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# Quinoa- A nutritive and health perspective

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**Abstract**

Quinoa *(Chenopodium quinoa)* is plant species which belongs to goosefoot family Chenopodiaceae, which has been cultivated in Andean region for thousands of years. It is an annual herbaceous plant that can grow 1-3cm high, seeds of quinoa are round and flat with a diameter about 1.5-4.0mm. The plant shows strong tolerance in acidic, alkaline and salty soils. Quinoa regarded as pseudo-cereal and highly nutritious due to abundant in protein, fiber, lipids, vitamins and minerals. It is one of the rare plants which have all nine essential amino acids and highest protein content in all cereals. It contains good amount of compounds including betaine, saponins, polyphenols, isoflavones and carotenoids in it. Glycemic index of quinoa ranges in between 35-53 depend upon cooking time. Quinoa shows considerably positive effects on celiac disease, serum lipid, and diabetes. Consumption of quinoa significantly reduces total cholesterol levels, triglycerides and LDL in the human body. Quinoa as low glycemic index food showed positive results on obese and type 2 diabetes patients. Quinoa is used to substitute rice, maize and wheat in various recipes. Consumer acceptability for different quinoa-based items are positive.

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**Introduction**

All around the world, cereals give approximately 35% of the daily dietary energy being a fundamental part of the human diet. This includes explicitly grains such as wheat and barley and pseudo-grains which include quinoa and buckwheat. The addition of whole grains in the diet provides with many health benefits, including a decline in the development of diabetes and cardiovascular diseases (Van Der Kamp *et al.*, 2014).

These potential health benefits resulted in the establishment of new dietary guidelines that encourage the consumption of whole grains in the diet on a regular basis (Nowak *et al.*, 2016). Researchers have begun to study such specific grains which offer a wide range of health benefits and play an essential role in human nutrition. Quinoa *(Chenopodium Quinoa)* is a plant which belongs to *Chenopodiaceae* family. Other members of this family include beet and spinach as well. This family constitutes of approximately 250 different species all around the world. There are different names used for this grain in local languages such as *jupha, suba, supha* and *dahue,* it is known as *quinua* and *quinoa* in Peru, Argentina, Bolivia, Chile and Ecuador. It has been consumed as a sacred plant by people because of its high protein content and remarkable balance of essential amino acids (Maradini *et al.*, 2015). Quinoa is known as *pseudo-cereal* because its seeds can be milled into flour and thus can be used as a cereal crop, but it does not belong to Gramineae family. The seeds of quinoa can also be fermented in order to make beer, known as "chicha", which is a traditional ceremonial beverage commonly used in South America (Navruz-Varli & Sanlier 2016).

Quinoa has been cultivated in the Andean region of Bolivia and Peru for the last 5,000-7,000 years. This grain is believed to have an exceptional nutritional value. The United Nations declared 2013 as the International Year of Quinoa in order to recognize the significant potential of this grain and to promote its production, consumption and preservation. It has a low Glycemic Index (GI), unsaturated fatty acids, high amount of protein and all essential amino acids. In addition to these, quinoa also contains minerals, vitamins and many other beneficial compounds. Another major benefit of this grain is that it is gluten-free by nature, easy to cook and has a wide variety in preparations (Tang *et al.*, 2015). In the level of dietary fiber, lipids, vitamin B1, vitamin B2, vitamin B6, vitamin C, vitamin E and minerals specifically calcium, iron, phosphorus and zinc quinoa overcomes other cereals. Due to the absence of gliadins and protein fractions corresponding to gliadins which are present in rye, barley, oats and malt, makes this grain suitable for the production and preparation of "gluten-free" products which are appropriate to supply healthy and nutritious food for patients with celiac disease (Tang *et al.*, 2015).

Thus, the data from the previous studies suggested quinoa is rich in anti-inflammatory phytonutrients, which render it highly useful to human health in the prevention and treatment of diseases. It produces significant levels of heart-healthy omega-3 fatty acids. Quinoa is a good source of protein as compared to other grains and it is naturally rich in dietary fiber, slowly digested starch, making it a good low-GI option.

