Nutritional Properties, bioactive compounds content and rheological analysis of Quinoa (*Chenopodium quinoa*) seeds flour: Application in Cake

Areeg S. Aly and Ragaa A. Sadeek

Department of Home Economics, Faculty of Specific Education, Minia University, Minia, Egypt

Abstract: Quinoa (*Chenopodium quinoa* Willd, Family: *Chenopodiaceae*), has been cultivated in the American continent for several thousand years, being one of the main grain crops supplying highly nutritious food for the peoples. The nutritional characteristics and healthy benefits of quinoa, its rusticity, its wide adaptability and its multiple uses, explain the interest in the crop not only in American continent but also worldwide. In the present study, quinoa seeds were milled, sieved to obtain flour by 91% extraction rate. Quinoa seeds flour (QSF) was chemically analyzed and incorporated into cake at two different levels, 10 and 20% as a potential source of nutrients and bioactive compounds as well as enhancement the dough quality. Chemical analysis indicated that the protein, fat, fiber and ash of QSF were recoded 15.77, 6.74, 3.53 and 3.61 g/100 g dry wt, respectively higher than that of wheat flour were 11.10, 1.54, 1.89 and 1.86 (g/100 g dry wt). Also, total phenolic compounds (mg GAE/100 g), flavonoids (mg /100 g) and carotenoids (mg /100 g) in QSF have been reported to be 65.87 , 29.21 and 1.32 which are higher than that in wheat flour (WF) sample 31.09, 10.05 and 0.11, respectively. So, incorporation of cake samples with 10 and 20% of QSF leads to increase in all of those bioactive compounds by highly significantly ($p \leq 0.01$) rates. Additionally, significant ($P \leq 0.05$) improvements in rheological properties of cake dough including farinograph and extensograph parameters were reported by QSF incorporation. The QSF incorporated cake up to 20% doesn't affect on its organoleptic evaluation parameters. In conclusion, the results suggest that quinoa is promoted as an extremely healthy food. The effects of the dietary bioactive compounds such as rich in QSF and QSF incorporated cake are of a great current interest due to their antioxidative, anti-inflmmatory, antibacterial and anticarciongenic activities.

Keywords: Quinoa seeds flour, chemical composition, total phenolic compounds, carotenoids, cake dough, organoleptic evaluation.

Introduction

Quinoa (*Chenopodium quinoa* Willd) belongs to the Goosefoot family "*Chenopodiaceae*". It is distributed worldwide and includes 250 varieties. Such as reported by Gordillo-Bastidas *et al.*, (2016) quinoa classification is based on the color of the plant and fruits, or on plant morphology. Quinoa is widely distributed in Europe, North America, Asia and Africa coumtries including Egypt. The project “Quinoa: a multipurpose crop for the European Community”in Europe was approved since 1993 (Vega-Gálvez *et al.*, 2010). The economical part of the quinoa plant is the seeds which were traditionally, roasted and cooked, added to soups, used as a cereal, and even fermented into beer or chichi (traditional drink of the Andes) (Cooper, 2015 and

Gordillo-Bastidas *et al.*, 2016). It has been used in traditional folk medicine because of its role in treating a number of diseases and conditions, including reduced total cholesterol and LDL, increased glutathione anti-obesity, anti-hyperglycemic effects, efficient gluten-free diet for celiac disease and neuroprotective effects (Jenkins *et al.*, 2008; Ross *et al.*, 2011; McRae, 2013; De Carvalho *et al.*, 2014 and Zevallos *et al.*, 2014).Quinoa considerably health-beneficial and positive effects on metabolic, cardiovascular and gastrointestinal health in humans due to the high amount of phytochemicals including saponins, phytosterols, phytoecdysteroids (Navruz-Varli and Sanlier,2016).

It is known that quinoa has remarkable nutritional properties; not only from its protein content (15%) but also has rich fiber and has an higher contents of essential amino acids especially lysine, it considered an oil crop it is exceeds cereals in the amount of lipids with an interesting proportion of omega-6. It is an important source of vitamins B1, B2, B6, C and notable vitamin E, minerals main calcium, phosphorus, iron and zinc and has also found to contain compounds like polyphenols, and flavonoids. It has some functional (technological) properties like solubility, water-holding capacity (WHC),the potential of quinoa seeds as a valuable ingredient in the preparation of highly nutritious foods that allow diversified uses (Abugoch, 2009 ; Stikic *et al.*,2012 ; Navruz-Varli and Sanlier, 2016 and Maradini-Filho, 2017).

