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Use of Quinoa Meal to Produce Bakery Products to Celiac and Autism Stuffs

Atef A[1], Abou-Zaid[2], El-Faham[3], S.Y., Wafaa[4], H. Emam[5]

Food Technology Department, National Research Centre, Dokki, Giza, Egypt

Abstract: ***The current research aims to substitute wheat flour with quinoa meal to (1) produce gluten free bakery product such as cake or biscuits to use it in autism disease and celiac cases nutrition (2) reduce of wheat flour needs to reduce the gape in wheat production. Experiment the best quinoa grains treatment to remove the bitter taste as (washing with tab water, washed with hot water, microwave or germination), the best treatment washing with hot water. Quinoa meal (Q) as a substitute for wheat flour (W) were evaluated. The farinograph and amylograph properties of flour dough and product quality properties (physical, chemical, protein content, color and sensory characteristics) resulted from wheat flour and quinoa meal were examined in cake and biscuit manufacturing. Wheat flour was replaced by quinoa meal in ratios of 25, 50, 75 and 100%. The results showed that the water absorption, dough development time (DDT) and dough weakening increments and dough stability decrements. Baking properties, color and sensory evaluation tests showed that the 100% wheat flour amounts could be replaced by the same amounts of quinoa meal still providing good quality in cake. But substitution of wheat flour by 75% quinoa meal gave good biscuit but in the other ratios the quality was lacked as a resulted increasing the quinoa meal.***

Keywords: quinoa, chemical composition, rheological properties, farinograph, amylograph, cake, salt-biscuit

1. Introduction

Quinoa flat, oval-shaped seeds that are usually pale yellow but can range in color from pink to black **(Karyotis et al., 2003).** (Chenopodium sp.) is plant of the South America, belonging to pseudo cereals. Three thousand years ago, quinoa was planted by the Incas who referred it 'mother of all grains' **(Taylor and Parker 2002).** Nowadays, world 2009's production according to FAQ statistics was 68 thousand tons. For human nutrition, quinoa seeds are disintegrated to whole meal flour with high content of protein, minerals, vitamins and polyphenols. Quinoa is a lost crop of the Incas, a cereal-like crop with high seed yield. The seed protein content is high (about 15%), and its essential amino acid balance is excellent because of a wider amino acid spectrum than cereals and legumes **(Ruales and Nair, 1992),** with higher lysine (5.1-6.4%) and methionine (0.4-1.0%) contents **(Bhargava, et al., 2003).** Quinoa proteins may be one of the more promising food ingredients, In spite of the high nutritional value of quinoa proteins because of the high quality of amino acids, their use as food ingredients in the form of protein isolates depends largely on their functional properties. Also It is an important source of vitamins and minerals, Quinoa grains have vitamins C, E (tocopherols), and B complex, and important minerals (Ca, K, Fe, Mg, Mn, P), and has also been found to contain compounds like polyphenols, phytosterols, and flavonoids with possible nutraceutical benefits. isoflavons, and high quality lipids. Such a combination of factors contributes to excellent antioxidant properties and even the saponins in the seed coats, previously considered as antinutrients, can now be extracted for industrial and biomedical use. And it has some functional (technological) properties like solubility, water-holding capacity (WHC), gelation, emulsifying and foaming that allow diversified uses. Besides, it has been considered an oil crop, with an interesting proportion of omega-6. Quinoa starch has physicochemical properties (such as viscosity, freeze stability) which give it functional properties with novel uses. Quinoa has a high nutritional value and has recently been used as a novel functional food because of all these properties; it is a promising alternative cultivar **(Jancurová et al., 2009 and Vega-Gálvez et al., 2010).** This crop could be used also for gluten-free pasta manufacturing as pure with carboxymethylcellulose, so in blends with wheat flour as in case of millet, amaranth or buckwheat **(Hrusková et al. 2007).** The paradigms of world food and agriculture aim to show finer nutritional and functional properties of foods for human consumption, which go beyond traditional sanitary requirements and good agricultural practices. Moreover, chronic hunger is another world challenge. According to the Food and Agriculture Organization (FAO), between 2009 and 2010, just before the outbreak of the hunger crisis in Somalia, 925 to 1023 million people in the world were suffering chronic hunger; this situation was declared unacceptable since these were the FAO's highest records since the early 1970s **(FAO, 2011).** One way of addressing solutions for this tremendous issue, but also to the requirements for better quality foods, is to look for crops that are nutritionally rich and can also grow under stressful environmental and climatic conditions typical of the world hunger areas, such as East Africa, and salinity under a very diverse array of soil and climatic conditions, for example **(Bhargava et al., 2006).** The long Chilean mainland territory between 18º and 43ºC (stretching over 3000 km) and 4000 m above sea level. offers an extended natural laboratory to test environmental effects on the nutritional properties of quinoa. Quinoa has been cultivated within this latitudinal distribution since ancient times. Three different biogeographic regions or genetic pools of quinoa are now recognized in Chile, the North-Altiplano, the Center, and the South **(Fuentes et al., 2009).** Quinoa is reported to be one of the few crop plants grown in the salt level of southern Bolivia and northern Chile **(Tagle and Planella, 2002).** Only at high salinity, protein content increases in these seeds, while total carbohydrate content decreases **(Koyro and Eisa, 2007).** The astonishing nutritional quality of some new world crops, Nowadays, increasing consumers' interest in

