

## IMPROVING BISCUIT NUTRITIONAL VALUE USING QUINOA FLOUR

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### ABSTRACT

The purpose of this study was to improve a traditional biscuit by increasing the value of vitamin B1, vitamin B2, vitamin B3, vitamin E, fiber, protein and fat by the addition a natural source for all of this to biscuit formula. Quinoa has gained an increasing interest due to its nutritional value as well as its vitamins(B1, B2, B3 and E) content. In this experiment quinoa flour was blended with wheat flour in ratio of 10%, 15% and 20%. These samples were thereafter subjected to functional properties analysis. The proximate composition of the various flour blends used for the preparation of biscuits were determined using standard methods. The physico-chemical analysis and sensory evaluation was done to know the acceptability of quinoa biscuits. These were evaluated for sensory analysis that included color, taste, Texture and overall acceptability. The quinoa biscuits were analyzed for analytical and chemical analysis, which includes moisture content, fiber, fat, protein and ash. On the basis of nutritional value quinoa biscuits containing 20% quinoa flour is acceptable as it contains higher fiber content than other samples, at the same time on the basis of sensory evaluation quinoa biscuit containing 20% quinoa flour scored high score for over-all acceptability.

**Keywords:** Quinoa Flour; Quinoa Biscuits; Physico-chemical Analysis; Sensory Evaluation, Vitamin content, nutritional value

### INTRODUCTION

Quinoa seed is resistant to drought and frost and is frequently cultivated on poor soils (Vilche *et al.*, 2003). The Incas appreciated their high nutritional value, and the ease in milling these crops made it possible for the rural populations to take advantage of their nutritional value (; Repo-Carrasco *et al.*, 2003; Bhargava *et al.*, 2006; Comai *et al.*, 2007). Nowadays, many country have expanded the production of this quinoa seed focusing on great technological and commercial interest not only for human nutrition but also due to the releases of by-products that offer good nutritional alternatives for animals feeding as well as applications in pharmaceutical industry (Repo-Carrasco *et al.*, 2003; Tolaba *et al.*, 2004; Bhargava *et al.*, 2006; Brady *et al.*, 2007; Gely and Santalla 2007)

Biscuits are the most popular bakery items consumed nearly by all sections of the society in Egypt. Some of the reasons for such wide popularity are low cost in comparison with other processed foods, good nutritional quality and availability in different forms, varied taste and longer shelf life. Bakery products are used as a vehicle for incorporation of different nutritionally rich ingredients (Gandhi, *et al.*, 2001; Sudha, *et al.*, 2007).

The improving Nutritional Value of a commercially viable biscuit attractive to children and adults that will have a significant increase in vitamins, protein and fibers. An approach in the present study was to replace the wheat flour in biscuit by quinoa flour in order to increase the vitamins and other nutrients. The objective was to develop biscuit with good taste texture and appearance, which resembles as closely as possible to the wheat flour based product. The textural property and sensory quality of biscuit are taken into consideration to improve the quality of biscuit. (; Ruales ; Nair 1993; Chaney., 2006; and Miranda M *et al.*, 2010).

**MATERIALS AND METHODS**

**Sample Preparation**

Wheat flour 72% extract used for bread and biscuit making was the commercial wheat flour 'ELKAWTHR', obtained from Kawther Flour Milling(in North Sinai). Quinoa seeds, *Chenopodium quinoa* wild., were obtained from Middle Sinai research station (El Maghara)- desert research center in North Sinai. Soaking of quinoa seeds (300 g) in distilled water (2 L) was carried out for 72 h . During soak, quinoa seeds were rinsed twice a day with 400 ml of distilled water. After soak, samples were washed carefully with distilled water and then dried and at 60°C. Dried samples were ground to pass through a 60-mesh sieve using an analytical mill.( S. H. Park and N. Morita, 2005)

**Flour Mixes**

Three flour mixes were prepared from quinoa and wheat flour based on the earlier studies on nutritional fortification. The Blends combinations were B1 (90% WF + 10% QF) - B2 (85% WF + 15% QF) - B3 (80% WF + 20% QF). According to the method discribed by (Sukhcharn Singh, *et al.*, 2010)

**Formulations**

The levels mentioned in Table( 1) Standard procedures were adopted for the flour mixes. The biscuit dough was chilled for 2 h at 10C before dividing into parts and rolling on a flat surface. This facilitated proper dough development, permitting easy spreading. Baking was performed in a preheated oven at 200C for 10 min or until the biscuits turned stiff and light golden brown. The standard procedures for the biscuits were adopted. (Manley, . 2001; Lovis,. 2003;Chaney, 2006; and Jisha *et al.*, 2010).

