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Research Article

Chemical and Technological Evaluation of Quinoa (*Chenopodium Quinoa Willd*) Cultivated in Egypt

Abdelazim Sayed Abdelazim Abdellatif*

Food Technology Research Institute (FTRI), Agriculture Research Center (ARC) Giza, Egypt

***Corresponding Author:** Abdelazim Sayed Abdelazim Abdellatif, Food Technology Research Institute (FTRI), Agriculture Research Center (ARC) Giza, Egypt. **Email:** Abdelazim_73@yahoo.com

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Abstract

Chemical and technological properties of quinoa (Chenopodium Quinoa Willd), Natoil1, cultivated in two seasons in Beni Suef Governorate (2014/2015 and 2015/2016) Egypt were evaluated. The proximate analysis showed that the quinoa flour booths all 2 year and quinoa flat bread contained 14.73 ± 0.31% and 13.09 ± 0.22 crude protein, 6.51 ± 0.22% and 8.66 ± 0.11ether extract, 2.83 ± 0.20% 4.52 ± 0.15 total ash, 4.15 ± 0.02% and 5.96 ± 0.24 crude fiber , 60.28 ± 0.11% and 49.67 ± 0.33 carbohydrate and 358.63 ± 0.12% and 328.98 ± 0.05 Energy on dry weight. Quinoa flour had great amino acid balance with higher total essential amino acids (TEAA) 34.72, Phenylalanine + Tyrosine 6.09, Leucine 5.95 and lysine 5.42g/100g protein but the contents of total non-essential amino acids (TNEAA) 39.66, glutamic 12.19, glycine 8.22 and aspartic 6.55g/100g protein. The protein quality for quinoa seed flour protein efficiency ratio (PER) a, b Value and the biological value% (B.V) were 2.99, 2.87 and 87.73 %. Quinoa flour and quinoa flat bread had the balanced minerals content as (mg/100 gm) Magnesium 502 and 560, Potassium 732 and 755, Manganese 4.44 and 4.89, Copper 0.75 and 0.88, Iron 10.5 and 15.56, Phosphorous 411 and 487, Zinc 4.1 and 5.66, calcium 86.3 and 89.56 and Sodium 2.44 and 1130.55 mg/100 gm respectively. The physical and chemical properties of the extracted quinoa seed oil (Crude oil) were: Refractive index 1.46390, Peroxide value 2.45 ± 0.22, (meq O/kg oil), acid value 1.80 ± 0.03(mg KOH/g oil), Unsaponifiable matter 2.11 ± 0.25 (g/kg) and saponification value 197 ± 3.33(mg/g oil) and acidity % 0.65 ± 0.01%(as Oleic acid). Fatty acids composition of crude fat of quinoa seed flour and flat bread were ∑Saturated Fatty acid (SFA) 15.21 and 15.4905, ∑Monounsaturated Fatty acid 30.09 and 32.60, ∑Polyunsaturated Fatty acid (PUFA) 60.96 and 62.69 (g/100 gm) respectively. Quinoa flour and flat bread had a good source of vitamins such as Vitamin A (IU) 14.50 and 13.85 A (IU), Vitamin C15.5 and 15.1, Vitamin E 2.30 and 2.00 Thiamin (B1) 0.36 and 0.35, Riboflavin (B2) 0.32 and 0.33, Niacin (B3) 1.52 and 1.50, Pyridoxine (B6) 0.487 and 0.477 (mg/100 gm) and Folate total (µg) 184 and 182 (µg) /100gm respectively. The Overall palatability (10) had higher values 9.5 ± 0.20 than firmmess (10) had lower 4 ± 0.22 Proof of the possibility of the manufacture of bread from quinoa.

Keywords: Quinoa Seed Flour; Free Gluten; Chemical Composition; Minerals; Amino Acid; Fatty Acid; Vitamin; Flat Bread, Sensory Evaluation

Introduction

Family chenopodiaceae, genus chenopodium and species quinoa. The full name Chenopodium quinoa Willd [1-3]. There are hundreds of varieties of quinoa, ranging in colour from white to red and purple to black [3]. Quinoa is considered a pseudocereal or pseudograin [4,5]. Quinoa is grown in different regions of South America, especially in the and es region and it was recently introduced in Europe, North America, Asia and Africa [2,5]. Quinoa, as a plant, grows 1 - 3m high. The seeds can germinate very fast, i.e. in a few hours after having been exposed to moisture [6]. The adaptation of certain quinoa varieties is possible even under marginal environments for the production of seeds with high protein and mineral content [7]. Quinoa is considered as a complete food due to its protein quality [4,5]. Quinoa seed is a complete food with high-nutritional value due mainly to their high content of good quality protein [8]. It has remarkable nutritional properties; not only from its protein content (15%) but also from its great amino acid balance [4] with higher lysine (5.1% - 6.4%) and methionine (0.4% - 1.0%) contents [5,9,10]. The Food and Agriculture Organization (FAO) observed that quinoa seeds have high quality proteins and higher levels of energy, calcium, phosphorus, iron, fibre and B-vitamins than barley, oats, rice, corn or wheat [4,11] and has also been found to contain compounds like polyphenols, phytosterols and flavonoids with possible nutraceutical benefits [4,12]. Quinoa, albumins and globulins are the major protein fraction (44% - 77% of total protein), which is greater than that of prolamins (0.5% - 7.0%). Quinoa is considered to be a gluten-free grain because it contains very little or no prolamin. Quinoa provides a nutritional, economical, easy-to-prepare, flavourful food source which is of particular relevance for people with gluten intolerance, such as those with celiac disease [6]. The quinoa has a high proportion of d-xylose (120.0 mg/100g) and maltose (101.0 mg/100g) and a low content of glucose (19.0 mg/100g) and fructose (19.6 mg/100g), suggesting that it would be useful in malted drink formulations [13]. Quinoa seeds are an excellent example of functional food and defined as lowering the risk of various diseases (celiac disease) and exerting health-promoting effects [14,15].

