EFFECT OF REPLACING RICE FLOUR WITH QUINOA, MILLET, CHICKPEA AND CAROB FLOURS ON NUTRITIONAL AND SENSORY PROPERTIES OF GLUTEN-FREE BISCUITS

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Effect of Replacing Rice Flour with Quinoa, Millet, Chickpea and Carob Flours on Nutritional and Sensory Properties of Gluten-Free Biscuits

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Abstract:

Celiac disease affects human of all ages and is described by gluten intolerance, and the only treatment is a lifelong gluten-free diet. This research was undertaken to investigate the effect of utilization of rice (RF), quinoa (QF), millet (MF), chickpea (CF) and carob flours (CRF) on the preparation of gluten-free biscuits in the following proportions 100:0:0:0:0 (control), 50:50:0:0:0 (B1), 40:50:0:0:10 (B2), 30:50:0:20:0 (B3), 20:50:0:20:10 (B4), 50:0:50:0:0 (B5), 40:0:50:0:10 (B6), 30:0:50:20:0 (B7), 20:0:50:20:10 (B8), 50:25:25:0:0 (B9), 40:25:25:0:10 (B10), 30:25:25:20:0 (B11) and 20:25:25:20:10 (B12), respectively. The physicochemical parameters and sensory qualities of biscuits were studied. Current data clarified that CF contained the highest level of protein (22.80%) and fat (6.00%), while CRF contained the highest value of fiber (7.40%) and ash (3.40%) compared with other flours. CF contained the highest level of P, K and Fe than other flours. CRF contained the highest value of Ca and Zn, while the highest amount of Mg was estimated in QF comparing to other flours. The substitution of RF with QF, MF, CF and CRF significantly improved *($P \leq 0.05$)* the nutritional profile of biscuits, as a result of the increase in protein, fat, ash and minerals. The highest value of protein (13.25%), fiber (4.43%) and ash (2.44%) were recorded in sample (B4) comparing to control. Protein, fiber and ash values in (B4) were approximately 3-times, 8-times and 5-times, respectively, more than control biscuits. Minerals content significantly increased *($p \leq 0.05$)* in gluten-free biscuits than the control. Results proved that all gluten-free biscuits were

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acceptable by panelists. Diameter & thickness of biscuits did not record any significant effects *($P \leq 0.05$)* in all samples comparing to control. The addition of MF significantly increased *($p \leq 0.05$)* the L^* value of biscuits than control. Therefore, biscuits with QF, MF, CF and CRF can be recommended to be used for celiac patients.

Key words: Celiac disease; gluten-free biscuits; chickpea; quinoa; millet

Introduction:

Recently, the demand for gluten-free foods which are suitable for celiac patients has increased. Celiac disease happens when the human body's natural defense system reacts to gluten (wheat, rye and barley proteins) by attacking the membrane of the small intestine. There is no drug of celiac disease instead of eating gluten–free foods. Furthermore, celiac patients eat foods with low amount of fiber & poor quality, thus usually face the problems of constipation and malnutrition. Celiac patients expose to infect with many complications such as fatigue, weight loss, diarrhea, anemia, osteoporosis and depression **(Gao *et al.*, 2018)**.

Biscuits are convenient food products that are gaining popularity in both rural and urban areas worldwide. It is easier to make biscuits with gluten-free flours than other bakery products because the structure of biscuits is less dependent on the protein network **(Di Cairano *et al.*, 2018)**. Low cost compared with other processed foods; longer shelf life & varied taste are some of the reasons for biscuits widespread popularity.

Quinoa (*Chenopodium quinoa*) is a pseudo-cereal crop, which is grown mainly for their edible seed belongs to the family *Amaranthaceae* **(Limam, 2020)**. Quinoa has been cultivated in Egypt since 2005, first in the south of Sinai to test its ability to withstand harsh conditions. Soon after, QS were introduced in Upper Egypt by local community leaders as a cheap way to provide school children with nutritious meals **(Soliman *et al.*, 2019)**. Quinoa is gluten-free and deemed simple to digest, so it can used by people who are allergic to wheat gluten. Protein level is higher in quinoa seeds (QS) than that of wheat and corn, ranging from 12 -18%. QS Contain a balanced set of essential amino acids (EAAs), with a higher content of lysine (5.1-6.4%) & methionine (0.4-1.0%) **(Nowak *et al.*, 2016; El-Sohaimy *et al.*, 2019)**. QS Have high minerals (calcium, phosphorus, iron, magnesium, manganese, potassium) & vitamins (E, C and B complex) and high-quality lipids **(Miranda *et al.*, 2012)**. Moreover, QS are a good source of dietary fiber **(Alvarez-Jubete *et al.*, 2010)**. QS are also rich in antioxidants like polyphenols (phenolic acids & flavonoids) (**Tang *et al.*, 2016)**. QS Have medicinal properties like antimicrobial, antioxidant, anti-inflammatory, antitumor, anti-carcinogenic **(Galvez *et al.*, 2010)** and anti-diabetic **(Alsuhaibani *et al.*, 2022)**. QS Can be utilized to make flour for baking, soup, desserts and varieties of dishes.

Pearl millet (*Pennisetum glaucum*) is a gluten free and low-cost cereal **(Dias-Martins *et al.*, 2018)**. Millet is called a “nutri-cereals” result to its high protein, fiber, mineral, and fatty acids levels, moreover its antioxidant properties **(Saleh *et al.*, 2013)**. Millet contains a higher content of EAAs like lysine, leucine and isoleucine than other conventional grains, like wheat & rye **(Dias-Martins *et al.*, 2018)**. Millet grains contain a large number of phytochemicals, especially phenolic compounds **(Shahidi and Chandrasekara, 2013)**. Many potential health benefits for millet have been published like lowering blood pressure & preventing cardiovascular diseases and cancer **(Saleh *et al.*, 2013)**. Millet has a low glycemic index, which means it can help to lose weight and decrease the risk of chronic diseases like diabetes **(Dias-Martins *et al.*, 2018)**.

Chickpea (*Cicer arietinium*) is a commonly cultivated legume with a global production of about 14.3 million tons in 2019 **(FAO, 2019)**. Based on cultivated area, chickpea is the third largest legume worldwide. Chickpea proteins (18.4–29.0%) show high solubility and digestibility (89.0%) **(Boye *et al.*, 2010)**. Chickpea seeds are high in complex carbohydrates (low glycaemic index), are abundant in minerals & vitamins and are relatively free of anti-nutrients **(Muzquiz and Wood, 2007; Wood and Grusak, 2007)**. Health benefits associated with chickpea consumption include reduced risks of diabetes, cardiovascular disease & cancer **(Abou Arab *et al.*, 2010)**. Among legumes, chickpea is the most popular hypocholesterolemic agent **(Zia-Ul-Haq *et al.*, 2007)**.