**Table(1)Compatible biscuit mixes quinoa flour**

Ingredients	Blends			
	Control	B 1	B 2	B 3
Quinoa flour	-	10	15	20
wheat flour 72% ext.	100	90	85	80
Milk	40	40	40	40
Powdered sugar	70	70	70	70
Egg	50	50	50	50
Melted shortening	30	30	30	30
Baking powder	0.5	0.5	0.5	0.5
Salt	0.5	0.5	0.5	0.5

Blends : B1, B2 and B3

### **Nutritional Studies**

The biscuits made from each blends were dried and powdered. The samples were analyzed for the nutritional parameters, carbohydrate , fiber, crude protein, ash, fat and moisture were determined by the method of A.O.A.C 2000. The energy value (on dry weight basis) was computed using the Atwater formula as:

$$\text{energy (kcal/100 g)} = 4 \times \text{protein (\%)} + 9 \times \text{fat (\%)} + 4 \times \text{carbohydrate (\%)}$$

**Determination of vitamins in flour and biscuit samples:**

#### **Vitamin E ( $\alpha$ -tocopherol)**

Samples were extracted with methanol-BHT (butylhydroxytoluene) (1mg/mL) solution as described by (Miranda *et al.*, 2010). The separation was carried out using a Symmetry column (150×4.6mm, 5 $\mu$ m) from Water (Milford, MA, USA) with methanol : acetonitrile (1:1 v/v) as mobile phase with a flow rate of 1.0 mL/min. Detection was performed by fluorescence using 295 nm and 325 nm as excitation and emission wavelengths, respectively. All solvents were of HPLC grade (Merck, Darmstadt, Germany). The vitamin E content was expressed in mg/100g. (AOAC, 1995).

#### **Determination of vitamin B1 (Thiamine)**

Samples were extracted by acid hydrolysis with 0.1M H<sub>2</sub>SO<sub>4</sub> and enzymatic hydrolysis centrifugation, where thiamine is oxidated to a thiochromo fluorescens derivated. The separation was carried out using a Supelco column C-18 (250 x 4.8mm, 5  $\mu$ m) with buffer sodium citrate (ajust to pH 7), citrate : methanol (65:35 v/v) as mobile phase with a flow rate of 1.5 mL/min in HPLC, Merck Hitachi. Detection was performed by fluorescence using 365 nm and 436 nm as excitation and emission wavelengths, respectively. All solvents were of HPLC grade (Merck, Darmstadt, Germany). The vitamin B1 content was expressed in mg/100g (AOAC, 1995).

#### **Determination of vitamin B2 (Riboflavine)**

Samples were extracted by an acid hydrolysis with 0.1M H<sub>2</sub>SO<sub>4</sub> 10 min in boiling water and enzymatic hydrolysis centrifugation, The separation was carried out using a Supelco column C-18 (250 x 4.8mm, 5  $\mu$ m) with n-heptane sulphonic acid acetronitile as mobile phase with a flow rate of 2.0 mL/min in HPLC. Detection was performed by fluorescence using 450nm and 530nm as excitation and emission wavelengths, respectively. All solvents were of HPLC grade (Merck, Darmstadt, Germany). The vitamin B2 content was expressed in mg/100 d.m (AOAC, 1995).

#### **Determination of Vitamin B3 (Niacina)**

Samples were prepared after (A.O.A.C. 1995) and measurements were performed in a Perkin Elmer Spectrophotometer (model lamda 2S) at 470 nm. All solvents were of HPLC grade (Merck, Darmstadt, Germany). The vitamin B3 content was expressed in mg/100 g (AOAC, 1995).

#### **Evaluation of Physical Characteristics of Biscuits.**

The control and samples were analyzed for physical parameters such as weight, diameter (D), thickness (T) and spread ratio using the following formulae:

- (1) D = diameter of biscuits (cm).
- (2) T = thickness of biscuits (cm)..

(4) (DR) spread ratio = D/T

(3) spread factor (S) = spread ratio for test biscuits X 100.( K. Nandeesh,. *et al.*, 2010)

**Evaluation of Sensory Characteristics of Biscuits**

Sensory evaluation was carried out by a panel of six judges with over 10 years of experience in the field of food science and technology. Sensory analysis of biscuits prepared with wheat flour–quinoa flour blends was conducted for various sensory parameters by assigning scores for color: 1 = dull brown/whitish, 10 = golden brown; surface characteristics: 1 = rough surface, 10 = smooth surface; crumb color: 1 = brown, 10 = creamish white; texture: 1 = hard/brittle, 10 = crisp and mouthfeel: 1 = doughy/gritty, 10 = clean mouthfeel/no residue were analyzed. The overall quality score (50) is the combined score of all these parameters. (Sukhcharn Singh, *et al.*, 2010)

**Statistical Analysis:**

Data were presented as means ± standard deviation (SD). Values were statistically analyzed by one-way analysis of variance (ANOVA test) according to Sendecor and Cochran (Sendecor *et al.*, 1967). using SPSS 10.1 software package. Differences were considered significant at P values ≤0.05.