Gluten is an essential structure building protein that provides viscoelasticity to the dough, good gas-holding ability and good crumb structure of the resulting baked product [16]. The celiac disease in susceptible people is gluten induced/sensitive entropy characterized by damage of small intestinal mucosa caused by a gliadin fraction of wheat [17,18].

To date, the only treatment available for celiac disease is a strict lifelong adhesion to a gluten-free diet [19]. Therefore, celiac patients must avoid the consumption of gluten-containing foods. However, this may prove a difficult and overwhelming task for the celiac patients as the majority of the cereal-based foods available in the market (such as pasta, baked products, snacks and breakfast cereals) are prepared with gluten-containing grains, such as wheat [20]. Although gluten-free alternatives are readily available, finding good quality gluten-free products has been reported as a major issue for celiac patients who are trying to adhere to a gluten- free diet [21,22]. Efforts have been made to enrich gluten-free products in micro- and macroelements and proteins. Quinoa grains do not contain gluten [23-25]. Utilized for the manufacture of products such as pastas, bread, cakes and baby foods [23-26] discussed that the incorporation of quinoa flour for the manufacture of enriched gluten-free bakery products.

The aim of the present study was to evaluate that the chemical and technological quality of quinoa (chenopodium quinoa willd) Natoil1 - cultivated in Egypt and falt bread made from quinoa seed flour.

Materials and Methods

Materials

Quinoa seeds (Natoil1) were obtained from the Egyptian Company for Natural Oils, Cairo, Egypt. It was cultivated in Eldwalalta village - Beni Suef Governorate 2014/2015 and 2015/2016 seasons. The collected seeds were cleaned of foreign materials and stored at room temperature (25 ± 2°C) till chemical analysis. All chemical used in this study were analytical grade.

Sunflower oil: Refined and fresh sunflower oil was obtained from Arma for food industry, 10th of Ramadan, Egypt

Sugar, guar gum, sodium chloride, fat and dry instant yeast active were obtained from local markets, Cairo, Egypt.

Used chemical evaluation: All chemicals used in this study were analytical grade.

Methods

Physical properties of the quinoa seed

To evaluate the weight of 1000 seeds W1000 was determined by weighing 100 seeds in triplicate and 1000 grain mass, 1000 grains r and omly selected for the bulk were averaged. The mass of grain was measured using an electronic balance to an accuracy of 0.001g. Seed size (diameter) was determined by lining up and measuring the length of 20 seeds. The average seed diameter was calculated from 3 repeated measurements. Hectolitre weight (HLW) was determined using a Dickey-John GAC2100 where 500g of quinoa was poured into the top hopper. This method was applied according to Gloria [27].

Preparation of Quinoa Flour

Quinoa flour was prepared according to Margarita., *et al* [28]. Quinoa seed were washed with cold water 4 - 5 times or until there was no foam to remove saponins drying was carried out at 60ºC using a convective dryer and ground using a cyclone sample mill into meal that could pass through a 60 - 80 mesh screen.

Preparation of quinoa flat bread

The dough was prepared by mixing the following dry ingredients: saponin-free quinoa (100g), sugar (3g), guar gum (1.5g), sodium chloride (1.5g) Add the fat (3.5g), (2g) dry instant yeast active Add after heat treatment. Mixing by boiling water (50 ml). After kneading the dough is done and then the individual is formed, bread was baked in the oven at 380 - 390°C/2 minutes, then cooled to room temperature, then the bread is filled in plastic bags.

Chemical composition of quinoa flour and quinoa flat bread

Moisture, ash, ether extract, fiber and crude protein were determined according to A.O.A.C. [29]. Moreover, total carbohydrates were determined by difference. Energy value (cal./100gm) of the cooked samples was calculated using the following equation: Energy value = [(% of carbohydrate x 4) + (% of protein x 4) + (% of fat x 9)]. All results were recorded as the mean value of 3 replicates and values are means of cultivated in two seasons 2014/2015 and 2015/2016.

Determination of Minerals

Ash content was determined by calcinations, overnight at 550ºC in a muffle furnace, to constant weight [29]. The obtained ash was dissolved in HCL(0.1N) and Sodium, potassium, magnesium, iron, manganese, calcium, phosphors, copper and zinc were determined using atomic absorption spectrophotometer (Perkin Elmer model 3300, Merck hydride system USA).

Determination of vitamins

HPLC technique was used for fractionation of vitamin A (retinol) according to the method described by Leth and Jacobsen [30]; B1 (thiamine), B2 (riboflavin), B3 (niacin), B6 (pyridoxine), total folate and vitamins C determined according to the method described by Bogner [31] and Romeu - Nadal., *et al*. [32] respectively.