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healthier nutrition constrains food industry to extend offered assortment about products with increasing portion of fiber, vitamins, minerals etc. **(Vega-Gálvez et al., 2010),** have the additional benefit of being able to withstand extreme climatic and soil conditions **(Martínez et al., 2009).** This has also raised their potential use as sources of new grains in the fight against hunger. In recent years, the cultivation of crops such as quinoa (Chenopodium quinoa Willd.) has gained increasing attention due to the attractive nutritive value of its grains, as well as an effort to expand the number of species which contribute to human nutrition **(Hirose et al., 2010).** Quinoa varies in Bolivia, Peru, and Ecuador, and can be grown from Colombia to the southern regions of Argentina and Chile as a result of a long-lasting domestication process **(Fuentes et al., 2009; 2012).** Quinoa production has increased in the last 20 years, especially in Bolivia. The main producing countries are Bolivia, Peru, and Ecuador, which in 2007 produced 61,490 tons, up from 19,000 tons in 1973 **(FAOSTAT, 2008).** During 2007 quinoa production was 34,000 tons in Peru, 26,800 tons in Bolivia, and 690 tons in Ecuador **(FAOSTAT, 2008).**

It does not contain gluten, so it can be eaten by people who have celiac disease as well as by those who are allergic to wheat It does not contain gluten, so it can be eaten by people who have celiac disease as well as by those who are allergic to wheat. **(Tellers, 2008).** The first few quinoa products are beginning to appear in the European market. In 2003, the UK-based Anglesey introduced a chilled quinoa meat substitute called Quinova. With increasing interest in grain diversification, the food industry in 2008 can show a change in its tactics leading to new ways of revenue potential from these ancient grains **(Tellers, 2008).**

The aim of the research presented in this paper was: (1) to produce bakery products for autism and celiac stuff on the other hand, (2) to study the rheological properties of dough prepared from mixtures of wheat and quinoa meal on the dough properties, properties of wheat and quinoa starches in viscoamylograph. In addition, the quality parameters of experimental cakes and biscuits, as influenced by quinoa flour addition, were also studied.

2. Materials and Methods

Materials:

Wheat flours (72% extraction) were obtained from the North Cairo Flour Mills Company, Egypt. Commercial quinoa seed sample (grown in Egypt in 2012 season) was also used in the experiments. Was purchased from The Ministry of Agriculture in season 2011–2012 and kept at 3– 4°C until used in technological studies.

Flour Preparation:

The seeds were treated with one of these treatments (washed with cold water, washed with hot water, microwave or germination) to remove saponins. The seeds were washed many times with cold or hot water to remove saponins until there was no more foam in the washing water, and they were then dried at 50^{O}C. The quinoa seeds were ground to fine powder in an electric grinder stainless steal using a Laboratorial disc mill (Quadrumat Junior flour mill, Model Type No: 279002, ©Brabender ® OHG, Duisburg 1979, Germany) and sifted through a 60 mesh. The flour so obtained was defatted for 24h with hexane in a 10% (w/v) suspension with continuous stirring, air-dried at room temperature, and finally stored at 4^{O}C until used.

Blends Preparation:

Preparation of quinoa meal-wheat flours blends. Wheat flour (72% extraction rate) was well blended with the quinoa meal to produce individual mixtures containing 0, 25, 50, 75 and 100% replacement levels. All samples were stored in airtight containers and kept at 3–4°C until required.

Chemical Composition:

Standard Association of Official Analytical Chemistry methods, **AOAC (2005)** were adopted for estimating moisture, ash, crude fiber, protein and fat contents. Total carbohydrates were calculated as: 100 - (protein + fat + moisture + ash).

Determination of Amino Acids:

Amino acid compositions were determined according to the method described in **AOAC (2005).**

Minerals determination:

Minerals were determined according to **(AOAC, 2005).**

Gluten content in flour samples:

Gluten was obtained from flour using gluten washing apparatus according to the **AACC Method (2005).**

Farinograph Properties:

Actually, 0, 25%, 50%, 75% and 100% amounts of quinoa meal were replaced the same amounts of wheat flour. The effect of the different flour replacement levels on dough rheology was determined by farinograph apparatus (Model Type No: 81010, ©Brabender® OHG, Duisburg, 1979, Germany) according to the standard methods of **AACC (2005).** The measured parameters were water absorption, dough development time, dough stability and mixing tolerance index (MTI).

Starch isolation:

Separation of starch from quinoa meal was carried out by diluted alkaline solution as described by **Sodhi and Singh (2005).**

Study of the viscoamylograph properties of quinoa starch:

The viscoamylograph test was carried out according to the procedure mentioned by the **AACC (2005)**.

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Salt-biscuit making:

Salt-biscuit was manufactured according to **Dovaldk and William (1975)** and supplemented with (0, 25, 50, 75 and 100%) quinoa flour.

Cake Making:

Cake making was carried out at automatic commercial baking line according to **AACC (2005).** The cake ingredients were100g flour, 104 g sugar, 40 g shortening, 56 g egg albumen, 11.5 g skimmilk, 5.8 g baking powder, 0.5 g vanillia, 1g emulsifier agent (Glecrid Mono Stearat) and 64ml water with modification didn't added the skimmilk. The cake was manufactured as follows:

The sugar and shortening were mixed together and the egg albumen was added and the mixture was whipping. The other components were added and the whipping process was completed and after that, the paste was put in bowel and baking at 170-175^{o}C for 35-40min. After two hours the organoleptic evaluation test was carried out. The cakes were allowed to cool at room temperature for 2 h before being packaged in polyethylene bags and stored at room temperature for further analysis.