Carob (*Ceratonia siliqua*) is a member of the *Leguminosae* family and is widespread in the Mediterranean countries **(Dakia *et al.,* 2007)**. Carob is rich in sugars, tannins, amino acids, minerals like K, Ca, Zn, Na, P & Fe and vitamins like D, E, C, B6, Niacin & folic acid which has important functions in our health **(Ayaz *et al.,* 2007; Youssef *et al.,* 2013)**. Carob is an excellent source of dietary fiber and has been utilized successfully in the preparation of gluten-free products like cake **(Berk *et al.,* 2017)**. Carob has been utilized to replace cocoa due to it having low-fat and calorie and hypo-allergenic **(Vekiari *et al.,* 2011)**. Another reason why the food industry prefers carob as an alternative to cocoa or chocolate because it is free of theobromine & caffeine **(Sahin *et al.,* 2009)**. Carob also has many polyphenolic components which could decrease several diseases as cancer, diabetes, lactose intolerance, hyperlipidemia & heart problems result to its antioxidant activity **(Zhu *et al.,* 2019; Mouas *et al.,* 2021; Gregoriou *et al.,* 2021)**. Also, Carob had strong antimicrobial activity (**Darwish *et al.,* 2021)**.

Rice (*Oryza sativa*) is the most widely consumed cereal worldwide, and is utilized as a constant food for nearly 50% of the world's population **(Limam, 2020)**. Chemical analysis of rice includes 6.3-7.1% protein, 0.3-0.5% fat, 0.3-0.8% ash and 77-89% available carbohydrates. It is the most basic food in the human diet and has the second largest global production after maize, providing 27% of the total energy intake in the developing countries, compared with 4% in the developed countries **(Chaudhari *et al.,* 2018)**. Furthermore, it has been recorded to be one of the most suitable cereal flours for making many products for celiac patients **(Arendt and Bello, 2008)**.

Consumer demands high quality of gluten-free products. Carob flour is a health-promoting compound and can be utilized in developing gluten-free products **(Tsatsaragkou *et al.,* 2014)**. Chickpea is considered a low-cost, high-quality protein source in the diets of millions of humans in developing countries who cannot afford animal protein for balanced nutrition. Quinoa flour has been considered a super food result to its higher protein level and more balanced amino acid composition. Furthermore, since quinoa flour is naturally gluten-free, it may also be utilized as a healthy and nutrient-dense alternative ingredient in the development of functional gluten-free products **(Cannas *et al.*, 2020)**. Millet is a good grain in terms of nutritional quality and offers many health benefits and is an essential food alternative for patients with celiac disease **(Shahidi and Chandrasekara, 2013; Saleh *et al.*, 2013)**. Therefore, the aim of this research was to study sensory, nutritional and physical properties of gluten-free biscuits prepared from rice, quinoa, millet, carob and chickpea flours.

Materials and Methods:

Materials:

brought from Crop Research Institute, Quinoa and pearl millet were Center and Giza, Egypt. Chickpea, carob, rice, sugar Agriculture Research powder, shortening, sodium bicarbonate, ammonium bicarbonate, baking powder & salt were bought from the local market in Sharkia Governorate, used in this research were bought from El-Gomhoriya Egypt. Chemicals Company for Trading Drugs, Chemicals and Medical Instruments, Sharkia Governorate, Egypt.

Methods:

Preparation of raw materials:

Pearl millet cereals were cleaned. The cleaned cereals were milled into flour using laboratory milling **(Kulthe *et al.*, 2018**). Carob was ground to flour after removing the seeds **(Ibrahim *et al.*, 2015)**. Quinoa seeds were washed many times under running tap water until there was no foaming formation to remove saponin from outer layers because it imparts a bitter taste. Then seeds were dried by sun drying method. Quinoa seeds were ground to flour in an electric grinder **(Puri *et al.*, 2020)**. Chickpea and rice were milled using a laboratory mill. All flours were sieved and packed in zip-lock bags, then stored at 4ºC for further analysis.

Biscuit production:

Biscuits were produced from the formulas clarified in Table (1) by **Manohar and Rao, (1999)** method. Sugar & fat were creamed in a blender for 3-4 min. Salt, sodium bicarbonate & ammonium bicarbonate were dissolved in water (20-22 ml). The solution was added to the above cream and mixed for 5 min to obtain a homogenous cream. RF or mixtures of RF with other flours were sieved twice with baking powder and were added to the above cream. Then all were mixed for 3 min. Biscuits dough were rolled to a thickness of 5.0 mm and were cut using a cutter (45 mm diameter). Biscuits were baked at 160°C for 15 min, and then allowed to cool for 1 hr. Biscuits were kept in polyethylene bags and stored in an air sealed container till analysis.

Table (1): Ingredients for gluten-free biscuits (g).

Ingredient	Treatment												
	Control	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**B8**	**B9**	**B10**	**B11**	**B12**
RF	100	50	40	30	20	50	40	30	20	50	40	30	20
QF	-	50	50	50	50	-	-	-	-	25	25	25	25
MF	-	-	-	-	-	50	50	50	50	25	25	25	25
CF	-	-		20	20	-	-	20	20	-	-	20	20
CRF	-	-	10	-	10	-	10	-	10	-	10	-	10
Sugar	30	30	30	30	30	30	30	30	30	30	30	30	30
Shortening	20	20	20	20	20	20	20	20	20	20	20	20	20
Salt	1	1	1	1	1	1	1	1	1	1	1	1	1
Baking powder	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Sodium bicarbonate	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Ammonium bicarbonate	1	1	1	1	1	1	1	1	1	1	1	1	1

RF: Rice flour**; QF:** Quinoa flour; **MF:** millet flour; **CF:** Chickpea flour and **CRF:** Carob flour.

Chemical analysis:

The samples of flours and products were subjected to proximate chemical analysis including protein, ash, fiber, fat and moisture as described by **AOAC, (2012)**. Carbohydrate level was calculated by difference. Caloric value was estimated by calculation according to **Chaney, (2006)** using the following formula: caloric value (Kcal/100g sample) = (protein content x4) + (fat content x9) + (carbohydrate content x4). Minerals value (Ca, K, Zn, Fe and Mg) were determined by Atomic Absorption Spectrophotometer (Hitachi Z6100, Tokyo, Japan) as described by **AOAC, (2012)**. Whereas, phosphorus content was estimated by the phosphovanado-molybdate (yellow) method **(AOAC, 2012)**.

Physical characteristics of gluten-free biscuits:

Physical characteristics of produced biscuits (diameter (D), thickness (T) & spread ratio (D/T)) were measured according to **(Man *et al.*, 2017)**.

Color analysis of gluten-free biscuits:

The surface color of biscuits was estimated using a Hunter Lab color analyzer (Hunter Lab Color Flex EZ, USA) to determine L^* value (light – dark), a^* value (red – green) and b^* value (yellow – blue). The total color difference (ΔE) was calculated as **Shrestha *et al.*, (2012)** method.

