Production of free-gluten bread from some cereal crops

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ABSTRACT

Bread is an important source of nutrition around the world. But there are a large number of people have gluten sensitivity which found in wheat and barley, so the manufacture of bread from free- gluten cereal is essential for these people. This study concerned with the production of free- gluten flat bread using corn and rice, in addition to a new crop that has recently cultivated in Egypt, which is the quinoa crop due to its high nutritional value and free of gluten. Flat bread was produced using mixture of 100% extraction rate of quinoa, 100% extraction rate of white rice flour and 97% extraction rate of yellow corn flour. Blends were prepared by adding them in different proportions. Physicochemical properties were studied using chemically analyzed for both row materials and different blends. The sensory evaluation and the staling were conducted to the flat bread in order to determine the best blend. By studying the sensory evaluation and the staling, it became clear that the blends of quinoa flour supplemented by white rice flour is the best. On the other hand, the increasing of the ratio of the yellow corn in the blends leads to decreasing the freshmen of the flat bread. While, the existence of the white rice flour in the blends decreases the effect of the yellow corn flour.

Keywords: Flat bread; Quinoa flour; White rice flour; Yellow corn flour.

INTRODUCTION

Celiac disease (CD) is an immune-mediated enteropathy triggered by the ingestion of certain cereals, including wheat, rye, barley, triticale and oats in genetically susceptible persons (Bascuñán *et al.,* 2017 and Leonard *et al.,* 2017). To develop gluten-free (GF) breads for celiac patients, a number of alternative flour types, such as corn, rice, cassava, soybean, chickpea, teff and pseudocereals (e.g. quinoa, buckwheat and amaranth) have been evaluated to substitute wheat flour (Capriles and Areas, 2014; Martínez and Gomez, 2017; Sarabhai *et al.*, 2017 and Romero *et al.,* 2018 a).

Quinoa flour is used as a food for patients suffering from celiac disease, where quinoa flour is mixed with white rice flour and yellow corn flour to increase nutritional value (Pico *et al.*, 2017 and Romano *et al.*, 2018 b).

Different flour types have been investigated for developing free- gluten of flat bread.

Quinoa, which follows the Chenopodium quinoa Willd family, is a source of protein, mineral salts and vitamins. It is also free of gluten and therefore is considered as the suitable diet for celiac disease patients, which provides them with beneficial nutrients (Föste *et al*., 2014 and Peñas *et al*., 2014).

Rice is the seed of the grass species *Oryza sativa* (Asian rice) or *Oryza glaberrima* (African rice). As a cereal grain, it is the most widely consumed staple food for a large part of the world's human population, especially in Asia (Torres *et al*., 2014).

The corn is followed *Zea mays* L., and it is the essential item for the production of bread. Corn has become a staple food in many parts of the world, with total production surpassing that of wheat or rice (Brites *et al*., 2010).

The objectives of this study are to compare the influence of replacing 20%, 40%, 60% and 80% of quinoa flour with white rice flour and yellow corn on the textural characteristics of the flat bread, freshly baked and stored for 3 days, and to assess the sensory characteristics of the fresh flat bread .

MATERIALS AND METHODS

Characterization

Commercial types of quinoa flour (100 % extraction), white rice flour (100 % extraction) and yellow corn flour (97 % extraction) were milled to obtain different blends using hummer laboratory mill as presented in Table (1).

Preparation of Flat Bread

Different blends were used to prepare the flat bread, with the addition of yeast and low sugar, to activate the yeast function, with the use of boiling water temperature of 100°C (traditional method). The bread was formed and flattened manually. The dough left to ferment for 30 minutes and then bread. The following blends, which include the raw materials (quinoa flour, white rice flour and yellow corn flour) are used.

Table 1. The percentage of different experimental flour blends.

Blends	quinoa flour %	white rice flour %	yellow corn flour %
1	100	-	-
2	-	100	-
3	-	-	100
4	80	20	-
5	60	40	-
6	40	60	-
7	20	80	-
8	80	-	20
9	60	-	40
10	40	-	60
11	20	-	80
12	-	80	20
13	-	60	40
14	-	40	60
15	-	20	80
16	80	10	10
17	60	20	20
18	40	30	30
19	20	40	40

Chemical Analysis

Raw materials and blends were chemically analyzed using eleven properties. Some of the properties are related to the basic components of the grain, namely: Moisture, Protein Content, Total Fat, Total Carbohydrate, Fiber and Ash Content. The other is concerned with minerals elements, namely: Calcium (Ca), Iron (Fe), Zinc (Zn), Sodium (Na), Potassium (K). According to method described by A.O.A.C. (2005).