Physical characteristics of salt-biscuits:

Physical characteristics were determined according to the method described by **Manohar and Rao (1997).** Diameter and thickness of five biscuits were measured by placing those edges and by staking one above the other, respectively. To obtain the average, measurements were made by rearrangement and restacking. The spread ratio obtained was the ratio between diameter and thickness. The average weight of five biscuits was recorded. Volume (cm^3) was determined by displacement of rap seeds. The bulk density was calculated and expressed as g/m^3.

Physical Characteristics of Cakes:

Weight, volume and specific volume of cakes were measured according to the methods described by **Bennion and Banford (1983).** A graduated scale (in centimeters) was used to measure the height of cakes. For measuring cakes volume, a glass box designed to hold the article was used. The box was placed on the tray and filled with rap seeds delivered from its container in a steady stream to a fixed height until the box was filled and the seeds over flowed into the tray. The surface of the seeds was then leveled by removing the surplus by straight edged scraper. The seeds in the box which representing the volume of the box were transferred to an empty container and the cake was placed in the measuring box. The seeds were filled into the box containing the cake until the box over flowed. Leveling of surface of the seeds and the excess seeds in the container were measured. The volume of the cake was the volume of rape seed rest. The specific volume of the cake was calculated by using the following equation:

Specific volume = volume (cm3) / weight (gm)

Sensory Evaluation of salt-biscuits:

The sensory evaluation of baked salt-biscuit was estimated by ten panelists for appearance, odor and taste as the method described by **Gerczyca and Zabic (1979).** Assigning scores for various qualities attributes such as: crust color (10), taste (10), odor (10) and overall acceptability (10).

Sensory Characteristics of cakes:

The cakes were allowed to cool on racks for about 1h before evaluation. Cakes were organoleptically estimated for the testedattributes by 10 well trained panelists according to **Bennion and Banford (1983).**

Color Determinations:

Objective evaluation of surface crust and crumb color of cake samples was measured. Hunter a*, b* and L* parameters were measured with a color difference meter using a spectro-colorimeter (Tristimulus Color Machine) with the CIE lab color scale (Hunter, Lab Scan XE - Reston VA, USA) in the reflection mode. The instrument was standardized each time with white tile of Hunter Lab Color Standard (LX No.16379): X= 72.26,

Y= 81.94 and Z= 88.14 (L*= 92.46; a*= -0.86; b*= -0.16) **(Sapers and Douglas, 1987).**

Statistical Analysis:

The obtained results were statistically analyzed using SPSS statistical package (Version 9.05) according to **Rattanathanalerk et al., (2005),** analysis of variance (ANOVA). Duncan's multiple range test and least significant difference (LSD) was chosen to determine any significant difference among various treatments at $p<0.05$.

3. Results and Discussion

Chemical composition of quinoa and wheat flour samples:

The chemical composition of crude quinoa, boiled quinoa, microwave treated quinoa, washed quinoa with cold water and wheat flour were given in Table (1). It is clear to notice that the (protein, crude fat, ash and crude fiber) of all quinoa were higher than those of wheat flour **(Abugoch et al., 2008).** While, total carbohydrate in wheat flour higher than that in all quinoa samples. The results are agreement to the results of **Jancurova, et al., (2009).** Quinoa which was washed with hot or cold water had (protein, crude fat, and ash) lower than those in crude quinoa, its due to the washing treatment caused losses in water soluble matters of (proteins, sugars, minerals and fats), on the other hand, total carbohydrates was negligible increased compared to crude quinoa its due to the losses of other components like protein, it's due to pseudo cereals, such as quinoa, had albumins and globulins (water soluble components) are the major protein fraction (44–77% of total protein), which is greater than that of prolamins (0.5–7.0%). **Jancurova, et al., (2009).**

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Table 1: Percentages of approximate analysis of quinoa meal and wheat flour

Constituents	*Crude quinoa*	*Boiled quinoa*	*Microwave treated quinoa*	*Washed quinoa with cold water*	*Wheat flour*
Moisture	11.65	12.6	10.10	11.81	12.2
Protein*	14.10	13.52	14.00	13.70	12.8
Crude fat*	5.90	5.81	5.80	6.00	0.80
Ash*	3.79	3.70	3.90	3.65	0.52
Crude fiber*	4.35	4.40	4.50	4.50	0.41
Carbohydrate*	71.86	72.57	71.80	72.15	85.47

*On dray bases

Minerals content of quinoa and wheat flour:

Data presented in Table 2 showed mineral content of quinoa meal and wheat flour as mg/100g sample. The obtained data showed that minerals content of (Ca, P, K, Mg, Fe, Mn, Cu and Zn) in quinoa sample was higher than those of wheat flour. Sample which were (126.94, 427.26, 1577.91, 214.57, 8.86, 3.46, 1.23 and 3.74), respectively in quinoa. But there were (11.86, 129.63, 138.84, 114.52, 0.71, N.D., 0.33 and 0.48), respectively in wheat flour. While Na in wheat flour was higher than this in quinoa meal it was 26.02 in wheat flour and 11.91 in quinoa meal. The results are in agreement with the results reported by **Miranda, et al., (2012).**

Table 2: Mineral content of quinoa meal and wheat flour (mg/100g sample)

Minerals mg/100g	*Quinoa meal*	*Wheat flour*
Ca	126.94	11.86
P	427.26	129.63
K	1577.91	138.84
Mg	214.57	114.52
Fe	8.86	0.71
Mn	3.46	N.D.
Cu	1.23	0.33
Zn	3.74	0.48
Na	11.91	26.02

Amino acids composition of whole quinoa and wheat flour 72% extraction proteins:

Data given in Table 3 showed that the amino acids composition (g/100g protein) of whole quinoa meal protein.