Physical and chemical properties of the quinoa seed oil

The Peroxide value (meq O/kg oil), acid value, odor, color, refractive, saponification value (mg/g oil Unsaponifiable matter (g/kg) and free fatty acid% (FFA) as Oleic acid) were determined according to A.O.A.C [29].

Determination of Fatty acids profile

Fatty acid of quinoa flour were esterified into their corresponding FAMEs using methanoleic NaOH and BF3 with methanolic (Boron triflouride) as described by A.O.A.C [29].

Determination of amino acids

The amino acids content of quinoa seed flour determined according to the method described by A.O.A.C [29]. The human pattern of amino acid requirements [33] suggested pattern of amino acid requirements for human adolescent adults of amino acid score was calculated as follows:

Protein Efficiency Ratio (PER) a = 0.456 + 0.454 (Leucine) - 0.047 (pro) and Protein Efficiency Ratio (PER) b = 0.498 + 0.454 (Leucine) - 0.105 (Tyrosine) were calculated [34]. The Biological value (B.V) was assayed according to the following equation which recommended by Eggum., *et al.* [35] by the following equation: B.V.% = 39.55 + 8.89 × lysine (g/100g protein).

Sensory evaluation of quinoa Balady bread

Quinoa flat bread were organoleptically evaluated for the scores regarding its general rollability (10), firmness (10), dryness (10), taste (20), odor (20), color (20) and overall palatability = 100. Ten panelists from the staff of Food Technology Research Institute, Agriculture Research Center Giza, Egypt, were asked to evaluate these attributes by using these scores, where bread served to panelists then the results were statistically analyzed.

Texture profile analysis of quinoa flat bread

Samples texture measurements were carried out according to [36] with universal testing machine (Cometech, B type, Taiwan). Provided with software. An Aluminum 25 mm diameter cylindrical probe was used in a ''Texture Profile Analysis'' (TPA) double compression test to penetrate to 50% depth, at 1 mm/s speed test. Firmness (N), gumminess (N), chewiness (N), adhesiveness (N.s), cohesiveness, springiness and resilience were calculated from the TPA graphic. Both, springiness and resilience, give information about the after-stress recovery capacity. But, while the former refers to retarded recovery, the latter concerns instantaneous recovery (immediately after the first compression, while the probe goes up).

Statistical analysis

The collected data and organoleptic evaluation were statistically analyzed using Anova by the least significant differences (L.S.D) at the 5% level of probability procedure according to the method of Snedecor and Cochran [37].

Results and Discussion

Physical properties of the quinoa seed

Physical properties of the quinoa seed (Color, Weight of 1000 seed (g/1000 seed), Diameter of seed (mm) and Hectoliter (kg/l)) Nat oil1 cultivated two seasons in Beni Suef Governoratel 2014/2015 and 2015/2016 Egypt were screened and we are shown that the results in the figure 1 and table 1. The Physical properties of the quinoa seeds reflect grain quality. The Physical properties of the grains were estimated after the cleaning of the foreign material and the graduated of the crop. From the results of the two seasons it could be noticed that the most seeds color percentage was yellow but a very small percentage (three plants in an area of 1400 square meters), the color was pink. The Incas has been home (mother of all seed) to quinoa cultivation for thousands of years. Quinoa has multiple colors of yellow, brown and pink colors [7]. The Weight of 1000 seed (g/1000 seed) is a determinant of grain quality and is indicator of an increase in the percentage of high density compounds such as proteins and mineral compared to low density like fat. Results showed that the Weight of 1000 seed (g/1000 seed) ranged from 3.63 ± 0.034 to 4.725 ± 0.022g for two seasons, the quinoa 1000 seed weight was 2.69g [38] ranged from 1.99 to 5.08g of 17 cultivars quinoa [39]. The grain diameter (mm) guide to grain size increases grain size by increasing diameter. The diameter of the grain ranged from 1.0361 ± 0.0534 to 1.2188 ± 0.0404 mm. Test weight is the measure of grain density determined by weighing a known volume of grain. The grain grading specifications, it is expressed in grams per 0.5 litre or kilograms per hectolitre. The Hectoliter (kg/100L) of seeds ranged between 75.6 ± 0.56 and 77.6 ± 0.70 (kg/100L). The results indicate that the quality of Nat oil1 seeds cultivated two seasons in Beni Suef Governoratel 2014/2015 and 2015/2016 Egypt was of high quality.

Table 1: Physical properties of the quinoa seed.

Items	Value*
Color	Yellow
Weight of 1000 seed (g/1000 seed)	3.63 ± 0.034 to 4.725 ± 0.022g
Diameter of seed mm	1.0361 ± 0.0534 to 1.2188 ± 0.0404mm
Hectoliter (kg/100L)	75.6 ± 0.56 to 77.6 ± 0. 0.70

