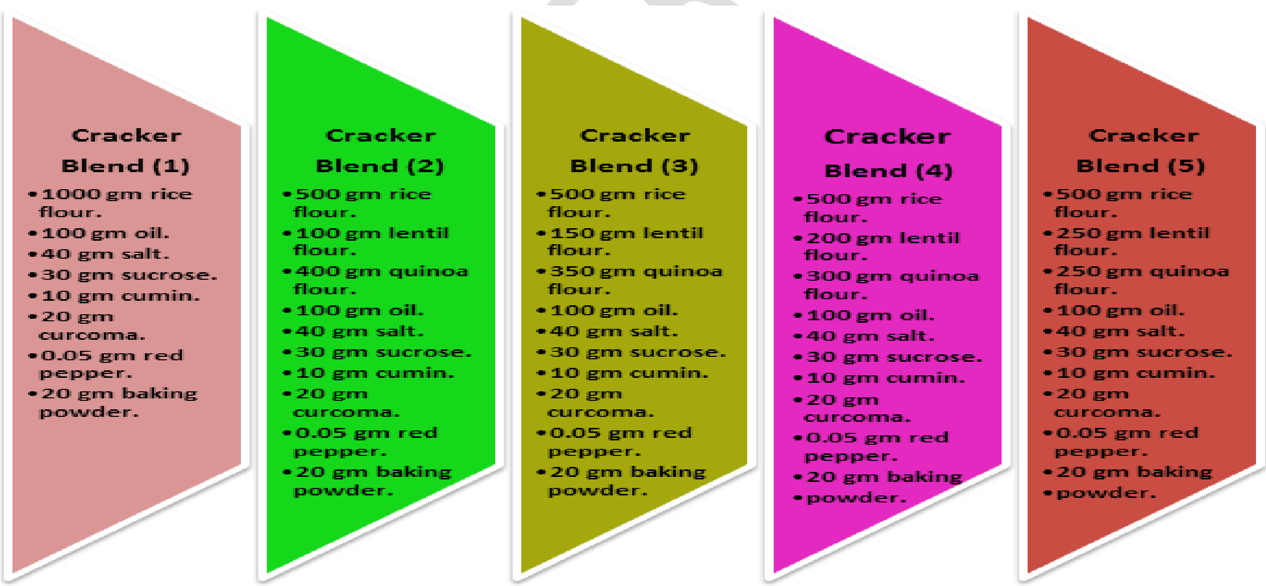
Gluten-Free Crackers Preparation

Abstract

The current study was carried out to make gluten free crackers with high quality for celiac disease patients. The chemical analyze as minerals, amino acids of broken rice, lentil and quinoa flour and its blends was determined. Also, chemical composition for gluten free crackers blends was determined and results showed that ash, protein, ether extract and fibre contents were higher in all blends prepared using rice flour, quinoa flour and lentil flour than those blend prepared using rice flour. All sensory properties of free gluten crackers blends B2, B3, B4 and B5 prepared using rice flour, lentil flour, and quinoa flour were somewhat higher than crackers prepared from rice flour B1. As a noticed decrease in hardness from 74.97 newton in blend No.1 made from 100% rice flour to 35.19 newton in blend (5) made from 50% rice flour, 40% lentil flour and 10% quinoa flour.



Keywords: Celiac, rice, Quinoa, Lentil, Crackers.

Introduction

As a result of urbanization and modernization, snack food consumption has increased. However, most snacks have high levels of fats, sugars, and salts, as well as low levels of dietary fibre, which can lead to health problems[1]. Therefore, consumer demand for nutritious snacks is growing. As a result of their outstanding eating quality and superior nutritional properties, snack crackers are one of the most desirable snacks.

Crackers are a type of biscuit with flaky inner layers (SLS 251: 2010). Crackers have a low sugar content, a moderate fat content, and a low salt content[2]. Consequently, crackers can be used to replace sweeter foods. Crackers can also be used to incorporate a variety of nutritionally rich components for variety[3]. Dietary fibre has gained a lot of attention as one of these additional components. According to Valencia et al., there is a growing need for high fibre food products to help people overcome health problems like hypertension, diabetes, and colon cancer[4].

Lentil (*Lens culinaris Medik*.) is a very significant legume crop that is widely cultivated and consumed. The plants are farmed for their lens-shaped edible seeds, which are high in protein (35-40%) and carbohydrates, as well as calcium, phosphorus, iron, and vitamins B-complex[5]. It is one of the earliest known food crops utilized only for human use. It's also abundant in lysine, making it a wonderful complement to cereal grains' amino acid content[6].

Wheat flour is the most common flour used in bread goods. Prolamins (ethanol soluble) and glutenin are the two types of proteins found in grain flour (ethanol insoluble). When these proteins are hydrated, they form a gluten-like protein complex. Gluten is responsible for the dough's viscoelastic qualities, which are required for making many varieties of wheat flour breads. Some people are allergic to gluten, and as a result, they develop celiac disease. This is an autoimmune disorder caused by a combination of environmental, genetic, and immunological factors. Due to the harmful effect of the alcohol soluble portion of gluten, the prolamins, Celiac disease is associated with decreased digestion and absorption of nutrients, vitamins, and minerals in the gastrointestinal tract. This protein causes inflammatory bowel disease as well as a variety of other side effects. Other cereals, such as barley, rye and oats, have similar effects to wheat and are hence classed as gluten-containing cereals[7] .