Table 3: Amino acids composition of quinoa and wheat flour protein (g/100g proteins)

Amino acid	*Quinoa*	*Wheat flour*
Essential amino acids		
Threonine	3.54	2.30
Valine	4.44	4.45
Isolucine	3.60	3.40
Lucine	6.50	6.00
Tyrosine	2.77	3.30
Phenylalanine	3.57	4.55
Lysine	5.93	2.10
Histidine	2.75	2.40
Methionine	2.80	1.35
Cysteine	1.73	2.78
Tryptophan	1.14	1.12
Summation	38.77	33.75
Non-essential amino acids		
Aspartic acid	9.50	4.38
Serine	4.80	4.30
Glutamic acid	14.35	33.2
Proline	4.00	10.6
Glycine	5.50	4.55
Alanine	4.50	3.20
Arginine	8.70	4.20
Summation	51.35	64.43

The obtained results indicated that the amount of essential amino acids content of whole quinoa meal protein was relatively high and the reverse was recorded for wheat flour 72% extraction protein sample, it was 38.77 in whole quinoa meal protein and it was 33.75 in wheat flour 72% extraction protein.

Table 3: Amino acids composition of quinoa and wheat flour protein (g/100g proteins)

Amino acid	*Quinoa*	*Wheat flour*
Essential amino acids		
Threonine	3.54	2.30
Valine	4.44	4.45
Isolucine	3.60	3.40
Lucine	6.50	6.00
Tyrosine	2.77	3.30
Phenylalanine	3.57	4.55
Lysine	5.93	2.10
Histidine	2.75	2.40
Methionine	2.80	1.35
Cysteine	1.73	2.78
Tryptophan	1.14	1.12
Summation	38.77	33.75

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Non-essential amino acids		
Aspartic acid	9.50	4.38
Serine	4.80	4.30
Glutamic acid	14.35	33.2
Proline	4.00	10.6
Glycine	5.50	4.55
Alanine	4.50	3.20
Arginine	8.70	4.20
Summation	51.35	64.43

Actually, the nutritional value of whole quinoa meal protein samples showed the slightly high nutritional value based on essential amino acids determination. Results in agreement with results were recorded by **Gęsiński and Nowak (2011).** Amino acids of (threonine, lucine, lysine, methionine, aspartic acid, glycine, alanine and arginine) in quinoa were higher than those in wheat flour protein, there were (3.54, 6.50, 5.93, 2.80, 9.5, 5.50, 4.50 and 8.70), respectively in quinoa, while those were (2.30, 6.00, 2.10, 1.35, 4.38, 4.55, 3.20 and 4.20), respectively in wheat flour, but amino acids like (valine, isolucine, histidine, tryptophan and serine) in quinoa slightly or negligible higher compared to those in wheat flour, those were (4.44, 3.6, 2.75, 1.14 and 4.80), respectively in quinoa but there in wheat flour were (44.5, 3.40, 2.40, 1.12 and 4.30), respectively. On the other hand other amino acids in quinoa protein of (tyrosine, phenylalanine, cysteine, glutamic acid and proline) lower than those compared to wheat flour protein. Those were (2.77, 3.57, 1.73, 14.35 and 4.00) respectively in quinoa, while those were (3.30, 4.55, 2.78, 33.2 and 10.6) respectively in wheat flour protein. The results were harmonized to others found by **Ranhotra et al., (1993).**

Gluten content in flour samples:

Wet and dry gluten, water capacity gluten and gluten protein content, were found in table (4). Wheat flour show a significant different wet gluten content, which is about three times higher than dry gluten content as noted elsewhere **Enriquez et al., (2003).** From table (4) it is obvious that the wet gluten of wheat flours were (35.6%). While dry glutens were (11.88%). The protein content of wheat gluten flour 85.10%. but quinoa meal haven't gluten net work the results according to the results were reported by **Enriquez et al., (2003).**

Table 4: dry gluten, wet gluten, water capacity gluten and gluten protein content of quinoa and wheat flour

The test.	*Quinoa flour*	*Wheat flour.*
Wet gluten net work%.	-	35.60
Dry gluten net work%.	-	11.88
Water capacity of gluten%	-	66.60
Gluten protein content%.	-	85.10

Flour color:

The proximate composition and color tristimulus parameters of the flours used in this study are presented in Table 5.

