). Combine the flours, sugar, salt and oil until the mixture resembles coarse meal. Blend in the milk slowly. Stir until the dough is thick and comes together into a solid ball. Divide the dough into 2 equal halves. On a floured surface or pastry cloth, roll the dough thin, 1/16 to 1/8 inch. If desired, lightly sprinkle the tops with salt and gently roll the dough with rolling pin. With a sharp knife, cut the crackers into 2-inch squares or use your favorite cookie cutter. Bake 20 to 25 minutes in an oven at 400 °C, or until the crackers are lightly browned. After baking, crackers were removed from the pan and left 30 min for cooling until their measurements and analyses.

Analytical methods

Physical and chemical analysis

The main physical and chemical parameters of the raw materials and fresh cakes and crackers were assessed. Volume (cm3) and weight (gm) of cake and crackers samples were recorded. Specific volume (gm/ cm3) was calculated by dividing of the volume to weight according to the method described in AACC (2000).

Moisture, protein, fiber, fat and ash contents of different cakes and crackers were determined according to AACC (2000). Total

carbohydrates were calculated by difference. Minerals elements (Ca, P, K, Na, Fe, Mg, and Cu) in all samples were determined according to the method described by Isaac and Johnson, (1985). These analyses were determined in Central Laboratory for Chemical Analysis, Faculty of Agriculture, Assiut University.

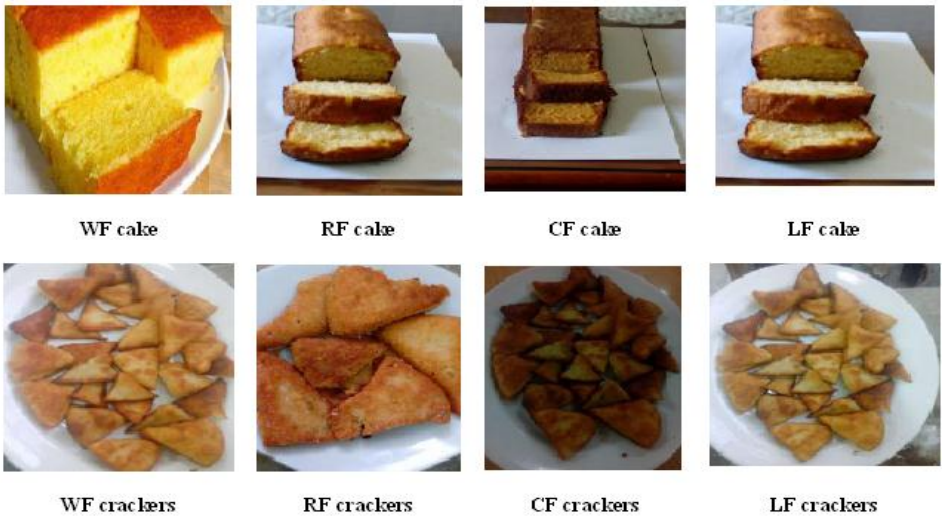

Figure 1: Gluten-free cakes and crackers

Table 1: Cake and crackers ingredients (g)

	WF (control cake)	RF1 Cake	CF2 Cake	LF3 cake	Control crackers	RF4 crackers	CF5 Crackers	LF6 Crackers
Wheat flour	100	-	-	-	100	-	-	-
Rice flour	-	100	-	-	-	100	-	-
Corn flour	-	-	100	-	-	-	100	-
Lupin flour	-	-	-	100	-	-	-	100
Sugar	120	120	120	120	5	5	5	5
Salt	3	3	3	3	4	4	4	4
Sunflower oil	50	50	50	50	30	30	30	30
Baking powder	5	-	-	-	-	-	-	-
gluten-free baking powder	-	5	5	5	-	5	5	5
Dry Milk	150	150	150	150	100	100		
Egg	125	125	125	125	75	75	75	75
Vanillin	5	5	5	5	-	-	-	-

WF: Wheat flour, RF: Rice flour, CF: Corn flour, LF: Lupin flour

Sensory evaluation of gluten-free cakes and crackers

Gluten-free cakes and crackers samples were sensory evaluated after baking by 30 panelists who were graduate students, staff and non-staff members of the Department of Home Economics, Faculty of Specific Education, Assiut University. All samples were provided in plates having white color at ambient temperature. The panelists were asked to rinse their plates with water (at room temperature) between samples. Cakes and crackers were evaluated on the basis of acceptability of their color, odor, taste, texture, crispiness, chewing ability, appearance, overall acceptability, using a hedonic 9-point scale (1=dislike extremely, 2=dislike very much, 3= dislike moderately, 4=dislike slightly, 5=neither like nor dislike, 6=like slightly, 7=like moderately, 8=like very much and 9=like extremely) according to Stone and Sidel (1992). Scores were collated and analyzed statistically.