Preparation of Flat Bread

Flat bread was prepared using the gelatinization method.

In traditional method, (100g) of flour from any raw materials or blends were mixed with (0.5 g) salt, (1 g) yeast and (1 g) sugar. Then added 80 mL boiled water at degree up to 100 ˚C, to form dough which was divided into (50g) portions 20 Cm diameter shaping and left to ferment for 30 minutes. The dough was baked in oven at 350 °C for two min, then ventilated the bread, packed in polyethylene bags and stored at 4°C until analyses. This coincides with the results of (Choi and Kerr, 2004).

Evaluation of Flat Bread

To evaluate the resulting bread, the sensory evaluation and the staling were done to the flat bread.

Sensory Evaluation of Flat Bread

Flat bread was evaluated for Loaf rising, Crust Quality, Crust color, Crumb color, Odor, Taste and Crumb uniformity. The quality scoring was conducted by using a maximum of twenty a committee of experienced panelists from food technology research institute (FTRI) to evaluate organolyptically the different characteristics of flat bread. Score of each parameter as reported by Twillman and white (1988).

Staling Evaluation of Flat Bread

The staling of flat bread at different storage times 0, 12, 24, 36 and 72 h at room temperature, was tested by alkaline water retention capacity (AWRC) determination according to the method of Kitterman and Rubenthaler 1971. The loaves were dried in air oven at 35-40 °C, milled in hummer mill and passed through wire sieves with 30 mish. five grams of dried flat bread was placed into a dry plastic centrifuge tube of 50 mL capacity then, 25mL of $NaHCO_3$ solution (8.4 g sodium bicarbonate dissolved in one litter distilled water) was added. The tube was stoppered and shacked until all flat bread flour was wetted, the mixture left for 20 min with shacking every 5 minutes. The contents were centrifuged at 2500 r.p.m. for 15 min, the supernatant was decanted and the precipitate was left for 10 min at 45 angles (to get rid of free water). The alkaline water retention capacity (A W R C) are given using the equation:

A W R C = **(**Weight of Precipitated of bread loves – weight of bread loaves) X 100

Statistical Analysis

All the data are analyzed using SPSS v 20.

The two ways analysis of variance (ANOVA) (Blocked Design) is used to analyses the data. The null hypothesis (H_0) is that all the means are equal (there is no significant differences between the treatments), and the alternative hypothesis (H_1) is that all the means are not equal (there we a significant difference between the treatments). We accept the null hypothesis when the *p*-value for the interaction F-test is greater than 0.005 ($P > 0.05$), and reject the null hypothesis when the *p*-value for the interaction F-test is less than 0.005 ($P < 0.05$). (Kleinbaum *et al*., 1998 and Snedecor and Cochran, 1980.

To show the relationship between the staling and its factors, a regression equation was gotten (Graybill *et al.*, 1994).

RESULTS AND DISCUSSION

Physicochemical Properties

The physicochemical analysis for the used materials and different blends are shown in Table (2).

It is noticed that, the protein content found with the highest value in the quinoa flour (14.4) and the lowest value in the white rice flour (6), while the yellow corn flour contains (6.6).

To explain the result of the ash content, it must be looked into the data of the total fiber, since there is a positive relation between them. It is found that the quinoa flour has the greatest amount of the fiber (6.8), followed by the yellow corn flour (3.3) and the white rice flour has the lowest rate (2.4). Due to the bran layers has the highest mineral content.

Table 2. Physicochemical properties of 100% extraction rate of quinoa flour, 100% extraction rate of white rice flour and 97% extraction rate of yellow corn flour and different blends.