L (lightness) value of quinoa meal was lower than that observed for wheat flour, strong brown color. The (a) value for wheat flour was positive (red hue) values, positive (yellow hue), quinoa had a characteristic yellowish color. In consequence, quinoa-wheat flour blends will lead to a range of colored bakery products. It due to quinoa which was extremely rich in (protein, fat and ash) content. Results concerning quinoa were close to the data previously reported by **Rosell et al., (2010).**

Table 5: Color tristimulus parameters of quinoa and wheat flour

Sample	*L*	*a*	*b*
Quinoa meal	80.42	0.33	14.12
Wheat flour	89.50	0.72	10.38

Influence of quinoa addition to wheat flour on Farinograph Properties of Dough:

Variation in blending ratios (0, 25, 50, 75 and 100%) of quinoa-wheat flour blends on dough properties in Farinograph. The results are obvious mentioned indicated in Table (6). Addition of quinoa meal mainly increased the water absorption. By increasing the sample level from 0% to 100% the highest increase in water absorption was found with the addition of 100% quinoa flour was (65.5%) compared to control it was (57.0%). The increase in the water absorption in the case of quinoa meal was marginal.

Table 6: Influence of quinoa meal addition to wheat flour 72% extraction on the Farinograph measurements of the dough

Sample	*Water absorption (%)*	*Arrival time (min)*	*Developing time (min)*	*Stability time (min)*	*Weakening value (BU)*
100% wf	57.0	2.0	3.5	4.0	40
25% q + 75% w	59.0	2.0	4.0	6.0	70
50% q + 50% w	61.2	2.5	4.0	6.0	110
75% q + 25% w	63.5	2.5	4.5	5.5	140
100% q	65.5	3.0	5.5	3.0	160

Where: 100% (wf) = wheat flour, (25% q + 75% w) = 25% quinoa meal + 75% wheat flour, (50% q + 50% w) = 50% quinoa meal + 50% wheat flour, (75% q + 25% w) = 75% quinoa meal + 25% wheat flour, (100% q) = 100% quinoa meal.

Similar effects on water absorption were observed by **Abou-Zaid et al., (2012)** when matter was protein rich was added **Abou-Zaid et al. (2011)** reported that the differences in water absorption are mainly caused by addition rich matter in fiber, protein and/or starch, which exist in the higher protein content which retain more water. Arrival time which increased by quinoa meal ratio increasing in the blend, it was increased from 2.0min at

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25% to 3.0 min in 100% quinoa meal blend compared to 2min in control. The extent of increase in dough development time (DDT) and dough stability were increased by quinoa meal increasing from (4.0) at 0% quinoa meal to (6.0 min) at 25 and 50% quinoa meal after that the increasing in quinoa meal cusses decreased in arrival time to 5.5 min and 3 min. for (75% and 100% quinoa meal), respectively. On the other hand, results showed the weakening of dough was increased with the increasing level from 0% to 100% of quinoa meal. It is due to that with quinoa meal increased, the net work proteins was diluted and cussed an increase in weakening values, as reported by **Abou-Zaid (2011)** by increasing legumes flour the weakening value was increased, similar results were obtained by **Abou-Zaid et al., (2012)** for the addition of milled mushroom micelles to the blends.

Quinoa and wheat starch properties as Measurements of the viscoamylograph:

The quinoa starch exhibited high amylograph viscosity than wheat starch as reported by **Rodriguez-Sandoval et al., (2012).** Was related to high α-amylase activity in wheat compared to quinoa. Temperature at maximum viscosity, maximum viscosity, viscosity after fixing the temperature at 95^{o}C for 10 min. and viscosity after cooling to 50^{o}C in quinoa starch than those of wheat starch. Table (7) clear the quinoa starch was higher than wheat starch in (maximum viscosity, temperature at maximum viscosity, viscosity at 95^{o}C, viscosity at 50^{o}C and set back point) the values in quinoa were (3010B.U, 94.5 C^{o}, 1980, 3000 and 3030B.U.), respectively but in wheat they were (480B.U., 92.5 C^{o}, 530, 1200 and 710B.U.), respectively. But quinoa starch was lower than wheat starch in transition point it was in 67.5^{o}C in quinoa but it was in wheat 77^{o}C, it may be due to the amount of hydrogen bonds in quinoa starch molecule lower than that in wheat starch molecule so that the quinoa starch need to low temperature to transition to gel case than wheat starch. Also the amylase activity in wheat its higher than that in quinoa it's cause degradation in amylase and amylopectin chains produced different kinds of dextrins had low viscosity. Therefore all properties except transition point lower than that in wheat starch. It may be due to the degree of branching in amylopectin of quinoa starch its higher than that in wheat starch amylopectin. Therefore the slurry it was kept with its viscosity at high temperature in quinoa starch than wheat starch and quinoa starch was needed to long time for maked-up gel than that of wheat starch so that time temperature at maximum viscosity become higher. **(Abou-Zaid, 2001).**

Table 7: Quinoa and wheat starch properties as measurements of viscoamylograph

Sample	Transition point (C°)	Maximum viscosity (B.U)	Temp. at max. viscosity (C°)	Viscosity at 95°C (B.U.)	Viscosity at 50°C (B.U.)	Set-back point (B.U.)
Quinoa starch	67.5	3010	94.50	1980	3000	3030
Wheat starch	77.00	480	92.50	530	1200	710

Influence of quinoa flour addition on physical characteristics of biscuits:

Physical characteristics of biscuits, such as thickness, diameter and spread ratio were affected by the substitution increment of the level of quinoa meal (Table 8). The changes in diameter and thickness reflected the spread ratio which was consistently increased to from 5.82% in control sample to 6.89 in quinoa meal biscuit 100% substitution.