The disease is treated with a gluten-free diet. Rice (*Oryza sativa*) and corn (*Zea mays*) are gluten-free, have a high number of easily digestible carbohydrates, and their flour is utilized to make gluten-free foods.

Quinoa is classified as a pseudo-cereal since it is a starchy dicotyledonous seed, rather than a cereal[8]. It's gluten-free, therefore it's suitable for both CD sufferers and wheat allergy sufferers. Quinoa seeds are high in protein, fats, carbohydrates, minerals, and vitamins such as vitamin B[9].This work aimed to study the use of the rice flour, lentil flour and quinoa flour for the enhancement of gluten-free crackers for people suffering from celiac disease patients.

2.Materials and Methods:-

2.1. Materials

Lentil flour whole seeds, broken rice flour, quinoa flour, sugar(sucrose), salt(sodium chloride), cumin, curcuma, red pepper, vegetable oil, baking powder and plastic bags were purchased from the local market, Cairo, Egypt. All chemicals and reagents used in this study were of analytical grade and Sigma Company.

2.2. Crackers Preparation

Crackers formulation is shown in Table 1. The dry ingredients including lentil flour, rice flour and quinoa flour, salt(Sodium chloride), cumin, curcuma, red pepper and baking powder except sucrose were placed in the bowl of mixing for 30 s according to the method described by[2]. Then mixing wet ingredients alone (sucrose, water and oil) for 30 s, then all the ingredients were mixed. Until we acquire dough, let it rest for 10 min at room temperature before cutting it into a circular shape. The crackers were then baked for 4 minutes at 175 degrees Celsius in an electric oven, cooled for 30 min, packaged in plastic bags, and stored at room temperature.

Table 1. Crackers formulation

components	B1	B2	B3	B4	B5
Rice flour (g)	1000	500	500	500	500
Lentil flour(g)	---	100	150	200	250
Quinoa flour(g)	---	400	350	300	250
Oil(g)	100	100	100	100	100
Salt(g)	40	40	40	40	40
Sucrose (g)	30	30	30	30	30
Cumin(g)	10	10	10	10	10

Curcuma(g)	20	20	20	20	20
Red pepper(g)	05	05	05	05	05
Baking powder((g))	20	20	20	20	20

B1= 1000 g Rice flour

B2= 500 g Rice flour+100g Lentil flour +400g Quinoa flour

B3= 500g Rice flour+200g Lentil flour +300g Quinoa flour

B4= 500g Rice flour+300g Lentil flour +200g Quinoa flour

B5= 500g Rice flour+400g Lentil flour +100g Quinoa flour

2.3. Chemical analysis

Crude ash (method 08-01), crude protein (method 46012), and crude fat (method 30-25) were performed using AACC procedures[10].[10]

The total carbohydrates were determined using Equation **Vaz *et al.*,** [11] and the results of related nutrients were given on dry weight basis (DWB) as mean value of three measurements: carbohydrate (%) = 100% – (protein% +Crude fibre%+ fat% +ash %).

Calorie value (kcal/100g) = (%carbohydrate × 4.1) + (% protein×4.1) + (% fat× 9.1).

were performed using AACC procedures[10].

2.4.Determination of Minerals

Minerals including Calcium, Potassium, Magnesium, phosphorus, Sodium, manganese, Iron, and Zinc were measured in ash solution using ICP-OES Agilent 5100 VDV according to the US EPA[12].

2.5. Determination of amino acids composition:

Amino acids composition of blends of crackers preparation from rice flour, lentils flour and quinoa flour were performed in National Research Center, Cairo, Egypt as the procedure of **Duranti and Cerletti** (1979) using amino acid analyzer (Beckman amino acid analyzer, Model 119CL) [13].

2.6.Estimation of tryptophan

Tryptophan content of samples was determined calorimetrically according to the method described before[14].

2.7. Sensory Evaluation of Crackers

Appearance, color, odor, taste, crispiness, and overall acceptability of all the crackers products prepared from different ratios of rice flour, lentils flour and quinoa flour were assessed using 20 staff members of Bread and Pastry Department, Food Technology Research Institute, Egypt. According to[15], the panellists were asked to score the above characteristics on a standard hedonic rating scale ranging from 9 (like extremely) to 1 (dislike extremely).

2.8. Texture profile analysis of baked Crackers:

Texture profile analysis was conducted by Brookfiled CT3 Texture Analyzer No. M08-372-C0113 (version2.1, 1000gram unit). Parameters were automatically recorded by computer software (TA-CT-PRO software).According to **A.A.C.C.** [][16] the samples (2.5 cm height and 4 cm diameter) were compressed twice to 40% deformation using Prope-36 mm Cylindrical, trigger load 5 N, and test speed-2 mm/s. The experiments were conducted under ambient conditions.

2.9. Determination of Water activity (a_w)

Water activity (aw) was measured at 25°C using a Decagon A qualab Meter Series 3TE (Pullman, WA, USA). All samples of storage crackers were broken into small pieces immediately before water activity measurement[17].[17]

2.10. Statistical analysis:

Duncan's multiple range tests were used for mean comparison in the statistical analysis, which was done using SPSS software (version 16).