The Materials	Moisture	Protein Content	Total Fat	Total Carbohydrate	Fiber	Ash Content	Ca	Fe	Zn	Na	K
Quinoa flour	13.6	14.4	6.0	64.2	6.8	2.2	52.0	4.1	3.0	8.0	540
White rice flour	12.1	6.0	1.2	80.0	2.4	0.6	14.0	0.5	0.6	4.0	86
Yellow corn flour	11.4	6.6	2.9	79.0	3.3	0.6	6.0	1.0	0.6	3.0	128
Q 80 + R 20	13.3	12.8	5.1	66.8	5.8	1.8	45.0	3.3	2.5	7.0	440
Q 60 + R40	13.1	11.1	4.0	70.5	5.1	1.5	35.0	2.7	2.1	6.5	350
Q 40 + R60	12.9	9.3	3.2	73.6	4.0	1.2	30.0	1.8	1.7	5.0	270
Q 20 + R80	12.4	7.7	2.3	76.6	3.4	1.0	20.0	1.2	1.1	4.0	180
Q 80 + C20	13.2	12.7	5.2	67.0	6.0	1.8	41.0	3.4	2.5	7.0	455
Q 60 + C40	12.5	11.4	4.9	69.8	5.3	1.7	33.0	2.9	2.0	6.0	370
Q 40 + C60	12.1	9.6	4.2	72.2	4.8	1.3	25.0	2.1	1.7	5.0	290
Q 20 + C80	11.8	8.0	3.4	76.3	3.9	1.0	15.0	1.7	1.0	4.0	210
R 80 + C20	12.1	6.0	1.4	79.8	2.6	0.55	13.0	0.6	0.6	4.0	95
R 60 + C40	11.8	6.1	1.8	79.7	2.8	0.57	11.0	0.7	0.6	4.0	105
R 40 + C60	11.8	6.4	2.2	79.5	2.9	0.59	9.0	0.8	0.6	4.0	115
R 20 + C80	11.4	6.5	2.5	79.2	3.0	0.60	8.0	0.9	0.6	4.0	122
Q80 + R 10 + C10	13.4	12.8	5.1	67.5	6.0	1.88	45.0	3.4	2.4	7.0	450
Q60 + R 20 + C20	13.0	11.3	4.5	70.3	5.3	1.50	35.0	2.7	2.0	6.0	370
Q40 + R 30 + C30	12.6	9.6	3.6	73.0	4.5	1.25	27.0	2.0	1.6	5.0	280
Q20 + R 40 + C40	8.0	5.5	2.5	76.6	2.7	0.72	13.0	1.2	0.9	3.0	160

Source: prepared by the researcher based on the results of the experiments.

Sensory Evaluation

The objective of sensory evaluation method is to measure the human response to product characteristics that can be perceived by the sense evaluation. Seven characteristics of sensory evaluation were evaluated by twenty panelists. The seven characteristic are: Loaf rising, Crust Quality,

Crust color, Crumb color, Odor, Taste and Crumb uniformity. Results of sensory evaluation of flat bread prepared with quinoa flour 100% extraction rate blended with yellow corn flour 97 % and white rice flour 100 % extraction rate are shown in Table (3).

Table 3. Sensory Evaluation of flat bread prepared from quinoa flour 100% extraction rate blended with yellow corn flour 97 % and white rice flour 100 % extraction rate.

Blends	Loaf rising	Crust Quality	Crust color	Crumb color	Crumb uniformity	Odor	Taste	Total Scores
Score	10	10	15	15	10	20	20	100
Quinoa flour	5	5	5.5	5.5	5	13	13	52.0
White rice flour	8.5	8.5	13.5	13.5	8	19	14	90
Yellow corn flour	5	5	6	6	5	19	14	55
Q 80 + R 20	7	7.5	11.5	12	7.5	18	18.5	82
Q 60 + R40	7	7.5	11.5	11.5	7.5	18	18	81
Q 40 + R60	7	7	11	11	7.5	18	18	79.5
Q 20 + R80	7	7	10.5	10.5	7	17.5	17.5	76.5
Q 80 + C 20	5	5	6.5	6.5	5.5	15	15	58.5
Q 60 + C40	5.5	5.5	7	7	6	15.5	15.5	62
Q 40 + C60	6	6	8	8	6	16	16	66
Q 20 + C 80	6	6	8.5	8.5	6	16.5	16	67.5
R 80 + C 20	8	8	13	13	8	18	18	86
R 60 + C40	7.5	8	12	12.5	8	18	18	84
R 40 + C60	7	7.5	12	12	8	18	18.5	83
R 20 + C 80	7	7	10.5	10.5	7.5	17.5	18	78
Q80 + R 10 +	6	6	9	9	7	17	16	70
Q60 + R 20 +	6	6.0	9	9	7	17	16.5	71
Q40 + R 30 +	6.5	7	10	10	7	17.5	17	75
Q20 + R 40 + C 40	7	7	9	9	7.5	18	18	75.5

Source: prepared by the researcher based on the results of the experiments

From the statistical analyzed for the three raw materials (the quinoa flour, the white rice flour and the yellow corn flour), it is found that all the characteristics have significant differences ($P < 0.05$). while, when using the multiple comparisons, it is found that there is similarity in all characteristics ($P > 0.05$) (except the crumb uniformity) between the quinoa flour and the corn flour. This similarity may be due to the composition of rice starch differs from maize and quinoa starch in terms of percentage of amylose and amylopectin.

