

Review Article

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Quinoa 21st Century Golden Grain for Nutrition Security and Health Benefits: A Review

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ABSTRACT

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This grain has attracted scientific community for its high nutritional value as it is quantitatively rich in proteins, dietary fiber, poly-unsaturated fatty acids, vitamins, minerals and natural antioxidants such as phenols and flavanoids, it is considered as “superfood”. Also absence of gluten has made it an important and healthy food option for celiac patients. Quinoa also helps to reduce the risk of various diseases like cardiovascular diseases, type-2 diabetes, some cancer, high blood pressure, obesity and is also a good option for people who are allergic to certain food groups.

Introduction

Quinoa (*Chenopodium quinoa* Willd.) is a plant belonging to the family Amaranthaceae, native to the Andean regions being adaptable to different types of soil and climatic conditions, Its composition has aroused the attention of the scientific community for its high nutritional value, being rich in proteins, unsaturated fats, dietary fiber, vitamins and minerals, with an extraordinary balance of essential amino acids, It is also characterized by being a gluten-free grain, that enables its use in the diet of celiac patients (Maradini *et al.*, 2017 and Alvarez *et al.*, 2010).

Quinoa is a species of the goosefoot genus. It's a crop grown primarily for its edible seeds. Being high in various important nutrients, it is considered as world's one of the most popular health foods. The Food and Agricultural Organization of the United Nations (FAO) officially declared the year 2013 as “The International Year of The Quinoa”. FAO declared quinoa as a food with high nutritive value, vast biodiversity and as a food which can have an important role to play in the achievement of food security worldwide (Gordillo-Bastidas *et al.*, 2016). Humans currently derive 30% to 70% of their daily energy from cereal-based foods,

indicating that innovation of grain or grain-like functional foods plays a “gate-keeping” role in the conversion of agricultural crops to consumables (Poutanen *et al.*, 2014). Quinoa (*Chenopodium quinoa* Willd.) is a grain-like food crop that has provided nutrition and sustenance to Andean indigenous cultures for thousands of years and now plays an increasing role in human diets worldwide. Quinoa has been promoted as an alternative agricultural crop due to its stress-tolerant characteristics and marketed as a “super food” for its nutritious qualities. A plethora of research has recently emerged on quinoa's chemical constituents and therapeutic properties, depicting the crop as an important resource for functional food development.

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 phyto nutrients, 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 (Vega-Gálvez, *et al.*, 2010 and Repo-Carrasco *et al.*, 2011).

Superfood

Quinoa's average protein content (15%) surpasses that of wheat (12%) and rice (6%). It has high-quality protein and well-balanced amino acids with vitamins and minerals, iron in particular. Quinoa is gluten free and good for people with digestive disorders. Dr A A Dixit's (Department of Sociomedical Sciences, Columbia University, New York) team reported that “quinoa replacement with one serving of white rice in diet can prevent obesity and cardiovascular disease.

National Aeronautics and Space Administration (NASA) integrated quinoa in the diet of astronauts and considered it as a new crop for Controlled Ecological Life Support System (CELSS) because of its balanced and unique amino acid composition (Bhathal *et al.*, 2015 and Bhathal, *et al.*, 2015).

Agronomic aspects of Chenopodium

C. quinoa is a dicotyledonous plant and is botanically classified as follows:

Subclass : Dicotyledoneae
Group : Thalamiflorae
Order : Caryophyllales
Family : Chenopodiaceae
Genus : *Chenopodium*
Species : *quinoa*

The family *Chenopodiaceae* is composed of herbs and shrubs, or rarely small trees that usually grow in alkaline soil. The plants are usually scruffy because of their external cells that dry into white flakes. The leaves are simple, sometimes more or less succulent or reduced to small scales, and usually alternate but rarely opposite. There are no stipules and the flowers are bisexual or rarely unisexual (Trease and Evans, 1983).

This grain has attracted attention as a new food resource, because of the quality and nutritional value of its proteins. It is mainly rich in lysine, making its protein more complete than most vegetables, having in particular amino acid composition close to the ideal protein balance recommended by the Food and Agriculture Organization (FAO) and similar to milk (Maradini-Filho *et al.*, 2017, Vega-Gálvez *et al.*, 2010 James, 2009).

Quinoa is a complete food with high-nutritional value due mainly to its high content of good quality protein. Besides

protein content, many studies have been made of their lipids, starch, minerals and saponins it also contains minerals and vitamins like vitamin B, vitamin C and vitamin E. In 1996, quinoa was catalogued by FAO as one of the most promising crops for the humanity, not only for its great properties and its multiple uses, and it is also considered an option to solve human nutrition problems (FAO, 2011).