*Cultivation and Botanical description of Quinoa*

The botanical name of the plant which is usually known as quinoa is *Chenopodium Quinoa Willd.* It belongs to a Goosefoot family named as *"Chenopodiaceae".* This family also include other members such as Spinach *(Spinacia Oliracea),* Swiss chard *(Beta sp.)* and Lamb's quarters *(Chenopodium Album).* Quinoa is a plant that can grow for 1-3cm high. It is a dicot plant and is not known as a true grain but rather called a fruit. The seeds of quinoa are flat and round, having a diameter of about 1.5-4.0mm. The colour of seeds usually varies from white to grey and even black, with tones of many other colours such as red, yellow, violet and purple. This plant possesses a strong tolerance alkaline, acidic and salty soils in both climates either hot (up to 35°C) or cold (-5°C). There are 250 different varieties of quinoa which were distributed worldwide. The classification of this plant typically depends on the morphology or colour of the plant or fruit. Many countries had authorized to sow quinoa include Asia, Africa, North America and Europe (González Martín *et al.*, 2014).

*Nutritional Composition*

Throughout the world, the dietary patterns, behaviours and lifestyle among different communities have been influenced due to urbanization and globalization. Foods consumed as traditional products such as foods rich in complex carbohydrates, fiber, micronutrients and phytochemicals are nowadays being replaced with high amounts of refined carbohydrates, animal fat and oils that directly influence human health and contribute to several chronic diseases (Jarvis *et al.*, 2017). Quinoa is known to be one of the best vegetal sources of protein, and the proteins present in it are higher than that of cereals such as maize, wheat and rice. The protein content present in quinoa is the same as that of milk. Quinoa has also been used to fulfil human needs during space missions by the National Aeronautics and Space Administration (NASA) due to its versatility.

*Protein*

The protein content of quinoa usually varies from 13.8% to 16.5% with an average amount of 15% dm. The protein content present in quinoa is higher than many other cereals such as rice, barley, corn, rye and sorghum (Table 1). However, wheat lies closest with an average protein content of 14.8% dm. Globulins (11S) and albumins (2S) contributes to most of the storage proteins present in quinoa, i.e., 37% and 35% respectively, however, the concentration of prolamins are low, and this ratio varies among different species. The globulin 11S, also known as chenopodin, has high amounts of asparagine-aspartic acid, glutamine-glutamic acid, leucine, serine, glycine and arginine. However, it has low concentrations of sulfur amino acids as compared to the total composition of protein in quinoa seeds. The albumin 2S present in quinoa has a composition of high histidine, arginine and cysteine, all of which play an essential role in maintaining adequate nutritional status, especially in children. This fraction of protein in quinoa contributes to the higher concentration of sulfur amino acids which enhances its potential to be used as dietary supplementation especially for children in the form of enrichment as well as food supplementation with either quinoa grain or its derivatives (González *et al.*, 2015).

Quinoa is one of the rarest plants which supply all nine essential amino acids (phenylalanine, leucine, threonine, methionine, isoleucine, lysine, valine, histidine and tryptophan). Bioavailability of amino acids or protein digestibility found in quinoa varies in the grain as well as the nutrition obtained by the crop, which increases considerably with the cooking of grain (Jarvis *et al.*, 2017).

*Carbohydrates and fiber*

Quinoa constitutes a major portion of carbohydrates usually varies from 67% to 74% of the dry matter, out of which 52% to 60% is made up of starch. The perisperm of the seeds contains starch compound; starch can be located as spherical aggregates or as simple units. The content of amylose is approximately 11%, which is less than that of other cereals such as wheat (22%0, rice (17%) and barley (26%). The diameter of starch granules present in other cereals is greater than that of quinoa. Due to the small diameter of starch granules present in quinoa, it exhibits a higher gelatinization temperature which ranges from 57°C to 64°C. Small amounts of carbohydrates are also present in quinoa such as crude fiber (2.5-3.9%), monosaccharide (2%), disaccharide (2.3%) and pentosans (2.9-3.6%) (Filho *et al.*, 2017). The total dietary fiber present in quinoa is relatively close to that of other grain products, i.e., 7% to 9%. However, the content of soluble fiber in quinoa is known to be in the 1.3% to 6.1% band (Schaffer-Lequart *et al.*, 2017).