Bakery products such Cakes represent one of the most popularly consumed bakery items in almost countries all over the world including Egypt because of their ready to eat nature, affordable cost, good nutritional quality and availability in different tastes (Érica *et al.*, 2010). Many studies were carried out on the use of oat bran, wheat bran, rice bran as a source of dietary fiber content in bread and other bakery products as well as the influence of these different cereal brands on sensory characteristics of cakes (Sidhu *et al.*, 1999, Sudha *et al.*,2007 and Emad, 2013). But other studies reported that quinoa dietary fiber concentrates have better nutritional quality than those found in other cereals due to higher proportion of soluble dietary fiber and significant content of dietary fiber associated antioxidant compounds (Geyang, 2015 and Gordillo-Bastidas *et al.*, 2016). According to our knowledge studies on the quinoa flour properties and bioactive compounds source are limited. Therefore, the objectives of this work were to prepare cakes with different proportions of quinoa and wheat flours, to characterize their nutritional value, bioactive compounds and rheological analysis and to evaluate the cakes acceptance by consumers.

Materials and Methods

Materials

Ingredients used in the preparation of cakes included whole quinoa seeds flour, wheat flour, fresh eggs, refined sugar, chemical baking powder, vegetable oil , milk and salt were purchased from the local markets of Minia City, Egypt.

Chemicals

Phenolic standards (α-tocopherol, BHA, BHT) and β-carotene were purchased from Sigmae-Aldrich Chemical Co agent, Egypt; linoleic acid was from J.T. Baker

Chemical Co., Phillipsburg, NJ, and Tween 20 was from BDH Chemical Co., Toronto, On. All other chemicals and solvents were of analytical Grade and purchased from AlGhomhoria Co., for Trading Drugs, Chemicals and Medical Instruments, Cairo, Egypt.

Methods

Preparation of quinoa seeds flour (QSF)

Seeds of quinoa were dried using conventional oven (20 minutes, 120 °C). Following natural cooling to room temperature (23 ^{0}C), the seeds were ground in a high mixer blender (Toshiba El Araby, Benha, Egypt) and sieved (750 µm mesh). Flour samples were taken, stored in plastic bags and kept in a freezer at -20 °C for further physical and chemical analyses as well as using in cake preparation.

Cake preparation

The cakes were prepared immediately after the flour preparation, following a sujested formulation by Érica *et al.*, (2010) with the addition of two different levels of QSF. The ingredients utilized in the cake preparation in gram were as follow: 256g WF, 28.4 QSF, 145g sugar, 30g baking powder, 60g oil, 150g egg, 60 ml milk (for formulation with 10% QSF) and 228.1g wheat flour, 56.8 QSF, 145g sugar, 30g baking powder, 60g oil, 150g egg, 60 ml milk (for formulation with 20% QSF). The ingredients egg yolk, sugar, and vegetable oil were homogenized with an electric mixer (Toshiba ElAraby, Benha, Egypt) at medium speed for 5 minutes; next, flour preparation, salt, and milk were added to the mixture. The mixture was homogenized until it was uniform in consistency, and the baking powder was added. The egg whites were incorporated into the cake batter which was placed into aluminum pans, previously oiled and sprinkled with WF. The resulted cakes were baked in a conventional oven pre-heated to 185 °C for 20 minutes. Cakes were taken, wrapped in plastic bags and kept in a freezer at -20 °C for chemical analysis.

Chemical analysis of QSF and cake samples

QSF and cake samples were analyzed for moisture, protein (TN× 6.25, micro - Kjeldahl method using semiautomatic apparatus, Velp company, Italy), fat (Soxhelt semiautomatic apparatus Velp company, Italy, petroleum ether solvent), ash and fiber contents were determined using the methods described in the A.O.A.C. (1995). Carbohydrates calculated by differences:

Carbohydrates (%) = 100 - (% moisture + % protein + % fat + % Ash + % fiber)

Water (WHC) and oil (OHC) holding capacity of QSF

Water (WHC) and oil (OHC) holding capacity were determined according to the method of Larrauri *et al.*, (1996). Twenty-five milliliters of distilled water or commercial corn oil were added to 0.5 g of QSF, shacked vigorously for 1 min and then centrifuged for 15 min at 10,000g. The residue was weighed and the WHC and OHC were calculated as g water or oil per g of dry sample, respectively.

Rheology properties measurements

Both WF control sample and samples with additions of QSF were determined by using of farinograph and extensograph tests according to the methods of A.A.C.C. (1969). Farinograph test was carried out on a Brabender R Farinograph (Brabender R GmbH & Co, Duisburg, Germany) to determine the water absorption, dough

development time, dough stability and dough weakening of WF control sample and samples with additions of QSF such as described in Elhassaneen *et al.*,(2014). Extensograph test was carried out on a Brabender R Extensograph (Brabender R GmbH & Co, Duisburg, Germany) to determine the maximum resistance to extension extensibility and strength of the dough (energy) of WF control sample and samples with additions of QSF such as described in Elhassaneen *et al.*, (2014).

Determination of total phenolics, carotenoids, total dietary fiber and antioxidant activity

Total phenolics, carotenoids and Total dietary fiber in QSF and cakes samples were analyzed as follow: QSF was extracted with 80% acetone and centrifuged at 10,000g for 15 min. For cakes samples, one gram of cakes powder was extracted with 20 ml of 80% acetone and centrifuged at 8000g at room temperature. The supernatant obtained from both samples were used for the analysis of total phenolics, carotenoids and antioxidant activity.