3. Results and Discussion

3.1 Chemical composition of rice flour, lentil flour and quinoa flour (On dry weight basis)

The chemical analyze of rice flour, lentil flour and quinoa flour, revealed in Table 2, showed that rice flour contained 0.846% ash; 7.781% crude protein; 0.681 % ether extract; 0.336% crude fiber; 90.418 % available carbohydrates and 408.243kcal/100g Caloric value. These results agree with. [18] reported that rice flour contains 7.95% crude protein, 0.67% fat; 0.93% ash, 0.32% crude fiber and 90.13% total carbohydrates.

As for lentil flour flour, results revealed 25.547% crude protein, 2.656% ether extract, 3.415% ash, 20.472% crude fiber, 47.881% available carbohydrates and 325.343 kcal/100g Caloric values. The data were harmony with the reported work stated that lentil flour had 2.20% fat, 21.70% crude fiber, 2.77% ash, 25.63% proteins, and 48.70% total carbohydrates[19].

Results of Quinoa flour analysis showed that crude protein was 14.574%; ether extract reached 6.176%, while crude fiber was 6.510 %, ash was 4.449 %, and available carbohydrates were 68.290% and 395.948 kcal/100g Caloric value. The data are accord with the study of *El-Hadidy et al*. who indicated that quinoa flour had 13.13% crude protein, 6.52% crude ether extract, 4.65% ash, 75.70% total carbohydrates, and 414 kcal/100g Caloric value[9].

Table 2. chemical composition of rice, lentil and quinoa flour (on dry weight):-

	Raw materials		
	Rice flour	Lentil flour	Quinoa flour
Moisture content%	9.550± 0.190^{b}	10.552± 0.150^{a}	7.333± 0.130^{c}
Crude protein%	7.781 ± 0.140^{c}	25.574 ± 0.893^{a}	14.574 ± 0.738^{b}
Crude ether extract%	0.618 ± 0.093^{c}	2.656 ± 0.720^{b}	6.176 ± 0.846^{a}
Crude fiber%	0.336 ± 0.059^{c}	20.472 ± 0.957^{a}	6.510 ± 0.893^{b}
Ash%	0.846 ± 0.079^{c}	3.415 ± 0.532^{b}	4.449 ± 0.665^{a}
Available carbohydrates%	90.418 ± 0.253^{a}	47.881 ± 0.309^{c}	68.290 ± 0.313^{b}
Caloric value (kcal/100 g)	408.243 ± 0.381^{a}	325.343 ± 0.251^{c}	395.948 ± 0.219^{b}

- a, b, c and d different superscript letters in the same rows are significantly different at LSD at ($p \leq 0.05$).

-Each value was an average of three determinations ± standard deviation.

*Available carbohydrates = 100 – (crude protein + ash + ether extract + crude fibre).

3.2 Proximate chemical composition of blends crackers (on dry weight):-

Proximate chemical composition of crackers for blends made from rice, lentils and quinoa flour in Table 1. Data revealed that moisture content of the crackers made from different proportions with rice, lentils and quinoa flour for each of the blend (1), blend (2), blend (3), blend (4) and blend (5) were 3.061%, 7.352%, 6.335%, 6.091% and 5.996%, respectively. Regarding to Table 1 protein ratio in blend (5) increased to 11.414% comparison with blend (1), blend (2), blend (3) and blend (4) were 6.436%, 10.058%, 10.410% and 10.964%, respectively (on dry basis).Table 1 show that, blend (5) highest value of crude fibre and crude ether extract followed by blend (4), blend (3), blend (2) and blend (1) which contained (5.633% and 10.220%), (5.070% and 10.370%), (4.506% and 10.505%), (4.013% and 10.668%) and (0.290% and 8.686%), respectively (on dry basis).On the other hand, in Table 1 found the decreased ratio of carbohydrates and reached to 70.829% and also, found the decreased ratio of energy value and reached to 430.202 kcal/100gm samples in blend (5) compared with blend (1), blend (2), blend (3) and blend (4) were (83.874%, 73.077%, 72.485% and 71.659%) and (44.316, 437,936, 435,876 and 433.124 kcal/100gm samples), respectively. These data agree with **Elhadidy et al.,** study that addition quinoa flour to rice flour increase crude protein in bakery products[9].

Table 3. chemical composition of rice, lentils and quinoa blends crackers (on dry weight):-