Sensory qualities of gluten-free biscuits:

Biscuits were evaluated for its sensory attributes by 20 trained panelists from the staff members of the Food Sci. Dept., Fac. Agric., Zagazig Univ., Egypt. Panelists were asked to assess each kind of biscuits for appearance, color, texture, flavor, taste & overall acceptability using a 9-point hedonic scale, ranging from 9 as like extremely to 1 as dislike extremely according to **Mehra and Singh, (2017)**.

Statistical analysis:

Results were subjected to analysis of variance using the "Statistical Package for Social Sciences" (SPSS) version 25 (IBM Corp., Armonk, New York. 2017). Data were presented as means ± standard deviations of three values. Significant difference was established at $(p \leq 0.05)$. Differences between means were estimated using one way-ANOVA and Duncan Multiple Range **(Bailey, 1995)**.

Results and Discussion:

Chemical composition of RF, QF, MF, CF and CRF:

The chemical composition of RF, QF, MF, CF and CRF is summarized in Table (2). Results indicated that significant differences *($p \leq 0.05$)* were estimated between RF, QF, MF, CF and CRF. Current data clarified that CF had the highest level of protein (22.80%) and fat (6.00%) comparing to other flours. While, CRF contained the highest value of fiber (7.40%) and ash (3.40%) compared with other flours. In addition, RF had the highest carbohydrate level (79.34 %) and moisture (11.92%) comparing with other kinds of flour. Also, results exhibited that the nutrient amount of QF was protein (17.20%), fat (4.27%), fiber (5.88%), ash (2.87%), carbohydrate (58.46%) & moisture (11.32%). **Cannas *et al.*, (2020)** reported that QF had 17.61% protein, 4.06% fat, 2.51% ash, 63.45% carbohydrates and 12.37% moisture, while RF contained 6.76% protein, 1.3% fat, 0.8% ash, 77.09% carbohydrate and 14% moisture. **Hussein *et al.*, (2020)** stated that CF had 20.1٠% protein, 5.7٠% fat, 3.8٠% fiber and 7.53% moisture. According to **El-Said *et al.*, (2021)**, the chemical analysis of CF was 24.73% protein, 5.6٠% fat, 3.91% fiber, 1.96% ash, 63.81% carbohydrate and 7.60% moisture, whereas QF contained 20.60% protein, 6.10% fat, 5.70% fiber, 2.43% ash, 65.17% carbohydrate and 13.20% moisture. Protein and ash contents of CRF in this study are close to those measured by **El-Naggar and Hassan, (2018)** who found that protein and ash levels were 6.69 and 3.33%, respectively, in CRF. Chemical composition of MF showed that moisture, protein, fat, fiber, ash and carbohydrate were 10.50, 12.47, 3.21, 2.40, 2.20 and 69.22%, respectively. Chemical composition of MF estimated during current study is in concurrence with obtained results of **Ikegwu *et al.*, (2021)** for protein. Pearl millet flour had moisture (8.43%), protein (12.11%), fat (1.89%), ash (5.20%), fiber (2.92%) and carbohydrate (77.88%) on dry weight **(Hassan *et al.*, 2020)**. The differences in chemical composition between the current investigation and the reported data may be because of the environmental conditions of the plants.

Table (2): Chemical composition of RF, QF, MF, CF and CRF (on a wet weight base).

Component (%)	Raw Material				
	RF	**QF**	**MF**	**CF**	**CRF**
Moisture	11.92±0.05^{a}	11.32±0.06^{b}	10.50±٠.05^{cd}	10.17±٠.04^{d}	10.80±0.05^{c}
Protein	6.82±0.03^{d}	17.20±0.07^{b}	12.47±0.04^{c}	22.80±0.08^{a}	6.90±٠.04^{d}
Fat	0.46 ±0.01^{d}	4.27 ±0.03^{b}	3.21±0.03^{c}	6.00±0.04^{a}	0.76±٠.02^{d}
Fiber	0.76±0.02^{e}	5.88±0.02^{b}	2.40±0.02^{d}	4.10±0.03^{c}	٧.٤٠±0.04^{a}
Ash	0.70±0.02^{d}	2.87±0.02^{b}	2.20±0.01^{c}	3.33±0.02^{ab}	3.40±0.03^{a}
Carbohydrate	79.34 ±0.14^{a}	58.46 ±0.10^{d}	69.22±0.11^{c}	53.60±0.09^{e}	70.74±0.12^{b}

Within rows, values (n=3) with the different letters are significant difference *($p \leq 0.05$)* according to Duncan's test. RF: Rice flour**; QF:** Quinoa flour**; MF:** millet flour**; CF:** Chickpea flour and **CRF:** Carob flour.

Minerals content of RF, QF, MF, CF and CRF:

Results reported in Table (3), demonstrated that significant differences *($p \leq 0.05$)* were obtained among fours in all minerals. Results revealed that CF contained the highest level of P, K and Fe than other flours. CRF had the highest value of Ca and Zn, while, the highest amount of Mg was recorded in QF when comparing to other flours. Current finding indicated that the lowest content of all minerals recorded in RF comparing with other kinds of flours. Ca, P, K, Mg, Fe and Zn contents were 71.50, 360.00, 540.00, 134.00, 4.40 and 3.10 (mg/100g), respectively, in MF. The average mineral content of different types of chickpea was Ca (264.69), P (394.48), K (989.56), Mg (176.22), Fe (3.61) and Zn (2.68) (mg/100g dry matter) **(Costantini *et al.,* 2021)**. **Gaikwad *et al.,* (2021)** estimated that Ca, P, Mg, K & Fe levels were 86.7, 410.8, 731.6, 501.3 and 15.5 (mg/100g), respectively, in quinoa. Minerals level of carob pulp from various regions in Morocco were Ca (270.4 - 305.3 mg/100g), P (41.9 - 57.2 mg/100g), K (1121.1-1300.2 mg/100g), Mg (40.4 - 144.8 mg/100g), Fe (5.26 - 6.66 mg/100g) and Zn (1.80 - 2.61 mg/100g) **(EL Oumlouki *et al.,* 2021)**. **Hassan *et al.,* (2020)** mentioned that pearl millet flour contained calcium (47.55), phosphorus (330.0), potassium (305.9), magnesium (176.6), iron (10.50) and zinc (5.45) (mg/100g), whereas RF had Ca (28.85), P (160.0), K (111.0), Mg (25.50), Fe (4.21) and Zn (2.10) (mg/100g) as dry weight. **Ikegwu *et al.*, (2021)** stated that MF contained 4.00 ppm calcium and 491.76 (mg/100g) phosphorus.

Table (3): Minerals content of RF, QF, MF, CF and CRF (on a wet weigh base).