Total phenolics were determined using Folin-Ciocalteu reagent (Singleton and Rossi, 1965). A 200 mg of sample was extracted for 2 h with 2 mL of 80% MeOH containing 1% hydrochloric acid at room temperature on an orbital shaker set at 200 rpm. The mixture was centrifuged at 1000g for 15 min and the supernatant decanted into 4 mL vials. The pellets were combined and used for total phenolics assay. One hundred microliters of extract was mixed with 0.75 mL of Folin-Ciocalteu reagent (previously diluted 10-fold with distilled water) and allowed to stand at 22 ^{0}C for 5 min; 0.75 ml of sodium bicarbonate (60 g/L) solution was added to the mixture after 90 min at 22 0C, absorbance was measured at 725 nm. Results are expressed as ferulic and equivalents. The total carotenoids in 80% acetone extract were determined by using the method reported by Litchenthaler, (1987). Total dietary fiber content in the QSF was estimated according to the method described by Asp *et al.*, (1983).

Antioxidant activity of QSF, cakes samples extract and standards was determined according to the β-carotene bleaching method following a modification of the procedure described by Marco, (1968). For a typical assay, 1mL of β-carotene solution, 0.2 mg/mL in chloroform, was added to round-bottom flasks (50 mL) containing 0.02 mL of linoleic acid and 0.2 mL of Tween 20. Each mixture was then dosed with 0.2 mL of 80% MeOH (as control) or corresponding plant extract or standard. After evaporation to dryness under vacuum at room temperature, oxygenated distilled water (50 ml) was added and the mixture was shaken to form a liposome solution. The samples were then subjected to thermal auto-oxidation at 50 0C for 2 h. The absorbance of the solution at 470 nm was monitored on a spectrophotometer (Beckman DU-50, Tokyo, Japan) by taking measurements at 10 min intervals, and the rate of bleaching of β-carotene was calculated by fitting linear regression to data over time. All samples were assayed in triplicate. Various concentrations of BHT, BHA, and α-tocopherol in 80% methanol was used as the control. Antioxidant activity (AA) was calculated as percent inhibition relative to control using the following equation (Al-Saikhan *et al.*, 1995).

$$AA= (R_{control} - R_{sample}) / R_{control} \times 100$$

Where: $R_{control}$ and R_{sample} were the bleaching rates of beta-carotene in reactant mixture without antioxidant and with plant extract, respectively.

Sensory evaluation of cake

The sensory characteristics of control cake and that incorporated with QSF were conducted to determine the acceptability of the product. Cakes samples were presented in a sealed pouch coded with different numbers to twenty panelists who were asked to rate each sensory attribute. Cakes were evaluated for crust appearance, crust colour, texture, taste and flavor, mouth feel and overall acceptability on a 10-point hedonic scale.

Statistical analysis

All data of antioxidant activity tests was the average of triplicate analyses. The data were recorded as mean ± SD. Significant differences between means were determined by student's-*t* test, *p* values ≤ 0.05 were regarded as significant.

Results and Discussion

Chemical analyses of quinoa seed flour (QSF) and wheat flour (WF)

Table 1. Proximate composition (g /100 g) and total energy (Kcal /100 g) of QSF and WF.

Component	QSF	WF
Moisture	7.12 ± 0.96	8.56 ± 1.11
Total protein	15.77 ± 0.42	11.10 ± 1.24
Crude fat	6.74 ± 0.11	1.54 ± 0.78
Crude fiber	3.53 ± 1.02	1.89 ± 0.88
Ash	3.61 ± 0.44	1.86 ± 0.49
Carbohydrates (by difference)	63.23 ± 3.51	75.05 ± 5.03
Total energy	377 ± 3.68	358 ± 4.19

Each value represents the mean of three replicates ±SD.

The proximate chemical compositions of QSF and WF are shown in Table (1). The results showed that the moisture, protein, fat, fiber, ash and total carbohydrates content of QSF were recoded 7.12, 15.77, 6.74, 3.53, 3.61 and 63.23 g/100 g dry wt, respectively higher than that of WF were 8.56, 11.10, 1.54, 1.89, 1.86 and 75.05 (g/100 g). The total energy (Kcal.100 g) of QSF and WF was 377 and 358, respectively.

The present data are in accordance with Stikic *et al.*, (2012) who confirmed that seed was remarkably good in protein content ranging from 15.16 to 17.41 % on a dry weight basis and in the same line with Ogungbenle,(2003) who reported that quinoa flour contained 13.5% protein, 1.2% total ash and 58.3% carbohydrate. In general, the present data reflected the quinoa properties; it is a promising alternative cultivar and could be used successfully in food technology applications due to its high nutritional value (Abugoch, 2009).

Table 2. Bioactive compounds content of QSF and WF

Component	QSF	WF
Total phenolic compounds (mg GAE/100 g)	65.87 ± 10.67	31.09 ± 8.32
Total flavonoids (mg /100 g)	29.21 ± 6.73	10.05 ± 2.94
Total carotenoids (mg /100 g)	1.32 ± 0.19	0.11 ± 0.06

Each value represents the mean of three replicates ±SD.

