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Effect of Adding Corn Flour to Quinoa Flour to Produce Gluten-Free Pan Bread

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ABSTRACT

The effect of adding corn flour to quinoa flour (*Chenopodium quinoa*) at different levels was studied. The proximate chemical composition, physical properties and sensory evaluation of gluten free pan (GFP) bread made of corn flour and quinoa flour at different levels were investigated. Baking trials were conducted at different levels of substitution (25, 50, 75 and 100% quinoa seeds flour) Results indicated that moisture, crude protein, lipids, ash and dietary fiber content were increased in substituted levels of quinoa seeds flour. On the other hand, total carbohydrates decreased by increasing quinoa levels. Also, (GFP) bread samples prepared from75% corn flour(CF) and 25% quinoa flour(QF) proved to be of lower content in macro mineral (K, Ca, Mg, Na & P) and micro mineral (Fe, Mn& Zn) content ,while(G.F.P) bread samples prepared from 100% quinoa flour(QF) recorded high contents of all mineral under investigation. Weight (g) gradually increased in (G.F.P) bread samples parallel to the increase in substitution levels by quinoa flour (QF).,While volume and specific volume (cm^3/g) of (GFP) bread gradually decreased by increasing levels of quinoa flour(QF). Organoleptic properties indicated that non-significant differences ($P<0.05$) proved in all sensory properties between the control sample and (GFP) bread prepared by 25% quinoa flour except in crust colour and odor of sample. the (GFP) bread samples containing 50, 75 and 100% QF were significantly differences ($P < 0.05$) in all sensory properties as compared to the control pan bread and the (GFP) bread sample containing 25% QF.

Keywords: Celiac Disease, Free Gluten, corn Flour, quinoa Flour, Pan Bread and Sensory Evaluation

INTRODUCTION

Recently, several authors have reported data on the prevalence of celiac disease in Asia, the Middle East, North Africa, and South America. Prevalence of celiac disease has increased sharply in recent years because of better recognition of the disease and its associated disorders (Niewinski, 2008).

Celiac disease is an autoimmune disease characterized by intestinal damage resulting from the ingestion of products containing gluten, or other prolamin (storage) proteins found in cereal grains (Alvarez-Jubete *et al*., 2010). The autoimmune response leads to inflammation in the digestive tract, damages the microvilli, and inhibits nutrient absorption. Gluten is the main protein complex formed from wheat flour, and it gives breads and other baked products their porous, spongy texture. In addition to being found in wheat, prolamins that can trigger the autoimmune response are found in rye, barley, and possibly oats

For the majority of celiac disease patients, adherence to a strict gluten-free diet will lead to progressive clinical improvement in parallel with the healing of the intestinal mucosa (Catassi and Fasano, 2008; Chand and Mihas, 2006 & Rodrigo, 2006). For instance, staple foods in many areas of the world such as bread and pasta contain gluten and should therefore be avoided in the gluten-free diet (Catassi and Fasano, 2008) without adequate resistance, the carbon dioxide diffuses out of the product resulting in a decrease in volume in the baked good.

As a result product developers add gum, such as xanthan gum or guar gum, and proteins, such as egg whites and soy protein isolate, to improve the loaf volume and texture (Arendt and Bello, 2008). Stikic *et al*. (2012) they also studied the Agronomical and nutritional evaluation of quinoa seeds as an ingredient in bread formulations, and they found that quinoa purified seeds contained 11.43% moisture, 15.16 % protein, 5.79 % fat, 2.22 % ash and 5.69 %. Another evaluation of yellow corn varieties were reported by Yuan and Rolando (1996)and they found that, the protein content was ranged from 5.2 to 10.1%, oil from 2.9 to 5.5%, and starch was ranged from 45.7 to 62.7% (on 15% moisture basis).

Caperuto *et al.* (2001) studied the application of quinoa and corn in the production of a gluten-free spaghetti-type product. Cooking quality, texture and viscosity were determined. A sensory panel was also conducted and the products were found to be moderately acceptable with a mild corn taste. Amaranth, quinoa and buckwheat were also used by Schoenlechner *et al.* (2004) to produce gluten-free pasta. Gluten-free bread are usually characterized by inferior quality characteristics as compared with wheat breads. Problems related to volume and crumb texture are associated with gluten-free breads (even when rice flour is used, which seems to be the best raw material for this type of bread) (Gujral *et al*., 2003).