	Chemical composition of rice, lentils and quinoa flour blends (g /100 g)						
	Moisture content	Crude protein	Crude ether extract	Crude fibre	Ash	carbohydrates	Caloric value (kcal/100 g)
Blend (1)	3.061 ± 0.010^{c}	6.436 ±0.016^{e}	8.686 ± .028^{e}	0.290 ± 0.028^{e}	0.713 ±0.017^{e}	83.874 ± 0.055^{a}	449.316 ± 0.080^{a}
Blend (2)	7.352 ± 0.054^{a}	10.058 ±0.119^{d}	10.668 ±0.030^{a}	4.013 ± 0.156^{d}	2.039 ±0.022^{a}	73.077 ± 0.296^{b}	437.936 ± 0.797^{b}
Blend (3)	6.335 ± 0.063^{b}	10.410 ±0.176^{c}	10.505 ±0.041^{b}	4.506 ± 0.029^{c}	1.993 ±0.020^{b}	72.485 ± 0.117^{c}	435.876 ± 0.208^{c}
Blend (4)	6.091 ± 0.126^{b}	10.964 ±0.119^{b}	10.370 ±0.028^{c}	5.070 ± 0.026^{b}	1.984 ±0.018^{c}	71.659 ± 0.071^{d}	433.124 ± 0.011^{d}
Blend (5)	5.996 ± 0.044^{b}	11.414 ±0.040^{a}	10.220 ±0.027^{d}	5.633 ± 0.024^{a}	1.903 ±0.017^{d}	70.829 ± 0.069^{e}	430.202 ± 0.075^{e}

- a, b, c and d different superscript letters in the same columns are significantly different at LSD at ($p \leq 0.05$).

-Each value was an average of three determinations ± standard deviation.

B1= 1000 g Rice flour
B2= 500 g Rice flour+100g Lentil flour +400g Quinoa flour
B3= 500g Rice flour+200g Lentil flour +300g Quinoa flour
B4= 500g Rice flour+300g Lentil flour +200g Quinoa flour
B5= 500g Rice flour+400g Lentil flour +100g Quinoa flour

3.3 Mineral content of crackers blends (on dry weight):-

In order to study in Table 3 showed that mineral contents of crackers observed the most minerals such as calcium, potassium, magnesium, phosphorus and sodium as a macro elements and zinc, iron and manganese as a micro elements content of crackers made in blend (1) were found to 16.000, 361.667, 140.000, 126.000 and 6.501 mg /100g samples as a macro elements and 1.080, 1.986 and 2.493 m g /100g samples as a micro elements, respectively. Regarding crackers, the results indicate that the blend (5) contains high amounts of calcium, potassium, magnesium, phosphorus, sodium, zinc, iron and manganese were 64.166, 783.250, 232.916, 286.916, 33.167, 2.614, 5.494 and 2.983 mg /100g samples, respectively compared with blend (1) crackers.

Table 4. influence of addition lentil and quinoa flour to rice flour for making blends crackers (on dry weight):-

	Macro elements (mg/100gm)				Micro elements (mg/100gm)			
	Ca	K	Mg	P	Na	Zn	Fe	Mn
Blend (1)	16.00 $\pm1.000^{b}$	361.667 $\pm7.637^{e}$	140.00 $\pm10.01^{e}$	126.00 $\pm1.010^{e}$	6.501 $\pm0.500^{e}$	1.080 $\pm0.045^{e}$	1.986 $\pm0.047^{e}$	2.493 $\pm0.031^{e}$
Blend (2)	66.466 $\pm2.250^{a}$	857.301 $\pm7.660^{a}$	291.167 $\pm4.817^{a}$	278.667 $\pm1.069^{d}$	30.217 $\pm0.501^{d}$	2.420 $\pm0.036^{d}$	5.946 $\pm0.009^{a}$	3.289 $\pm0.041^{a}$
Blend (3)	65.683 $\pm1.875^{a}$	832.613 $\pm7.667^{b}$	271.750 $\pm4.953^{b}$	281.416 $\pm0.833^{c}$	31.201 $\pm0.377^{c}$	2.481 $\pm0.033^{bc}$	5.795 $\pm0.013^{b}$	3.183 $\pm0.044^{b}$
Blend (4)	64.933 $\pm1.501^{a}$	627.401 $\pm3.774^{d}$	249.00 $\pm2.946^{c}$	284.167 $\pm0.651^{b}$	32.183 $\pm0.256^{b}$	2.548 $\pm0.039^{ab}$	5.645 $\pm0.021^{c}$	3.078 $\pm0.047^{c}$
Blend (5)	64.166 $\pm1.127^{a}$	783.250 $\pm7.697^{c}$	232.916 $\pm5.257^{d}$	286.916 $\pm0.577^{a}$	33.167 $\pm0.144^{a}$	2.614 $\pm0.045^{a}$	5.494 $\pm0.028^{d}$	2.983 $\pm0.065^{d}$

- a, b, c and d different superscript letters in the same columns are significantly different at LSD at ($p \leq 0.05$).

-Each value was an average of three determinations ± standard deviation.

3.4 Amino acids content of crackers blends -

Data in Table 4 show the all essential amino acids and the all non-essential amino acids. Regarding to this table decreasing the total essential amino acids in blend (5), blend (4), blend (3) and blend (2) compared with blend (1).on the other hand, the blend (2), blend (3), blend (4) and blend (5) are best in the percentage of protein and lysine than blend (1) crackers made from 100% rice flour. In the same table explain different between all blends crackers for amino acids and its clearly the ratio of lysine in blend (5), blend (4), blend (3) and blend (2) were 5.475, 5.460, 5.445 and 5.430 g/100g samples, respectively compared with blend (1) was 3.800 g/100g samples. Generally, it can be concluded that, the chemical results of all blends showed that gave the highest values of protein, fat, fiber and lysine amino acid.