*Lipids*

Quinoa is known to be an alternative oily seed due to the quality and quantity of its lipid fraction. It contains an adequate amount of oil that varies from 2.0% to 9.5%. Quinoa is also rich in essential fatty acids which include linoleic acids and alpha-linoleic acids. It also contains higher concentrations of antioxidants such as alpha and gamma-tocopherol. Quinoa's oil content is higher corn (4.7%) and many other grains, but lower than soybeans (19.0%) as shown in Table 1. However, the levels of linoleic acid, oleic acid and alpha-linoleic acid in quinoa were found to be similar than that of corn and soybeans when the fatty acid profiles are being compared. Such fatty acids contribute approximately 88% and

Palmitic acid contributes 10% of the total fatty acid content of quinoa seeds. It exists as an essential saturated fatty acid in quinoa. The unsaturated fatty acids contributes 87.2% to 87.6% of the total fatty acid content of quinoa, among which the contribution of oleic acid is 19.7%-29.5%, linoleic acid is 49.0%-56.4%, and alpha-linoleic acid is 8.7-11.7%, which makes its total fatty acids composition similar to that of soybean (Szakiel *et al.*, 2011).

**Table 1.** Comparison of nutrition values of quinoa and other grains.

| Composition | Quinoa | Wheat | Rice | Barley | Corn | Sorghum | Rye |
|---|---|---|---|---|---|---|---|
| Protein (g) | 14.12 | 13.68 | 6.81 | 9.91 | 9.42 | 10.62 | 10.34 |
| Carbohydrate (g) | 64.16 | 71.13 | 81.68 | 77.72 | 74.26 | 72.09 | 75.86 |
| Fiber (g) | 7.0 | 10.7 | 2.8 | 15.6 | 7.3 | 6.7 | 15.1 |
| Lipid (g) | 6.07 | 2.47 | 0.55 | 1.3 | 4.74 | 3.46 | 1.63 |
| Ash (g) | 2.7 | 1.13 | 0.19 | 0.62 | 0.67 | 0.84 | 0.98 |
| Energy (kcal) | 368 | 339 | 370 | 352 | 365 | 329 | 338 |

*Glycemic Index (GI)*

The Glycemic Index (GI) is defined as the property of the food itself, a percentage or an index which represents the quality of carbohydrate foods. Foods that consist of carbohydrates that were easily digested, absorbed and metabolized are known as high GI foods (GI ≥ 70 on glucose scale). However, foods on which carbohydrates are digested, absorbed and metabolized slowly are considered as low GI foods (GI ≤ 55 on the glucose scale) (Pineli *et al.*, 2015). Low GI foods have more beneficial effects than high GI food, especially in weight loss as well as maintaining adequate glucose level in the body. They lead to improved glucose and lipid levels in the body as well as reduce insulin resistance, the incidence of cardiovascular diseases and many other health problems, including some cancers.

The glycemic index (GI) of quinoa ranges approximately 35 to 53 depends in the time of cooking. For example, the GI of 150g of quinoa when cooked, refrigerated and heated in the microwave for about 1.5 minutes is 53. Hence it has been proved that even if quinoa is overcooked, it still maintains a low glycemic index (GI). In Table 2, a summary of essential amino acids, unsaturated fatty acids and glycemic index (GI) of cooked quinoa in comparison with other cereals (also cooked) were presented (Augustin *et al.*, 2015).

**Table 2.** Comparison of cooked quinoa with other cooked cereals.

| Food | Glycemic Index (GI) | Essential amino acids (number) | Unsaturated fatty acids (g) |
|---|---|---|---|
| Quinoa | 35-53 | 42653 | 1.61 |
| Rice (white, medium grain) | 75-89 | 42623 | 0.12 |
| Corn (sweet, yellow) | 60 | 42623 | 0.98 |
| Wheat (soft, white) | 48 | 42653 | 0.35 |

*Portion size of each food is taken as 100g; usually cooked food increases 3 times of its size.