So, the aim of this investigation was designed to prepare (G.F.P.bread) by utilization of quinoa seed flour with other cereal grains like corn flour to nourish gluten sensitive patients

MATERIALS AND METHODS

Materials:

Quinoa seeds were obtained from Egyption company for natural oil naser city Egypt,corn flour was obtained from Sky Live Co. for Food Industry, Giza, Egypt.

Other ingredients such as Instant active dry yeast (Saccharomyces cerevisiae), was imported by AKMAYA Co., Turkey was obtained from local market at Mansoura city,Egypt.,.corn oil, fresh hen eggs and sugar (sucrose), salt and Xanthan gum were obtained from local market at Mansoura city,Egypt.

All chemicals analytical grade were purchased from sigmacompany for medical materials, Gaza, Egypt

Methods

Preparation of quinoa seeds flour:

Quinoa seeds were cleaned by removing foreign matters, then washed by cold water several times to remove possible saponin residues and conditioned at 16% moisture in order to improve the separation of the botanical seeds tissues (endosperm from pericarp). Seeds were then milled by protein laboratory mill 3100 to whole quinoa meal. The whole quinoa meal was then sieved through a 50-mesh screen, then packaged in plastic bags and stored at 7˚C until used.

Preparation of gluten free pan (G.F.P) bread blends:

Different composite flour samples were prepared by partially substituting of quinoa flour by different ratios of corn flour to prepare different blend samples which used in preparation of gluten free pan bread samples as presented in the following table. Table (1): Ingredients used in production of gluten-free pan bread as described by Ann-sophiehagerelke and k.arendt (2013)

Table 1. Percentage of ingredients used in the production of gluten-free pan bread. (G.F.P)

Ingredients	%
CF or its blends*	55.98
corn Starch	23.03
Xanthan Gum	0.60
Sugar	2.41
Salt (sod. chloride)	1.44
active dry yeast	1.33
Fresh Egg	5.42
Vegetable Oil	6.75
Water	As Required
	100

*** CF: Corn flour.**

Chemical analysis:

Moisture, crude protein, ash, crude fiber and lipids were determined according to the method described in A.O.A.C (2000).

Total carbohydrates were calculated by difference from the sum of the protein, fat, ash and crude fibers content.

Mineral contents were determined by wet acid-digestion, using nitric acids mixture (HNO3: HClO4, 5:1 w/v) ccording to the method described by Chapman and Pratt (1978). Then the total amounts of K, Ca, Mg, Na, P, Fe, Mn and Zn in the digested samples were determined by atomic absorption spectrophotometry. (PEKMAN)

Rheological measurement of dough samples:

The Rheological measurement of dough samples were performed by Mixolab (Chopin, Tripetteet Renaud, Paris, France) according to A.A.C.C. (2010) standard.

Preparation of gluten-free pan (G.F.P) bread:

All samples were prepared according to method of (Barbone, 2012) and (Zannini *et al.,* 2012).

Physical properties:

The weight of gluten free pan bread loaves was determined after cooling for one hour. gluten free pan bread loaves volume was measured by rape seed displacement method as described by A.A.C.C. (2000) (G.F.P) Specific volume of(G.F.P) bread was calculated by dividing volume of the loaves (cm^3) by their weights (g).

Determination of alkaline water retention capacity (AWRC %):

The staling rate of gluten-free pan bread samples were determined by alkaline water retention capacity as described by Kitterman and Rubanthaler (1971).

Sensory evaluation:

Samples of gluten free pan bread were organoleptically evaluated for appearance, color (crumb and crust), taste, odor, softness, crumb structure and overall acceptability according to the methods described by Lazaridou *et al*. (2007).

Statistical Analysis:

The results were analyzed by method as described by Snedecor and Cochran (1989). Means were separated using Duncan test at a degree of significant *($P \leq 0.05$)*.