Table 5. amino acids in blends crackers made from lentil and quinoa flour to rice flour(g/100g Protein):-

	Blend (1)	Blend (2)	Blend (3)	Blend (4)	Blend (5)
Lysine	3.800	5.430	5.445	5.460	5.475
Iso_leucine	4.300	4.410	4.365	4.320	4.275
Leucine	8.500	8.430	8.395	8.360	8.325
Phenyl alanine	8.300	7.200	7.100	7.000	6.900
Tyrosine	5.340	4.120	4.145	4.170	4.195
Histidin	2.900	3.100	3.050	3.000	2.950
Valine	4.470	4.445	4.450	4.455	4.460
Thereonine	4.760	4.280	4.230	4.180	4.130
Methionine	2.800	3.000	2.850	2.700	2.550

Tryptophan	1.500	1.322	1.326	1.329	1.333
Cysteine	N.D.	0.070	0.105	0.140	0.175
Total (EAA)	37.370	45.807	45.461	45.114	44.768
Aspartic acid	9.800	8.037	7.730	7.560	7.118
Glutamic acid	17.500	14.165	13.623	13.296	12.537
Serine	5.200	4.770	4.718	5.015	4.613
Proline	0.850	2.515	2.560	3.095	2.650
Glycine	4.470	6.195	5.925	6.015	5.385
Alanine	4.600	4.770	4.755	5.210	4.725
Arginine	7.300	5.130	5.420	5.710	6.000
Total (NEAA)	49.670	45.582	44.731	45.605	43.028

Total (EAA) = Total Essential Amino Acids Total (NEAA) = Total Non-Essential Amino Acids

3.5 Hedonic sensory evaluation and overall acceptability of blends

The sensorial qualities appearance, color, odor, crispiness, taste and overall acceptability of crackers prepared from rice flour, lentil flour and quinoa flour of different proportions and crackers prepared from 100% of rice flour were assessed by twenty panelists. The results were statistically studied and recorded in Table 5. From the data presented in Table 5, it could be observed that Appearance, color, odor, crispiness and overall acceptability blend (2) and blend (3) have higher scores than blend(1). Other blends(4) and (5) sensorial attributes of gluten free crackers blends contained rice flour; lentil flour and quinoa flour were nearly similar with those of blend (3). it could be observed that crispiness of blend (1) have lower scores than other blends B2, B3, B4, B5. *El-Hadidy et al*., stated that addition quinoa flour to make high nutritional value biscuits improve of color, taste, appearance and odor[9]. Sensory evaluation is seen to be a useful approach for resolving issues with food acceptability. It can be used to improve products, maintain quality and more importantly develop new products.

Table 6.Hedonic sensory evaluation and overall acceptability of blends

Blends	Appearance (9)	Color (9)	Odor (9)	Taste (9)	Crispiness (9)	Over all acceptability (9)
Blend (1)	7.8±0.13ab	8±0.00a	8.6±0.16a	7.15±0.07c	6.10±0.23b	7.36±0.10c
Blend (2)	7.89±0.15ab	7.93±0.27a	8.6±0.22a	8.21±0.10a	7.33±0.15a	7.99±0.13a
Blend (3)	7.94±0.12a	7.93±0.27a	8.6±0.22a	8.21±0.41a	7.45±0.13a	8.03±0.13a
Blend (4)	8.25±0.23a	8.05±0.029a	8.6±0.12a	8.45±0.13a	7.45±0.13a	8.16±0.18a
Blend (5)	7.75±0.21ab	7.75±0.21ab	8.6±0.17a	8.15±0.07ab	7.25±0.24a	7.90±0.16ab

- a, b, c and d different superscript letters in the same columns are significantly different at LSD at ($p \leq 0.05$).

-Each value was an average of twenty determinations ± standard deviation.