Results and Discussions

Proximate chemical composition of raw materials (flours) (% d.b.)

Data in the Table (2) represent the proximate chemical composition of wheat flour (72 %), (rice, corn and sweet lupin) flour. The moisture was (12.45%, 11.2%, 7.75% and 7.54%) in (wheat, rice, corn and sweet lupin) flour respectively. Protein was (8.67%, 6.50%, 9.70% and 34.54%) in (wheat, rice, corn and sweet lupin) flour respectively. Also, the fiber was (3.20%%, 4.40%, 2.63% and 6.50%) in (wheat, rice, corn and sweet lupin) flour respectively. While the fat was (2.04%, 1.90%, 4.60% and 6.37%) in (wheat, rice, corn and sweet lupin) flour respectively. Concerning, the ash was (2.70%, 0.80%, 1.82% and 2.84%) in (wheat, rice, corn and sweet lupin) flour respectively. Total carbohydrate (89.29%, 91.60%, 85.70% and 59.09%) in (wheat, rice, corn and sweet lupin) flour respectively. Similar results have been reported in previous works Nareman, (2016) and Leidi *et al*., (2011) in wheat flour, Ronda *et al.,* (2009) and Rachel *et al.,* (2013) in rice flour, Abiose *et al.,* (2014) and Ahmed *et al.,* (2011) in corn flour, Marcia *et al.,* (2014) and Kohajdova *et al.,* (2011) and Leidi *et al.,* (2011) in lupin flour.

The results of analysis proximate minerals of raw material (flours) are tabulated in Table (3). The results revealed that concentration of calcium in WF was the highest (237 mg/kg) followed by (54.34, 51.34, 23.86 mg/kg) in CF, LF, and RF respectively. Phosphorus was the highest in WF (780 mg/kg) followed by (128.15, 89.65, 72.0 mg/kg) in LF, RF, and CF respectively. Potassium was the highest in WF (425

mg/kg) followed by (234.10, 78.94, 75.23 mg/kg) in LF, RF, and CF respectively. Sodium was the highest in WF (151mg/kg) followed by (65.85,4.26, 1.30 mg/kg) in CF, LF, and RF respectively. The highest concentration of iron was in WF (38.04 mg/kg) followed by (10.85, 2.70, 2.15 mg/kg) in RF, LF and CF respectively. Magnesium was the highest in CF (54.0mg/kg) followed by (53.23, 11.54, 5.46 mg/kg) in LF, RF, and WF respectively. The highest concentration of copper was in RF (10.86 mg/kg) followed by (1.38, 0.48, 0.45 mg/kg) in LF, WF, and CF respectively. The rich mineral content of RF, CF, and LF caused to increase in the mineral content of cake and crackers formulations. Results of present study are supported by the results of Nareman, (2016) and Nermin and Hacer, (2014) in WF, Rosniyana *et al.*, (2009) and Anjum et al., (2007) in RF, Jeffrey and Maria, (2014) and Abiose et al., (2014) in CF and Nermin and Hacer, (2014) and Tizazu and Emire, (2010) and Pingault *et al.*, (2009) in LF.

Table 2. Chemical composition of raw material (% on d.b.)