RESULTS AND DISCUSSION

Proximate chemical composition of gluten-free pan bread prepared from yellow corn and quinoa flour:-

The Proximate chemical composition of gluten-free pan bread is presented in table (2). Data indicate that substitution of gluten-free pan bread prepared from yellow corn flour substituted by increasing levels of quinoa flour resulted in parallel increases of moisture and crude protein contents (from 32.17 to 38.37%) and (10.25 to 16.80)at 100% QF respectively. This behavior is due to the fact that quinoa flour is rich in protein content.

As for lipids, and ash contents, there were a moderate alteration in lipids and ash content in all bread samples with increasing of QF levels from 25% to 100% in flour blends used for bread making. These increases were from (7.66 – 8.72 %) and, (1.43 – 4.86 %) respectively as the dietary fiber content of gluten-free pan bread samples prepared from yellow corn flour (control) as compared to that prepared from substituted corn flour by increasing percentage of quinoa flour (QF). Substitution levels were 25, 50, 75 and 100% respectively. Bread control samples prepared from unsubstituted yellow corn flour (CF) proved to be of lower content in total insoluble and soluble fiber 8.25, 1.56 and 6.69 g/100g respectively, and increased up to 10.42, 1.85 and 8.57 g/100g at 100% quinoa flour.

Table 2. Proximate chemical composition of gluten-free pan bread prepared by partial replacement of yellow corn flour by quinoa flour (% on dry weight basis):-

Bread samples	Chemical composition (%)					Dietary fiber			
	Moisture	Crude protein	Lipids	Ash	Crude fiber	Total	Soluble	insoluble	Total carbohydrates
Control (CF)	32.17	10.25	7.66	1.43	1.72	8.25	1.56	6.69	78.94
75%CF+25%QF	33.54	11.90	7.92	2.25	2.47	١8.6	1.67	6.94	75.46
50%CF+50%QF	35.20	13.42	8.21	3.07	2.98	9.34	1.71	7.63	72.32
25%CF+75%QF	36.93	15.17	8.55	4.30	3.66	9.88	1.78	8.12	68.32
100% QF	38.37	16.80	8.72	4.86	4.23	10.42	1.85	8.57	65.39

(cf) corn flour (qf) quinoa flour

In contrast, carbohydrates were decreased progressively when the QF ratios increased in all bread samples which were ranged between 65.39in 100% QF sample - 78.94 % in 100% CFsample

These results are in accordance with those found by Caperuto *et al*. (2001); Rosell *et al*. (2009) and Calderelli *et al*. (2010) whom reported that substitution of bread flour by quinoa flour resulted in improvement of its nutritional value as chemical composition of gluten-free bread except with decrease in the total carbohydrate contents.

Mineral content of gluten-free pan bread prepared from yellow corn and quinoa flour:-

The mineral content of control sample (gluten pan bread prepared from100% yellow corn flour) and pan bread samples containing quinoa flour (QF) at substitution levels of 25, 50, 75 and 100% respectively, were determined and indicated in table (3)

Substitution levels were 25, 50, 75 and 100% QF; respectively, was accompanied by gradual increase in minerals content for all samples. The increase in the minerals content from control sample (100%yellow corn flour) to 100% quinoa flour which ranged between (326.14 – 867.90) for potassium; (158.36 – 205.32) for calcium; (143.70 – 285.72) for manganese; (1271.76 – 1428.58) for sodium; (230.84 – 412.50) for phosphorus; (2.96 – 8.86) for iron; (1.35 – 2.87) for manganese and (1.20 – 4.96) mg/100g for zinc. Consequently, it is worth to mention that quinoa flour can improve the minerals content in gluten-free pan bread produced from corn flour. This increase might be attributed to higher minerals content in quinoa flour.

These results are in a good agreement with those obtained by Alvarez-Jubete *et al.* (2010) and Stikic *et al.* (2012). They found that the incorporation of quinoa purified seeds up to 20% in wheat bread induced some changes in mineral content. An increase in the majority of minerals was registered. Thus, the addition of quinoa seeds fortified bread quality in Fe and Mn contents. Furthermore, almost two-fold increase in Mg content as well as slight increase in K content was observed.