Chemical composition of quinoa flour and quinoa flat bread

The proximate analysis of the quinoa flour and flat bread were determined, and the obtained results are shown in the figure 1 and table 2. Data indicated that the quiona flour had lower percentage of chemical contents than quinoa flat bread (QFB) 14.73 ±0.31% and 13.09±0.22crude protein, 6.51 ±0.22% and 8.66±0.11ether extract, 2.83 ±0.20% and 4.52±0.15 total ash, 4.15±0.02% and 5.96±0.24 crude fibre, 60.28 ±0.11% and 49.67±0.33 carbohydrate and 358.63 ±0.12% ,328.98±0.05% energy and moisture 11.5 and 18.10% on dry weight respectively. The protein content of quinoa 14.5% seeds compared with wheat 12.0%. The fat content for quinoa seeds was 5.2%, more than twice that of wheat 2.5%. The ash content was significantly higher for all pseudocereal seeds in comparison with wheat 1.5%, where the highest values obtained were for amaranth 2.8% and quinoa 2.7%, [40]. The results of the present study approved the previous results that showed the quinoa seed contained 13.5 - 15 % crude protein carbohydrate about (58.3%) whereas contained a, 9.5% crude fiber, 1.2% total ash [4,41-43] which is higher than the investigated seeds in this study (4.15 ± 0.02% crude fiber, 2.83 ± 0.20% % total ash). Protein content of the grain of the 4 varieties was between 14.0 and 15.5% [44]. The previous studies reported that the mean protein content of quinoa seeds ranged between 12% and 23% [7,8]. According to these authors, the protein content of quinoa is between 11.0 and 15.0%. Guzman-Maldonado and Paredes-Lopez [45]. Compared to cereal grains, the total protein content of quinoa seed flour is higher than that of (11%) barley rice (7.5%) and corn (13.4%) [8]. The reported protein value is higher than groundnut (8.8 - 11.6%). On the other h and, quinoa seeds contain relatively minor proteins compared to legume seeds (22.75 - 37.9%) reported by Ogungbenle [41]. The protein content of quinoa seeds ranged from 14.5% to 18% and 4.7% to 7.1 % fat [46]. The flat bread manufacturing at different with wheat flour levels (10, 20, 30, 40 and 50%) had higher chemical contents than the control data indicated that the flat bread with 10% and control made with wheat flour levels 100% contents 13.36 % and 120.63% crude protein, 2.30% and 1.83% ether extract, 2.29% and 1.91% total ash, 5.44 % and 4.23% crudefibre, 76.61% and 79.39% carbohydrate on dry weight respectively [47]. The nutrient content of the quinoa bread made, was 100% was also higher than in the weaht control bread, [40]. The raw quinoa flour had higher amounts of crude protein (14.02%), crude fat (5.13%) and total ash (3.83%). Likewise, the amounts of lysine (6.5g/100g protein), methionine (2.37g/100g protein) and tryptophan (0.97g/100g protein) [48].

Figure 2: Quinoa plants, quinoa seeds and quinoa flat bread 100% quinoa flour.

Table 2: Chemical composition of quinoa flat bread and quinoa seed flour Cultivated in two seasons in Beni Suef Governorate 2014/2015 and 2015/2016 Egypt (g/100gm) on dry weight sample.

Items	Chemical composition of sample gm /100g on dry wieght	
	Quinoa Seed Flour	Quinoa flat bread100%*
Crude protein (N × 6.25)	14.73 ± 0.31	13.09 ± 0.22
Ether extract	6.51 ± 0.22	8.66 ± 0.11
Crude Fibre	4.15 ± 0.02	5.96 ± 0.24
Ash	2.83 ± 0.20	4.52 ± 0.15
Carbohydrates	60.28 ± 0.11	57.33 ± 0.33
Energy (kcal/100g)	358.63 ± 0.12	328.98 ± 0.05

value are means of three replicates ± standard deviation (SE).

Amino acid contents quinoa flour

Amino acid contents of quinoa were determined as g/100g protein and the obtained results of amino acids are shown in table 3. Results showed that the Total Essential Amino Acids (TEAA) and Total Non-Essential Amino Acids (TNEAA) content of the quinoa flour was 34.72 and 39.66 g/100g protein respectively. The content of essential amino acids indicates that quinoa flour had higher percentage of Phenylalanine + Tyrosine (6.09%), Leucine (5.95%) and Lysine (5.42%). Some amino acid cause hypocholesterolemic effect such as arginine, lysine, methionine and glycine and hence they are of great importance (Mortia., et al. 1997). Present results are in agreement with those reported by [49]. Quinoa is considered a good source of some essential amino acids such as lysine and methionine [5]. The calculating chemical score was compared according to scoring pattern gm/g protein requirement for adults. Protein quality assessments of tested formula: FAO/WHO (2011) reported that calculating amino acid score pattern was based on the amount of the first limiting amino acid and it aimed to suggest the requirement pattern of amino acids to evaluate the quality of dietary protein for each age group according to FAO/WHO/UNU (2011) expert council based on previous human studies. The calculation of chemical score are presented in table 3, in which is shown that the lowest score obtained for the indispensable amino acids in a protein of quinoa flour, that of the most limiting amino acid would indicated a first approximation of its efficiency of utilization by adults, allowing a correction of the protein requirement for the quality of dietary protein. The first was leucine, second valine and third iso leucine (100.84, 107.49 and 119 respectively). Lysine, the limiting amino acid in cereals can be found in high amounts. The high content of arginine and histidine, both essential for infants and children, makes amaranth and quinoa interesting for the nutrition of Celiac Disease children. Moreover, pseudo-cereals and minor cereals contain amino acids like methionine and cysteine which are essential to human health [3]. This observation is in agreement agree with Millward [50] who emphasized that leucine and lysine are the most abundant amino acids in growth requirement. While sulfuric is one of AA required for maintenance. Non-essential amino acids (NEAA) : Data on table 3 show the mean values of total non-essential amino acid in quinoa flour. In particular, the results showed that total non-essential amino acids (TNEAA) had lower value than total essential amino acids 39.66, 132.01 gm/100 gm protein) respectively. Protein quality for quinoa seed flour are evaluated in table 4 the value of protein efficiency ratio (PER) a, protein efficiency ratio (PER) b 2.99, 2.87 and biological value % (B.V) 87.73 %. Protein quality not only depends on the amino acid composition, but also on the bioavailability or digestibility. Protein digestibility, available lysine, net protein utilisation (NPU) or protein efficiency ratio (PER) are widely used as indicators for the nutritional quality of proteins. In this respect, the values for pseudo-cereal proteins are definitively higher when compared to cereals and are close to those of casein the values for pseudo-cereal proteins are definitively higher when compared to cereals and are close to those of casein [51,52]. The final results indicate that the high quality of quinoa flour protein.

