International Journal of Food Science and Nutrition
ISSN: 2455-4898; Impact Factor: RJIF 5.14
Received: 08-05-2019; Accepted: 19-06-2019
www.foodsciencejournal.com
Volume 4; Issue 4; July 2019; Page No. 155-159

Traditionally important and environmental stress-tolerance pseudocereal quinoa with high nutritional value and more health benefits

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Abstract
Quinoa is a one of the most important pseudocereals (exceptionally nutritious food source), it is rich in proteins, lipids, fiber, vitamins, and minerals, and has an extraordinary balance of essential amino acids. Quinoa also contains a high amount of health-beneficial phytochemicals including saponins, phytosterols, phytoecdysteroids. It is known that quinoa has considerably positive effects on metabolic, cardiovascular, and gastrointestinal health in human body. It is characterized by being gluten-free feature allowing obtaining a greater variety of foods more suitable and nutritious to holders of celiac disease Finally, quinoa could represent a strategic crop used to complement the diet in rural/marginal regions where energy-protein malnutrition affects a greater part of the population in certain developing countries.

Keywords: chenopodium quinoa wild, nutritional value, health benefits, glycemic index

Introduction
Quinoa (Chenopodium quinoa Willd.) is a seed-producing crop, which has been cultivated in the Andes for thousands of years. It was important food in some civilizations of the past. Cultivated quinoa was originated some seven thousand years ago from South America and in today's it is receiving considerable attention as an alternative crop in the World. 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. During 2007 quinoa production was 34,000 tons in Peru, 26,800 tons in Bolivia, and 690 tons in Ecuador. The plants able to tolerate extreme environmental conditions (salinity, cold, solar radiation, and drought), and it can be cultivated in high altitudes in the mountain areas where it is not possible to grow maize. Its genetic variability is great, with cultivars of quinoa being adapted to growth in a wide range of environments from 20° latitude North in Colombia to 40° latitude South in Chile, and from sea level to an altitude of 3,800m. The high adaptability of this crop to diverse agro-climatic habitats and edaphic conditions has increased the yields of diverse varieties in countries outside South America, such as USA, Canada, Europe, India, and China. Thus, the world production of quinoa has augmented in the last years and was close to 150,000 tons in 2016.

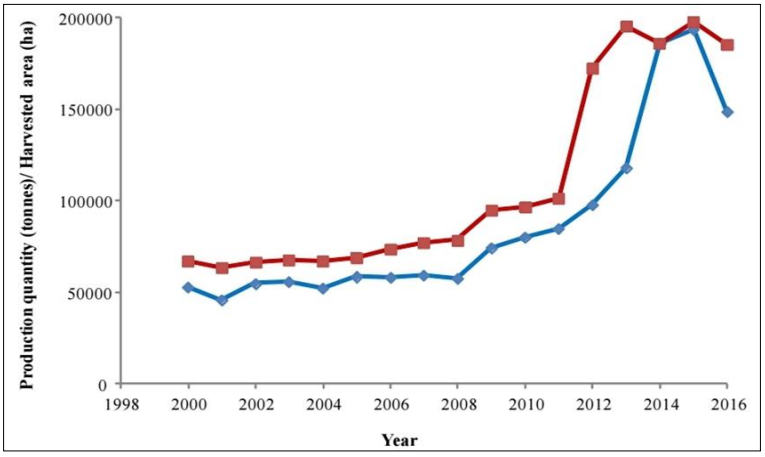

Fig 1: World production quantity (in tonnes, blue rombus) and harvested area (in ha, red square) of quinoa from 2000 to 2016 (FAOSTAT 2018).