Table 3. Minerals content of gluten-free pan bread prepared by partial replacement of yellow corn flour by quinoa flour (mg/100g on dry weight basis):-

Bread samples	Potassium (K)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Phosphorus (P)	Iron (Fe)	Manganese (Mn)	Zinc (Zn)
Control (CF)	326.14	158.36	143.70	1271.76	230.84	2.96	1.35	1.28
75%CF+25%QF	458.22	171.87	176.25	1292.15	276.26	4.45	1.70	2.11
50%CF+50%QF	607.93	180.14	214.71	1338.92	310.61	5.98	2.05	2.90
25%CF+75%QF	734.46	195.56	246.00	1385.37	372.08	7.27	2.64	3.85
100% QF	867.90	205.32	285.72	1428.58	412.50	8.86	2.87	4.96

(CF) corn flour (QF) quinoa flour

Mixolab properties of dough behavior of yellow corn flour and its blends with different percentage of quinoa flour.

The rheological properties of dough samples prepared by using yellow corn flour substituted by 25, 50, 75 and 100% of quinoa flour were evaluated by Mixolab apparatus.

As it is well known wheat flour possesses the unique bread making properties due to the ability of wheat storage protein to form viscoelastic dough when wetted and kneaded (Stauffer, 2007). Therefore, Mixolab curve obtained for the wheat flour system was used as a standard curve. The aim was to create gluten-free mixtures which would have as much as possible similar Mixolab profiles to the standard one.

During initial mixing, the distribution of the material,also the disruption of the initially spherical protein particles and the hydration of the flour compounds occur together with the stretching and alignment of the proteins, leading to the formation of a three-dimensional viscoelastic structure with gas retaining properties; Collar *et al*., 2007; Angioloni and Collar, 2009). The results presented in table (4) and illustrated in Figure(A) showed the effect of substitution of yellow corn flour with 25, 50, 75 and 100% quinoa flour. From the obtained data, it could be noticed that the water absorption of yellow corn flour was gradually increased as the level of substitution with quinoa flour increased which reached to 70.4, 75.0, 79.2 and 82.6% for corn flour dough's replaced with 25, 50, 75 and 100% of quinoa flour, respectively in compared to 68.1% for the control yellow corn flour dough. The increased in water absorption of the dough which prepared by using quinoa flour probably due to the higher fiber and protein contents of quinoa flour than yellow corn flour. These results are in agreement with Abd El-Moniem and Yassen (1993) & Marco and Rosell (2008).

Also, from the same table, it could be revealed that dough development time (min) in blended samples with quinoa flour slightly decreased from 3.78 to 2.22 min as the substitution level increased from 25 to 75% respectively. Meanwhile dough development time for control yellow corn flour was 3.90 min. As for dough development (C1) the results indicate by increasing the substitution levels of yellow corn flour by quinoa flour, the dough development increase in all flour blends from 1.070 (Nm) for control (100% yellow corn flour) to 1.150 (Nm) in 100% quinoa flour. These results may be related to increasing level of quinoa flour which more time required for complete hydration of the material, and could be related to the composition and characteristics of protein and starch (Abugoch *et al.*, 2009; Matos *et al.,* 2014 & Aprodu *et al.,* 2016).

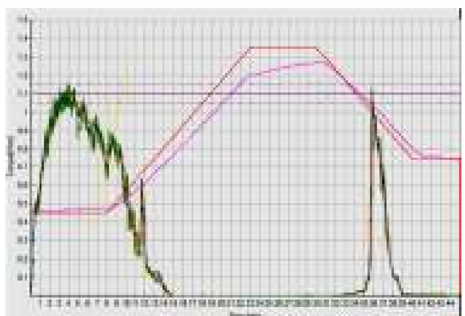
According to the values presented in table (4), it can be concluded that dough stability (min) was progressively decreasing parallel to the increase of replacement levels with quinoa flour. Quinoa flour addition increased from 25 to 100% tested blends, while dough stability recorded 3.87, 3.55, 2.90 and 1.37 min as the replacement rate increased from 25 to 100% of quinoa flour in the blends respectively, as compared to 4.72 min for control (100% yellow corn flour). These results are in agreement with those mentioned by Bonet *et al.* (2006) & Marco and Rosell (2008).