Table 3: Essential amino acids content of quinoa seed flour.

Essential Amino Acid (EAA)	g/100g protein	FAO/WHO Adult*	Amino AcidScore (AAS)	Non-Essential AminoAcids (NEAA)	g/100g protein
Leucine	5.95	5.9	100.847	Glutamic	12.19
Valine	4.21	3.9	107.949	Glycine	8.22
Lysine	5.42	4.5	120.444	Arginine	0.99
Phenylalanine + Tyrosine	6.09	3	203	Serine	3.55
Isoleucine	3.57	3	119	Proline	3.5
Methionine+ Cysteine	3.62	2.2	164.545	Aspartic	6.55
Threonine	2.98	2.3	129.565	Alanine	4.66
Histidine (SemiEAA)	2.88	1.5	192		
Total Essential Amino Acids (TEAA)	34.72	26.3	132.015	Total Non-Essential Amino Acids (TNEAA)	39.66

*Amino acid score (CS) Chemical score was calculated as a percentage of the FAO/WHO/UNU, 2011.

Table 4: Evaluation of protein quality for quinoa seed flour.

Items	Value
Protein Efficiency Ratio (PER)a	2.99
Protein Efficiency Ratio (PER)b	2.87
Biological value% (B.V)	87.73

Mineral content of quinoa and Flat bread

Mineral contents of quinoa flour compared to flat bread and its percentage from recommended dietary allowance of adults aged year were presented on table 5. Mineral salts. These are essential nutrients. They include major minerals (calcium, phosphorus, sodium, potassium, chloride and magnesium) and trace elements (iron, zinc, selenium). Micronutrient deficiency is a common public health problem, specifically for vulnerable groups (infants, childhood, adolescent, pregnancy and lactation) in many low and middle-income countries. For example, anemia, vitamin A and zinc deficiency are serious threats for previous group's development [53]. Flat bread had the highest concentration mineral contents than quinoa flour. The content of potassium, magnesium, manganese and phosphorous had higher values (732 and 760), (502 and 560) and (4.44 and 4.89) and (411 and 487). Iron, magnesium, phosphorous and zinc concentration in the quinoa flour compared to flat bread 10.5 ± 0.11, 502 ± 4.22, 411 ± 2.22 and 4.1 ± 0.21compared to 15.56 ± 1.56, 560 ± 4.69, 487 ± 3.33 and 5.66 ± 1.22mg/100 gm on dry weight and its cover about to 105% 143.43, 51.38 % and 27. 33% compared to155. 6%, 160%, 60% and 37.73 of daily iron. Magnesium, phosphorous and zinc requirement respectively. Iron deficiency is the major causes of iron deficiency anemia. Baseline survey data on iron deficiency anemia in Egypt 2010, reported that 47% of women aged 20 - 50 years, 40% of children less than 5 years of age and 35% of children 6 - 18 years were anemic [54]. According to Cesar., *et al.* [55] bone mass in elderly people results from the rate of mineral loss and the mass accumulated during skeletal growth, which in turn depends on dietary calcium and vitamin D status calcium contents of quinoa flour compared to flat bread ranged from 89.3 to 89.56 mg/100 gm on dry weight and it covered 10.79% to 11.19%, respectively, of daily calcium requirement for adolescents. On the other h and, they found that the distribution of minerals in quinoa seeds revealed that phosphorus and magnesium were localized in embryonic tissue, while calcium and potassium were present in the pericarp Kiaus., *et al.* [56] and Konishi., *et al.* [57] found that abrasion of quinoa seeds (for saponin elimination) caused specifically a decrease in calcium content. calcium (83.33 mg/100g), magnesium (202.17 mg/100g), zinc (4.23 mg/100g) and acid were also higher in raw flour [48]. The total content of minerals in amaranth, quinoa and oats is about twice as high as in other cereals (Dyner etal., 2007 and Sadiq etal., 2008). In teff, iron and calcium contents (11 - 33 mg and 100 - 150 mg, respectively) are higher than those of wheat, barley, or sorghum and rice. In Ethiopia, an absence of anaemia seems to correlate with the levels of teff consumption and is presumed to be due to the grain's high content of iron. The content of minerals in buckwheat seeds is lower than in wheat. However, except for calcium, buckwheat is a richer source of nutritionally important minerals than many cereals such as rice, sorghum, millet and maize [58,59]. Minerals are located in the germ; therefore, we may expect that they are not completely lost during the refining process.

Table 5: Mineral content of quinoa compared with Flat bread (mg/ 100 gm).