Figure 1. World production quantity (in tonnes, blue rombus) and harvested area (in ha, red square) of quinoa from 2000 to 2016 (FAOSTAT 2018). 2013 was declared by the United Nations as the International Year of Quinoa as recognition of its significant potential. Quinoa has high concentrations of protein, all essential amino acids,

unsaturated fatty acids, and a low glycemic index (GI); it also contains vitamins, minerals and other beneficial compounds, and is gluten-free by nature. Quinoa is easy to cook and has versatility in preparation. Quinoa content is rich in vitamin A, B2, E and minerals such as calcium, iron, zinc, magnesium and manganese, which give the grains high value for different target populations: for instance, adults and children benefit from calcium for bones and from iron for blood functions Quinoa is considered a pseudo-cereal with proteins of high biological value, phytosteroids, and omega-3 and 6 fatty acids that bring benefits to the human health. Edible seed of the quinoa plant has been called both a pseudo-cereal and a pseudo-oil seed because of its unique nutritional profile. The nutrient composition is very good compared with common cereals. Oil content in quinoa ranges from 1.8% to 9.5%. It has been reported unsaturated fatty acid level of about 70%, having linoleic (38.9%) and oleic acids (27.7%). Also, quinoa protein is exceptionally high in methionine, lysine and cysteine amino acids. Quino is an extremely healthy food (gluten-free) of the twenty-first century. By the FAO, quinoa has been declared to be a good alternative crop to provide food security and to prevent poverty in next century. Also, the United Nations General Assembly has therefore declared 2013 as the International Year of Quinoa.

Nutritional Properties

Here are the quinoa nutrition facts, there are many surprising benefits of quinoa nutrition, Quinoa is packed with essential nutrients such as antioxidants, vitamins and minerals. It's also considered a complete protein.

Table 1: Chemical composition of quinoa and some cereals and legumes (g/100 g dry wt.) (Valencia-Chamorro 2003) [9]

	Quia	Barley	Maize	Rice	Wheat	OatbRyeb Bean		Lupine
Protein	17.	11.	10.	8.	14.	12.	13.	28.0
Fat	6.	2.	5.	2.	2.	5.	2.	1.
Fibre	4.	4.	2.	6.	3.	10.	3.	5.0
Ash	4.	2.	12.	3.	2.	3.	2.	5.
Carbohydrates	69.0	81.	81.	80.	78.	70.	80.	61.
kcal/100 ga399	383	408	372	392	372	390	367	361