Flour	**WF**	**RF**	**CF**	**LF**
Moisture	12.45	11.2	7.75	7.54
Protein	8.67	6.50	9.70	34.54
Fiber	3.20	4.40	2.63	6.50
Fat	2.04	1.90	4.60	6.37
Ash	2.70	0.80	1.82	2.84
Carbohydrates	70.94	75.2	73.5	42.21

Table 3. Minerals of raw material (mg/kg)

Flour	**WF**	**RF**	**CF**	**LF**
Ca	237	23.86	54.34	51.34
P	780	89.65	72.0	128.15
K	425	78.94	75.23	234.10
Na	151	1.30	65.85	4.26
Fe	38.04	10.85	2.15	2.70
Mg	5.46	11.54	54.00	53.23
Cu	0.48	10.86	0.45	1.38

WF: Wheat flour, RF: Rice flour, CF: Corn flour, LF: Lupin flour

The results of analysis chemical composition of cake and crackers ingredients are presented in Table (4). The results in cakes and crackers revealed that the highest value of moisture was found in WF cake and crackers were (28.08% and 11.5% respectively) and lowest in LF_3 and LF_6 were (17.47% and 8.54% respectively). The gradual decrease in moisture contents of cake and crackers WF to LF_3 and LF_6 might be due to lower moisture contents in lupin flour as compared to wheat flour

(Amir *et al.*, 2015). Moreover, higher amounts of bran decrease moisture content in flours (Mueen *et al.*, 2009). The highest protein content was found in LF_3 and LF_6 while lowest protein content was found to be in RF_1 and RF_4. Results of the present study are supported by the results of Yaseen *et al.*, (2010) and Hacer and Nermin, (2012). Highest value crude fiber content was found in LF_3 (3.50%) and LF_6 (3.98%) and the lowest value was observed in WF cake and crackers (1.99% and 2.29%). Fiber is especially valuable for people with celiac disease because they often suffer prolonged constipation due to adherence to a gluten-free diet, which is low in dietary fiber (Green and Jabri, 2003) and Kupper (2005). Lupin flour substitution increased more fiber content as compared to wheat flour. Results are in accordance with the results of (Giwa and Victor, 2010) in biscuits. The crude fat contents showed highly value by the substitution lupin flour. The highest value of crude fat content was found in LF_3 (33.67%) and LF_6 (29.87%). The lowest fat content was found in RF_1 (13.82%) and RF_4 (10.79%). Lupin flour substitution increased more fat content compared to rice flour substitution. Results matched with the findings of Leidi *et al.*, (2011). Ahmed *et al.*, (2012) reported that corn flour and cake produced from it were higher in fat content compared with RF and WF. The results indicated that LF_3 and

Table 4. Chemical composition of cake and crackers ingredients (% d.b.)

Ingredients	Cakes				Crackers			
	WF (Control)	**RF_1**	**CF_2**	**LF_3**	**WF (Control)**	**RF_4**	**CF_5**	**LF_6**
Moisture	28.08	25.22	19.32	17.47	11.50	10.90	8.86	8.54
Protein	15.91	7.15	11.65	29.56	10.59	7.91	11.54	27.32
Fiber	1.99	2.62	2.14	3.50	2.29	2.97	1.74	3.98
Fat	14.28	13.82	28.01	33.67	11.21	10.79	22.56	29.87
Ash	1.96	0.97	1.65	2.01	2.30	1.04	1.95	2.76
Carbohydrates	37.78	50.22	19.94	13.79	37.89	66.39	53.35	27.53

WF: Wheat flour, RF: Rice flour, CF: Corn flour, LF: Lupin flour

LF_6 possessed the maximum ash content as 2.01% and 2.76% respectively. Lowered values were observed in RF_1 (0.97%) and RF_4 (1.04%). Lupin flour substitution increased more ash content compared to rice flour substitution. Results found matching with the observation of Adebowale (2012). Rice cakes and crackers produced from it contained a lower percentage of protein, fat, and ash and higher content in total

carbohydrate than (WF, CF and LF) cakes and crackers. These results are in agreement with results were obtained by Ahmed *et al.,* (2012).