**RESULTS AND DISCUSSION**

**Nutritional Studies**

**Chemical composition of wheat flour 72% ext. and quinoa flour:**

The result of the proximate composition of the flour samples is shown in Table (2). From data presented in Table(2); His obvious that moisture content of quinoa flour was 12.53% and the ash content was 1.96%. The carbohydrate content in quinoa was 59.18% where the protein content of quinoa flour was 15.26% which was higher than that of wheat flour 13.24% and the fat content was 5,29% which was higher than that of wheat flour 0.72%. The crude fibers was found to be 5.87% in quinoa flour which was higher than that of wheat flour 1.53% .

**Table (2) Chemical composition of flour samples on dry weight basis.**

<b>Content ( %)</b>	<b>Quinoa Flour</b>	<b>Wheat flour</b>
Moisture	12.53	12.31
Protein	15.26	13.24
Fat	5.29	0.72
crude fiber	5.87	1.53
Ash	1.96	0.69
Carbohydrate	59.18	72.53

The result showed in Table (3) that protein and fat contents of biscuits increased significantly due to higher protein and fat content of quinoa flour . The fibers content of biscuit increased significantly, due to higher fiber

content of quinoa flour. As fibers absorbs large amount of water, it gives a sensation of fullness .

**Table( 3).Chemical composition of biscuit products on dry weight basis**

Blends	Total carbohydrate	Crude fibers %	Crude protein%	Fat %	Moisture %	Ash %	Total energy (kcal)
Control	75.64	2.13	10.53	8.59	1.32	2.84	418.63
B1	70.41	3.34	11.67	10.86	1.36	2.89	427.18
B2	63.18	3.96	13.48	15.37	1.54	2.93	445.67
B3	55.89	4.63	16.31	19.24	1.61	2.91	464.94

**Chemical composition of biscuit produced from wheat flour72%ext. replaced by different levels of quino flour on dry weight basis**

In the present study the formulation was based on 00:100% (control) , 10:90% ( B1 ) , 15:85%, (B2 ) and 20:80% (B3) of quinoa flour : wheat flour blend

In table (3) you can be seen that no significant difference was found in the moisture, and ash contents in the blends ( B1, B2 and B3). Whereas, there was a significant change in the values of fibers, fat and protein contents. Quinoa flour has a lower carbohydrate content but high protein, fat and fiber content whereas, wheat flour is rich in moisture and carbohydrate content. Therefore, a significant difference was observed between the samples .

The protein and fat contents of biscuits increased linearly with increase in concentration of quinoa flour, this is attributed to high capacity of quinoa which retained higher protein and fat contents in ultimate products. The results for moisture and ash contents of the biscuit were similar in samples. Both wheat and quinoa flour were having lower content of ash and same content of moisture whereas there was slight increasing in fat contents with increase concentration of quinoa flour incorporation. according to ( K. Nandeesh,. *et al.*, 2010) .

The carbohydrate content of biscuits decreased significantly due to lower content of quinoa flour. The fibers content of biscuit increased significantly, due to higher fibers content of quinoa flour. The energy content of the biscuits was found to range from 426.25 to 471.22 kcal/100 g. The results of proximate composition of quinoa based biscuits are similar with the results obtained by (Manley,2001).

**Vitamins Composition :**

The results in Table (4) showed that vitamins composition of quinoa flour blends of biscuits (B1,B2 and B3) and wheat flour control. It could be noticed that, quinoa flour contained (4.68 mg/100g) vitamin E, (0.64 mg/100g) vitamin B1, (0.8 mg/100g) vitamin B2 and (1.56 mg/100g) vitamin B3 . In addition, quinoa flour had the high content of vitamin E, which is an important dietary antioxidant. These results were in line with the fin dings obtained by Jancurová (Jancurová *et al.*, 2009). On the other hand, there were insignificant differences in vitamin E content between blends of biscuits samples. In the same table,. Biscuits replaced with 20% quinoa flour had the

highest content of vitamin E (12.89 mg/100 g), vitamin B1 (1.53 mg/100g), vitamin B2 (0.76 mg/100g) and vitamin B3 (3.91 mg/100g) . As shown in Table (4), there were insignificant differences among biscuits replaced with quinoa flour as compared to the control for vitamin E and vitamin B1, B2, B3. Our results indicate that, replacement of wheat flour with quinoa flour at 10, 15, 20% levels increased the vitamin E ( $\alpha$ -tocopherol), B1 (Thiamin), B2 (Riboflavin), and B3 (Niacin) contents of biscuits. (Sukhcham Singh, *et al.*, 2010) .