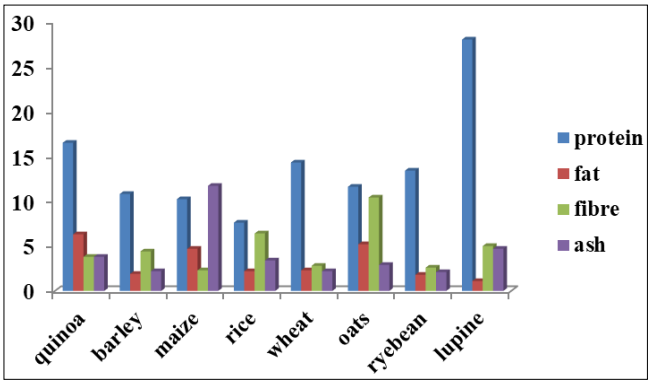

Fig 2

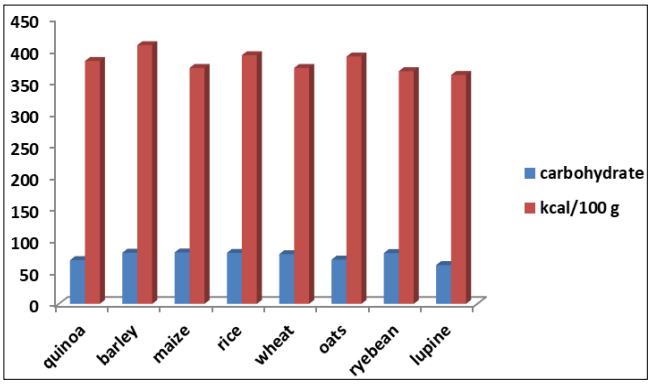

Fig 3

Fig 2&3: Chemical composition of quinoa and others cereals

Protein

Proteins and amino acids are major biological macromolecules that serve as structural constituents and as catalysts for enzymatic reactions, energy sources and protein synthesis in the body. The protein biological value measures the proportion of protein absorbed from a food which then becomes incorporated into the proteins of the body. Quinoa has a high biological value (73%), similar to that of beef (74%), and higher than those of white rice (56%), wheat (49%) and corn (36%). Quinoa also contains all ten essential amino acids, and its protein content ranges from 12.9 to 16.5%. Of primary interest is the high Lys value, an essential amino acid that is deficient in many grains. Quinoa is also high in the essential amino acid met, which is deficient in many legumes. According to the daily recommended amounts of amino acids indicated by the Food and Agriculture Organization (FAO) of the United Nations and by the World Health Organization (WHO), quinoa fulfills the amino acid requirements for adults: 180% of histidine (his), 274% of isoleucine (ile), 338% of lysine (lys), 212% of methionine+cysteine (met+cys), 320% of phenylalanine + tyrosine (phe+tyr), 331% of threonine (thr), 228% of tryptophan (trp) and 323% of valine (val). For these reasons, quinoa could represent a valuable source of nutrition, especially for infants and children, and may be used in nutritive foods and beverages. Another feature of note is the high sustainability of plant food consumption due to their low carbon, water and ecological food prints. In this sense, quinoa is an excellent protein source such as beef, but it has a carbon and water food print that is between 30 and 60 times lower in value.

Carbohydrates

The main carbohydrate component of quinoa is starch, and it constitutes 52%-69% of it. Its total diet fiber is close to that in grain products (7%-9.7%) while it's soluble fiber content is known to be in the 1.3% -6.1% band. Quinoa contains sugar by about 3%. It mostly contains maltose, D-galactose, and D-ribose in addition to low levels of fructose and glucose. Due to its perfect freeze-thaw stability, low gelling point, and endurance at low storage temperatures, quinoa is an ideal thickener for sauces, soups, and flours. Moreover, its resistance to retro gradation makes it possible to use quinoa in other applications and in obtaining a

creamy and smooth texture similar to that of fats. Amylase content in quinoa starch varies between 3% and 22%, which is lower in quantity than that of wheat and corn, higher than that of some kinds of barley, and similar to that of basic rice types. When compared to wheat and barley starch, quinoa starch has maximum viscosity, a higher water absorption capacity, and a bigger swelling capacity. In addition, it has a wonderful stability even in freezing and retrogradation processes

Fiber

Dietary fiber is the indigestible portion of food derived from plants and has two main components: soluble and insoluble. Soluble fiber dissolves in water, is readily fermented in the colon into gases and physiologically active products, and has prebiotic properties. Insoluble fiber, which does not dissolve in water, is either metabolically inert and provides bulking mass, or it can be prebiotic and metabolically ferment in the large intestine. Bulking fibers absorb water, easing defecation. Greater consumption of fiber-rich whole grains is associated with a lower risk of type 2 diabetes and cardiovascular disease. Quinoa is an excellent source of dietary fiber, comprising about 2.6%-10% of the total weight of the grain; about 78% of its fiber Content is insoluble and 22% soluble.

Glycemic index (GI)

The GI is a ranking of carbohydrates on a scale from 0 to 100 according to their impact on blood sugar levels during the 2 h following consumption. Low GI (<55) foods produce gradual rises in Blood sugar and insulin levels. Low GI diets have been shown to improve glucose and lipid levels and weight control because they help control appetite. Low GI diets also reduce insulin resistance and the risk of cardiovascular diseases, diabetes and some cancers. It is reported that fasting insulin is lower in individuals with higher dietary fiber intakes and that the ingestion of complex carbohydrates promotes longevity. And also that a high GI diet increases the levels of inflammation biomarkers. In patients with celiac disease, a reduced inflammatory state could provide certain protective mechanisms, thus, following a low GI diet could meliorate this disease. The GI for quinoa ranges 35-53 depending on the cooking time; 150 g of quinoa, cooked, refrigerated and reheated in the microwave for 1.5 min has a GI of 53. Therefore, even when more or less “overcooked”, quinoa maintains a low GI.

