



Quinoa: New Light on An Old Superfood: A Review

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10.18805/ag.R-1927

ABSTRACT

In the busy lifestyle it's very important to meet the nutrient from a few of sources, for nutritious and healthy diet there is a range of cereals and pulses. Among of them the quinoa has methionine and lysine amino acids. Besides quinoa is considered as a Super Food, majority of the population are still unaware about the dietary benefits of this food. Quinoa can be seen as a complete food for celiac patients too because of its gluten free property. MQB (malted quinoa beverages), have a diabetic and antihypertensive potential and hence, can be effectively included among diet choices for the management of diabetes and hypertension. Starch have higher water-binding capacity and higher swelling power than wheat and barley starch and is highly freeze thaw stable and shows little retrogradation due to low amylase content. The crude fat content in quinoa is 4.4-8.8%, with the essential fatty acids linoleic and linolenic acid accounting for 55 to 63%. After 48 hr of germination, vitamin 'C' in enhanced between the range of 10.56 mg/100g and 13.23 mg/100g.

Key words: Celiac patients, Germination, Nutrition, Quinoa, Super food.

Cultivated quinoa (*Chenopodium quinoa* Wild.) was originated some seven thousand years ago from South America and today it is receiving considerable attention as an alternative crop in the World (Caperuto *et al.*, 2001; Comai *et al.*, 2007; Gely and Santalla, 2007). This crop constitutes a great potential for agronomic demands because it can adapt to produce high grain yields under adverse or stressing conditions (Comai *et al.*, 2007; Gely and Santalla, 2007).

With approximately 7000 years of cultivation history, great cultures like the Incas and Tiahuanacu had domesticated and conserved this ancient crop (Jacobsen, 2003). Quinoa belongs to the family Chenopodiaceae, genus *Chenopodium* and species quinoa. The full name is *Chenopodium quinoa* Willd (Nisar *et al.*, 2017). The *Chenopodium* genus is found worldwide, with approximately 250 species identified. It is a granifer species native to South America and domesticated by the people inhabiting the Andes, mainly in Peru and Bolivia, for thousands of years (Filho *et al.*, 2017). It is a very interesting food due to its complete nutritional characteristics (Nisar *et al.*, 2017).

India located between 8° and 38°N and 68° and 93.5°E, exhibits enormous diversity for agro-climatic regions and edapho-climatic conditions. In India, Himalayan region and plains of North India have successfully produced the crop with high yield having good agricultural potential. Quinoa seeds were reported to have been cultivated in North East Regions of India and systematic trials were initiated by NBRI, Lucknow during 1990-2000.

Quinoa was successfully grown under the project "Ananta" both at Hyderabad and in Anantapur region in Andhra Pradesh. Though, quinoa is considered as a Super Food, majority of the population are still unaware about the dietary benefits of this food and its consumption is very limited in our country. Quinoa is one of the most nutritious food crops currently known. The seeds contains high quality protein, which has all of the essential amino acids including lysine, methionine and threonine that are scarce in cereals and legumes and is also gluten-free. European and North American consumers are increasingly aware of the

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How to cite this article: Rana, G.K., Singh, N.K., Deshmukh, K.K. and Mishra, S.P. (2019). Quinoa: New Light on An Old Superfood-A Review. *Agricultural Reviews*. 40(4): 319-323.

Source of support: Nil

Conflict of interest: None

Submitted: 13-08-2019 **Accepted:** 09-12-2019 **Published:** 14-12-2019

exceptional nutritional qualities of quinoa seeds that, together with sprouts, are now considered "functional foods" and "Super food". Quinoa seeds are also rich in bioactive compounds, such as vitamins (vitamin B2, vitamin E), carotene, tocopherols and other molecules exerting antioxidant properties (e.g., phenolics) that scavenge harmful radicals

Lindeboom (2005) stated that quinoa is a very interesting food due to its complete nutritional characteristics. It is a starchy dicotyledonous seed, though not a cereal and hence it is known as a pseudocereal. This seed has been attracting attention because of the quality and nutritional value of its proteins.