The bioactive compounds content of QSF and WF is shown in Table (2). Also, total phenolic compounds (mg GAE/100 g), flavonoids (mg /100 g) and carotenoids (mg /100 g) in QSF have been reported to be 65.87 , 29.21 and 1.32 which are higher than that in WF 31.09, 10.05 and 0.11, respectively.

Data of total phenolic compounds was highest than result by Repo-Carrasco-Valencia *et al.*, (2010) was (41.87 mg GAE 100 g^{-1}). On other hand result was lower than that observed by Nickel *et al.*, (2016) that the phenolic compound content in nature quinoa grains was (97.60 mg GAE/100 g) and (87.2 mg GAE/100 g^{-1}) quinoa extracts (Rocchetti *et al.*, 2017).The difference in the phenolic concentration causes by the difference in the environmental conditions such as temperature or genetic background. In general Phenolic compounds in grains have antioxidant properties that are related with the health benefits of grains and grain products (Repo-Carrasco-Valencia *et al.*, 2010).

Physical properties of QSF and wheat flour

Table 3. Physical properties of QSF and WF

Parameters	QSF	WF
Water holding capacity (WHC, g H_2O /.g^{-1})	7.34 ± 0.55	6.03 ± 0.42
Oil holding capacity (OHC, g oil /g^{-1})	3.65 ± 0.39	2.72 ± 0.39

Each value represents the mean of three replicates ±SD.

The water (WHO) and oil (OHC) holding capacity of QSF and WF were listed in Table (3). From such data it could be noticed that QSF recorded higher WHC and OHC being 7.34 ± 0.55 g $H_2O.g^{-1}$ and 3.65 ± 0.39 g oil.g^{-1}, respectively than WF which recorded 6.03 ± 0.42g $H_2O.g^{-1}$ and 2.72 ± 0.39 g oil.g^{-1}. QSF has rich fiber and Sharoba, *et al.,(2013*) explain that water holding capacity (WHC) and oil-holding capacity (OHC)are an important physical characteristics affecting the quality of manufactured foods. The properties WHC have been shown to be closely related and are mainly determined by the food content (like dietary fiber).

Effect of QSF on the rheological parameters of flour cakes

Farinograph parameters

Data in Table (4) showed that all farinograph parameters of WF and WF substituted with 10 and 20% QSF. The incorporating of tested QSF in dough increased the water absorption, arrival time, dough development time, dough stability and farinograph quality number for dough contained 10 and 20% QSF. This increment dough water absorption may be due to high content of dietary fiber in QSF which with significant difference with control. The increasing in dough development time and dough stability increased with 10 and 20% incorporation of QSF may be due to high content of dietary fibers in QSF and pectin which act as a food hydrocolloid. Dough stability in minutes is the most important index for dough strength. The present data are in accordance with Ogungbenle,(2003) and Tömösközi *et al.*, (2011) whose confirmed that the flour of quinoa has a high water absorption capacity and low foaming capacity and stability that increase of water absorption capacity depended on the proportion of quinoa flour in comparison to wheat flour.

Table 4. Farinograph parameters of the control and composite flour cakes

Treatment	Water	Arrival	Dough	Dough	Farinograph

	absorption (WA, %)	time (AT, min)	development time (DDT, min)	stability (DS, min)	quality number (FQN)
Control cakes (CC)	55.11 ± 0.98 [c]	1.2 ± 0.10 [c]	2.9 ± 0.11 [b]	3.98 ± 0.33 [b]	139 ± 2.6 [c]
CC + 10% QSF	61.41 ± 1.11 [b]	2.12 ± 0.29 [b]	3.7 ± 0.61 [b]	6.10 ± 0.79 [ab]	153 ± 3.9 [b]
CC + 20% QSF	65.31 ±2.05 [a]	3.04± 0.38 [a]	4.5 ± 0.44 [a]	7.21 ± 1.03 [a]	162 ± 5.8 [a]

Each value represents the mean of three replicates ±SD. Mean values with the different letters in the same column mean significantly different at level p≤0.05.

Addition of QSF to flour samples showed markedly longer stability periods than the control samples (flour without addition of QSF). This affect was significantly with the addition of 10 and 20% of QSF for WF. This affect could be attributed to the effect of QSF addition on the quality of protein and dietary fiber flour in particular the binding force property. From the dough farinograph quality number (QSF), statistically significant difference was found between the control sample and the dough with additions of 10 and 20% of QSF. It is meaning that an improvement in the quality of the dough occurred after the addition of 10 and 20% of QSF, when the QSF value significantly increased in comparison with the control sample. The result agree with Chauhan *et al.*,(1992) who reported that presence of quinoa in the blend had a marked effect on dough mixing properties and dough development time.