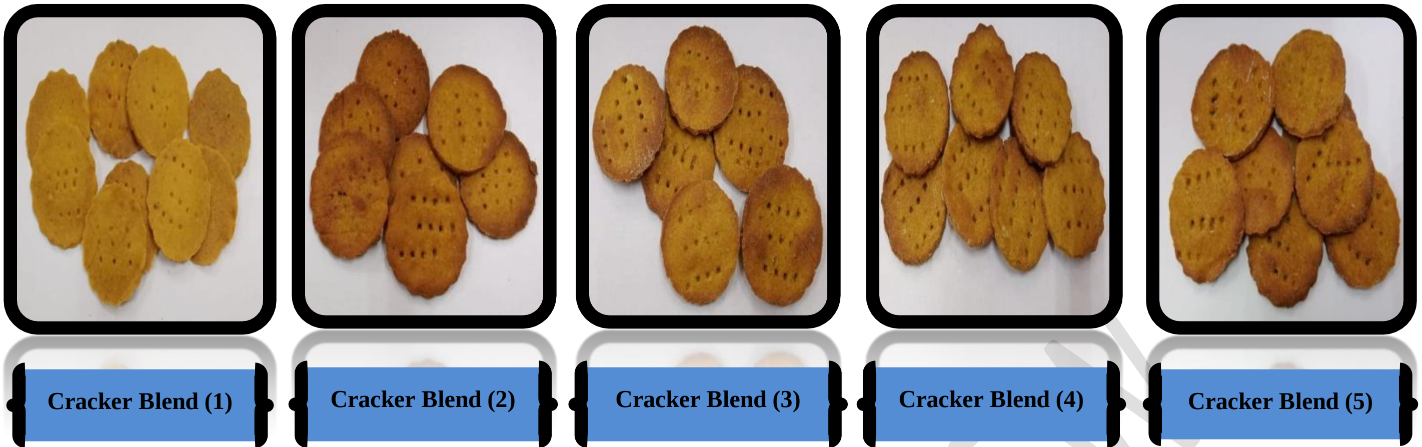


Image 1 : Different images of cracker blend

3.6 Hardness and water activity of crackers

Data in Fig. 1 presented the hardness of gluten free crackers blends. As a noticed decrease in hardness from 74.97 newton in blend (1) made from 100% rice flour to 35.19 newton in blend (5) made from 50% rice flour, 40% lentil flour and 10% quinoa flour. These results due to increasing lentil flour ratio in crackers blend (5). It is well acknowledged that texture has a significant role in customer acceptance. Due to its tight link with human perception of freshness, **Karaolu and Kotancilar** stated that hardness is the most important factor in assessing baked products[20].

On the other hand, Fig. 2 show that tracking water activity in different blends were 0.329, 0.389, 0.412, 0.385 and 0.395 in blends (1), (2), (3), (4) and (5), respectively.

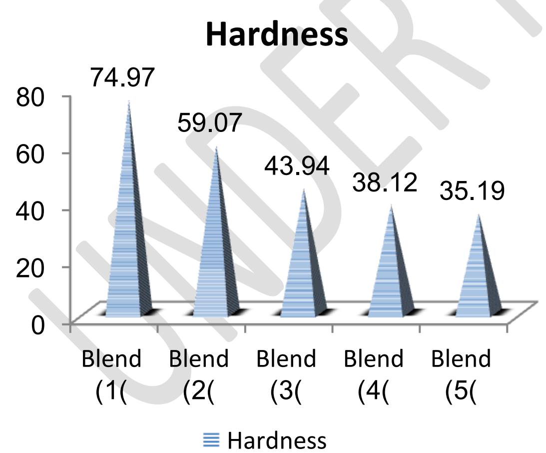


Fig1. Hardness of crackers

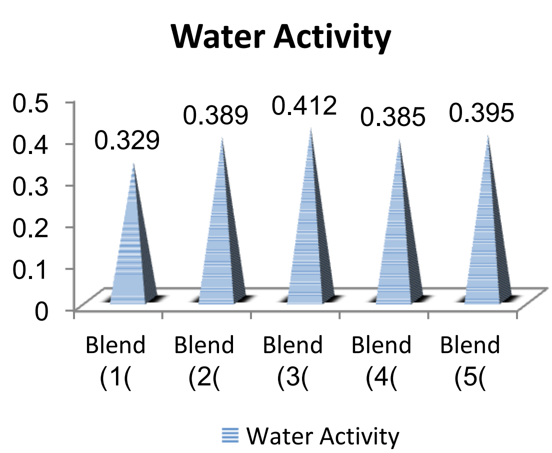


Fig2. Water activity of crackers

Discussions

This work confirms that there is a great interest for organic and inorganic compounds due to the different applications for these compounds different fields[21-29].

The texture properties of many cereal snack items, such as cellular, brittle, and crisp, contribute to their widespread popularity. For many cereal-based foods, texture is a significant sensory properties. Crispness is linked to a pleasant textural experience as well as freshness and quality, and its loss is a leading cause of customer rejection. Breakfast cereals, wafers, biscuits, and snacks are examples of low moisture baked and extruded products that have a crispy feel. If the moisture content of these foods increases as a result of water sorption from the atmosphere or mass transit from neighbouring components, a soggy, soft texture[30]. Water is a food constituent that influences the stability, quality, and physical attributes of the food. The ratio of the vapour partial pressure of water in food to the vapour partial pressure of pure water at the same temperature and total pressure is described as water activity – a_w. [31] a measure defining 'water availability' in materials. In both the liquid and solid states, water has an impact on the rheological properties of food. Water has an effect on the responsiveness of solid foods to force. Plasticizing or antiplasticizing effects might occur when the water content is increased[32] .Deformation is facilitated by the plasticization of polymer chains, and brittle material becomes more soft and flowable while losing crispness. Until date, the antiplasticizing impact has been a mystery. The texture of snack products like crackers and chips has been described as a result of water activity by Katz and Labuza[33]. They reported that when water activity exceeded 0.35 to 0.50, baked saltine crackers, popcorn, and fried potato chips lost their crispness. At $a_w \leq 0.5$, the crispness of breakfast cereal decreased slightly. After that, a rapid loss of crispness was seen until aw = 0.8, at which point the product fully lost its brittleness[34] . For crackers with various water activity values (a_w = 0.14-0.80), force-deformation curves for a uniaxial compression test were recorded[35] . With increased water activity, the curves got smoother and the maximum force decreased. The compression test was studied by Roudaut et al., [36] to investigate the textural qualities of crispy bread as a function of water content. They detected plasticizing effects of water between 3 and 9 percent, followed by apparent hardness of the material up to 11 percent. The perceived stiffness modules reduced after 11 percent water content, and the softening effect of water became dominant. The antiplasticizing effect has been seen in several circumstances. Adsorbed water gives the material more strength and makes it less brittle.According to Marzec, [37] failure stress of flat wheat and rye bread increased as moisture was absorbed, reaching at an aw range of 0.5 to 0.6. Cooking causes the majority of crystalline structures in native starch to disappear, hence baked and extruded cereal products are often glassy. Above their glass transition temperature, products suffer modifications that present themselves in a variety of ways, including changes in mechanical properties. The tensile characteristics of cellular products can increase as they densify[38].The force-deformation correlations of brittle and crunchy foods are known to be very irregular and irreproducible[39].