Quinoa has exceptionally high protein content. Unlike wheat, rice and corn which are low in lysine, quinoa contains balanced set of essential amino acids such as methionine, cysteine and lysine thus making quinoa a good complement to legumes which are limiting in these amino acids (Drzewiecki *et al.*, 2003). Quinoa protein is low in prolamins (0.5-7.0%) which indicates that it is gluten free and therefore, non-allergenic. Starch is found to have higher water-binding capacity and higher swelling power than wheat and barley starch and is highly freeze thaw stable and shows little retrogradation due to low amylase content.

Quinoa contains 4.4-8.8% crude fat with the essential fatty acids linoleic and linolenic acid accounting for 55 to 63% of the total fatty acids and has lipid lowering effect (Alvarez *et al.*, 2009). The main flavonoids in quinoa are kaempferol and quercetin which are strong antioxidants and free-radical scavengers (Dini *et al.*, 2004). Quinoa grains contain large amounts of minerals like Ca, Fe, Zn, Cu and Mn (Repo *et al.*, 2003).

Germination, a simple process can enhance the nutritive value of seeds by bringing the desirable changes in the availability of nutrients, texture and organoleptic properties. Secondary metabolites *viz* phenolics, flavonoids, various vitamins etc also found to increase during germination, which are considered as biological antioxidants.

NUTRITIONAL AND FUNCTIONAL PERSPECTIVES OF QUINOA

Utilization of quinoa flour in cookies

The nutrient composition of quinoa is very good as compared to common cereals. Due to their low manufacturing cost, convenience, long shelf life, good eating quality and ability to serve as a vehicle for important nutrients cookies have become one of the most desirable snacks for all ages.

Demir and Kılınc, (2017) revealed that, the use of quinoa flour (QF) instead of wheat flour (WF) in cookies. QF was used in cookie formulation at different levels (0%, 10%, 20%, 30%, 40% and 50%). Afterwards, in order to determine the effects of QF on physical, chemical, nutritional and sensory properties of cookies were analyzed. The use of QF led to a slight increase in the product thickness values of the cookie samples. Also, diameter values decreased as levels of QF increased in cookie formulation but significant decrease was not noted with 10% QF addition. Moreover, addition of QF to the formulations containing decreased the spread ratio of the samples. The use of QF increased ash, crude protein, crude fat, total phenolic content (TPC) content of cookie samples ($p < 0.05$). As expected a substantial increase in the levels of phytic acid was found in all cookie samples containing QF. Generally potassium (K), magnesium (Mg), calcium (Ca), iron (Fe) and zinc (Zn) contents of the cookies increased with increasing levels of QF. Moreover, QF affected the scores of sensory properties of cookie samples. QF addition had statistically significant effect at $p < 0.05$ on colour, taste, crispness and overall acceptability except odour scores. As a result cookies were satisfactorily improved in terms of chemical, nutritional and sensory properties nutritional properties by quinoa flour.

Quinoa flakes

A small, flat, very thin piece of something, typically one which has broken away or been peeled off from a larger piece is flake.

Quinoa is considered a sacred plant. It has exceptional nutritional balance because of their peculiar composition such as protein and lipids, high protein content, sulphur amino acids and lysine and the minor components.

Prince *et al.* (2018) reported that quinoa is good source of gluten free diet which cannot digest gluten in their intestine. It is considered as a complete food, quinoa flakes

and corn flakes provides a potent amount of fat, protein, carbohydrates and energy along with SFA, MUFA, PUFA, ash and moisture. Quinoa flakes provides a rich amount of Fe, Zn, Ca, Mg, Na, K, P, Cu and Mn. Quinoa flakes and corn flakes were provide a significant amount of vitamin B1, B2, B3 and C which were 0.34, 0.40, 1.11, 5.02 (mg/100g) and 0.89, 1.07, 3.57, 10.21(mg/100g) respectively. Both are considered as rich source of macronutrients and micronutrients. So as concluding remark quinoa flakes and corn flakes both are good cardiovascular health, brain health and human body.