Table 2: we present a summary of the nutritional profile of cooked quinoa, in comparison with common cereals (also cooked).

Food	Energy (kcals)	Proteins (g)	Essential amino acids (number)	Carbo-hydrates (g)	Lipids (g)	Unsaturated fatty acids (g)	Fiber (g)	GI
Quinoa	120	4.4	10/10	21.3	1.92	1.61	2.8	35-53
Rice (white, medium grain)	130	2.8	9/10	28.59	0.21	0.12	0.3	75-89
Wheat (soft, white)	113	3.6	10/10	25.12	0.66	0.35	4.23	48

Health Benefits of Quinoa

It is stated that quinoa may benefit high-risk group consumers, such as children, the elderly, high-performance sports people, individuals with lactose intolerance, women prone to osteoporosis, people with anemia, diabetes, dyslipidemia, obesity, and celiac disease due to its properties including a high nutritional value, therapeutic features, and gluten-free content. These features are considered to be linked with the existence of the fiber, minerals, vitamins, fat acids, antioxidants, and especially photochemical in quinoa, and they provide quinoa a big advantage over other crops in terms of human nutrition and health maintenance.

Promotes Weight Loss

Quinoa’s fiber content makes it a great food for weight loss and treating other digestive issues like constipation. The fiber also protects the heart and prevents deadly diseases like cancer. The antioxidants this food contains work magically for skin and hair health.

Helps Prevent Osteoporosis

Let us bust a common myth that only individuals above fifty years must be really concerned about bone health. In actuality (unless one happens to be a distant relative of a walrus), everyone must be concerned about the health of their bones.

Improves Metabolism

It’s common sense, if you ask us. When quinoa is replete with so many nutrients, it is impossible that your metabolism wouldn’t improve if you consume it regularly.

Protects the Heart

Getting to the point, the soluble fiber is what makes quinoa a wonder food for your heart. The soluble fiber combines with the bile acids in your liver and produces a jelly-like substance that’s excreted in your bowels. Your liver utilizes some of the cholesterol in your body to produce these bile acids. When the stores are depleted, your liver pulls cholesterol from your blood to produce these acids.

Improves Skin Health

We already saw quinoa is rich in B vitamins, nutrients that help treat age spots and other conditions related to skin pigmentation by reducing the deposits of dark melanin in the skin. And the vitamin B12 in quinoa interacts with the other B vitamins to maintain a healthy skin complexion. Quinoa also contains tyrosinase inhibitors, enzymes that decrease pigmentation and the associated problems.

Fights Inflammation

The fiber in quinoa produces butyrate, an important fatty acid that turns off genes related to inflammation. And the B vitamins in quinoa reduce homocysteine levels (an inflammatory hormone) in the body. Quinoa also contains compounds called saponins, which studies have shown to have anti-inflammatory properties.

Strengthens Hair Follicles

The protein content of quinoa is what we must look at here. Hydrolyzed protein extracted from quinoa acts as a natural and gentle coating that protects and nourishes the hair follicles from within. The protein extracted from this grain is also used to produce high-quality hair products. The nine

essential amino acids quinoa contains act as natural strengtheners and protect the hair shaft. They also repair damaged hair and promote hair growth.

Enhances Digestive Health

Quinoa is rich in fiber, and that makes this point self-explanatory. Pretty much. Fiber adds bulk to the food churned in your stomach, and this stimulates the walls of your digestive tract. Your tract contracts and this promotes better absorption of nutrients in the small intestine. In the large intestine, this fiber prevents constipation. The B vitamins in quinoa also play a role in digestion. One of these is thiamin, which helps in the production of hydrochloric acid (the acid in your stomach that aids digestion).

Helps Fight Diabetes and Hypertension

Quinoa is a whole grain, and whole grains are great for diabetes. The fiber in quinoa doesn't raise blood sugar levels. It also prevents diabetes-related weight gain and other chronic conditions. A part of living with diabetes is all about taking foods that have low glycemic index, and quinoa, thankfully, is on the lower end. Quinoa also has all the amino acids to make protein (unlike most other grains), which also does a good job in controlling blood sugar levels.