Data presented in Table (5) showed minerals content of cakes and crackers. The highest value of calcium was in CF_2 (59.47 mg/kg) and CF_5 (57.42 mg/kg) which followed WF cakes (246 mg/kg) and crackers (240.78 mg/kg), followed by LF_3 (58.63 mg/kg) and LF_6 (61.33mg/kg). The value of phosphor was high in LF_3 (156.13mg/kg) and LF_6 (142.64 mg/kg) which followed WF cakes (897 mg/kg) and crackers (801.70 mg/kg). Also, the highest value of potassium was in LF_3 (254.11mg/kg) and LF_6 (250.20 mg/kg) which followed WF cakes (645mg/kg) and crackers (632.20 mg/kg). While sodium, the highest value was in WF cakes (198 mg/kg) and crackers (179 mg/kg), followed by CF_2 (79.98 mg/kg) and CF_5 (66.78 mg/kg). Concerning iron the highest value was in WF cakes (45.62 mg/kg) and crackers (43.76 mg/kg), followed by RF_1 (16.37 mg/kg) and RF_4 (15.42 mg/kg). The highest value of magnesium was in LF_3 (64.39 mg/kg) and LF_6 (64.30 mg/kg), but the lowest was in WF cakes (18.32mg/kg) and crackers (11.37 mg/kg). Finally copper was the highest in LF_3 (12.47 mg/kg) and LF_6 (11.98 mg/kg), but the lowest was in WF cakes (1.28 mg/kg) and crackers (1.03 mg/kg).

Table 5. Minerals of cake and crackers ingredients (mg/kg)

Ingredients	Cakes				Crackers			
	WF (Control)	RF_1	CF_2	LF_3	WF (Control)	RF_4	CF_5	LF_6
Ca	246	28.01	59.47	58.63	240.78	25.894	57.42	61.33
P	897	102.03	89.01	156.13	801.70	99.46	86.34	142.64
K	645	90.07	89.71	254.11	632.20	88.21	85.23	250.20
Na	198	3.70	79.98	6.72	179	2.56	66.78	5.89
Fe	45.62	16.37	9.02	8.13	43.76	15.42	7.05	7.59
Mg	18.32	25.34	65.19	64.39	11.37	15.45	60.18	64.30
Cu	1.28	12.47	1.48	2.96	1.06	11.98	1.03	2.13

WF: Wheat flour, RF: Rice flour, CF: Corn flour, LF: Lupin flour

This is important since adequate amounts of these nutrients are usually lacking in the gluten-free diet and recent studies have shown nutritional inadequacy associated with these diets (Thompson, 2000 and Hallert *et al.,* 2002). In addition, since many gluten-free products are neither enriched, fortified nor naturally rich sources of micronutrients (Thompson, 2000), celiac disease patients do not meet recommended nutrient intakes (Thompson *et al.,* 2005 and Ohlund *et al.,* 2010). This present study showed that preparation of gluten-free foods by lupin, corn and rice flours was an excellent source of iron and a good source of

other minerals. The results are close to the findings of Hacer and Nermin, 2012). Literature knowledge confirmed our ash, protein and mineral analyses for different flours (Bilgicli, 2009). The obtained results are in agreement with those reported by Hussein *et al.,* (2006), but disagree with Hussein *et al.,* (2011) who reported that the mineral contents of flour and cake of wheat were the lowest values, this due to the separation of germ and bran during milling, on contrary to CF and LF.

Physical analysis of cake and crackers ingredients are given in Table (6). Cake and crackers volume produced from LF was highest compared with other samples, followed by RF. Also, cake and crackers weight produced from RF was highest compared with other samples, followed by RF cake and crackers. This effect may be due to high fiber content in LF and RF as shown in Table (2). Fiber is characterized by their high water-holding capacity. This result disagrees with Halina *et al.,* (2009) who reported that the negative impact of the amount of dietary fiber on the quality of cake was even more pronounced concerning volume. From the same table, the specific volume of cake produced from CF and WF crackers had higher values compared with that of other samples. The specific volume of the cakes and crackers decreased proportionally with the addition of CF and RF. This result is in line with that obtained by Tess *et al.,* (2015) and Seleem and Omran (2014).

Sensory evaluation of gluten-free cakes and crackers

The mean sensory scores for color, odor, taste, texture, crispiness, chewing ability, appearance and overall acceptability are presented in Table (7). In the cakes, the highest score was obtained by WF (control) for color, odor, taste, texture and overall acceptability. The color scores for WF were (8.3) much good as compared to other cake samples (7.9, 7.5 and 6.2) in LF_3, RF_1 and CF_2, respectively. This result is in line with

Table 6. Physical analysis of cake and crackers ingredients (% d.b.)