**Table( 4): Vitamins composition in quinoa flour, blends of biscuits and wheat flour (control) on (mg/100 g dry weight basis).**

Vitamin	QF	B1	B2	B3	WF Control
Vit E ( $\alpha$ -tocopherol)	4.68	11.35 <sup>c</sup>	12.13 <sup>b</sup>	12.89 <sup>a</sup>	10.63 <sup>d</sup>
Vit B1 (Thiamine)	0.64	1.32 <sup>bc</sup>	1.53 <sup>b</sup>	1.84 <sup>a</sup>	1.10 <sup>c</sup>
Vit B2 (Riboflavine)	0.08	0.52 <sup>a</sup>	0.69 <sup>a</sup>	0.76 <sup>a</sup>	0.44 <sup>b</sup>
Vit B3 (Niacine)	1.56	2.84 <sup>c</sup>	3.26 <sup>b</sup>	3.91 <sup>a</sup>	2.36 <sup>d</sup>

**The physical properties of the biscuit product :**

Table (5) shows that there was a significant decrease in the diameter of control and different blends (B1, B2 and B3) after incorporating biscuits with quinoa flour. There was a slight decrease in the thickness and spread ratio of control and different blends (B1, B2 and B3) after replacing biscuits with quinoa flour. The results were in conformity with (Ruales and Nair . 1993). The result showed that increase in the weight of control and different blends (B1, B2 and B3) after replacing biscuits with quinoa flour. The result showed that increase in level of quinoa flour resulted in linear decrease of thickness and diameter of biscuit. This is due to the higher water holding capacity of quinoa flour. The weight increased in the similar manner. This may be due to higher fiber content in the quinoa flour. (Sukhcham Singh, *et al.*, 2010) .

**Table (5) Physical propearties of biscuits product.**

Treatments	Weight/biscuit (g)	Diameter (D, mm)	Thickness (T, mm)	Spread ratio (D/T)
Control	6.57 <sup>a</sup>	55.6 <sup>a</sup>	5.8 <sup>ab</sup>	9.59 <sup>a</sup>
B1	6.62 <sup>a</sup>	50.9 <sup>b</sup>	5.6 <sup>c</sup>	9.08 <sup>b</sup>
B2	6.63 <sup>a</sup>	50.4 <sup>c</sup>	5.9 <sup>a</sup>	8.54 <sup>d</sup>
B3	6.65 <sup>a</sup>	50.2 <sup>d</sup>	5.7 <sup>bc</sup>	8.81 <sup>c</sup>

Where: control 100% of wheat,B1:90%WF+10% quinoa flour , B2:85%WF+15% QF and B3:80%WF+20% QF

**Sensory evaluation for product standardization**

Biscuits replaced by different levels of substitutions of quinoa flour were sensory evaluated and compared with control biscuits 100% whole wheat flour . 72% ext.

Data indicated that the percent score of biscuits containing 20% quinoa flour were found to be the most acceptable. At 20% level of replacing all the attributes scored highest level. The color scores of biscuits with 20% quinoa flour reached maximum than to the rest of the proportions similar to the

control sample. Thus, replacement of quinoa flour at 20% level improved the sensory attributes namely texture, flavor, color and overall (Sudha, *et al.*, 2007). The nutritional quality of the developed biscuits was enhanced due to the addition of quinoa flour. Thus, the sensory evaluation Table (6 ) depicts that highest amount of quinoa flour that can be replaced to develop acceptable biscuit was 20%, i.e. sample B3 was the best regarding all sensory attributes.

The result of the sensory evaluation is shown in Table (6)below. From the result; the appearance of the biscuit samples was fairly good. From the results; it was observed that the best crispness clean mouthfeel/no residue as indicated by the panelist was from the 100% wheat flour biscuit which had a mean value of ( 9) closely followed by the product from 15% and 20% substitutions with quinoa flour which had ( 9), though there was no significant difference between them.