Concerning the degree of minimum torque (C2) or dough breakdown, it could be remarked that the degree of dough weakening decreased as the substitution level of quinoa flour increased. This values decrease from 0.050 to 0.030 Nm when the substitution levels increased from 25 to 100% quinoa flour as compared to 0.067 Nm for control sample (100% yellow corn flour). In addition, Protein weakening increased from 1.030 to 1.120 Nm when the substitution levels increased from 25 to 100% quinoa flour as compared to 1.003 Nm for control sample (100% yellow corn flour). These results are in agreement with Mariotti *et al*. (2008) & Rosell *et al*. (2009).

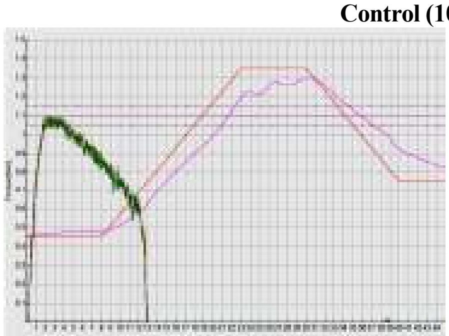
Table 4. Mixolab properties of dough behavior of yellow corn flour and its blends with different percentage of quinoa flour

Flour Blends	Mixolab parameter					
	Water Absorption (%)	**Development time (min)**	**Dough Stability (min)**	**Dough Development C1 (Nm)**	**Protein Breakdown C2 (Nm)**	**Protein Weakening (C1-C2) (Nm)**
Control (CF)	68.1	3.90	4.72	1.070	0.067	1.003
75%CF+25%QF	70.4	3.78	3.87	1.080	0.050	1.030
50%CF+50%QF	75.0	3.13	3.55	1.084	0.040	1.044
25%CF+75%QF	79.2	2.22	2.90	1.160	0.030	1.130
100% QF	82.6	3.32	1.37	1.150	0.030	1.120

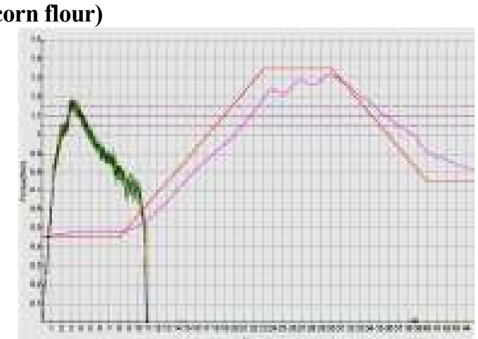
***CF: Corn flour & QF: Quinoa flour.**



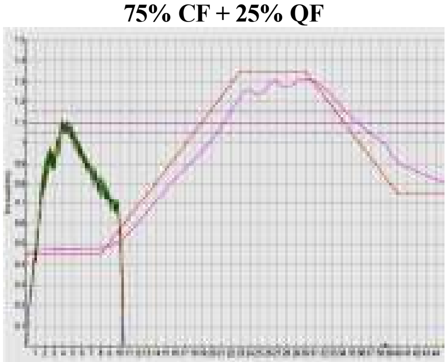
Control (100% Yellow corn flour)



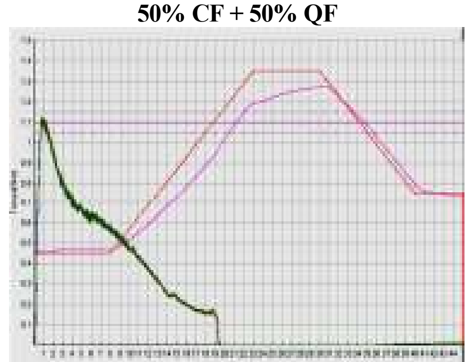
75% CF + 25% QF



50% CF + 50% QF



25% CF + 75% QF



100% Quinoa flour

Figer A. Effect of substituted corn flour with different levels of quinoa flour on mixolab parameters