Ingredients	Cakes				Crackers			
	WF (control)	**RF_1**	**CF_2**	**LF_3**	**WF (control)**	**RF_4**	**CF_5**	**LF_6**
Weight (g)	116.8	118.3	117.7	118.8	59.4	62.3	60.7	61.8
Volume (cm)	125	130	118	132	37.2	73.5	40.9	49.2
Specific volume (g/cm^3)	0.93	0.91	0.99	0.90	1.60	0.85	1.48	1.26

WF: Wheat flour, RF: Rice flour, CF: Corn flour, LF: Lupin flour

Table 7. Sensory evaluation of cake and crackers

Sensory Evaluation	Cakes				Crackers			
	WF (Control)	**RF_1**	**CF_2**	**LF_3**	**WF (Control)**	**RF_4**	**CF_5**	**LF_6**
Color	8.3	6.9	6.1	7.8	8.7	8.9	6.4	8.4
Odor	8.6	7.5	6.2	7.9	8.9	8.6	8.3	8.7
Taste	8.7	8.1	6.9	8.5	9.1	8.9	6.8	8.8
Texture	8.6	8.1	6.5	8.2	9.1	7.9	6.4	8.5
Crispiness	3.3	3.9	4.7	3.8	9.1	8.9	7.9	8.8
Chewing ability	7.5	8.2	7.1	7.4	8.9	8.7	7.9	8.8
Appearance	9.1	9.2	7.5	9.1	9.4	8.4	6.7	8.9
Overall Acceptability	8.9	8.6	7.4	8.7	8.9	8.8	7.3	8.7

N= 30; 1–9 point scoring scale (1=dislike extremely, 9= like extremely).

that obtained by Ronda *et al.,* (2009) who reported that the color was affected significantly by the presence of different kinds of flours. As a consequence, an evolution toward a more yellowish and more whiter. As it was in our results CF_2 (more yellowish) and LF_3 (more whiter). Although the original color of ingredients could have some influence on cake color, it has to be mainly associated with Maillard and caramelization reactions (Turabi *et al.,* 2008). The odor of cakes was affected if the type of flour is different. LF_3 odor was 7.9, followed by (7.5 and 6.2) in RF_1 and CF_2 respectively. The taste of LF_3 was 8.5 almost equal the control, followed by (8.1 and 6.9) in RF_1 and CF_2 respectively. The texture of cakes refers to the smoothness, feel of the cakes. It was (8.2, 8.1 and 6.5) in LF_3, RF_1 and CF_2 respectively, which shows nearly equal the ratio in LF_3 and RF_1. Crispiness was (4.7, 3.9 and 3.8) in CF_2, RF_1 and LF_3 respectively. Chewiness is one of the texture parameters easily correlated with sensory analyses through trained panels (Esteller *et al.,* 2004). From the scores of the sensory evaluation table of chewing ability, The RF1 cake has the highest (8.2) after the control, followed by (7.4 and 7.1) in LF_3 and CF_2 respectively. The appearance of RF_1 has a little higher mean than the other samples. The results indicate that WF (control cake) is ranked as the best from in comparison with other samples in terms of overall acceptability followed by LF_3, RF_1 and CF_2 by the panelists. The overall acceptability scores revealed slight differences between the three samples (WF, RF_1, CF_1) while CF_1 was the lowest. Sensory evaluation showed that all tested substances improved the overall acceptability of RF_1. However, none of them attained the WF, although in some cases, they came close. It has to be taken into account that the untrained panelists were, in general, wheat cakes consumers and were more used to wheat cake characteristics. Rice cake was the highest acceptance scores.

Among crackers, the highest score of color was received by RF_4 (8.9). Similarly was recorded for the WF crackers control (8.7). The odor of crackers was affected if the type of flour is different. The highest value of odor was in WF (8.9), followed by LF6, RF4 and CF5 (8.7, 8.6 and 8.3 respectively). The taste of RF_4 was the (8.9) almost equal the control (9.1), followed by (8.8 and 6.8) in LF_6 and CF_5 respectively. The texture was (8.5, 7.9 and 6.4) in LF_6, RF_4 and CF_5 respectively. Because crispiness is the most important texture parameters of gluten-free products, they were closely monitored in the analyzed products (Gambus et al., 2004), where was (8.9, 8.8 and 7.9) in RF_4, LF_6 and CF_5 respectively, which shows nearly equal the ratio in RF_4 and LF_6. From the scores of the sensory evaluation table of chewing ability, WF crackers have the highest (8.9), followed by (8.8, 8.7 and 7.9) in LF_6, RF_4 and CF_5 respectively. The appearance of LF_6 has a little higher mean than the other samples except for WF crackers. Sensory evaluation showed that all tested substances improved the overall acceptability of WF and RF_4 crackers (8.9 and 8.8 respectively), followed by (8.7 and 7.3) in LF_6 and CF_5 respectively.