Gluten-free bakery products

Currently the gluten-free food manufacturers are investing in the use of whole grains including corn, rice, sorghum, buckwheat, amaranth and quinoa, since the majority of these are excellent fibre, iron and vitamin B sources.

Shehry, (2016) found that substitution of corn flour with quinoa flour to produce gluten free bakery product such as pan bread or biscuits to use it in autism disease and celiac cases nutrition. Quinoa flour (Q) as a substitute at 25, 50 and 75% for corn flour as a control (C) was evaluated. That protein, ash, fibre, fat and mineral elements levels is higher in the quinoa flour than corn flour, causing rise in protein, ash, fibre and fat in the composite flour, thus improve the nutritional characteristics of the product. Also, the results showed that, a decrease in physical and sensory characteristics with increased levels of quinoa flour to corn flour in pan bread and biscuits. Generally, replacement levels 25 and 50% of quinoa flour showed acceptable results in the sensory and physical properties in both pan bread and biscuits with a significant improvement in the nutritional qualities.

Quinoa as protein bank

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 higher total protein content (12.9% to 16.5%). The storage proteins of quinoa consist mostly of globulin and albumin, with little to no presence of prolamins, the major storage proteins in many cereal crops.

Quinoa has remarkable nutritional properties; not only from its protein content (15%) but also from its great amino acid balance. The quinoa grain protein is rich in amino acids like lysine and methionine that are deficient in cereal proteins. The grain is used to make flour, soup, breakfast, cereal and alcohol, while the flour is utilized in making biscuits, bread and processed food. Quinoa starch having small grains and high viscosity can be exploited for various industrial applications. It is also been found to contain minor compounds like phytosterols and flavonoids with possible nutraceutical benefits. Quinoa starch has some functional (technological) properties like solubility, good water-holding capacity, gelation, emulsifying and foaming that allow diversified uses. Besides, it has been considered an oil crop, with an interesting proportion of omega-6 and notable vitamin-E content. Quinoa starch has physico-chemical properties (such as viscosity, freeze stability) which give it functional properties with novel uses. Quinoa has a high

nutritional value and has recently been used as a novel functional food because of all these properties, investigated by Sharma *et al.*, (2015).

Nutritional significance of germinated quinoa

Germination is a natural process occurred during growth period of seeds in which they meet the minimum condition for growth and development. During this period, reserve materials are degraded, commonly used for respiration and synthesis of new cells prior to developing embryo.

Padmashree *et al.*, (2019) found that White and red varieties of quinoa were germinated and studied for the changes in nutritional, anti-nutritional and rheological characteristics. Germination has significantly ($p \leq 0.05$) enhanced protein and crude fibre with the significant ($p \leq 0.05$) reduction in carbohydrate contents in both the varieties. Anti-nutritional factor like phytic acid was decreased by 8.56 and 18.80 units in white and red varieties respectively. Total phenols, total flavonoids enhanced significantly ($p \leq 0.05$) in both the varieties, showing more in red variety exhibiting comparatively higher antioxidant activity. After 48 hr of germination, vitamin 'C' in both the varieties enhanced between the range of 10.56 mg/100g and 13.23 mg/100g. Linoleic acid was the major fatty acid identified in both the varieties constituting more than 50 per cent of total fatty acids. Germination has reduced linoleic, linolenic and palmitic acids with the increase in stearic and oleic acids. Germination also caused significant ($p \leq 0.05$) decrement in breakdown, set back and final viscosities in both the varieties without much affecting their pasting temperature.

Quinoa as poultry feed

Healthy poultry require a sufficient amount of protein and carbohydrates, along with the necessary vitamins, dietary minerals and an adequate supply of water.

Quinoa seed should not exceed an inclusion level of 150 g/kg of the diet, while they found that dehulling of quinoa slightly improved broiler performance.

Jacobsen (1997) reported that in feed for broilers containing wheat, rapeseed, peas and soybean meal. The effect of dehulling to remove saponins from quinoa was assessed. In the first experiment the broilers received mash feed diets from 6 to 36 days of age. Diets containing 100, 200 and 400 g kg⁻¹ whole quinoa seed, unprocessed and dehulled, were compared with a control feed. A linear growth depression ($P < 0.01$) with increasing inclusion of quinoa was found. As the chickens grew older the growth depression decreased from 1.8 to 0.8% per 10 g kg⁻¹ quinoa added. A negligible beneficial effect of dehulling ($P > 0.05$) was found only for the first week of the experiment.