**Table (6) : Organoleptic properties of biscuits product**

Treatments	Surface Color (10)	Surface Character (10)	Crumb Color (10)	Texture (10)	Mouth Feel (10)	Overall acceptability score (50)
Control	8 <sup>c</sup>	8.5 <sup>b</sup>	8 <sup>c</sup>	8.5 <sup>a</sup>	9 <sup>a</sup>	42 <sup>b</sup>
T1	8 <sup>c</sup>	8.5 <sup>b</sup>	8 <sup>c</sup>	8.5 <sup>a</sup>	8.5 <sup>b</sup>	41.5 <sup>c</sup>
T2	8.5 <sup>b</sup>	9 <sup>a</sup>	8.5 <sup>b</sup>	8 <sup>b</sup>	9 <sup>a</sup>	43 <sup>ab</sup>
T3	9 <sup>a</sup>	8.5 <sup>b</sup>	9 <sup>a</sup>	8 <sup>b</sup>	9 <sup>a</sup>	43.5 <sup>a</sup>

Where: control 100% of wheat, B1:90%WF+10% quinoa flour , B2:85%WF+15% QF and B3:80%WF+20% QF

flour The score of Surface and Crumb colors was 8 with 100% wheat flour, this was due to increasing level of quinoa flour which gave a golden brown for surface and creamish white for crumb color to biscuit with score 9 for both which was liked by the panelist .

Based on appearance for surface character , the sample with 15% quinoa flour classified highest with value of 9. This was very close to 20% and 10% substitutions of quinoa flour and control there was no significant difference between the three samples .

The texture of the products were fairly accepted (slightly liked) at up to 20% substitution with quinoa flour. There was no significant difference in texture (B2, B3) while a significant difference (0.5) occurred between them and control sample.

From the results of the overall acceptability of the samples, there was no significant difference (0.5) between samples B1 (10% quinoa flour) and control with mean scores of 41.5, and 42 respectively. Also there was no significant difference (0.5) between samples B2 and B3 with a mean score of 43, and 43.5 respectively. This showed that the panelists accepted this product up to 20% level of substitution of quinoa flour with wheat flour . Since all the parameters used in this sensory evaluation had good sensory scores, it could be recommended that up to 20% quinoa flour be used in the substitution of wheat flour in the production of biscuits.

## CONCLUSION

It was found that quinoa flour contains a great amount dietary fibers, fat and protein, although rich in vitamins content, so a successful combination with wheat flour for biscuit production would be nutritionally advantageous. Quinoa flour with had significant effect on the functional properties of the flour blends. Replaced of quinoa flour at 10 % , 15% and 20% levels with wheat flour increased the total proteins, fibers, vitamin B1 (Thiamin), vitamin B2(Riboflavin), vitamin B3 (Niacin), vitamin E ( $\alpha$ -tocopherol) and fat contents. Blending QF with WF at 20% level produced samples which can be used for production of bakery goods with improved functional properties. This work shows the peculiar properties (moisture, protein, ash, fibers and fat) of quinoa flour. The results obtained could be very valuable in decision making for industries that want to take nutritional advantage of quinoa flour as alternative or supplement to cereal flours. Quinoa flour could be useful in the manufacture of highly nutritious cookies.

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**تحسين القيمة الغذائية للبسكويت باستخدام دقيق الكينوا**  
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**التصنيع الغذائي**

الهدف من هذه الدراسة هو تحسين القيمة الغذائية للبسكويت العادى بزيادة قيمة كل من فيتامين B1، فيتامين B2، وفيتامين B3 وفيتامين E والألياف الغذائية والبروتين والدهون, وذلك باستخدام دقيق الكينوا الذى يعتبر مصدر طبيعى لكل هذا المكونات المضافة الى البسكويت. قد اكتسبت الكينوا اهتماما متزايدا نظرا لقيمتها الغذائية وكذلك محتواها من الفيتامينات لها (B1، B2، B3 و E). في هذه الدراسة يتم خلط دقيق الكينوا مع دقيق القمح استخلاص ٧٢ % بنسبة ١٠% و ١٥% و ٢٠%. ثم تقدير الخصائص الفيزيائية والكيميائية والحسية لمعرفة مدى قبول بسكويت دقيق الكينوا. وتشتمل المواصفات الحسية للبسكويت المنتج على اللون والطعم والملمس والقبول العام. وكما تم تقدير الخصائص الفيزيائية والكيميائية لبسكويت الكينوا، والذي يتضمن محتوى الرطوبة والألياف والدهون والبروتين والرماد. واطهرت النتائج ان القيمة الغذائية للبسكويت المحتوي على دقيق الكينوا بنسبة ٢٠% مقبول لأنه يحتوي على أعلى محتوى من الألياف عن العينات الأخرى، كما سجل ايضا أعلى درجة من حيث تقييم القبول العام القبول .