Physical properties of gluten-free pan bread prepared from yellow corn and quinoa flour:-

From the obtained data in table (5) describes the physical properties of gluten free pan bread prepared from100% yellow corn flour and supplemented with different levels (25%, 50%, 75% and 100%) of quinoa flour. The weight of (G.F.P) bread ranged from 268.53 at 25% QF and was increased up to 290.45 g at 100% QF. In contrast, Volume of pan bread samples gradually decreased from 355 cm^3 at 25% quinoa flour to 317 cm^3 at 100% quinoa flour, while control sample (100%yellow corn flour only recorded 368cm^3). Also, Specific volume (cm^3/g) of free gluten pan bread under study decreased from 1.32 cm^3 / g to 1.09 cm^3 / g by increasing supplemented levels of quinoa flour from 25%to 100 % .

This results are in agreement with Föste *et al.* (2014) whom reported that the replacement of rice and corn flour by 40% whole grain quinoa flour significantly increased product volume, while addition of the same amount of quinoa bran significantly decreased loaf volume. Elgeti *et al.* (2014) studied the volume and texture improvement of gluten-free bread using quinoa white flour; they found that rice and corn flour resulted in low bread volume due to a lack of mono- and disaccharides.

Table 5. Effect of replacement of yellow corn flour by quinoa flour on physical properties of gluten-free pan bread.

Bread samples	Weight (g)	Volume (cm^3)	Specific volume (cm^3/g)
Control (CF)	255.26	368	1.44
75%CF+25%QF	268.53	355	1.32
50%CF+50%QF	277.60	337	1.21
25%CF+75%QF	284.18	321	1.13
100% QF	290.45	317	1.09

(Cf) corn flour (Qf) quinoa flour

Alkaline water retention capacity (AWRC %) of gluten-free pan bread prepared from yellow corn and quinoa flour:

The changes in Alkaline Water Retention Capacity (AWRC %) of gluten-free pan bread prepared from yellow corn flour and replacement of yellow corn flour with quinoa flour with different levels, stored at room temperature for 0, 1, 2 and 3 days are shown in table (6). Results indicated that the alkaline water retention capacity (AWRC %) of all bread samples decreased by increasing in storage period. AWRC decreased from 138.60 at zero time and reached to 118.56 after 3 days for samples prepared from 25% CF. In this concern, AWRC for pan bread samples prepared from 100% QF decreased from 164.51 at zero time to 144.32 after 3 days of storage.

These results are in approximately similar with Elgeti *et al.* (2014) they reported that a gradual decrease in freshness for all prepared cake samples during storage period. The lower reduction in staling value (high freshness) was noticed in samples prepared from cassava flour followed by samples prepared from pumpkin flour and samples prepared from mixture of cassava, pumpkin and potato flours, where samples prepared from wheat and potato flours were the lowest in freshness in comparison to other samples.

Table 6. Alkaline water retention capacity (AWRC %) of gluten-free pan bread prepared by partial replacement of yellow corn flour with quinoa flour.

Bread samples	Storage periods (days)			
	Zero time	1	2	3
Control (CF)	138.60	132.93	125.48	118.56
75%CF+25%QF	142.87	137.82	130.89	123.31
50%CF+50%QF	144.06	139.38	133.62	128.89
25%CF+75%QF	147.55	142.16	136.82	131.34
100% QF	164.51	158.99	150.73	144.32

(Cf) corn flour (Qf) quinoa flour

Sensory evaluation of gluten-free pan bread prepared from yellow corn and quinoa flour:-

From the obtained date in table (7), it could be concluded that there were a-significant differences ($P<0.05$) in all sensory properties between the control sample and (G.F.P) bread prepared with25% quinoa flour except odor of sample. Also (G.F.P) bread samples prepared from 50% quinoa flour recorded non-significant difference in all sensory properties excpt Crumb structure of (G.F.P) pan bread samples compared to pan bread prepared from 25%QF and non-significant difference in all sensory properties excpt odor compared to (CF) control sample.

In this concern, Data recorded that non-significant different in most sensory properties between the pan bread prepared from 50%, 75% and 100% QF.