In the second experiment the broilers received pelleted diets from 0 to 39 days of age. Diets containing 150 g kg⁻¹ unprocessed, 150 g kg⁻¹ dehulled quinoa and 50 g kg⁻¹ quinoa germ were compared with the control diet. No effect of dehulling was found. A level of 150 g kg⁻¹ quinoa reduced liveweight at 20 and 39 days from 627 to 601g and from 1760 to 1709g, respectively and the feed conversion was increased at 20 days of age from 1437 to 1486g feed kg⁻¹ liveweight ($P < 0.05$). The performance of broilers receiving

50 g kg⁻¹ of a germ fraction from the dehulling was quite as good as the control. It was concluded that quinoa has potential as broiler feed, but the inclusion should not exceed 150 g kg⁻¹ of the diet.

Utilisation of saponins of quinoa

Saponins are steroid or triterpenoid glycosides, common in a large number of plants and plant products. The saponin content in quinoa varies between 0.1 and 5%. The pericarp of the quinoa grain contains saponin, which gives a bitter taste and must be eliminated so that the grain can be consumed.

Filho *et al.* (2017) revealed that the pericarp of the quinoa grain contains saponin, which gives a bitter taste and must be eliminated so that the grain can be consumed. Saponins are characterized, in addition to their bitter taste, by foaming in aqueous solutions. Foams are stable at very low concentrations, 0.1% and therefore saponins have applications in beverages, shampoo, soaps etc. Saponins have no well-defined chemical formula for the dual source explained above; however, in general, the following basic skeleton is suggested: C_nH_{2n-8}O₁₀ (with $n \geq 5$). Saponins extracted from bitter quinoa can be used in the pharmaceutical industry, whose interest in saponins is based on their hypocholesterolemic effects and their ability to induce changes in intestinal permeability, which can assist in the absorption of particular medications. Saponins also have antibiotic and antifungal properties as well as other pharmacological attributes. Because of the differential toxicity of saponins in various organisms, their use as potent natural insecticides that do not generate adverse effects on humans or large animals has been researched, emphasizing their potential for use in integrated programs of pest control. The use of quinoa saponins as a bio-insecticide was tested successfully in Bolivia (Vera *et al.*, 1997).

As a complete food

Quinoa Seed (QS) is considered as a complete food because of its high quality protein content; it maintains a good balance of essential amino acids, which are very important for the growth and development of the body.

Goyat and Handa (2018) concluded that Quinoa (*Chenopodium quinoa* Willd.), a pseudo-cereal is a stress tolerant annual crop of South America. It is considered as a complete food because of its protein quality. Quinoa is rich in high biological value protein, dietary fibre 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. It has all nine essential amino acids especially lysine which is a limiting amino acid in cereals. Quinoa can be seen as a complete food for celiac patients because of its gluten free property. It has some anti-nutrient factors also like saponins, tannins, phytic acids etc. which can be removed by simple heat treatments like roasting, toasting, etc. Quinoa may prove beneficial in reducing cholesterol, triglycerides and

hyperglycaemia in humans. All above properties prove the potential of quinoa to become an important industrial and food crop of the 21st century.

Glutelin free Indian foods

Ladoo, chapatti, parantha, mathri, cookies, kheer, Dalia and pop-up are the popular Indian food, being developed by using quinoa flour are nutritious and highly acceptable. Quinoa based recipes contain a balanced set of amino acid, fat and fibre content.