Nutritional composition

The nutrient composition of quinoa seeds have been studied and assessed by many researchers and organizations. QS are rich in protein content, essential amino acids, dietary fiber, fat, minerals, vitamins and natural antioxidants, also present some anti-nutritional factors in the pericarp but can be removed easily through washing (Fig. 1 and 2; Table 1–3).

Carbohydrates

Carbohydrates are organic compounds comprised of carbon, hydrogen, and oxygen. Carbohydrates act as signaling molecules, energy sources and structural components (Lee *et al.*, 2015).

Starch, as a carbohydrate, provides the major source of physiological energy in the human diet. The content of starch in quinoa ranges from 58.1% to 64.2% of dry matter, of which 11% is amylose. Moreover, quinoa has a high content of D-xylose and maltose and a low content of glucose and fructose.

Protein

The protein quantity and quality of quinoa are generally superior to those of cereal grains, while offering gluten-free property and high digestibility. Quinoa has a higher total protein content (12.9% to 16.5%) than barley (10.8% to 11.0%), oat (11.6%), rice (7.5% to 9.1%),

and maize (10.2% to 13.4%), and a total protein content equal to that of wheat (14.3% to 15.4%) (Comai *et al.*, 2007, Abugoch James *et al.*, 2009 and Peiretti *et al.*, 2013).

Quinoa is one of the most protein rich foods we can eat. Quinoa seeds contain high-quality protein (Quiros-Perez and Elvehjem, 1957) and large amounts of carbohydrates, fat, vitamins, and minerals. The seeds have a higher nutritive value than most cereal grains.

The protein content of about 15% in quinoa is much higher than that found in cereals such as wheat, barley, oats, rice, and sorghum. The soluble protein contents in quinoa are similar to those in barley and higher than those in wheat and maize (Gonzalez *et al.*, 1989).

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 (González Martín *et al.*, 2014 and Fardet, 2010).

Lipid content

Quinoa seeds have approximately 9% fat on a dry weight basis. Quinoa fat has a high content of oleic acid (24%) and linoleic acid (52%) (Ruales and Nair, 1993).

Quinoa oil is colourless to yellowish with a pungent, disagreeable, camphoraceous odour, characteristic of the seed. The flavour is bitter and burning.

Minerals

Potassium is an important component of cell and body fluids that helps controlling heart rate and blood pressure.

Quinoa is a good source of calcium, iron, potassium, magnesium and zinc when compared to daily mineral recommendations. It can be said that on an average quinoa is a better source of minerals.

Vitamin

As compared to other grains, quinoa is also a good source of B vitamins riboflavin and folic acid. Riboflavin improves energy metabolism within brain and muscle cells, and folic acid plays crucial role for proper brain function and is important for good mental and emotional health.

It is very important vitamin for pregnant women as it lowers the risk of neutral birth defects [30].

Quinoa also contains significant amount of vitamin E, which acts as antioxidant, although the quantity declines after processing and cooking (Kaziol, 1992).

Glycemic index (GI)

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 (Homas, Elliott, 2009 and Homas *et al.*, 2007).

Gluten free

Many researchers are considering quinoa as a suitable ingredient in gluten free diet especially for those people who don't want to give up staples like breads and pasta. Studies have shown that by using quinoa as a substitute of gluten free ingredients like refined tapioca, potato, corn and rice flour, it can increase the nutrient and antioxidant value of the diet many folds (Lee *et al.*, 2009 and Alvarez-Jubete, 2010).

Polyphenols

Gorinstein *et al.*, (2007) reported that the total phenolic content of quinoa was 60 mg GAE/100 g of grain. The total phenol content of quinoa was significantly higher than amaranth, lower than buckwheat (pquinoa > wheat > amaranth (Alvarez-Jubete *et al.*, 2010).