*Vitamins*

These compounds are essential for human health. Many vitamins are present in quinoa. 100g gram of quinoa grain have different vitamins like 78.1mg of folic acid, 0.20mg of vitamin B6, 0.4mg of thiamine, 1.4mg of calcium and 0.61mg of pantothenic acid (Granados-Silvestre *et al.*, 2014). Vitamin E content of quinoa ranges between 37.49-59.82µg/g. In quinoa seed, tocopherols isoforms have also been checked. Vitamin E is present in quinoa, and it has antioxidant properties, and it also stops lipid peroxidation. It also helps in protecting the nervous system and also helps in maintaining the stability of cell membrane structures. Vitamin A is also present in quinoa, and it has many functions such as embryonic development, cell differentiation, immune response, tasting, appetite, hearing and development. In developing countries, the inadequate intake of vitamin B1 leads to a deficiency called Beri Beri. The food sources of vitamin B1 are yeast, offal, milk, fish and eggs, grains, vegetables, legumes, tubers. RDA of vitamin B1 for 7 to 12 months children are 0.3mg/1000 kcal and RDA of vitamin B1 for adults are 1.2mg /day (Li & Zhu 2017).

*Minerals*

Minerals are an important part of food, and these are important for glucose homeostasis, regulating electrolyte balance, transference of nerve impulses and enzyme cofactors in the body (Vega-Gálvez *et al.*, 2018).

In quinoa, calcium, magnesium and potassium are present in large quantity. The amount of calcium, iron, phosphorus, potassium and magnesium in quinoa is 874mg/kg, 948.5mg/kg, 2735.0mg/kg, 9562.2mg/kg, 1901.5mg/kg respectively. Calcium is rich in quinoa, and calcium helps in osteoporosis and also stops decalcification. The functions of calcium are regulation of neuromuscular transmission of chemical and electrical stimuli, cell secretion and blood clotting. For 6 to 12 months children the RDA of calcium is 400mg/day and for adults is 1300mg/day (Pereira *et al*., 2019). Iron is found in quinoa 5 times more than rice and 3 times more than wheat. Potassium is found in quinoa four times more than corn, eight times more than rice and twice than wheat (Ibeas *et al*., 2019). Magnesium is also present in quinoa. RDA intake of magnesium for adults is 300 to 350mg/day. Magnesium is also a stabilizer for membranes and nucleic acid. Manganese is also present in quinoa, and its amount is higher in wheat. Zinc is also present in quinoa. The functions of zinc are degradation of lipids, proteins, carbohydrates and nucleic acids. RDA of zinc under 1 year of children are 8.3mg/day, 11.3mg/ day preschool and school children, 15.5 and 19.5mg/day for adolescents and 14mg/day for adults. Quinoa gives 4.8mg/100 g of dry matter (Giménez *et al*., 2016).

*Other Compounds*

*Betaine*

In methyl groups, betaine is a vital osmolyte origin. For help in cell volume regulation, betaine is used by mammals. As a methyl donor, betaine is used by mammals for the remethylation of homocysteine in methionine (Jiang *et al*., 2016). Person suffering from Hyper-homocysteinemia usually become more vulnerable to endothelial cell injury by starting inflammation pathways. Intake of betaine is useful because it changes homocysteine into methionine. By taking the large dose of betaine, the urinary excretion of betaine is low. In cooked quinoa, the amount of betaine is: 1310µg/g–2000µg/g whereas in white rice betaine is: 0µg/g. However cooked oat meal betaine is: 139µg/g, and cooked wheat spaghetti betaine is: 287µg/g (Dini, 2020).

*Isoflavones*

Isoflavones are organic compounds that act for growth factor actions, protein synthesis, differentiation and malignant cell proliferation. They also take part in biological activity through intracellular enzyme and sex hormone metabolism (Vega Gálvez *et al*., 2018). Many studies have shown that quinoa is an excellent source of flavonols such as kaemperol and quercetin, as well as isoflavones, particularly genistein and daidzein. Quinoa seeds which tested for Isoflavones resulted values ranging from 0.93 to 0.52mg/100 g for genistein and 0.60 to 1.93mg/100 g for daidzein. A significant variation observed between the contents of both isoflavones tested for different types of quinoa seeds. Despite this significant variation, it observed that the content of deidzein was higher than genistein in all the tested ecotypes of quinoa (Mohyuddin *et al*., 2019).