Bhathal and Kaur (2018) studied that Quinoa flour was used for the development and nutritional evaluation of gluten free products i.e. ladoo, chapatti, parantha, mathri, cookies and pop-ups. Test samples were found to be highly acceptable with overall acceptability score of 8.04 for ladoo(7.66), chapatti(7.36), parantha (8.04), mathri (7.02), cookies (7.94) and pop-ups (7.78) etc. Nutritional analysis revealed that test samples prepared from quinoa flour have higher crude protein ranging from 11.02 to 15.00percent, crude fat 4.09 to 59.14 percent, total ash 1.75 to 4.19 percent and crude fibre 0.27 to 3.24 percent as compared to controls. Lysine which is a limiting amino acid in cereals, have significant higher values ranging from 2.83-9.40g/100 protein among the developed products. Methionine, tryptophan, calcium, magnesium, iron and zinc content of test samples were also found to be significantly ($p < 0.05$) higher as compared to controls. Neutral detergent fibre values ranged from (24.90% to 73.30 percent) and acid detergent fibre values ranged from (19.70 to 35.50percent) for test samples. Gluten free quinoa flour products were found to be highly acceptable and nutritionally better as compared to the control samples.

Effect of processing on the nutritional composition

The germinated form of quinoa can be included in the diet of heart and anaemic patients. And the minimal processing of quinoa should be done in order to retain maximum health benefits.

Bhathal, *et al.*, (2017) carried out that the raw; roasted, boiled and sprouted forms of quinoa grains were nutritionally analyzed. Significant changes in nutritional composition of quinoa were observed due to processing. 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), as well as calcium (83.33mg/100g), magnesium (202.17mg/100g), zinc (4.23mg/100g) and acid detergent fibre (27.40%) were also higher in raw flour. Sprouting of quinoa enhanced the crude fibre (4.06%), neutral detergent fibre (77.73%) and the iron (5.67mg/100g) content. Raw flour and sprouted quinoa retained maximum nutrients as compared to other processed forms. The results revealed that minimal processing of quinoa should be done to retain maximum health benefits.

Quinoa beverages

A drink (or beverage) is a liquid intended for human consumption. In addition to their basic function of satisfying thirst, drinks play important roles in human culture. Instead of all

beverages, malted quinoa beverage (MQB) has higher protein content, total phenolic content, antioxidant activity.

Kaur and Tanwar, (2016) reported that malted quinoa beverage (MQB) showed higher protein content (2.9g/100ml), total phenolic content (2.9 mg Gallic Acid Equivalents (GAE)/g), antioxidant activity (92%) which was well correlated with higher antidiabetic potential (40% at 150 μ L) by α -glucosidase inhibition. Very low α -amylase inhibition was exhibited by all the beverages (0.4-1.5%). ACE inhibitor activity was almost negligible for raw quinoa beverages (RQB), soaked quinoa beverage (SQB), minor for germinated quinoa beverage (GQB) (0.2% at 300 μ L) and higher for MQB (0.9% at 300 μ L). Total phenolic content was found to be well correlated with DPPH (1, 1-Diphenyl 1-2-picryl-hydrazyl), α -glucosidase and α -amylase inhibition activity in all beverages but poor correlation was found in case of ACE inhibition activity. Among all, GQB was highly acceptable with acceptability magnitude at par with commonly available commercial soya milk and concluded that quinoa beverages can be effectively included among diet choices for the management of diabetes and hypertension.

CONCLUSION

On account of the several recent studies it has been concluded that the crop can grow easily in hardy condition. Quinoa the pseudocereal has protein of high biological value, carbohydrates of low glycemic index, phytosteroids and omega-3 and 6 fatty acids, bringing benefits to the human health, up to 70% of unsaturated fatty acid (linolenic 38.9% and oleic acid 27.7 %). Both the limiting amino acids methionine and lysine are found rich in the quinoa; including cysteine, rather than human nutrition it has potential as poultry feed, polishing or washing of quinoa prior to feeding or diluting the quinoa with another available feed are viable option can be considered to improve performance. Quinoa contains saponin about 0.1-5% which is used in the pharmaceutical industry and has antibiotic and antifungal properties along with bio-insecticide nature. Many Indian foods like; quinoa kheer, biscuits, cookies, flour, flakes, papad etc and salad, beverages, sprouts and microgreens and foreign are being made from the quinoa with the different supplementation ratio.

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ISSN: 0976-0539 (Online), 0253-1496 (Print), Naas Rating: 4.37