Mineral	Quinoa	Quinoa flat bread100%	RDA*
Calcium	86.3* ± 0.55**	89.56 ± 0.23	800
Copper	0.75 ± 0.11	0.88 ± 0.01	3.0
Phosphorous	411 ± 2.22	487 ± 3.33	800
Potassium	732 ± 3.33	755 ± 5.33	330
Magnesium	502 ± 4.22	560 ± 4.69	350
Iron	10.5 ± 0.11	15.56 ± 1.56	10
Manganese	4.44±3.22	4.89 ± 2.22	5.0
Zinc	4.1 ± 0.21	5.66 ± 1.22	15
Sodium	2.44 ± 0.11	1130.55 ± 5.22	500

*Value are means of three replicates ±**SE, ***RDA: Recommended Dietary Allowances FAO/WHO/UNU, 2011.adults19 - 50 year.

Physical and chemical characteristics of quinoa seed oil

The physical and chemical properties of the quinoa seed oil (crude oil) studied compared with Sunflower oil (Refined oil), the obtained results are shown in table 6. The acid values of the quinoa seed oil (Crude oil) compared to sunflower oil (Refined oil) was 1.80 ± 0.03 compared to 188 mg KOH/g oil the oil indicated its freshness state. Moreover, the physical and chemical properties of sunflower oil under study were found to be corresponding to the values approved by the Egyptian St and ard (49 - 1993), for sunflower seed oil (refractive index: 1.46390, acidity (0.65 ± 0.01 as % oleic acid), peroxide value 2.45 ± 0.22 equivalent of active oxygen/ kg. of oil, saponification value: 197 ± 3.33 and unsaponifiable matter % not more than 2.11 ± 0.25%). The above-mentioned data revealed that no lipolysis and /or oxidative rancidity occurred in the of the quinoa seed oil (Crude oil). Therefore, the of the quinoa seed oil (Crude oil) can be used as vegetable edible oils.

Table 6: Physical and chemical properties of the quinoa seed oil (Crude oil) compared to Sunflower oil (Refined oil)*.

Parameter	Quinoa seed oil (Crude oil)	Sunflower oil (Refined oil) *
Odor	Acceptance	Acceptance
Color	Yellow	Yellow
Refractive index	1.46390	1.4681
Acidity (as % oleic acid)	0.65 ± 0.01	0.05
Acid value (mg KOH/g oil)	1.80 ± 0.03	0.106
Peroxide value (meq O/kg oil)	2.45 ± 0.22	0.00
Unsaponifiable matter (g/kg)	2.11 ± 0.25	1.5
Saponification value (mg /g oil)	197 ± 3.33	178

*Sunflower oil according to Abdelazim (2017)

Fatty acid composition of crude oil from quinoa seed and quinoa flat bread

The fatty acids composition of quinoa seeds compared to flat bread are shown in table 7. The results indicated that quinoa seed compared to flat bread contain Linoleic acid (C18:2) and α-Linolenic acid (C18:3) as resulted in a value of 52.30% and 8.66% compared to 53.94% and 8.74%, respectively, comprising 60.96 compared to 62.69% of Polyunsaturated fatty acids (PUFA). Moreover, the monounsaturated fatty acids (MUFA), i.e. (16:1), (18:1) and (20:1) showed relative percentages of 0.95%, 26.78% and 1.15% compared to 0.96%, 27.60% and 2.80%, respectively, comprising 30.09% as further compared to 32.60% of monounsaturated fatty acids (MUFA). Also, these results were confirmed by the ratio between ∑PUFA/∑SFA, MUFA/∑PUFA and ∑USFA/∑SFA, (4.04 ,0.494 and 6.22) compared to (62.69,0.52 and 6.18), respectively, which showed that the oil had a high TU/TS ratio (5.99). This means that quinoa seed and flat bread are distinguished by containing fatty acids profile with high degree of unsaturation such as C18:2 (essential fatty acid). Moreover, that quinoa seed compared to flat bread contains five saturated fatty acids, i.e. merestic (14:0), palmetic (16:0), stearic acid (18:0) and arachidonic acid (C 20:0) in relative percentages of 2.44%, 11.2%, 1.12% and 0.45% compared to 2.44%, 11.44%, 1.13% and 0.48%, respectively, comprising 13.67% of saturated fatty acids (SFA).The lipid content of pseudo-cereals (quinoa) is higher compared to other plant foods, as these are characterized by a higher content of unsaturated fatty acids, particularly linolenic acid [58] an omega-3 fatty acid essential for all mammals. Consumption of α-linolenic acid (2 to 3g per day) has been considered important for the primary and secondary prevention of coronary heart disease [60]. Amaranth contains a high amount of squalene, a highly unsaturated open chain triterpen, which is usually only found in liver of deep see fish and other maritime species [58].

Table 7: Fatty acid composition of crude oil from quinoa seed and flat bread (g/ 100 gm).