*Polyphenols*

Polyphenols have massive structural units and are organic chemicals. Polyphenols are present in plant foods and the diet of humans. The amount of phenols is more in quinoa as compared to whole cereals, for example, wheat, barley. Ferulic acid and quercetin contain most ample phenols. 23 phenolic compounds are present in quinoa. For red, white and black quinoa total phenols are 466.99, 634.66 and 682.05 (mg/kg quinoa) (Pellegrini *et al*., 2018).

*Carotenoids*

Carotenoids are present in chromoplast, and chloroplast of plants and these are organic pigments. In humans, antioxidant activity shown by carotenoids and in plants carotenoids prevent chlorophyll from photodamage. In quinoa leaves, β-carotene is between 4.3µg/1 g-19.5µg/1 g. In white, red and black quinoa seeds total carotenoids are 11.87, 14.97 and 17.61µg/g (Multari *et al*., 2018).

*Gluten*

Gluten is crucial part of food. It is the complex of gliadin and glutenin proteins. Gluten substitutes or gluten-free grains used by patients who have celiac disease. High salt and fat and low minerals and vitamins present in gluten-free products.

Celiac disease is a cell-mediated immune response to gluten which is categorized by T-cell mediated immune response that enterprise small intestine inflammatory injury. Quinoa has a higher amount of vitamins and minerals so and is a best gluten-free grain so it can become an essential part of a healthy gluten-free diet (Turkut *et al.*, 2016).

*Saponins*

Saponins are formed of glycosylated secondary metabolites. They are used as a predator repellent by plants. Saponins are present in quinoa with a sour taste, and it causes gastric irritation. Quinoa in saponins are 0.1% and 0.5%. Quinoa in saponins are categorized as sweet (<0.11%) or bitter quinoa (>0.11%). Different studies are conducted for the elimination of saponins by washing with cold water without changing its nutritional value. There are many health benefits of confined saponins, for example, as an anti-inflammatory activity (Sun, 2019).

*Health Perspective of Quinoa*

*Quinoa and celiac disease*

Celiac disease is an autoimmune disease in which eating dietary gluten (storage protein in wheat, rye and barley) will trigger the immune response in the body. Quinoa originated in the Andean region of South America that does not contain gluten. Quinoa is known as a superfood and have a high source of protein, iron and calcium in it. In order to investigate the effects of quinoa on celiac disease, Dr. Zevallos and other researchers conducted a study in nineteen celiac patients ingested 50 grams/day of quinoa for 6 weeks. Patients eat a strict gluten-free diet. The investigators track all the data of patients including diet, serology, blood count, and gastrointestinal parameters as well detailed histological assessment of 10 patients before and after eating quinoa. Quinoa was well-tolerated and easy to digest for celiac patients. This study showed a positive result the ratio of villus height to crypt depth improved from slightly below normal value 2:8:1 to normal level 3:1, surface-enterocyte cell height improved from 28.76µm to 29.77µm. Median values of all patient's blood test were within the normal range. High density lipoprotein and triglycerides both decreased (Zevallos *et al.*, 2014).

*Quinoa and serum lipids*

Serum lipid profile is measured for predication of cardiovascular risks and diseases. It has basic parameters like triglycerides, low density lipoprotein, high density lipoprotein and total cholesterol level. A prospective and double-blind study was conducted on 35 overweight females with post menopause. In this study the researcher seen the effects of quinoa flakes vs corn flakes. Women take 25 grams of flakes daily for 4 weeks. The group of females that ingested quinoa flakes showed the notable reduction in serum triglyceride, and tendency to low the LDL and total cholesterol level. It also increased the glutathione level (Vilcacundo & Hernández-Ledesma 2017). Another study carried out in which 22 students between 18 and45 years were consumed quinoa bars for thirty days. Biochemical samples, anthropometric measurements and blood pressure are the indicators which are used to observe the effects of quinoa. The quinoa showed a reduction in levels of total cholesterol, triglycerides and low-density lipoprotein LDL (Li *et al.*, 2018). A research was carried out by Naratto *et al.* (2019) in order to observe the effect of protein isolated from quinoa seeds, 0.5% fat diet were fed to mice for 4 weeks. Quinoa protein showed remarkable results in prevention of liver total cholesterol level and plasma, in vitro protein isolates displayed bile acid-binding activity. Quinoa protein diet showed a decrease in activity of 3-hydroxy-3 methylglutaryl coenzyme A reductase (it plays a significant role in the regulation of cholesterol synthesis) and increase in activity of cholesterol-7 a-hydroxylase (it plays a crucial role in cholesterol metabolism). Hence this study concluded that quinoa protein isolate diet could be attributed in suppression of bile acids reabsorption in small intestines and control the synthesis and metabolism of cholesterol (Noratto *et al.*, 2019).