Extensograph parameters

Table 5. Extensograph of the control and composite flour cakes

Treatment	Extensibility (mm)	Relative resistance to extension (BU)	Proportional number	Energy (cm^2)
Control cakes (CC)	159 ± 4.2 [c]	498 ± 9.3 [b]	2.50 ± 0.20 [a]	103 ± 5.32 [c]
CC + 10% QSF	179 ± 3.2 [b]	531 ± 7.4 [a]	2.84 ± 0.42 [b]	115 ± 4.87 [b]
CC + 20% QSF	191 ± [1.9a]	543 ± 7.5 [a]	2.98 ± 0.35 [b]	126 ± 1.88 [a]

Each value represents the mean of three replicates ±SD. Mean values with the different letters in the same column mean significantly different at level p≤0.05.

Extensograph results of WF control dough and dough's with additions of QSF were tabulated in Table (5). The incorporating of QSF in dough increased the extensibility, relative resistance to extension, proportional number and energy for dough contained 10 and 20% of QSF. The effect of QSF on increasing the extensibility of the WF may be due to the alteration of the viscosity (Kent-Jones and Amos, 1967) and forced the gluten network (Abdel-Hamid *et al.*, 1986). Also, several reports suggest that different plant parts by-products such as QSF have antioxidant activity which could be easily prevented the oxidation process usually decreases dough extensibility (Geyang, 2015 and Gordillo-Bastidas *et al.*, 2016). Finally, data of the rheological studies reported that in order to improve the quality of bakery products such cakes additions of the QSF by up to 20% to dough are recommended.

Content of dietary fiber, carotenoids and total phenolics in QSF incorporated cakes

Table (6): Content of dietary fiber, carotenoids and total phenolics in QSF incorporated cakes

Treatment	Total dietary fiber ($g.100g^{-1}$)	Total carotenoids ($mg.100\ g^{-1}$)	Total phenolics ($mg\ EGA.100g^{-1}$)

QSF	31.26 ± 3.30	1.32 ± 0.19	65.87 ± 10.67
Control cakes (CC)	6.32±1.45 [c]	3.11± 0.76 [b]	87.54±6.65 [b]
CC + 10% QSF	9.14±0.76 [b]	4.06±0.66 [ab]	92.45±4.87 [ab]
CC + 20% QSF	11.87±0.89[a]	5.13±1.10 [a]	100.32±5.83 [a]

Each value represents the mean of three replicates ±SD. Mean values with the different letters in the same column mean significantly different at p≤0.05.

Data in Table (6) indicated that increased incorporation of QSF in the cakes formulated exhibited increased total dietary fiber (TDF), total carotenoids and total phenolics content. The TDF, total carotenoids and total phenolics contents were 6.32±1.45 g.100g^{-1}, 3.11± 0.76 mg.100 g^{-1} and 87.54±6.65 mg EGA.100g^{-1} in control cakes which increased to 11.87±0.89 g.100g^{-1}, 5.13±1.10 mg.100 g^{-1} and 100.32±5.83 mg EGA.100g^{-1} with the incorporation of QSF by 20%.

Beside the dietary fiber contributed by the QSF some other factors contributed to the formation of additional dietary fiber in cakes enriched samples. Those factors include oxidative enzymes like peroxidase and polyphenol oxidase catalyse the formation of cross-links between carbohydrates like arabinoxylans, also between carbohydrate and side chains of amino acids in protein via phenolic molecules like ferulic acid. Regarding the carotenoids, the increasing in total carotenoids content in cakes is partially due to the total carotenoids content contributed by the QSF. Finally, the total phenolics content in the control and treated cakes, data showed that incorporation of QSF increased the content of total phenolics in the treated cakes samples.

Antioxidant activity of QSF enriched cakes

Table (7) shows the antioxidant activities of control and enriched QSF cakes. The antioxidant activity (AA) in control cakes was 35.89 ± 5.11 % which increased to 45.67 ± 4.31 and 53.45 ± 3.98% with the incorporation of QSF by 10 and 20%, respectively. QSF enriched cakes showed strong activity probably due to its high bioactive compounds content including carotenoids, phenolics and flavonoids. The effects of dietary polyphenols are of great current interest due to their antioxidative (Dini *et al.*, 2005).

Table 7. Antioxidant activity of QSF enriched cakes

Treatment	Antioxidant activity AA (%)
QSF	78.56 ± 4.67
Control cakes (CC)	35.89 ± 5.11 [c]
CC + 10% QSF	45.67 ± 4.31 [b]
CC + 20% QSF	53.45 ± 3.98[a]

Each value represents the mean of three replicates ±SD. Mean values with the different letters in the same column mean significantly different at p≤0.05.

Sensory evaluation of cakes enriched with QSF

Table 8. Sensory evaluation of cakes incorporated with QSF

Treatment	Crust	Crust	Texture	Taste and	Mouth feel	Overall

	appearance	colour		Flavor		acceptability
Control cakes (CC)	9.21±0.14 [a]	8.61±0.81 [a]	8.15±0.40 [a]	8.50±0.34 [a]	9.01±0.33 [a]	9.26±0.15 [a]
CC + 10% QSF	8.80±0.30 [ab]	8.38±1.06 [a]	7.84±0.33 [a]	8.61±0.10 [a]	8.33±0.55 [a]	8.89±0.60 [a]
CC + 20% QSF	7.62±0.42 [b]	7.93±0.34 [a]	7.59±0.25 [ab]	8.20±0.56 [a]	8.10±0.37 [a]	8.69±0.43 [a]

[e] Each value represents the mean of ten replicates ±SD. Mean values with the different letters in the same column mean significantly different at p≤0.05.