Table.1 Nutritional composition of quinoa and chia seed (g/100g edible portion)

	Quinoa [1]	Chia [2]
Protein	14.1	21.5
Fat	6.1	35.4
Fiber	7	30.2
Carbohydrate	64.2	8.6
Ash	2.4	4.5
Moisture	13.3	8.4
Kcal/100g	368	439

References : (USDA, 2018)1 ; (Niro *et al.*, 2019)

Table.2 Amino acid composition (g/100g protein)

Amino acid	Quinoa [1]	Chia [2]
Histidine	2.9	1.37
Leucine	5.9	4.15
Isoleucine	3.6	2.42
Lysine	5.4	2.99
Methionine + Cysteine	3.6	2.78
Phenylalanine + Tyrosine	6.1	3.88
Threonine	3.0	1.8
Valine	4.2	2.85
Tryptophan	1.2	-
Alanine	4.2	2.68
Glycine	4.9	2.28
Proline	5.5	1.99
Serine	4.0	2.62
Glutamic acid	13.2	24.3
Aspartic acid	8.0	7.29
Arginine	7.7	4.23

References: (Dakhili *et al.*, 2019); (Sandoval-Oliveros and Paredes-López, 2013)
 “-” Indicates not determined or not quantifiable

Table.3 Compositional analysis of mineral and vitamins present in quinoa and chia seed (mg/100g edible portion)

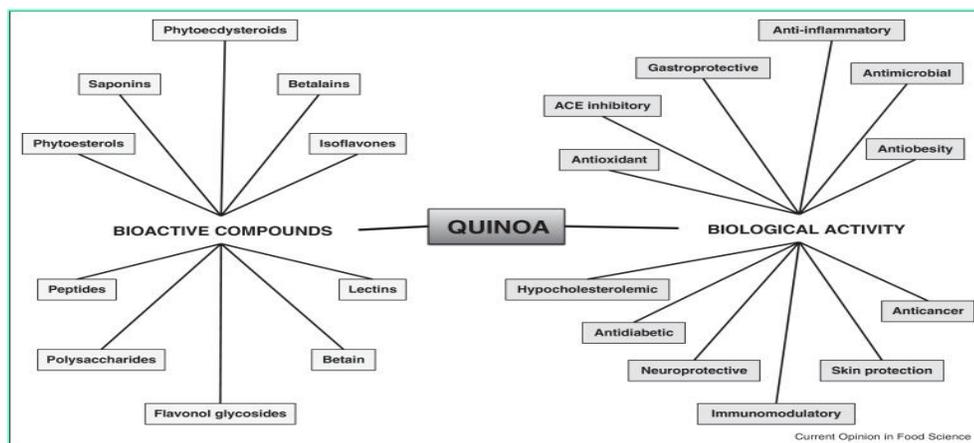
Minerals	Quinoa [1]	Chia [2]
Calcium	47	631
Magnesium	197	350
Potassium	563	407
Phosphorus	457	860
Iron	4.6	7.72
Copper	0.6	1.4
Zinc	3.1	4.58
Sodium	5	16
Vitamins		
Thiamin B1	0.36	0.62
Riboflavin B2	0.32	0.17
Niacin B3	1.52	8.82
Folic acid	78.1	-
α -Tocopherol	2.44	-
β -Carotene	8	-

References: (USDA, 2018); (USDA, 2015) “-” Indicates not determined or not quantifiable

Fig.1



Fig.2



Use of quinoa in food

Quinoa has coating substances such as saponins that keep insects away without application of pesticides. You can use quinoa in place of rice. Its small grains become soft in 15 minutes. It a versatile ingredient in the kitchen due to its subtle nutty taste. Quinoa keeps its pleasant, chewy texture when served chilled, warm, or at room temperature. We can use quinoa as a breakfast grain as well in cold salads, in burgers or even hot side dishes. We can also use it to thicken stews or soups (Choudhary Sanju *et al.*, 2020).

Quinoa is a highly nutritious food; the nutritional value of this crop has been compared to that of dried whole milk by the

Food and Agriculture Organization (FAO) of the United Nations. Quinoa is used to make flour, soup, breakfast cereal, and alcohol. Most quinoa sold in the United States has been sold as whole grain that is cooked separately as rice or in combination dishes such as pilaf. Quinoa flour works well as a starch extender when combined with wheat flour or grain, or corn meal, in making biscuits, bread, and processed food.

In conclusion quinoa has exceptionally good nutritional values. Quinoa is rich in high biological value protein, dietary fiber and polyunsaturated fatty acids which has a great potential to treat hypercholesterolemia, cardiovascular disease and obesity. It can be proved rich source of protein for Indians as

diet of majority of Indians is lacking sufficient amount and quality of proteins. Natural antioxidants are present in quinoa which helps in preventing degenerative disorders.

Quinoa is also a gluten free alternative food available for celiac patients. Being highly nutritious, quinoa can be used to complement the diet of those population who are suffering from malnutrition, are allergic to certain food groups or are purely vegans. All above properties prove the potential of quinoa to become an important industrial and food crop of the 21st century.

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