Fatty acid	Quinoa seed	Quinoa flat Bread100%
Saturated Fatty acid		
Myristic C14:0	2.44	2.44
Palmitic C16:0	11.20	11.44
Stearic C18:0	1.12	1.13
Arachidic acid C22:0	0.45	0.48
∑Saturated Fatty acid (SFA)	15.21	15.49
Monounsaturated Fatty acid		
Myristoleic C14:1	1.21	1.24
Palmitoleic C16:1	0.95	0.96
Oleic C18:1	26.78	27.60
Gondoic acid C20:1	1.15	2.80
∑Monounsaturated Fatty acid	30.09	32.60
Polyunsaturated Fatty acid (PUFA)		
Linoleic C18:2 (n - 6)	52.3	53.95
Linoleic C18:3 (n - 3)	8.66	8.744
∑Polyunsaturated Fatty acid (PUFA)	60.96	62.69
Others Fatty acid	0.55	0.55
∑PUFA/∑ SFA	4.01	4.04
∑MUFA/∑PUFA	0.49	0.52
∑USFA/∑SFA	6.22	6.18
C18:2/C18:3	6.04	6.17

Vitamins content of quinoa flour and Flat bread

An adequate intake of vitamins is particularly important for celiac patients to prevent vitamin deficiencies. Data of vitamins content of quinoa flour, compared to flat bread, include thiamin B1, riboflavin B2, niacin B3, pyridoxine B6 a and folate total (μg) (Table 8). The vitamin contents of the quinoa flour compared to Flat bread. Vitamin A is a group of unsaturated nutritional organic compounds that includes retinol, retinal, retinoic acid and several provitamin A carotenoids (most notably beta-carotene), [61]. Vitamin A has multiple functions: it is important for growth and development, for the maintenance of the immune system and good vision [61,62]. Vitamin A is needed by the retina of the eye in the form of retinal, which combines with protein opsin to form rhodopsin, the light-absorbing molecule necessary for both low-light (scotopic vision) and color vision [63]. Vitamin A also functions in a very different role as retinoic acid (an irreversibly oxidized form of retinol), which is an important hormone-like growth factor for epithelial and other cells [64]. Content of Vitamin A(IU) in quinoa flour had higher content than Quinoa flat bread 14.50 than 13.85 (IU) respectively. Vitamin C was higher in the Quinoa flour (15.5 mg/100 gm) compared with the Quinoa Flat bread (15.1 mg/100 gm). Vitamin C losses increase with extended storage, higher temperature, low relative humidity, physical damage, chilling injury, large genotypic variation and climatic conditions; all these factors are responsible for the wide variation in vitamin C content [65-67]. Citrus fruit contained more vitamin C when grown under cool temperatures rather than hot temperatures Lee and Kader [65]. The vitamin C content found in this investigation was similar to other data reported by Ruales and Nair (1993) for quinoa seed (16.4 mg AA/100g DM) but not similar with those of Dini., *et al.* [68], who worked with quinoa from Ecuador and Peru (13.0 and 12.0 mg AA/100g DM, respectively). Lower values of vitamin C have also been reported in the literature by Koziol [69] (4 to 5 mg AA/100g DM). Wall (2006), reported that the quinoa fruit ecotypes grown in Hawaii, commented that ascorbic acid levels in fruit are influenced by the availability of light to the crop and to individual fruits. In addition, an excess of soil N or P tends to decrease ascorbic acid content in fruit, while an excess of K could increase vitamin C content. Vitamin E is a well-known antioxidant that acts as a free scavenger by preventing the oxidation of polyunsaturated lipids by free radicals such as the hydroxyl radical OH (Fardet., *et al* 2008). As shown in table 8, quinoa vitamin E values ranged from 2.44 to 4.64 mg/100g DM with the Villarrica ecotypes showing the highest value. Similar levels of vitamin E were reported for quinoa with 2.30 mg/100g but the quinoa flat bread 2.00 mg/100g, while wheat, rice and barley had lower values (1.15, 0.18 and 0.35 mg/100g DM, respectively). Rephrase, it does not make any sense.

The B-group vitamins are water-soluble molecules and play an important metabolizing role, particularly in the metabolism of carbohydrates (thiamine or B1), proteins and fats (riboflavin or B2 and pyridoxine). Table 8 shows vitamin B1, B2 and B3 contents in the quinoa. Vitamin B1 content was the highest in quinoa flour than quinoa flat bread probably because of a higher temperature as compared with quinoa flour. The results are in agreement with Koziol [69] Vitamin B1 content is comparable to values of 0.38 mg/100g DM. but disagreement by Ruales and Nair (1993) 0.4 mg/100g DM. Batifoulier., *et al.* (2006) reported values for vitamin B1 that ranged from 0.259 to 0.613 mg/100g DM for 49 northwestern European wheat ecotypes, while Lebiedzińska and Szefer (2006) reported values from 0.344 to 0.369 mg/100g DM for barley. Vitamin B2 values are much lower than those reported by Koziol [69] and Ruales and Nair (1993) with 0.39 mg to 0.2 mg/100g DM. Vitamin B3 (niacin) supply is low on quinoa ecotypes, even lower than those reported by Lebiedzińska and Szefer (2006) on brown rice and barley with 4.36 and 4.07 mg/100g DM, respectively. Koziol [69] reported 1.06 mg 100g DM for quinoa B3 content. Batifoulier., *et al.* (2006) reported significant differences in vitamin B contents in wheat due to variety, growing location (for thiamine and riboflavin), soil type and years (for thiamine and pyridoxine). Folic acid is present in green leafy vegetable, liver and cereals. High concentration of folic acid has been found in gluten free cereals such as quinoa (78.1 µg/100g) and amaranth (102 µg/100g) with respect to wheat (40 µg/100g). Both amaranth, quinoa and oats are also good sources of riboflavin, vitamin C and vitamin E [70,71]. Folate, distinct forms of which are known as folic acid, folacin and vitamin B9, is one of the B vitamins. The recommended daily intake of folate in the US is 400 micrograms from foods or dietary supplements. Folate in the form of folic acid is used to treat anemia caused by folic acid deficiency. Folic acid is also used as a supplement by women during pregnancy to prevent neural tube defects (NTD) in the baby [72].