4. Conclusion

The obtained results in this work exposed that crackers were prepared from rice flour, lentil flour and quinoa flour at different ratios. The final products were rich of crude protein, crude fibre, ash and ether extract. These products were a rich source of indispensable amino acids especially lysine and minerals especially potassium, calcium, magnesium and iron. The sensorial properties of prepared crackers from rice flour, lentil flour and quinoa flour were nearly similar of products prepared using rice flour. These products were free of gluten therefore; they are very appropriate for celiac disease patients. Finally, it could prepare some bakery products using raw materials free of gluten such rice flour, lentil flour and quinoa flour with high quality that are proper for celiac disease patients.

.

References

1. Williams F.L., Mwatsama, M., Ireland, R., and Capewelll, S. Small changes in snacking behavior: the potential impact on CVD mortality. Public Health Nutr., 2008, 12(6) , 871-876. https://doi.org/10.1017/s1368980008003054

2. Han J., Janz, J.A.M., and Gerlat, M.**)** Food Development of Gluten-Free Cracker Snacks Using Pulse Flours and Fractions. Int. Food Res. J., 2010, 43(2), 627-633. https://doi.org/10.1016/j.foodres.2009.07.015

3. Sudha M. L., VetrimanI R., and LeelawathI K. Influence of Fiber from Different Cereals on the Rheological Characteristics of Wheat Flour Dough and on Biscuit Quality. Food Chem., 2007, 100(4), 1365-1370. https://doi.org/10.1016/j.foodchem.2005.12.013

4. Valencia V.N., GranadoS P.E., Agama A. E., Tovar J., Ruales, J., and Bello P.L.A. Fiber concentrate from mango fruit: Characterization, associated antioxidant capacity and application as a bakery product ingredient. LBWTAP, 2006, 40(4),722-729. https://doi.org/10.1016/j.lwt.2006.02.028

5. Giannakoula A. E., Ilias F. I., Dragišić Maksimović J., Maksimović V. M., and Zivanović B. D. The effects of plant growth regulators on growth, yield, and phenolic profi le of lentil plants. J. Food Comp. Anal, 2012,28(1), 46–53.

6.Iqbal A., Khalil I. A., Ateeq N., and Khan M. S.**.** Nutritional quality of important food legumes. Food Chem., 2006, 979(2), 331–335.

7. Preichardt L.D., and Gularte M. A. Gluten Formation: Its Sources, Composition, and Health Effects. In: Walter, D.B. Gluten: Sources, Composition and Health Effects. New York, USA, Nova Science Publishers, 2013, p. 55-70.

8. USDA U.S. Department of Agriculture, Agricultural Research Service.USDA National Nutrient Database for Standard Reference, Release18.Nutrient Data Laboratory. 2005, Home Page, http://www.nal.usda.gov/fnic/foodcomp.

9. El-Hadidy G. S., Rizk., E.A., and El-Dreny E. G Improvement of Nutritional Value, Physical and Sensory Properties of Biscuits Using Quinoa, Naked Barley and Carrot. Egypt. J. Food. Sci, . 2020, 48, (1),147-157

10. American Association of Cereal Chemists (AACC). Approved methods of the American Association of Cereal Chemists. 8th ed. United States: AACC. 1990.

11. Vaz, J. A., Barros, L., Martins, A., Santos-Buelga,C., Vasconcelos, M. H. and Ferreira, I. C. F. R. Chemical composition of wild edible mushrooms and antioxidant properties of their water soluble polysaccharidic and ethanolic fractions. Food Chemistry, 2011 **,**126(2): 610-616.

12. U.S. EPA . Method 200.7: Determination of Metals and Trace Elements in Water and Wastes by Inductively Coupled Plasma-Atomic Emission Spectrometry. Revision 4.4. Cincinnati. **1994**

13. Duranti, M., & Cerletti, P. Amino acid composition of seed proteins of *Lupinus albus*. J. Agric. Food Chem., 1979, 27(5), 977-978.

14. Miller E. L. Determination of the tryptophan content of feeding stuffs with particular reference to cereals. J. Sci. Food Agric., 1967 ,18 (9) 381-387.

15. Venkatachalam, K. and Nagarajan, M. Physicochemical and Sensory Properties of Savory Crackers Incorporating Green Gram Flour to Partially or Wholly Replace Wheat Flour. Ital. J. Food Sci., 2017, 29(4), 599-612.