Mineral (mg/100g)	Raw Material				
	RF	QF	MF	CF	CRF
Calcium	25.90±0.10[e]	149.60±0.40[c]	71.50±0.22[d]	226.00±0.51[b]	297.73±0.40[a]
Phosphorus	130.19±0.30[e]	430.23±0.60[b]	360.00±0.50[c]	775.20±0.91[a]	222.66±0.35[d]
Potassium	79.00±0.21[e]	680.00±0.85[c]	540.00±0.70[d]	1479±1.50[a]	970.00±0.84[b]
Magnesium	35.00±0.11[e]	196.00±0.55[a]	134.00±0.40[c]	189.60±0.80[b]	54.00±0.20[d]
Iron	1.10±0.01[d]	4.60±0.03[c]	4.40±0.04[c]	7.13±0.05[a]	6.69±0.05[b]
Zinc	1.40±0.02[c]	4.50±0.04[a]	3.10±0.03[b]	4.77±0.04[a]	4.85±0.04[a]

Within rows, values (n=3) with the different letters are significant difference *($p\leq0.05$)* according to Duncan's test. RF: Rice flour**; QF:** Quinoa flour**; MF:** millet flour**; CF:** Chickpea flour and **CRF:** Carob flour.

Chemical characteristics of gluten-free biscuits:

The chemical characteristics of gluten-free biscuits are clarified in Table (4). Findings exhibited that control biscuits recorded low values of moisture (2.36%), protein (4.90%), fat (12.43%), fiber (0.54%) and ash (0.51%) except carbohydrate (79.26%) and caloric (448.51 Kcal/100g) values compared with all other treated biscuit samples. Results demonstrated that the addition of QF, MF, CF and CRF to RF increases the nutritional value of gluten-free biscuits. Findings indicated that moisture, protein, fat, fiber & ash levels significantly increased *($p\leq0.05$)* in gluten-free biscuits containing QF or MF or QF+MF in addition of CRF and/or CF (B1 to B12) comparing to control biscuits. While, carbohydrate & caloric values significantly decreased *($p\leq0.05$)* comparing with control sample. These results probably are result to QF, MF, CF and CRF contain higher level of protein, fat, fiber and ash than RF. Similar data were published by **Fidan *et al.*, (2020)** who found that replacing WF with CRF increased the amount of dietary fiber & protein in the sponge cake. **Franco *et al.*, (2021)** stated that protein, ash and fat significantly increased *($p<0.05$)* in bread made from RF and QF. Moisture, fiber, fat and ash elevated in cookies produced from substituting WF with MF **(Kulkarni *et al.*, 2021)**. Protein, fat, fiber, ash and moisture significantly increased *(p≤0.05)* in shamy bread produced from 80% WF and 20% CF **(El-Said *et al.*, 2021).**

The protein amount of gluten-free biscuits was significantly different *(p≤0.05)* than control. Control biscuits contained the lowest amount of protein (4.90%), while the highest content of protein (13.25%) was recorded in sample B4 (20%RF: 50%QF: 20% CF:10% CRF). Protein value in (B4) was approximately 3-fold more than control biscuits. Also, the highest fiber (4.43%) and ash (2.44%) levels were estimated in sample (B4) comparing with control. Fiber & ash contents in (B4) were approximately 8-times and 5-times, respectively, more than control biscuits. These results might be because of QF, MF, CF and CRF have higher values of protein, fiber & ash comparing with RF.

There was significant difference *(p≤0.05)* in the fat level of gluten-free biscuits compared with control. Control biscuits contained the lowest value of fat (12.43%), whereas the highest amount was recorded in sample B4 (14.68%). The fat value of biscuits (B4) increased by 18.00% comparing to control. These findings probably are due to QF, CF and CRF had higher content of fat comparing with RF.

The highest moisture value (4.70%) was noticed in (B4), whereas the lowest content (2.36%) was estimated in control biscuits. These findings perhaps are result to the elevate in water retention ability of fibers in QF, MF, CF and CRF comparing with RF.

Carbohydrate and caloric values of gluten-free biscuit samples reduced with the addition of QF, MF, CF and CRF to the RF. The highest carbohydrate and caloric values were estimated in control biscuits, whereas the lowest amount was found in (B4). Carbohydrate and caloric values of samples (B4) decreased by 23.7 and 4.80%, respectively, compared with control biscuits.

Table (4): Effect of replacing RF with QF, MF, CF and CRF on chemical characteristics of gluten-free biscuits (on a wet weigh base).

Sample	Component						
	Moisture %	Protein %	Fat %	Fiber %	Ash %	Carbohydrate %	CV Kcal/100g
Control	2.36 ±0.02^{e}	4.90 ±0.04^{g}	12.43 ±0.12^{e}	0.54 ±0.01^{g}	0.51 ±0.01^{f}	79.26 ±0.35^{a}	448.51 ±0.62^{a}
B1	3.50 ±0.03^{bcd}	10.00 ±0.05^{d}	13.78 ±0.12^{cd}	3.10 ±0.02^{c}	1.60 ±0.01^{bcde}	68.02 ±0.30^{ef}	436.10 ±0.55^{g}
B2	4.40 ±0.04^{ab}	10.14 ±0.04^{d}	13.80 ±0.14^{cd}	3.76 ±0.03^{b}	1.90 ±0.02^{abcde}	66.00 ±0.25^{g}	428.76 ±0.50^{k}
B3	4.00 ±0.03^{abcd}	13.16 ±0.05^{a}	14.58 ±0.15^{ab}	3.80 ±0.04^{b}	2.15 ±0.03^{abc}	62.31 ±0.24^{j}	433.10 ±0.53^{i}
B4	4.70 ±0.04^{a}	13.25 ±0.06^{a}	14.68 ±0.14^{a}	4.43 ±0.04^{a}	2.44 ±0.02^{a}	60.50 ±0.22^{k}	427.12 ±0.45^{l}
B5	3.10 ±0.02^{de}	7.66 ±0.05^{f}	13.41 ±0.13^{d}	1.36 ±0.01^{f}	1.26 ±0.01^{e}	73.21 ±0.33^{b}	444.17 ±0.60^{b}
B6	3.70 ±0.03^{bcd}	7.72 ±0.06^{f}	13.47 ±0.14^{d}	2.10 ±0.02^{e}	1.53 ±0.02^{cde}	71.48 ±0.35^{c}	438.03 ±0.52^{e}
B7	3.40 ±0.04^{cd}	10.94 ±0.06^{c}	14.11 ±0.13^{bc}	2.18 ±0.03^{de}	1.83 ±0.02^{abcde}	67.54 ±0.35^{f}	440.91 ±0.55^{c}
B8	4.00 ±0.03^{abcd}	11.06 ±0.05^{c}	14.29 ±0.14^{ab}	2.70 ±0.02^{cd}	2.10 ±0.03^{abc}	65.85 ±0.33^{g}	436.25 ±0.50^{g}
B9	3.30 ±0.03^{cd}	8.90 ±0.07^{e}	13.59 ±0.15^{d}	2.23 ±0.02^{de}	1.43 ±0.02^{de}	70.55 ±0.36^{d}	440.11 ±0.61^{d}
B10	4.10 ±0.04^{abc}	9.10 ±0.08^{e}	13.69 ±0.14^{cd}	2.93 ±0.03^{c}	1.68 ±0.03^{bcde}	68.50 ±0.34^{f}	433.61 ±0.54^{h}
B11	3.70 ±0.03^{bcd}	12.00 ±0.07^{b}	14.39 ±0.16^{ab}	3.00 ±0.03^{c}	2.00 ±0.02^{abcd}	64.91 ±0.37^{h}	437.15 ±0.66^{f}
B12	4.40 ±0.04^{ab}	12.20 ±0.08^{b}	14.44 ±0.15^{ab}	3.70 ±0.04^{b}	2.22 ±0.03^{ab}	63.04 ±0.34^{i}	430.92 ±0.٤٦^{j}