These results indicated that the addition of quinoa meal adversely affected the thickness, diameter and spread ratio of the supplemented biscuits. It's due to that the gluten network was weakened. Cookies having higher spread ratios are considered most desirable **(Abou-Zaid, et al., 2012).** Other research workers also reported that the thickness of supplemented biscuits increased, whereas diameter and spread ratio of biscuits decreased with the increasing level of rice bran-fenugreek blends, fenugreek flour and different bran blends **(Sharma and Chauhan, 2002; Hooda and Jood, 2005** and **Sudha et al., 2007).**

Table 8: Influence of quinoa meal addition on physical characteristics of biscuits

Biscuit sample	*Thickness (mm)*	*Diameter (mm)*	*Spread ratio (d/t)*	*Weight (g)*	*Volume (cm^3)*	*Density (g/Cm^3)*
100% wf	11.0	64.0	5.82	56.1	140	0.40
25% q + 75% w	10.5	65.0	6.19	53.3	130	0.41
50% q + 50% w	10.0	65.0	6.50	58.0	135	0.43
75% q + 25% w	10.0	65.5	6.55	61.1	130	0.47
100% q	9.50	65.5	6.89	61.3	125	0.49

Where: 100% (wf) = wheat flour, (25% q + 75% w) = 25% quinoa meal + 75% wheat flour, (50% q + 50% w) = 50% quinoa meal + 50% wheat flour, (75% q + 25% w) = 75% quinoa meal + 25% wheat flour, (100% q) = 100% quinoa meal.

The changes in the density which was consistently increased to from 0.40 g/cm3 in control sample to 0.49 in quinoa meal biscuit 100% substitution. It may be due to; increasing of resistant starches addition, the gluten net work become weak and the spread of dough in negative relation to gluten net work strength. **El-Hadidi (2006)** and **Abou-Zaid, et al., (2013).** The results were agreed to **Hassan, (2002)** who found that biscuits samples prepared

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with replacement of wheat flour by 50% resistant corn starch showed spread ratio higher than control sample. Also **Hassan, (2002)** founded that by addition resistant starches to wheat flour led to produce biscuits with high spread ratio and low thickness than control in linear relation.

From the obvious data could be concluded that by increasing quinoa meal in the blends were used to made biscuit the diameter, spread ratio and specific volume was increased, but by increasing quinoa meal ratio produce biscuit with low thickness.

Influence of quinoa flour addition on physical characteristics of cakes:

Physical characteristics of pan cake, such as volume, weight and density, were affected by the increase in the level of quinoa meal presented in (Table 9). The changes in volume and weight values are reflected in density which consistently decreased from 0.462 in control sample to 0.432 in 100% quinoa meal cake. These results indicated that the addition of quinoa meal adversely affected the volume, weight and thus, density of the supplemented pan cake. The increasing in volume due to increasing the replacement of wheat flour with quinoa meal caused weakened the gluten network which is responsible for retaining the leavening gases. However, the density of cakes was decreased by quinoa meal replacement levels. These results are confirmed with those found by **Abou-Zaid (2011).** However, **El-Hadidi (2006)** reported that addition of high levels of resistant starch decreased volume and increased weight of cake. It may be due to; increasing of resistant starches addition, the gluten net work become weak.

Table 9: Influence of quinoa meal addition on physical characteristics of cakes

Cake sample	*Specific volume (g/Cm^3)*	*Volume (Cm^3)*	*Weight (g)*
100% wf	0.462	400.43	185.0
25% q + 75% w	0.455	405.49	184.5
50% q + 50% w	0.448	414.06	185.5
75% q + 25% w	0.440	420.45	185.0
100% q	0.432	425.93	184.0

Where: 100% (wf) = wheat flour, (25% q + 75% w) = 25% quinoa meal + 75% wheat flour, (50% q + 50% w) = 50% quinoa meal + 50% wheat flour, (75% q + 25% w) = 75% quinoa meal + 25% wheat flour, (100% q) = 100% quinoa meal.

Sensory Evaluation of Biscuit:

The effects of quinoa on sensory characteristics of biscuits are presented in Table (10). With the increase in the level of quinoa meal in the formulation, the sensory scores for color, taste, odor and general appearance of biscuits decreased. Replacement of wheat flour with 25% and 100% of quinoa meal impaired the color which decreased from 9.8 in control to 8.1 in 100% quinoa meal. Taste of biscuits (control samples had 10 score), which significantly decreased from 9.5 to 7.9, control samples had maximum color, taste, odor and general appearance. The color, taste, odor and general appearance attributes score for control sample was (9.8, 9.5, 10.0 and 9.6), respectively on a 10-point hedonic scale. Biscuits made from blends containing 100% level of quinoa meal was in significantly ($p<0.05$) differ than the control. The color, odor, taste and general appearance of 100% level substitution was rated as poor and was significant differed then the control sample. Similar observations were also reported with supplementation of mushroom-wheat flour blends with wheat flour as reported by **Eissa, et al., (2007).** Biscuits made from blends containing 25% level of quinoa meal slightly difference at ($p<0.05$) compared to control. At 100% level of substitution, the color, taste, odor and General appearance was rated significantly poor. From the sensory acceptability rating, it was concluded that biscuits were made from 25 and 50% quinoa meal could be incorporated up to 50% level of quinoa meal in the formation of biscuits without significantly affecting on sensory quality.