The previous results show that the quinoa flour flat bread had lower content of vitamin A(IU), C, E, B1, B2, B3, B6(mg/100 gm) and Folate total (µg) than the quinoa flour. These results indicate that the quinoa flour compared to flat bread is the best source of vitamin.

Table 8: Vitamins content of quinoa compared with quinoa flat bread (mg/ 100 gm).

Vitamins contents	Quinoa flour	Quinoa flat bread	RDA*
Vitamin A (IU)	14.50	13.85	0.9 ug/d
Vitamin C	15.5	15.1	90
Vitamin E	2.30	2.00	0.12
Thiamin (B1)	0.36	0.35	1.2
Riboflavin (B2)	0.32	0.33	1.3
Niacin (B3)	1.52	1.50	16
Pyridoxine (B6)	0.487	0.477	1.7
Folate total(µg)	184	182	0.4

*RDA Food and Nutrition Board, Institute of Medicine, National Academies.

Sensory evaluation

The quinoa flour 100% preparing flat bread were organoleptic ally evaluated to assess the consumer acceptability this product showed in table 9. The samples were evaluated for rollability (10) firmmess (10) dryness (10) taste (20) odor (20 (color (20(overall palatability (10) as presented in table 9 Color often the first sensory quality by which foods are judged. It is a major parameter in sensory evaluation of products as the perception of color influences a taster's reception of a product. It is necessary to appreciate the synergy effect between the sensory responses of sight and taste of balady bread. Therefore, color is an important attribute in the assessment of the quality and the consumer acceptability of flat bread produced from the quinoa flour 100% under investigation. Comparing the different properties of flat bread produced from the quinoa flour 100% regarding the color, odor Taste and had scored the highest value (19.0 ± 0.21, 18 ± 0.11 and 18 ± 0.55). Meanwhile firmness and dryness had the lowest value (4 ± 0.22 and 3c ± 0.21). This observation may be attributed to the attractive brown color of flat bread produced which is highly accepted by the consumers. The values of rollability, firmness and dryness for quinoa bread indicates the flexibility and high quality of the bread the overall palatability had higher values 9.5 ± 0.20 than firmness had lower 4 ± 0.22 proof of the possibility of the manufacture of bread from quinoa.

Table 9: Sensory evaluation of quinoa flat bread.

Items	Quinoa flat bread.
Rollability (10)	9.5^{b} ± 0.84
Firmness (10)	4^{c} ± 0.22
Dryness (10)	3^{c} ± 0.21
Taste (20)	18^{a} ± 0.55
Odor (20)	18^{a} ± 0.11
Color (20)	19^{a} ± 0.21
Overall palatability (10)	9.5^{b} ± 0.20
L.S.D at 5%	0.79

Textural properties of quinoa flat bread

Texture properties such as firmness, cohesiveness, gumminess, chewiness, springiness and resilience of quinoa flat bread, during storage at room temperature for 72 hours, were measured by Texture Profile Analysis'' (TPA) assay. Texture Profile Analysis ''(TPA) (firmness, cohesiveness, gumminess, chewiness, springiness and resilience) are important rheological properties of quinoa flat bread. The results obtained are shown in table 10. It was observed that in storage period of 24 hours firmness recorded the lowest value (4.81 ± 0.22) compared to storage periods of 48 hours and 72 hours (5.08 ± 0.32 and 5.59 ± 0.03). It could be mentioned, that all rheological properties at storage periods of 24 hours scored the lowest value, compared to rheological properties measured at storage periods of 48 hours and 72 hours [73-76].

Table 10: Texture profile analysis of quinoa flat bread storage at room temperature to 72 hours.

Storage periods	Firmness	Cohesiveness	Gumminess	Chewiness	Springiness	Resilience
24hr	4.81 ± 0.22	0.636 ± 0.01	3.059 ± 0.12	2.151 ± 0.22	0.703 ± 0.01	0.584 ± 0.01
48hr	5.08 ± 0.32	0.708 ± 0.10	4.306 ± 0.22	3.165 ± 0.02	0.735 ± 0.01	0.698 ± 0.11
72hr	5.59 ± 0.03	0.774 ± 0.01	4.326 ± 0.26	3.469 ± 0.22	0.802 ± 0.02	0.77 ± 0.01

Conclusion

These results suggest that Natoil1 could be cultivated successfully in genotypes cultivated in two seasons in Beni Suef Governoratel 2014/2015 and 2015/2016 region, although more extensive field trials are required to select the best genotypes and to develop optimal protocols for their cultivation. The results indicate that there is no significant difference between the results for both seasons. The chemical composition of the seeds shows that this pseudocereal can be successfully used as a food ingredient to develop new products with interesting nutritional and organoleptic properties. Finally, it could be clearly concluded through this study that quinoa is a very important crop processing of high nutritional value. Besides, it is very economical and practicable to utilize in processing bread spectal especially gluten-free flat bread.

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