Within columns, values (n=3) with the different letters are significant difference *($p \leq 0.05$)* according to Duncan's test. CV: Caloric value. **Control:** 100% RF**; B1:** 50%RF+50%QF**; B2:** 40% RF+50%QF+10%CRF**; B3:** 30%RF+50%QF+20%CF**; B4:** 20%RF+50%QF+20%CF+10%CRF**; B5:** 50%RF+50%MF**; B6:** 40%RF+50%MF+10%CRF**; B7:** 30%RF+50%MF+20%CF**; B8:** 20%RF +50%MF+20%CF+10%CRF**; B9:** 50%RF+25%QF+25%MF**; B10:** 40%RF+25%QF+25%MF+10% CRF**; B11:** 30%RF+25%QF+25%MF+20%CF and **B12:** 20%RF+25%QF+25%MF+20%CF+10% CRF.

Minerals content of gluten-free biscuits:

Minerals content of gluten-free biscuits made with RF, QF, MF, CF and CRF are summarized in Table (5). Significant differences *(p≤0.05)* of minerals content between control and other biscuits were recorded. Results clarified that calcium, potassium, phosphorus, magnesium, iron & zinc values significantly increased *(p≤0.05)* in gluten-free biscuits containing QF or MF or QF+MF plus CRF and/or CF compared with control biscuits. These findings perhaps are attributed to elevate the content of Ca, P, Mg, K, Fe and Zn in QF, MF, CF and CRF than RF (Table 3). Similar data were stated by **El-Sohaimy *et al.,* (2019)** who found that flat breads with QF had a higher minerals content (Ca, Mg, K, Fe & Zn) than wheat breads. Phosphorus, calcium, and iron values increased in cookies produced from pearl millet flour **(Kulkarni *et al.,* 2021)**. Adding carob powder to the rice biscuits increased Zn, K, Fe and Ca levels **(Ibrahim *et al.,* 2015)**. The amount of calcium, manganese, potassium, iron & zinc was higher in shamy breads containing 20% chickpea than control **(El-Said *et al.,* 2021)**. Minerals content in B4 (20%RF: 50%QF: 20% CF:10% CRF) such as calcium (119.10), phosphorus (321.93), potassium (575.85), magnesium (114.13), iron (3.60) and zinc (3.20) mg/100g were the highest than other samples and control (100% RF). Whereas, the lowest amount of Ca (19.92), P (100.15), K (60.77), Mg (26.92), Fe (0.85) and Zn (1.10) mg/100g was recorded in control. Ca, P, K, Mg, Fe & Zn contents in (B4) were approximately 6-times, 3-times, 9-times, 4-times, 4-times and 3-times, respectively, more than control biscuits.

These results might be beneficial in treating mineral deficiencies (particularly iron, zinc & calcium) that have a negative impact on human health and might lead to iron deficiency anemia, osteoporosis, rickets and diseases of the immune system. Therefore, gluten-free biscuits made with RF, QF, MF, CF and CRF could effectively contribute to the treatment of anemia & malnutrition in Egypt.

Table (5): Effect of replacing RF with QF, MF, CF and CRF on minerals content of gluten-free biscuits (on a wet weigh base).

Sample	Mineral (mg/100g)					
	Calcium	**Phosphorus**	**Potassium**	**Magnesium**	**Iron**	**Zinc**
Control	19.92 ±0.10^{l}	100.15 ±0.62^{m}	60.77 ±0.32^{m}	26.92 ±0.20^{k}	0.85 ±0.01^{e}	1.10 ±0.02^{f}
B1	67.30 ±0.30^{h}	215.57 ±0.75^{h}	291.92 ±0.75^{j}	88.84 ±0.40^{f}	2.22 ±0.02^{d}	2.27 ±0.03^{cde}
B2	88.00 ±0.50^{e}	222.70 ±0.73^{g}	360.47 ±0.73^{g}	90.30 ±0.42^{e}	2.65 ±0.03^{c}	2.53 ±0.03^{bcd}
B3	98.14 ±0.50^{c}	314.81 ±0.83^{b}	507.31 ±0.87^{d}	112.68 ±0.52^{b}	3.15 ±0.05^{b}	2.78 ±0.04^{abc}
B4	119.10 ±0.60^{a}	321.93 ±0.85^{a}	575.85 ±0.96^{a}	114.13 ±0.60^{a}	3.60 ±0.06^{a}	3.20 ±0.05^{a}
B5	37.46 ±0.15^{k}	188.60 ±0.71^{l}	238.10 ±0.61^{l}	65.00 ±0.30^{j}	2.12 ±0.02^{d}	1.74 ±0.02^{e}
B6	58.40 ±0.22^{i}	195.60 ±0.74^{k}	306.00 ±0.77^{i}	66.86 ±0.33^{i}	2.59 ±0.03^{c}	2.04 ±0.03^{de}
B7	68.00 ±0.30^{h}	287.50 ±0.64^{f}	453.47 ±0.83^{f}	88.84 ±0.42^{f}	3.05 ±0.05^{b}	2.25 ±0.03^{cde}
B8	89.20 ±0.46^{d}	294.96 ±0.68^{e}	522.70 ±0.90^{c}	90.59 ±0.45^{e}	3.48 ±0.04^{a}	2.50 ±0.04^{bcd}
B9	52.51 ±0.20^{j}	202.10 ±0.60^{j}	265.10 ±0.76^{k}	76.96 ±0.36^{h}	2.15 ±0.02^{d}	2.31 ±0.03^{cde}
B10	73.45 ±0.35^{g}	209.00 ±0.72^{i}	333.63 ±0.84^{h}	78.32 ±0.38^{g}	2.55 ±0.04^{c}	2.60 ±0.02^{bcd}
B11	83.35 ±0.40^{f}	300.00 ±0.83^{d}	477.00 ±0.88^{e}	100.00 ±0.52^{d}	3.08 ±0.05^{b}	2.82 ±0.04^{abc}
B12	104.25 ±0.52^{b}	308.43 ±0.82^{c}	549.01 ±0.94^{b}	102.00 ±0.60^{c}	3.50 ±0.06^{a}	3.00 ±0.04^{ab}