Table 10: Influence of quinoa meal addition on sensory evaluation of biscuits

Biscuit sample	*Color*	*Taste*	*Odor*	*Structure*	*General appearance*
	10	10	10	10	10
100% wf	9.8^{a}	9.5^{a}	10.0^{a}	9.5^{a}	9.6^{a}
25% q + 75% w	9.2^{a}	9.1^{a}	9.5^{a}	9.1^{a}	9.4^{a}
50% q + 50% w	9.0^{ab}	8.8^{ab}	9.1^{b}	8.4^{b}	9.4^{a}
75% q + 25% w	8.6^{b}	8.4^{b}	8.6^{b}	7.8^{c}	9.0^{b}
100% q	8.1^{bc}	7.9^{c}	8.0^{c}	6.5^{d}	7.5^{c}
L.S.D.	0.6	0.4	0.5	1.01	0.3

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Where: 100% (wf) = wheat flour, (25% q + 75% w) = 25% quinoa meal + 75% wheat flour, (50% q + 50% w) = 50% quinoa meal + 50% wheat flour, (75% q + 25% w) = 75% quinoa meal + 25% wheat flour, (100% q) = 100% quinoa meal.

Addition of quinoa meal adversely affected the salt-biscuit structure in negative linear relationship, led to biscuits contained 25% quinoa meal had negligible efficiency in structure character, while quinoa meal addition with 50% led to slightly effects in structure, but at 75% addition of quinoa meal in the blend produced biscuit with significant differences in structure score, more than 75% quinoa meal addition produced unacceptable structure of biscuit, due to increasing the replacement of wheat flour with quinoa meal caused weakened the gluten network which is responsible for retaining the leavening gases. However, the compact structure of biscuits was increased by quinoa meal replacement levels. These results are confirmed with those found by **Abou-Zaid (2011).** Biscuit was made from formula contained 75% quinoa meal had slightly differences compared to control, and the sample was contained 100%quinoa meal had poor in sensory scours.

Sensory Evaluation of pan cake:

The effects of quinoa meal supplementation on the sensory characteristics of cakes are presented in Table (11). With the increase in the level of quinoa meal in the blend, the sensory scores for (highest, taste, crust color, odor, crumb structure, texture, and general appearance) of cakes slightly decreased.
The sensory characteristics of cake as (highest, taste, crust color, odor, crumb structure, texture, and general appearance) which prepared from blends of wheat flour (72% extraction) and 0, 25, 50, 75 or 100% quinoa meal were evaluated by ten members of stuff of food science and technology department in national research center. The results presented in Table (11) showed that effect of wheat flour replacement by 25 or 50% of quinoa meal on cake characteristics. Results indicated negligible difference between control and sample contained 25 or 50% quinoa meal on (highest, taste, crust color, odor, crumb structure, texture, and general appearance) compared to control. While, quinoa meal replacement with 75% had no significant differences on properties of (highest, taste, crust color, odor, crumb structure, texture, and general appearance) compared to control, but sample was contained 100% quinoa meal had slightly lower scores in cake properties of (highest and taste) compared to 100% wheat flour sample. Mean while the other properties haven't significant effects.

Table 11: Influence of quinoa meal addition on sensory evaluation of cake

Cake sample	*Highest*	*Taste*	*Crust color*	*Odor*	*Crumb grain*	*Texture*	*General appearance*
	15	30	10	10	10	15	10
100% wf	15.0^{a}	29.4^{a}	9.8^{a}	9.5^{a}	9.9^{a}	14.8^{a}	9.9^{a}
25% q + 75% w	14.8^{a}	28.5^{a}	9.5^{a}	9.3^{a}	9.5^{a}	14.5^{a}	9.6^{a}
50% q + 50% w	14.6^{a}	28.4^{a}	9.7^{a}	9.2^{a}	9.4^{a}	14.3^{a}	9.5^{a}
75% q + 25% w	14.5^{b}	27.8^{b}	9.5^{a}	9.3^{a}	9.3^{b}	14.2^{a}	9.2^{b}
100% q	14.3^{b}	26.4^{c}	9.2^{b}	9.2^{a}	9.2^{b}	13.8^{b}	8.9^{c}
L.S.D.	0.51	1.32	0.50	0.95	0.6	0.92	0.50

Where: 100% (wf) = wheat flour, (25% q + 75% w) = 25% quinoa meal + 75% wheat flour, (50% q + 50% w) = 50% quinoa meal + 50% wheat flour, (75% q + 25% w) = 75% quinoa meal + 25% wheat flour, (100% q) = 100% quinoa meal.

Replacement of flour with 25, 50 and 75% quinoa meal impaired the taste of cakes (control samples had 29.4 score), which slightly decreased from 28.5 to 26.4. The control samples had a maximum overall acceptance, whereas cakes containing levels from 25% to 100% quinoa meal possessed significant lower values. At all levels of substitution by quinoa meal the crust colors were insignificant differences among samples and control (at $p<0.05$).