Discussion

Reported large variation in the concentration of minerals in quinoa seeds. The difference in the values obtained by the various authors may be related to the fact that the samples were of different genotypes and regions with varying soil types and different mineral compositions and/or applied fertilizers. According Alvarez-Jubete *et al*. calcium, magnesium, and iron are the main mineral deficiencies in gluten-free products. The pseudo-cereals, amaranth, quinoa, and buckwheat, are usually a good source of these and other important minerals for celiac disease patients. In particular, the high calcium content in these seeds has great relevance for celiac individuals due to the well-known prevalence of osteopenia and osteoporosis among patients recently diagnosed with this disease. Coronary heart disease is a leading cause of death in most developed countries and is growing rapidly in developing countries. Appropriate diets that include fruits, vegetables and whole grains may contribute to cardiovascular protection. Among these foods, cereals and pseudo-cereals play an important role. Conducted experiment on Protein content in the dry matter of quinoa seeds varies between 13.8% and 16.5%; however, it is reported as 15% on average. The total protein content of quinoa is higher than that of rice, barley, corn, rye, and sorghum, and is close to wheat (USDA, 2015) [13]. While the majority of the stored proteins in quinoa is composed of albumins (35%) and globulins (37%), it contains low concentrations prolamins, and these percentages may vary indifferent species. Vega-Galvez *et al*. (2010) [14] Quinoa contains sugar by about 3%. It mostly contains maltose, D-galactose, and D-ribose in addition to low levels of fructose and glucose. Due to its perfect freeze-thaw stability, low gelling point, and endurance at low storage temperatures; quinoa is an ideal thickener for sauces, soups, and flours. Moreover, its resistance to retrogradation makes it possible to use quinoa in other applications and in obtaining a creamy and smooth texture similar to that of fats. Quinoa's ash content (3.4%) is higher than that of rice (0.5%), wheat (1.8%), and most other grains. because of this, quinoa seeds contain large amounts of mineral. Its calcium and iron content is considerably higher than that of other commonly used grains. In comparison to wheat (0.16%) and corn (0.14%), quinoa contains approximately 0.26% magnesium. Since calcium, magnesium, and potassium in quinoa are found in biologically appropriate forms, their amounts in seeds are considered to be sufficient for a balanced diet.

Abugoch (2009) [1] conducted experiment on main carbohydrate component of quinoa is starch, and it constitutes 52%e69% of it. Its total diet fiber is close to that in grain products (7%e9.7%) while it's soluble fiber content is known to be in the 1.3%e6.1% band. Colour development of baked products is caused by Maillard reactions between sugars and proteins. Gorinstein *et al*. (2008) studied the Quinoa has some functional (technological) properties like solubility, water-holding capacity (WHC), gelation, emulsifying, and foaming that allow diversified uses. Quinoa starch has physicochemical properties (such as viscosity, freeze stability) which give it functional properties with novel uses.

Quinoa is also an excellent example of "functional food" which may help reduce the risk of various diseases. Its functional properties may be related to the presence of fibers, minerals, vitamins, fatty acids, antioxidants and phytonutrients, which contribute to human nutrition, especially in the protection of cell membranes, with proven results in improving neuronal functions. These characteristics provide the grain great advantage over other plant foods for human nutrition and health maintenance.

Conclusions

Quinoa is a traditionally important and environmental stress-tolerant pseudocereal with high nutritional value. The anti-nutritional factors in the quinoa grain could easily be inactivated or reduced to safe health levels when appropriate techniques for industrial processing or household preparation of this food are used. As for culinary applications, the replacement of refined flour by whole grains such as quinoa raises several challenges that need to be addressed, including changes in organoleptic properties. In addition to presenting high nutritional quality, it is characterized by being gluten-free feature allowing to obtain a greater variety of foods more suitable and nutritious to holders of celiac disease Finally, quinoa could represent a strategic crop used to complement the diet in rural/marginal regions where energy-protein malnutrition affects a greater part of the population in certain developing countries.

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