Within columns, values (n=3) with the different letters are significant difference *($p \leq 0.05$)* according to Duncan's test. Control: 100% RF**; B1:** 50%RF+50%QF**; B2:** 40%RF+50%QF +10%CRF**; B3:** 30%RF+50%QF+20%CF**; B4:** 20%RF+50%QF+20%CF+10%CRF**; B5:** 50%RF+ 50%MF**; B6:** 40%RF+50%MF+10%CRF**; B7:** 30%RF+50%MF+20%CF**; B8:** 20%RF+50%MF +20%CF+10%CRF**; B9:** 50%RF+25%QF+25%MF**; B10:** 40%RF+25%QF+25%MF+10%CRF**; B11:** 30%RF+25%QF+25%MF+20%CF and **B12:** 20%RF+25%QF+25%MF+20%CF+10%CRF.

Physical characteristics of gluten-free biscuits:

Physical characteristics like diameter, thickness & spread ratio of gluten-free biscuits are clarified in Table (٦). Results of measuring the diameter & thickness of samples did not record any significant effects *($P \leq 0.05$)* in all samples comparing to control. While, spread ratio in (B5), (B6) and (B10) significantly increased *($p \leq 0.05$)* compared with control. The spread ratio of the gluten-free biscuits increased from 8.18-8.85. Similar findings were published by **Ahmed *et al.*, (2017)** who found that no significant effects *(p≤0.05)* were determined in biscuits diameter between control and those contained different levels of quinoa seeds flour. Also, similar observations were recorded by **Ibrahim *et al.*, (2015)** who stated that the thickness of biscuits with carob powder decreased, while the diameter increased than control biscuits. According to **Nada *et al.*, (2016)**, the diameter did not have significant difference *(P≤0.05)* between biscuits contained 50% germinated millet and control. The incorporation of chickpea in cookies did not determine a clear impact on diameter, thickness & spread ratio **(Torra *et al.*, 2021)**.

Table (٦): Effect of replacing RF with QF, MF, CF and CRF on the physical characteristics of gluten-free biscuits.

Sample	Physical characteristic		
	Diameter (D) (mm)	**Thickness (T) (mm)**	**Spread ratio (D/T)**
Control	45.80±0.20^{a}	5.60±0.04^{a}	8.18±0.06^{c}
B1	45.60±0.17^{a}	5.40±0.03^{a}	8.44±0.07^{abc}
B2	45.70±0.16^{a}	5.30±0.02^{a}	8.62±0.06^{abc}
B3	45.5٥±0.14^{a}	5.50±0.03^{a}	8.28±0.05^{bc}
B4	45.٦٨±0.18^{a}	5.4٧±0.04^{a}	8.35±0.06^{bc}
B5	45.90±0.19^{a}	5.30±0.03^{a}	8.66±0.07^{ab}
B6	46.00±0.20^{a}	5.20±0.02^{a}	8.85±0.08^{a}
B7	45.8٦±0.16^{a}	5.40±0.04^{a}	8.49±0.07^{abc}
B8	٤٥.٩٦±0.17^{a}	5.3٦±0.05^{a}	8.57±0.06^{abc}
B9	45.7٦±0.15^{a}	5.٣7±0.02^{a}	8.52±0.05^{abc}
B10	45.٨٥±0.20^{a}	5.3٠±0.03^{a}	8.65±0.06^{ab}
B11	45.٧٧±0.21^{a}	5.٤٠±0.04^{a}	8.48±0.05^{abc}
B12	45.8٢±0.14^{a}	5.٣9±0.03^{a}	8.50±0.07^{abc}

Within columns, values (n=3) with the different letters are significant difference *(p≤0.05)* according to Duncan's test. Control: 100% RF; **B1:** 50%RF+50%QF; **B2:** 40%RF+50%QF +10%CRF; **B3:** 30%RF+50%QF+20%CF; **B4:** 20%RF+50%QF+20%CF+10%CRF; **B5:** 50%RF+ 50%MF; **B6:** 40%RF+50%MF+10%CRF; **B7:** 30%RF+50%MF+20%CF; **B8:** 20%RF+50%MF+ 20%CF+10%CRF; **B9:** 50%RF+25%QF+25%MF; **B10:** 40%RF+25%QF+25%MF+10%CRF; **B11:** 30%RF+25%QF+25%MF+20%CF and **B12:** 20%RF+25%QF+25%MF+20%CF+10%CRF.

Color analysis of gluten-free biscuits:

Results of color analysis of gluten-free biscuits are reported in Table (٧). Compared with the control sample, the addition of QF, CF and CRF significantly reduced $(p\leq 0.05)$ the L^* value, while the a^* value significantly increased $(p\leq 0.05)$, which indicated that the color of the biscuits was darker. CRF decreases the lightness of biscuits more than other samples because it has a brown color. Samples containing QF were darker and redder than the control. These results perhaps are result to QF contains a high level of polyphenols, ash and protein **(Cannas *et al.*, 2020)**. The L^* value significantly elevated $(p\leq 0.05)$ in biscuits with MF (B5), whereas (B5) did not record significant change $(p\leq 0.05)$ in the a^* value as compared with control biscuits. The b^* value significantly increased $(p\leq 0.05)$ in biscuits made using CF and MF, while the b^* value significantly decreased $(p\leq 0.05)$ in biscuits prepared by CRF comparing with control biscuits. Current results did not determine significant change $(p\leq 0.05)$ in the b^* value of sample (B1) compared with control biscuits. Findings revealed that sample containing 50% RF + 50% QF + 10% CRF had the highest ΔE value (32.74). The highest b^* values (yellow – blue) were estimated in biscuits produced from 30% RF+ 50% MF + 20% CF (B7), comparing with control. These findings perhaps are the results of CF and MF have natural yellow pigments. A similar trend was published by **Altiner, (2021)** for noodles with addition of CRF. Also, the same findings were stated by **Li *et al.*, (2020)** in bread produced by MF**.** A significant elevate in a^* & b^* values was noted in ladyfinger biscuits containing QF, while the L^* values significantly decreased comparing to control **(Cannas *et al.*, 2020)**. Similar findings were published by **Yamsaengsung *et al.*, (2012)** who found that chickpea addition decreased the lightness and elevated the yellowness & redness in white wheat cookies compared with control.

Table (٧): Effect of replacing RF with QF, MF, CF and CRF on the color analysis of gluten-free biscuits.