With respect to the sensory evaluation, the organoleptic characteristics of cakes samples made from wheat flour and different levels of quinoa meal are acceptable to customers, while the organoleptic characteristics of cakes samples made from wheat flour and quinoa meal more than 75% possessed lower significant values in all sensory properties of cake compared to the control sample. Similar observations were also reported with supplementation of rice bran-fenugreek blends flour **(Sharma and Chauhan, 2002),** fenugreek flour **(Hooda and Jood, 2005)** and bean flour **Abou-Zaid et al., (2011)** with wheat flour.

Cakes prepared quinoa meal at any level addition received non significantly difference for color, taste, odor and texture with the highest acceptability. Therefore, it could be concluded that quinoa meal could be incorporated up to 100% level in the formulation of cake without affecting their sensory qualities.

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Color Characteristics:

Color characteristic is a major criterion that affects the quality of the final product. The fortified flours blends showed a difference in color compared to the control (100% wheat flour). The slight improvement in color was interpreted as an intense color and it was dependant on the fortification level. Mean color values of biscuit of different treatments are recorded in Table (12). Data in the same table showed Hunter values of whiteness (L), redness (a) and Yellow (b) measured for upper surfaces colors. All fortified samples had slightly lower L values for crust than the control. All biscuits incorporating quinoa meal, had lower crust L values than the control, indicating darker color, it was due to dietary fiber level increased and color of quinoa meal was yellowish white. These results are in coincidence and confirmed with that obtained by **Saricoban and Yilmaz (2010).** Increasing the percentage of added quinoa meal to wheat flours, led the values of whiteness (L), redness (a) and Yellow (b), to be slightly increased in all fortified samples. Subjective evaluations confirmed that the quinoa meal biscuits samples were darker, more red (a-values) than control samples. The results showed that the a-values (redness) increased in the fortified biscuit samples with the increasing of quinoa meal level from 0% to 100% (Table 12). The results are consistent with that obtained by **Abou-Zaid et al., (2012).**

Table 12: Color characteristics of biscuit samples

Biscuit sample	*L*	*a*	*b*
100% wf	58.40	11.44	21.34
25% q + 75% w	57.59	11.59	19.41
50% q + 50% w	56.05	11.85	17.31
75% q + 25% w	55.11	12.10	15.32
100% q	53.42	12.24	14.60

Where: 100% (wf) = wheat flour, (25% q + 75% w) = 25% quinoa meal + 75% wheat flour, (50% q + 50% w) = 50% quinoa meal + 50% wheat flour, (75% q + 25% w) = 75% quinoa meal + 25% wheat flour, (100% q) = 100% quinoa meal.

Color characteristic is a major criterion that affects the quality of the final product. The fortified flours blends showed a difference in color compared to the control (100% wheat flour). The slight improvement in color was interpreted as an intense color and it was dependant on the fortification level. Mean color values of cake of different treatments are recorded in Tables (13). Table (13) shows Hunter values of whiteness (L), redness (a) and Yellow (b) measured for crust and crumb color. All fortified samples had slightly lower L values for crust than the control. All cake incorporating quinoa flour, had lower crust L values than the control, indicating darker color, it was due to dietary fiber level increased and the color of quinoa meal was yellowish white. There results are in coincidence and confirmed with that obtained by **Saricoban and Yilmaz (2010)** and **Abou-Zaid et al., (2012).** Increasing the percentage of added quinoa meal to wheat flours, led the values of whiteness (L), redness (a) and Yellow (b), to be slightly increased in all fortified samples.

Subjective evaluations confirmed that the quinoa meal cakes samples were darker, more red (a-values) than control samples. The results showed that the a-values (redness) increased in the fortified cakes samples with the increasing of quinoa meal level from 0% to 100%. The results are consistent with that obtained by **Abou-Zaid et al., (2012).**

Table 13: Color characteristics of cake crust and cake crumb color samples

	Crust color			*Crumb color*		
	L	a	b	L	a	b
100% wf	50.12	11.72	12.85	66.71	1.41	15.85
25% q + 75% w	48.01	11.60	13.45	66.00	1.38	18.68
50% q + 50% w	46.26	11.49	15.00	65.70	1.35	21.65
75% q + 25% w	42.63	11.41	15.61	64.21	1.31	24.85
100% q	39.21	11.30	15.75	63.82	1.27	27.30

Where: 100% (wf) = wheat flour, (25% q + 75% w) = 25% quinoa meal + 75% wheat flour, (50% q + 50% w) = 50% quinoa meal + 50% wheat flour, (75% q + 25% w) = 75% quinoa meal + 25% wheat flour, (100% q) = 100% quinoa meal.

4. Conclusions

The results obtained indicated that quinoa meal can be blended with wheat flour at levels as high as 75% without adversely affecting baking performance of salt-biscuit and pan cake, but with 100% of quinoa meal sample was acceptable with slightly differences compared control in cake sample. However, the addition of quinoa meal as a wheat substitute to produce gluten free bakery products to wheat flour affected the rheological, color and sensory characteristics of salt-biscuits and pan cake in various ways. Salt-biscuits involved 75% quinoa meal and pan cake containing quinoa meal 100% with low significant difference in sensory properties there were gluten free and acceptable. The quinoa meal showed that gluten, which plays a very important role in improving rheological, technological and sensory properties of baking products, could be used for produce bakery products as salt-biscuits and pan cake for celiac and autism stuffs. These studies have shown the potential for produce gluten free (salt-biscuits and pan cake).

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