16. A.A.C.C.,. American Association of Cereal Chemists. Approved Methods of the A.A.C.C. Published by the American Association of Cereal Chemists, 10th Ed., St. Paul, MN. USA. 2000

17. Nielsen O. F., Bilde M., and Frosch M .Water Activity. Int. J. Spectrosc., 2012 , 27 (5-6), 565–569. doi:10.1155/2012/414635

18. El-Dreny E. G., and El-Hadidy G. S. Preparation of Functional Foods Free of Gluten for Celiac Disease Patients. J. Sus. Agric. Sci. 2020, 46, (1), 13- 24.
DOI: 10.21608/jsas.2019.19473.1185

19. Fouad A. A., and Rehab F. M. A. Effect of germination Time on proximate Analysis, Bioactive Compounds and Antioxidant Activity of Lentil(*Lens Cclinaris Medik.*) Sports, Acta Sci. Pol. Technol. Aliment. 2015**,** 14(3), 233–246.

20. Karaoğlu M. M., and Kotancilar H. G. Quality and textural behaviour of par-baked and rebaked cake during prolonged storage. J. Food Sci. Technol., 2009, 44 (1) 93-99.

21. Elhadidy G. s. Chemical and Biological Studies on Some Hypoglycemic Foods. Ms c. Thesis, Food Techno. Dept., Fact. Agric. Kafrelsheikh Univ., Egypt. 2009.

22. El-Dreny E. G., and El-Hadidy G. S. Utlization of young green barley as a potential source of some nutrition substances. Zagazig J. Agric. Res., 2018, 45(4),1333-1344. DOI: 10.21608/ZJAR.2018.48580

23. Elhadidy G. s. Chemical, technological and biological studies on mulberry leaves and purslane in Egypt**,** Ph.D. Thesis, Food Indus. Dept., Fact. Agric. Mansoura Univ., Egypt. 2014**,**

24. El-Hadidy G. S. Preparation and Evaluation of Pan Bread Made with Wheat flour and Psyllium Seeds for Obese Patients, J. Curr. Sci. Int., 2020, 9(2),369-380. DOI: 10.36632/csi/2020.9.2.32

25. El-Hadidy G. S., Eman A. Yousef., and Abd El-Sattar A. S. Effect of Fortification Breadsticks with Milk Thistle Seeds Powder on Chemical and Nutritional Properties, Asian Food Sci ,J, 2020, 17(2), 1-9.DOI: 10.9734/AFSJ/2020/v17i230187

26. El-Hadidy G. S., Rizk E . A., and El-Dreny E . G. Improvement of Nutritional Value, Physical and Sensory Properties of Biscuits Using Quinoa, Naked Barley and Carrot. Egypt. J. Food. Sci. 2020, 48, (1**),** 147-157. DOI: 10.21608/EJFS.2020.27770.1050.

27. El Hadidy G. S. and Rizk E. A. Influence of Coriander Seeds on Baking Balady Bread , J. Food and Dairy Sci., Mansoura Univ., 2020, 9 (2), 69 – 72.
DOI: 10.21608/JFDS.2018.35197

28. El-Dreny E. G.; Maha A. Mahmoud., and El-Hadidy G. S. Effect of Feeding Iron Deficiency Anemia Rats on Red Beetroots Juices, J. Food and Dairy Sci., Mansoura Univ., 2020, 10(8), 243- 247. DOI: 10.21608/jfds.2019.58133

29. El-Hadidy G. S., and El-Dreny E. G. Effect of Addition of Doum Fruits Powder on Chemical, Rheological and Nutritional Properties of Toast Bread, Asian Food Sci, J, 2020, 16(2),22-31. DOI: 10.9734/AFSJ/2020/v16i230169

30. Nicholls R.J., Appelqvist I.A.M., Davies A.P., Ingman S.J., and Lillford P.L. Glass transition and fracture behaviour of gluten and starches within the glassy state. J. Cereal Sci., 1995**,** 21(1), 25-36.

31. Scott W. Water relations of food spoilage microorganisms. Adv. Food Res., 1957, 7, 83-124.

32. Lewicki P.P., Water as determinant of food engineering properties. A review. J. Food Eng. 2004,61(4), 483-495.

33. Katz E.E., and Labuza T.PEffect of water activity on the sensory crispness and mechanical deformation of snack food products. J. Food Sci., 1981, 46(2), 403-409.

34. Sauvageot F., and Blond G. Effect of water activity on crispness of breakfast cereals. J. Texture Studies, 1991, 22(4), 423-442.

35. Kohyama K., Nishi M., and Suzuki T. Measuring texture of crackers with a Multiple-point sheet sensor. J. Food Sci., 1997, 62(5), 922-925.

36. Roudaut G., Dacremont C., Le and Meste M. .Influence of water on the crispness of cereal-based foods: acoustic, mechanical and sensory studies. J. Texture Stud, 1998, 29(2), 199-213.

37. Marzec A. Influence of water activity on mechanical and acoustic properties of flat bread (in Polish). Ph.D. Thesis Warsaw Agricultural University (SGGW), Warsaw. 2002**.**

38. Roudaut G. Low moisture cereal products: Texture changes versus hydration. Workshop on Nondestructive Testing of Materials and Structures, Institute of Fundamental Technological Research, Warsaw, Poland, . 2003, 160-168.

39. Peleg M., and Normand M.D .Symmetrized dot-patterns (SDP) of irregular compressive stressstrain relationship. J. Texture Stud, 1992, 23(4), 427-438,