Sample	Biscuit color			
	L*	***a****	***b****	**ΔE**
Control	٨١.٥٦±0.42^{b}	0.٢٣±0.01^{g}	٢٠.٨٧±0.08^{e}	0.00±0.00^{m}
B1	٧٠.٣٦±0.34^{f}	٢.٧٤±0.02^{e}	٢١.٥٠±0.09^{e}	١١.٥٠±0.03^{h}
B2	٥٠.٦٢±0.20^{m}	٨.٠٤±0.04^{a}	١٣.٥٣±0.06^{h}	٣٢.٧٤±0.14^{a}
B3	٦٦.٣٥±0.30^{g}	٣.٩٠±0.03^{d}	٢٢.٥٠±0.09^{cd}	١٥.٧٣±0.06^{g}
B4	٥١.٥٢±0.23^{l}	٨.١٢±0.04^{a}	١٤.٥٠±0.07^{g}	31.71±0.11^{b}
B5	٨٢.٤٦±0.44^{a}	٠.٤٨±0.01^{g}	٢٣.١١±0.10^{c}	2.43±0.02^{l}
B6	٥٧.١٣±0.25^{i}	٥.٣٠±0.04^{c}	١٥.٠٤±0.06^{g}	25.62±0.13^{e}
B7	٧٩.٦٨±0.35^{c}	١.٤٠±0.02^{f}	٢٦.٠٠±0.10^{a}	5.59±0.04^{k}
B8	٥٧.٦٦±0.27^{h}	٥.٤٠±0.05^{c}	١٦.٣٠±0.07^{f}	24.88±0.10^{f}
B9	٧٥.٧٢±0.37^{d}	١.٦٠±0.02^{f}	٢٢.٣٠±0.08^{d}	6.17±0.03^{j}
B10	٥٥.٥٣±0.22^{j}	٦.٨٠±0.03^{b}	١٤.٤٠±0.06^{g}	27.61±0.12^{d}
B11	٧١.٨٢±0.35^{e}	٢.٥٠±0.02^{e}	٢٤.٢٣±0.10^{b}	10.55±0.05^{i}
B12	٥٣.٤٠±0.21^{k}	٦.٥٠±0.03^{b}	١٥.٩٠±0.07^{f}	29.27±0.14^{c}

Within columns, values (n=3) with the different letters are significant difference *($p \leq 0.05$)* according to Duncan's test. Control: 100% RF; **B1:** 50%RF+50%QF; **B2:** 40%RF+50%QF+ 10%CRF; **B3:** 30%RF+50%QF+20%CF; **B4:** 20%RF+50%QF+20%CF+10%CRF; **B5:** 50%RF+ 50%MF; **B6:** 40%RF+50%MF+10%CRF; **B7:** 30%RF+50%MF+20%CF; **B8:** 20%RF+50%MF+ 20%CF+10%CRF; **B9:** 50%RF+25%QF+25%MF; **B10:** 40%RF+25%QF+25%MF+10%CRF; **B11:** 30%RF+25%QF+25%MF+20%CF and **B12:** 20%RF+25%QF+25%MF+20%CF+10%CRF.

Sensory qualities of gluten-free biscuits:

The sensory qualities of samples are reported in Table (8). The attributes of the biscuits (texture, flavor and taste) significantly increased *($P \leq 0.05$)* with addition of QF or MF or QF+MF plus CRF and/or CF compared with control biscuits. The scores ranged from 7.7-8.75 for texture, 7.5-8.6 for flavor, 7.64-8.63 for taste. From the sensory evaluation, the findings revealed that the samples did not differ significantly *($P \leq 0.05$)* in appearance, color & overall acceptability comparing to control. The yellow and dark colors of biscuits produced with CF and CRF, respectively, were attractive to the panelists. Moreover, CF and CRF gave the biscuits a good flavor and taste. Results proved that all gluten-free biscuits prepared from QF or MF or QF+MF plus CRF and/or CF were acceptable by panelists. Therefore, it is possible to use any type of gluten-free biscuits, which contain a high nutritional value, taste and flavor comparing with the control according to the desire of the celiac patients. Shamy bread produced from 80% WF + 20% CF did not record any significant difference *($P \leq 0.05$)* concerning odor, taste and crust color comparing to control bread **(El-Said *et al.*, 2021)**. Replacing QF up to 50% of RF in biscuits did not have any significant *($P \leq 0.05$)* effects on color, taste and texture compared with control biscuits **(Ahmed *et al.*, 2017)**. Making cupcakes with CRF gave more flavor scores comparing to control **(El-Naggar and Hassan, 2018)**. Biscuits containing 65% RF and 35% CRF significantly improved sensory qualities compared with control biscuits **(Ibrahim *et al.*, 2015)**. The sensory qualities of biscuits containing 50% germinated MF and 50% RF were the most acceptable than control **(Nada *et al.*, 2016)**.

Table (8): Effect of replacing RF with QF, MF, CF and CRF on the sensory qualities of gluten-free biscuits.

Sample	Sensory attribute					
	Appearance	Color	Texture	Flavor	Taste	Overall acceptability
Control	8.50±0.09[a]	8.٦٦±0.09[a]	٧.٧0±0.٠٥[b]	٧.٥٠±0.٠٤[b]	٧.٦٤±0.٠٥[b]	8.٠0±0.٠6[a]
B1	8.42±0.08[a]	8.٥5±0.٠7[a]	8.٤٠±0.٠٦[a]	8.39±0.٠٦[a]	8.40±0.٠٧[a]	8.٤1±0.٠5[a]
B2	8.3٥±0.٠٨ [a]	٨.٣٠±0.٠٦[a]	8.٣٨±0.٠٧[a]	8.٥٠±0.٠7[a]	٨.٥٥±0.٠٩[a]	8.٤٥±0.٠٧[a]
B3	8.40±0.٠٩[a]	٨.٤٥±0.٠٧[a]	8.٤٤±0.٠٩[a]	8.٤0±0.٠٦[a]	٨.٥٠±0.٠٨[a]	8.٤٣±0.٠٨[a]
B4	8.٣٦±0.٠٧[b]	٨.٤٠±0.٠٦[a]	٨.٤٦±0.٠٨[a]	٨.٥٥±0.٠٨[a]	٨.٦٠±0.٠٩[a]	٨.٥٠±0.٠٩[a]
B5	8.50±0.٠٩[a]	8.٦٥±0.٠٩[a]	8.٧٥±0.٠٩[a]	8.٤١±0.٠٨[a]	8.47±0.٠٧[a]	8.٥0±0.٠6[a]
6B	8.4١±0.٠٧[a]	8.٣٥±0.٠6[a]	8.٧٠±0.٠٨[a]	8.٥٤±0.٠٩[a]	٨.٦٠±0.٠٩[a]	8.٥٦±0.٠٨[a]
B7	8.٤٥±0.٠٨[a]	٨.٥٥±0.٠٨[a]	8.٦٩±0.٠٧[a]	8.٤3±0.٠7[a]	٨.٥٤±0.٠7[a]	8.٥٥±0.٠٩[a]
B8	8.٤2±0.٠٩[a]	٨.٤٥±0.٠٧[a]	8.٧٣±0.٠٩[a]	8.٦0±0.٠٩[a]	٨.٦٣±0.٠٨[a]	8.٦٠±0.٠٩[a]
B9	٨.٤٠±0.٠٦[a]	٨.٥٠±0.٠٩[a]	٨.٥5±0.٠٨[a]	٨.40±0.٠٦[a]	8.43±0.٠٨[a]	٨.٤٥±0.٠8[a]
B10	8.٣٦±٠.٠٧[a]	8.٣٢±0.٠٧[a]	8.٥٣±0.٠٧[a]	8.5٢±0.٠٨[a]	8.٥٧±0.٠٦[a]	8.٥٢±0.٠6[a]
B11	8.42±0.٠٨[a]	8.٥١±0.٠٨[a]	8.٥١±0.٠٨[a]	8.٤٢±0.٠٥[a]	٨.٥٢±0.٠٧[a]	8.٥٠±0.٠5[a]
B12	8.3٨±0.٠٧[a]	٨.٤٣±0.٠٥[a]	8.٦0±0.٠٩[a]	8.٥٧±0.٠7[a]	٨.٦١±0.٠٩[a]	8.٥٦±0.٠٨[a]