Control cakes (CC) CC + 10% QSF CC + 20% QSF

Figure 1. Photo of cakes mixed with QSF

Results of sensory evaluation of cakes incorporated with QSF in terms of appearance, colour, texture and flavor, mouth feel and overall acceptability are presented in Table (8) and Figure (1). Colour, texture, taste and flavor, mouth feel and overall acceptability were not significantly different between the control and QSF cakes. Broyart *et al*., (1998) reported that the initial acceptance of baked products is much influenced by colour, which can also be an indicator of baking completion. The desirable colour of cakes is mainly due to the Millard browning during baking. However, in QSF cakes, the colour could be partially contributed by the phenolics and carotenoids in QSF flour which imparts a yellowish/brownish colour to the cakes. Similar observations were reported in a study by Brennan *et al.,* (2001) who observed that an increased flour and thus muffin visual lightness (with more yellowness and brownness) yield a higher aroma, texture and colour acceptability scores.

Also, in such data there was no significant difference in texture amongst the different samples with different composite flour cakes types. This observation could be due to the small percentage of wheat flour substitution in the cakes formulation, which did not affect the gluten network in the dough nor the development of an open internal structure upon baking. Furthermore, no significant difference was observed in terms of taste and flavor between the control and QSF cakes. This could probably be due to the

nature of QSF which did not impart any additional flavor to the cakes. Finally, there was no significant difference in term of overall acceptability among the control and QSF cakes. This could be attributed to the close resemblance of the cakes types in terms of the colour and taste/flavor of the commercial cakes in the market.

In conclusion, the purpose of using quinoa flour in cake making was replacement of traditional ingredients by introducing new foods to improvement the nutritive value of the end product.Chemical composition of QSF showed that it is a good source of protein, dietary fibers, energy and bioactive compounds such as total phenolics. Incorporation of QSF with cakes flour improved the rheological properties of the dough including farinograph and extensograph parameters subsequently their baking characteristics. Cakes samples enriched with QSF showed higher dietary fiber and total phenolics content than the control cakes. Increasing of such bioactive compounds in cakes samples exhibited significant improving in their antioxidant activity. The QSF incorporated cakes up to 20% doesn't effect on their sensory evaluation parameters/quality.

References

A.A.C.C. (1969). Approved Methods of the American Association of Cereal Chemists. Published by American Association of Cereal Chemists. Ins. St. Paul. Minnesota, MI.

A.O.A.C. (1995). "Official Methods of the Association of Official analytical Chemists" 16 th Ed. Published by the Association of Official Analytical Chemists. Arlington, Virginia, USA.

Abdel-Hamid, N.; Osman, A.; Mervat, A. and El-Farra, A. (1986). Effect of addition broad bean flour on rheological properties of dough and baking quality of balady bread. Egypt. J. Food Sci., 14 (2): 429 - 434.

Abugoch, L.E. (2009). Quinoa (Chenopodium quinoa Willd.). Adv Food Nutr Res 58:1-31.

Al-Saikhan, M. S.; Howard, L. R. and Miller, J. C.(1995). Antioxidant activity and total phenolics in different genotypes of potato (Solanum tuberosum, L.). J. Food Sci., 60 (2), 341-347.

Asp, N.G.; Johnson, C.G.; Hallomer, H. and Siljestrom, H. (1983). Rapid enzymatic assay of insoluble dietary fiber. Journal of Agricultural and Food Chemistry, 31, 476-482.

Brennan, J.; Norris, D.; Rodriguez, T.; Beddington, R. and Robertson, E. (2001). Nodal signaling in the epiblast patterns the early mouse embryo. Nature, 411: 965-969.

Broyart, B.; Trystramkinetic,G. and Duquenoy,A. (1998). Predicting colour kinetics during cracker backing. J Food Eng, 35(3): 351-368.

Chauhan, G.S.; Zillman, R.R. and Michael, N.A.(1992). Dough mixing and breadmaking properties of quinoa-wheat flour blends. Intc~rnational Journul of' Food Science and Teclinology. 27: 701 -705.

Cooper, R. (2015). Re-discovering ancient wheat varieties as functional foods. J Tradit Complement Med 5: 138-143.

De Carvalho, F.G.; Ovidio, P.P.; Padovan, G.J.; Jordao Junior, A.A., and Marchini, J.S.(2014). Metabolic parameters of postmenopausal women after quinoa or corn flakes intake- a prospective and doublé-blind study. Int J Food Sci Nutr 65: 380-385.