The obtained results indicated that all of the LF cake and RF crackers were highly accepted by the panelists (8.7 and 8.8 respectively) after WF cake and crackers, and can be described as very good. The author noticed, however, that using the corn flour in cakes and crackers caused lower acceptance by the panelists, it may be due to the dark color of corn flour that is not acceptable to the panelists. Yaseen *et al.,* (2010) reported in bread that corn- wheat bread was significantly rated lower in sensory scores than the control bread. The present results showed the positive impact of the amount of dietary fiber on the quality of cakes and crackers were even more pronounced concerning panelists acceptance. This result disagrees with Halina *et al.,* (2009).

Conclusion

CD is known as gluten sensitive enteropathy, is an autoimmune chronic disease causing inflammation of the upper small intestine in genetically predisposed individuals. Untreated CD is associated with an increased risk of developing other diseases, such as osteoporosis and reproductive problems in both women and men. In the present study, cake and cracker samples were made from RF, CF, and LF for celiac people. Such products exhibited good physical and chemical properties as well as high accepted sensory evaluation.

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إعداد وتقييم أطعمة خالية من الجلوتين للناس ذو الحساسية ضد القمح

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الملخص العربى:

أجريت هذه الدراسة لبهدف إعداد كيك ومقرمشات خالية من الجلوتين ومنتجة من أنواع الدقيق المختلفة مثل الأرز والذرة والترمس الحلو لتناسب الأفراد ذو الحساسية لجلوتين القمح، كما تم تقييم تأثير الدقيق على الخصائص الفيزيائية والكيميائية والحسية للكيك والمقرمشات مقارنة مع كيك ومقرمشات مصنوعة من دقيق القمح. العينات الستة كان ترتيبها كالاتي: كيك من دقيق الارز (رف١) ، (س ف٢) كيك من دقيق الذرة١٠٠% ، (ل ف٣) كيك من دقيق الترمس الحلو ١٠٠% ، مقرمشات (رف ٤) من دقيق الارز ١٠٠% ، (س ف٥) مقرمشات من دقيق الذرة ١٠٠% ، (ل ف٦) مقرمشات من دقيق الترمس الحلو ١٠٠%. أما العينات الضابطة من الكيك والمقرمشات كانت مصنوعة من دقيق القمح ١٠٠%. تم تقييم الخصائص الفيزيائية والكيميائية والحسية للكيك والمقرمشات. وقد أظهرت النتائج أن أعلي نسبة من الرطوبة والنحاس والحديد كانت في عينات (رف١) و(رف٤) مقارنة مع العينات الأخري. بينما عينات (ل ف٣) و(ل ف٦) أحتوت علي النسبة الاعلي من من البروتين والألياف والدهون والرماد والفوسفور والبوتاسيوم. أيضا أظهرت العينات (س ف٢) و(س ف٥) النسبة الأعلي من الكالسيوم والصوديوم. كما أظهرت النتائج أن الكيكات والمقرمشات المصنوعة من دقيق الترمس الحلو ودقيق الارز قد حسنت خصائص الجودة مثل زيادة الوزن والحجم وأنخفاض الكثافة النوعية. أما مقياس هيدونيك أظهر أن أعضاء الفريق فضلوا الكيك (ل ف) والمقرمشات (رف) بدرجات ٨,٧ و ٨,٨ على التوالي بعد كيك ومقرمشات (وف). وأشار التقييم العام إلى أن الكيك ومقرمشات (وف) قد أحرزت قبول أكبر من قبل أعضاء الفريق، في حين تعتبر الكيك والمقرمشات الخالية من الجلوتين جيدة في رأي أعضاء الفريق. وأخيرا أظهر التقييم الحسي أن استخدام دقيق الذرة في الكيك والمقرمشات قد لاقت قبول أقل من قبل أعضاء الفريق.

الكلمات المفتاحية: الأطعمة الخالية من الجلوتين، السيلياك، دقيق الأرز، دقيق الذرة، دقيق الترمس الحلو، الكيك، المقرمشات.