Within columns, values (n=3) with the different letters are significant difference *($p \leq 0.05$)* according to Duncan's test. Control: 100% RF**; B1:** 50%RF+50%QF**; B2:** 40%RF+50%QF +10%CRF**; B3:** 30%RF+50%QF+20%CF**; B4:** 20%RF+50%QF+20%CF+10%CRF**; B5:** 50%RF+ 50%MF**; B6:** 40%RF+50%MF+10%CRF**; B7:** 30%RF+50%MF+20%CF**; B8:** 20%RF+50%MF+ 20%CF+10%CRF**; B9:** 50%RF+25%QF+25%MF**; B10:** 40%RF+25%QF+25%MF+10%CRF**; B11:** 30%RF+25%QF+25%MF+20%CF and **B12:** 20%RF+25%QF+25%MF+20%CF+10%CRF.

Conclusion:

Improvements in nutritional & sensory properties have become of paramount importance in the development of gluten-free foods. Gluten-free flours (RF, QF, MF, CF and CRF) combinations could be utilized to prepare good quality biscuits with acceptable sensory & physical qualities. The substitution of RF with QF, MF, CF and CRF significantly improved *(P≤0.05)* the nutritional profile of biscuits, as a result of the elevate in protein, fat, fiber, ash, Ca, P, K, Fe, Zn and Mg. All kinds of gluten-free flours (QF, MF, CF and CRF) significantly improved *(p≤0.05)* the physical, color & sensory characteristics of biscuits. The highest value of protein, fat, fiber, ash & minerals were determined in sample B4 (20%RF: 50%QF: 20% CF:10% CRF) comparing to control. All kinds of gluten-free biscuits had higher nutritional value than control and were acceptable by panelists. Therefore, these biscuits can improve people's nutritional status, and also benefits those who suffer from gluten intolerance and low-income groups.

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تأثير استبدال دقيق الارز بدقيق الكينوا والدخن والحمص والخروب على الخصائص الغذائية والحسية للبسكويت الخالي من الجلوتين

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الملخص العربي:

يُصيب مرض السيلياك الإنسان في جميع الأعمار ويُوصف بعدم تحمل الجلوتين، وعلاجة الوحيد اتباع نظام غذائي خالٍ من الجلوتين مدى الحياة. يهدف البحث إلي دراسة تأثير استخدام دقيق الأرز (RF) والكينوا (QF) والدخن (MF) والحمص (CF) والخروب (CRF) على تحضير البسكويت الخالي من الجلوتين بالنسب التالية ١٠٠:٠:٠:٠:٠(كنترول)، ٥٠:٥٠:٠:٠:٠(B1)، ٤٠:٥٠:٠:٠:١٠(B2)، ٣٠:٥٠:٠:٢٠:٠(B3)، ٢٠:٥٠:٠:٢٠:١٠(B4)، ٥٠:٠:٥٠:٠:٠(B5)، ٤٠:٠:٥٠:٠:١٠(B6)، ٣٠:٠:٥٠:٢٠:٠(B7)، ٢٠:٠:٥٠:٢٠:١٠(B8)، ٥٠:٢٥:٢٥:٠:٠(B9)، ٤٠:٢٥:٢٥:٠:١٠(B10)، ٣٠:٢٥:٢٥:٢٠:٠(B11)، ٢٠:٢٥:٢٥:٢٠:١٠(B12)، على التوالي. تمت دراسة الخواص الفيزيائية والكيميائية والصفات الحسية للبسكويت. أشارت النتائج أن دقيق الحمص احتوى على أعلى نسبة من البروتين (٢٢,٨٠٪) والدهون (٦,٠٠٪)، بينما احتوى دقيق الخروب على أعلى قيمة للألياف (٧,٤٠٪) والرماد (٣,٤٠٪) مقارنة بانواع الدقيق الاخرى. واحتوى دقيق الحمص على أعلى مستوى من الفسفور والبوتاسيوم والحديد مقارنة بانواع الدقيق الاخري. واحتوى دقيق الخروب على أعلى قيمة للكالسيوم والزنك، وكانت أعلى كمية للماغنسيوم في دقيق الكينوا مقارنة بانواع الدقيق الاخرى. وأدى استبدال دقيق الارز بدقيق الكينوا والدخن والحمص والخروب إلى تحسناً معنوياً ($P \leq 0.05$) فى القيمة الغذائية للبسكويت، كنتيجة لزيادة البروتين والدهون والرماد والمعادن. وسُجلت أعلى قيمة للبروتين (١٣,٢٥٪) والالياف (٤,٤٣٪) والرماد (٢,٤٤٪) في (B4) مقارنة بالكنترول. وكانت قيم البروتين والالياف والرماد في (B4) حوالي ٣ مرات و٨ مرات و٥ مرات على التوالي، زيادة عن الكنترول. وزاد محتوى المعادن معنوياً ($p \leq 0.05$) في البسكويت الخالي من الجلوتين مقارنة بالكنترول. وأثبتت النتائج أن جميع أنواع البسكويت الخالي من الجلوتين كانت مقبولة من قبل المحكمين. ولم يُسجل قطر وسمك البسكويت أي اختلافات معنوية ($P \leq 0.05$) في جميع العينات مقارنة بالكنترول. وأدت إضافة دقيق الدخن إلى زيادة معنوية ($p \leq 0.05$) في قيمة L^* للبسكويت مقارنة بالكنترول. لذلك، يمكن التوصية باستخدام البسكويت المحتوى على دقيق الكينوا والدخن والحمص والخروب لمرضى السيلياك.

الكلمات المفتاحية: مرض السيلياك؛ البسكويت الخالي من الجلوتين؛ الحمص؛ الكينوا؛ الدخن.

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