Dini, I.; Tenore, G.C. and Dini, A. (2005): Nutritional and antinutritional composition of Kancolla seeds: an interesting and underexploited andine food plant. Food Chemistry, 92: 125–132.

Elhassaneen,Y.; Abd Elhady, Y. and Mohamed, N. (2014). The Use of Gum Arabic from Acacia Tree (Acacia senegal), a Food Additive to Improve the Nutritional and Rheological Properties of Wheat Flour Dough. Life Sci J ., 11(4):385-393.

Emad, A. H, (2013). Technological studies on some vegetables and fruits peels and their utilization on rasing the nutritional values of child foods" Ph.D. Thesis in Nutrition and Food Science, Faculty of Home Economics, Minoufiya University, Egypt.

Érica, A.M.;, Maria, I.S.; Dayane, C.M.; Cassiano, O.S.; Fátima, A.F.; Hércia, S.D. and Sônia, M.R. (2010). Sensory evaluation and nutritional value of cakes prepared with whole flaxseed flour. Ciênc. Tecnol. Aliment., Campinas, 30(4): 974-979.

Geyang, W. (2015). Nutritional Properties of Quinoa, In: Quinoa: Improvement and Sustainable Production, I st Ed. Edited by Kevin Murphy and Janet Matanguihan. John Wiley & Sons Inc. Washington, WA.

Gordillo-Bastidas, E.; Díaz-Rizzolo, D.A.; Roura, E.; Massanés, T. and Gomis, R. (2016). Quinoa (Chenopodium quinoa Willd), from Nutritional Value to Potential Health Benefits: An Integrative Review . J Nutr Food Sci., 6(3): 1-10.

Jenkins, D.J.; Kendall, C.W.; McKeown-Eyssen, G.; Josse, R.G. and Silverberg, J. (2008) Effect of a low-glycemic index or a high-cereal fiber diet on type 2 diabetes: a randomized trial. JAMA 300: 2742-2753.

Kent-Jones, D. and Amos, A. (1967). Modern cereal chemistry, Food Trade Press. LTD., London.

Larrauri, J.; Ruperez, P.; Borroto, B. and Saura-Calixto, F. (1996). Mango peels as a new tropical fibre: preparation and characterization. Lebensmittel-Wissenschaft–Food Science and Technology, 29(8): 729–733.

Lichtenthaler, H.K. (1987). Chlorophylls and carotenoids:Pigments of photosynthetic biomembranes.Methods Enzymol. 148:350-382.

Maradini-Filho, A.M.(2017) Quinoa: Nutritional Aspects. J Nutraceuticals Food. Sci., 2:1.

Marco, G. (1968). A rapid method for evaluation of antioxidants. J. Am. Oil Chem. Soc., 45:594-598.

McRae, M.P. (2013). Betaine supplementation decreases plasma homocysteine in healthy adult participants: a meta-analysis. J Chiropr Med 12: 20-25.

Navruz-Varli,S. and Sanlier, N.(2016).Nutritional and health benefits of quinoa (Chenopodium quinoa Willd.).Journal of Cereal Science. 69: 371-376.

Nickel, J.; Spanier,L.; Botelho,F.;Gularte,M. and Helbig,e.(2016). Effect of different types of processing on the total phenolic compound content, antioxidant capacity,and saponin content of Chenopodium quinoa Willd grainsFood Chemistry 209 (2016) 139–143.

Ogungbenle, H.N.(2003). Nutritional evaluation and functional properties of quinoa (Chenopodium quinoa) flourInternational Journal of Food Sciences and Nutrition. 54(2): 153-158.

Repo-Carrasco-Valencia, R.A.M.; Encina, C.R.; Binaghi, M.J.; Greco, C.B. and Ronayne de Ferrer, B.(2010). Effects of roasting and boiling of quinoa,kiwicha

and ka ˜ niwa on RAM Repo-Carrasco-Valencia et al composition and availability ofminerals in vitro. J Sci Food Agric 90: 2068–2073.

Rocchetti, G.; Chiodelli, G.; Giuberti, G.; Masoero, F.; Trevisan, M. and Lucini, L.(2017).Evaluation of phenolic profile and antioxidant capacity in gluten-free flours. Food Chem.1;228:367-373.

Ross, A.B.; Bruce , S.J.; Blondel-Lubrano, A.; Oguey-Araymon, S. and Beaumont, M. (2011). A whole-grain cereal-rich diet increases plasma betaine, and tends to decrease total and LDL-cholesterol compared with refined-grain diet in healthy subjects. British Journal of Nutrition 105: 1-12.

Sidhu, J.; Suad, N. and Al-Saquer, J. (1999). Effects of adding wheat bran and germ fractions on the chemical composition of high fiber toast bread. Food Chemistry, 67(4): 365–371.

Singleton, V. and Rossi, J. (1965). Colorimetry of total phenolics with phosphomolybdic-phosphotungstic acid reagents. Am. J. Enol. Vitic., 16: 144-158.