When adding the white rice flour by ratio 80% to quinoa flour, it decreased the values of sensory to the flat bread made from this blend compared with the 20%, 40% and 60%. This decline may be due to the different in chemical composition between the white rice flour and quinoa flour. From the statistical analysis for the four different levels of the quinoa flour supplemented by white rice flour, it can be noticed that all characteristics have no significant differences ($P > 0.05$) except the crumb color ($P < 0.05$). While using the quinoa flour as control, it is found that all characteristics have significant differences ($P < 0.05$). When using the white rice flour as control, the crumb uniformity and taste only have no significant differences ($P > 0.05$). These results are consistent with Patil and Arya (2018).

Concerning to the yellow corn blends group, values indicated that when increasing the ratio of yellow corn in blends, we observe an increase in the values of all characteristics. It may be due to the chemical composition is somewhat similar between both quinoa and yellow corn, which improves the quality of the resulting bread. When comparing statistically the results of the four blends (without control) it was found that each increase in the ratio of yellow corn in the blends leads to differences between the groups except crust quality, crumb uniformity and taste. Taking quinoa or corn as a control, it is found that there is a difference in all characteristics except crust quality. This shows that the differences occur in groups with high corn ratio, these results are in agreement with those reported by Al Shehry (2016).

Adding the white rice flour by 80%, 60%, 40% and 20% to yellow corn flour, decreased the values of the sensory. This may be due to the difference in the chemical structure between white rice flour and yellow corn flour. When comparing the blends without any control, there is no significant differences in crust quality, odder and taste only. Also using white rice as control there is no significant differences in crust quality and taste. While yellow corn flour and quinoa flour are used as control, it is found that all characteristics have significant differences. These findings are consistent with Ávila *et al.* (2017).

In the blends which containing the three raw materials, we note that increasing the ratio of white rice flour and yellow corn flour lead to increasing in the values of the sensory properties. This is may be due to the effect of the white rice flour is better than the effect of the yellow corn flour. When comparing statistically the blends which contains the three types of flour with quinoa flour as control. It is noticed that all characteristics have significant differences ($P < 0.05$). When comparing the blends without any control, there is no significant differences in crust quality, crumb uniformity, odor and taste. While using white rice flour and yellow corn flour as control all characteristics have significant differences except crumb uniformity.

Generally, starch grains (granules) in quinoa flour are small in comparison to starch grains (granules) in both white rice flour and yellow corn flour, which means that they carry a wide range of temperatures for the process of crystallization. Therefore, the high percentage of quinoa flour in the mixture may give good characteristics to the resulting bread

Staling Evaluation

From Table (4), it is noticed that the staling for flat bread prepared from white rice flour has the maximum values, followed by the quinoa flour. While the values of that prepared with yellow corn flour are the minimum. This is may be due to that the rate of amylose and amylopectin in the white rice starch are varying than their rate in the quinoa flour and yellow corn flour, this result agrees with Seyhun *et al.* (2005) and Sidhu *et al.* (1997). These reasons may be lead to that the flat bread is more refresh than which made from corn flour.

When comparing the different blends, it is found that the values of stalling are improved by increasing the ratio of white rice in the blends.

This means that the greater the proportion of rice flour in the produced bread, the more it will be freshness in other blends.

The regression equation is

$y = 368.725 + 0.29\ Q + 0.23\ R - 0.041\ C - 1.697$ hours.

Where: y is the staling values (the dependent variable). The independents variables are: Q: the proportion of quinoa flour. R: the proportion of white rice flour. C: the proportion of yellow corn flour. hours: time of staling .

Table 4. Staling of flat bread prepared with 100% extraction rate of quinoa flour, 100% extraction rate of white rice flour and 97% extraction rate of yellow corn flour and different blends.