On the other hand, the gluten-free pan bread samples containing 50, 75 and 100% QF were significantly differences ($P < 0.05$) in all sensory properties as compared to the control sample (100%CF).

Table 7. Sensory evaluation of gluten-free pan bread prepared from yellow corn flour and yellow corn flour substituted by different levels of quinoa flour.

Bread Samples	Appearance (20)	Color of crust (10)	Color of crumb (10)	Softness (10)	Crumb structure (10)	Taste (20)	Odor (20)	Over all acceptability (100)
Control (CF)	18.52±0.16^a	9.12±0.10^a	7.95±0.05^a	9.00±0.00^a	8.39±0.44^a	17.68±0.16^a	17.06±0.05^a	87.72±0.00^a
75%CF+25%QF	17.31±0.21^{ab}	8.45±0.44^{ab}	7.75±0.39^{ab}	8.45±0.43^{ab}	8.05±0.60^{ab}	16.45±0.44^{ab}	17.06±0.33^a	83.52±1.20^{ab}
50%CF+50%QF	17.30±0.48^{ab}	8.29±0.25^{ab}	7.75±0.68^{ab}	8.05±0.60^{ab}	7.88±0.28^b	16.10±0.64^{ab}	17.05±0.60^a	82.42±0.44^{ab}
25%CF+75%QF	16.25±0.35^b	7.99±0.19^b	7.75±0.35^{ab}	7.75±0.35^b	7.24±0.21^c	15.78±0.33^b	15.92±0.36^b	78.68±0.75^b
100% QF	13.66±0.44^c	6.77±0.30^c	6.50±0.65^b	6.20±0.26^c	6.88±0.16^d	15.90±0.13^b	15.56±0.56^b	71.47±0.43^c

Means followed by different letters in the same Colum are significantly by Duncan's multiple test($P < 0.05$)

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تاثير اضافة دقيق الذرة الى دقيق الكينوا لانتاج خبز القالب الخالى من الجلوتين

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تم دراسة تاثير اضافة دقيق الذرة الى دقيق الكينوا ومدى تاثير ذلك على التركيب الكميائى وعلى الخصائص الطبيعية والريولوجية وعلى التقيم الحسى لخبز القوالب الخالى من الجلوتين والمصنوع من الذرة مع نسب استبدال دقيق بذور الكينوا(٢٥-٥٠-٧٥-١٠٠%) واظهرت النتائج المتحصل عليها انة عند زيادة نسب استبدال دقيق بذور الكينوا يزداد كلا من البروتين الخام والدهون والعناصر المعدنية والالياف وفى مقابل ذلك انخفضت نسبة الكربوهيدرات الكلية. كما ظهرت النتائج المتحصل عليها ان خبز القالب الخالى من الجلوتين والمصنوع من ٧٥%دقيق الذرة و٢٥%كينوا يحتوى على مستوى منخفض من العناصرالمعدنية الكبري (البوتاسيوم – الكالسيوم – المغنسيوم صوديوم- فسفور)ومن العناصر المعدنية الصغري (حديد- منجنيز- زنك)بينما سجلت عينات خبز القالب الخالى من الجلوتين المستحضر من ١٠٠% دقيق بذور الكينوا الى محتواها العالى من المعادن كذلك اظهرت النتائج الى زيادة الوزن(جم) تدريجيا بزيادة نسب الاستبدال فى مقابل ذلك انخفض الحجم والحجم النوعى(سم٣|جم) بينما اظهرت نتائج التقيم الحسي الى عدم وجود فروق معنوية بين عينات خبز القالب الخالى من الجلوتين المحضر من ٢٥%دقيق كينوا وعينات الكنترول ماعدا لون القشره والرائحة فى حين وجد هناك فروق معنوية بين عينات الخبز المحضر من (٥٠-٧٥-١٠٠%) وعينات الكنترول المصنعة من ١٠٠% ذرة وعينات خبز القالب الخالى من الجلوتين المحضرة من ٢٥% دقيق كينوا .

الكلمات الدالة :مرض السليك - خالى من الجلوتين- دقيق الارز – دقيق الكينوا – خبز القوالب - التقيم الحسي