Sharoba, A.M.; Farrag, M.A., Abd El-Salam, A.M.(2013). Utilization of some fruits and vegetables waste as a source of dietary fiber and its effect on the cake making and its quality attributes Journal of Agroalimentary Processes and Technologies. 19(4): 429-444.

Stikic, R.; Demin, D.;Vucelic-Radovic, B.; Jovanovic, Z.; Milojkovic-Opsenica, D.; Jacobsen, S. and Milovanovic, M.(2012). Agronomical and nutritional evaluation of quinoa seeds (Chenopodium quinoa Willd.) as an ingredient in bread formulations. Journal of Cereal Science. 55 (2): 132-138.

Sudha, M.; Vetrimani, R. and Leelavathi, K. (2007). Influence of fibre from different cereals on the rheological characteristics of wheat flour dough and on biscuit quality. Food Chemistry, 100 (4): 1365–1370.

Tömösközi, S.; Gyenge, L.; Pelcéder, A.; Abonyi, T.; Schönlechner, R. and Lásztity, R.(2011). Effects of Flour and Protein Preparations from Amaranth and Quinoa Seeds on the Rheological Properties of Wheat-Flour Dough and Bread Crumb. Czech J. Food Sci. Vol. 29(2): 109–116.

Vega-Gálvez, A.; Miranda, M.; Vergara, J.; Uribe, E. and Puente, L. (2010). Nutrition facts and functional potential of quinoa (Chenopodium quinoa Willd.), an ancient Andean grain: a review. J Sci Food Agric 90: 2541-2547.

Zevallos, V.F.; Herencia, L.I.; Chang, F.; Donnelly, S. and Ellis, H.J. (2014). Gastrointestinal effects of eating quinoa (Chenopodium quinoa Willd.) in celiac patients. Am J Gastroenterol 109: 270-278.

الخصائص الغذائية والمحتوى من المركبات النشطة حيويا والتحاليل الريولوجية لدقيق بذور الكينوا: تطبيقات على الكيك

أريج سلامه على ، رجاء احمد صديق

قسم الاقتصاد المنزلى، كلية التربية النوعية، جامعة المنيا، المنيا، مصر

الملخص : تزرع بذور الكينوا في القارة الأمريكية منذ الأف السنين كونها واحدة من المحاصيل الرئيسية التي توفر غذاء صحى للشعوب. وكان يبستخدما الريفيون البسطاء لخصائصها الغذائية وفوائدها الصحية، وقدرتها علي التكيف واستخداماتها المتعددة مما يفسر الاهتمام بالمحصول ليس فقط في القارة الأمريكية ولكن أيضًا في جميع أنحاء العالم. في هذه الدراسة تم طحن ونخل بذورالكينوا للحصول على دقيق الكينوا (QSF) بنسبة استخراج ٩١%. وقد تم تحليلها كيميائياً ثم أضيفت الى الدقيق أثناء صناعة الكيك في مستويين مختلفين ١٠ ،٢٠ % كمصدر محتمل للمغذيات والمركبات النشطة حيوياً بالإضافة الى تحسين جودة العجين. تبين من التحليل الكيميائي لـQSF أن البروتين ،الدهون ،الألياف والرماد سجلت ١٥,٧٧ ،٦,٧٤ ،٣,٥٣ ،٣,٦١ (جم/١٠٠ جم وزن جاف) على التوالي وكانت أعلى من دقيق القمح ١١,١٠ ،١,٥٤ ،١,٨٩ ،١,٨٦ (جم/١٠٠ جم وزن جاف). وأيضا إجمالي المركبات الفينولية (GAE /١٠٠جم) والفلافونيدات (مجم /١٠٠جم) والكاروتينات (مجم/١٠٠جم) في (QSF) سجلت ٦٥,٨٧ ،٢١,٢٩ ،١,٣٢ وهي أعلى من تلك الموجودة في عينات دقيق القمح ٣١,٠٩ ،٠,٠٥ ،٠,١٠ ،٠,١١ على التوالي. لذا فأن دمج عينات الكيك مع ٢٠،١٠% من QSF يؤدي إلى زيادة في هذه المركبات النشطة حيوياً بزيادة معنوية ($p\leq0.01$). بالإضافة إلى ذلك زيادة تحسن في الخصائص الريولوجية لعجين الكيك($P\leq0.05$) بما في ذلك مؤشرات الفارينوجراف والأكستينسوجراف عند دمجQSF . لم يؤثر

إضافة QSF بنسبة ٢٠% للكيك علي معايير التقييم الحسية. في الختام تشير النتائج إلى أن الكينوا يتم الترويج له كغذاء صحي . أن تأثير المركبات الغذائية النشطة حيوياً الغني بها QSF والكيك المدمج بـQSF ذات أهمية كبيرة حالياً لنشاطها المضاد للأكسدة، مضاد للالتهاب، مضاد للبكتريا ومضاد للسرطان.

الكلمات المفتاحية: دقيق بذور الكينوا ، التركيب الكيميائي ، مركبات الفينول الكلية ، الكاروتينات،
عجينة الكيك ، التقييم الحسي.