The Materials	Hours								
	Zero time	12 h	Decreasing Rate %	24 h	Decreasing. Rate %	36 h	Decreasing Rate %	72 h	Decreasing Rate %
Quinoa flour	382	362	5.24	333	12.83	299	24.92	252	43.48
White rice flour	381	373	2.10	354	7.09	334	13.28	318	18.86
Yellow corn flour	380	358	5.79	328	13.68	287	28.35	248	45.99
Q 80 + R 20	380	363	4.47	337	11.26	280	26.32	255	32.89
Q 60 + R40	383	366	4.33	341	10.86	286	25.33	262	31.59
Q 40 + R60	381	369	3.25	346	9.29	292	23.36	270	29.13
Q 20 + R80	382	371	2.93	350	8.43	298	21.99	276	27.75
Q 80 + C 20	382	358	6.28	330	13.61	280	26.70	266	30.37
Q 60 + C40	383	360	6.01	331	13.58	281	26.63	270	29.50
Q 40 + C60	380	358	5.79	330	13.16	283	25.53	275	27.63
Q 20 + C80	381	360	5.62	332	12.86	285	25.20	279	26.77
R 80 + C 20	380	366	3.68	349	8.21	308	18.95	285	25.00
R 60 + C40	382	366	4.19	344	9.95	302	20.94	281	26.44
R 40 + C60	383	364	4.96	344	10.29	300	21.67	273	28.72
R 20 + C80	380	360	5.26	340	10.53	294	22.63	266	30.00
Q80 + R 10 + C 10	380	358	5.79	335	11.95	297	21.84	220	42.11
Q60 + R 20 + C 20	381	360	5.51	336	11.76	299	21.52	230	39.63
Q40 + R 30 + C 30	381	361	5.25	338	11.34	301	21.00	238	37.53
Q20 + R 40 + C 40	380	361	5.00	339	10.68	308	18.95	246	35.26

Source: prepared by the researcher based on the results of the experiments.

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دراسات على بعض محاصيل الحبوب لانتاج الخبز الخالي من الجلوتين

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[٣] شركة مخابز القاهرة الكبرى، الجيزة، مصر.

الملخص العربي

يعد الخبز مصدرا هاما للتغذية في جميع انحاء العالم. ولكن هناك عدد كبير من الناس لديهم حساسية الجلوتين الموجود في القمح والشعير، وبالتالي فان انتاج خبز من الحبوب الخالية من الجلوتين امر ضروري لهؤلاء المرضى. اهتمت هذه الدراسة بانتاج الخبز المسطح باستخدام الذرة الصفراء والارز الابيض، بالاضافة الى محصول جديد وهو محصول الكينوا بسبب قيمته الغذائية العالية فهو مصدر جيد للبروتين والاملاح المعدنية والفيتامينات. كما انه خالي من الجلوتين، وبالتالي يعتبر بمثابة نظام غذائي مناسب لمرضى داء الاضطرابات الهضمية، وتحاول وزارة الزراعة المصرية حاليا نشر زراعة نبات الكينوا بسبب انخفاض استهلاكه للمياه وامكانية زراعته في الاراضي المستصلحة حديثا. وتهدف هذه الدراسة لانتاج الخبز المسطح باستخدام خليط من دقيق الكينوا والارز الابيض و الذرة الصفراء للحصول على خليط عالي القيمة الغذائية لسد احتياجات مرضى حساسية الجلوتين ، حيث تم اضافة ٢٠٪ و ٤٠٪ و ٦٠٪ و ٨٠٪ من دقيق الكينوا الى دقيق الارز الابيض والذرة الصفراء لتكوين خلطات مختلفة ليصل اعداد الخلطات الى تسعة عشرة خلطة منها ثلاثة للمواد الخام واربع خلطات لكل من (دقيق الكينوا مع دقيق الارز الابيض - دقيق الكينوا مع دقيق الذرة الصفراء - دقيق الذرة الصفراء مع دقيق الارز الابيض - دقيق الكينوا مع دقيق الارز الابيض مع الذرة الصفراء) . وتم دراسة الخواص الفيزيائية والكيميائية لكل من المواد الخام والخلطات المختلفة كما تم اجراء التقييم الحسي والبيات على الخبز المسطح من اجل تحديد افضل الخلطات واوضحت النتائج ان مزيج دقيق الكينوا مع دقيق الارز الابيض هو الافضل من بين الخلطات، ومن ناحية اخرى، تؤدي زيادة نسبة الذرة الصفراء في الخلطات الى تقليل الطزاجة في الخبز المسطح. بينما يقلل وجود دقيق الارز الابيض في الخلطات من تاثير دقيق الذرة الاصفر.