*Quinoa and diabetes*

Diabetes is a group of metabolic disorders, in which pancreas no longer able to produce insulin or not properly respond to insulin. Insulin is a hormone which helps glucose to get inside our blood and make it energy. Wang *et al.*, (2015) conducted a study on low glycemic index diet in

which quinoa included. 210 participants with type 2 diabetes divided into 2 groups and were randomly assigned to take high-cereal fiber and low glycemic index diet for 6 months. They observed a significant decrease of haemoglobin A1c (HbA1c) -0.50% in low glycemic index diet and increase of 1.7mg/dL in high-density lipoprotein (Wang *et al*., 2015). Another research carried out in order to observe the effects of quinoa, amaranth and kaniwa consumption on type 2 diabetes and weight gain. 110 participants in which 22 diabetic and 88 non-diabetics of middle-age were included in the study. The individuals with normal body mass index (BMI) regularly consumed these grains than those who were obese and overweight. It was also discovered that individuals with diabetes eat these grains more frequently and flourless frequently than who were non-diabetics (Navruz-Varli & Sanlier 2016). Another study was conducted the randomized meta-analysis trial in which he used betaine supplements. This analysis involves the five randomized controlled trials, which published between 2002 and 2010. All studies used healthy adults as participants who take 4 grams/day of betaine supplements for between 6 to 24 weeks. The conclusion of meta-analysis was the betaine supplementation lowers the plasma homocysteine 1.23µmol/L. (McRae, 2013).

**Table 3.** Clinical studies of quinoa dosage on selected sample and its effects.

| Compound | Dose | Model | Effects | Reference |
|---|---|---|---|---|
| Quinoa | 50 grams | Celiac patients | Well digest in celiac patients and improves the histological parameters and cholesterol levels. | Victor F Zevallos *et al*., 2012 |
| Quinoa flakes | 25 grams | Overweight and postmenopausal women | Increase glutathione, lower the triglyceride, LDL and cholesterol levels. | De Carvalho FG *et al*., 2013 |
| Quinoa bars | WI | Healthy adults | Reduce triglycerides, LDL and total cholesterol levels | Farinazzi Machado *et al*., 2012 |
| Low GI diet include quinoa | WI | Type 2 diabetes patients | HbA1c decreased by 50%, and High-density lipoprotein increased 1.7mg/Dl | Jenkins DJ *et al*., 2008 |
| Betaine | 4 grams | Healthy adults | Supplementation lower the plasma homocysteine 1.23µmol/L. | McRae MP 2013 |
| Quinoa protein isolate | WI | Mice | Reduction in liver total cholesterol and plasma levels. | Takao *et al*., 2005 |

*Allergic effects of quinoa*

Allergic reaction is the misguided reaction of the immune system to the foreign invaders; usually, these are harmless substances like grains, milk, egg, soy and peanut that cause body defense system to react. The example of a 38-year-old female patient hospitalized with eosinophilic esophagitis owing to food consumption of other flours in diet. The sensitization study carried out on samples made by extract of quinoa seeds and buckwheat flour, skin prick test SPT were performed and showed positive results for both extracts. The doctors advised the patient to avoid quinoa and buckwheat flour. Sensitization study should be done before recommending quinoa and buckwheat flour to any patient in future (Navruz-Varli & Sanlier 2016). Another case reported in a 52-year old male patient who developed the severe allergic reaction by consumption of quinoa, fish and bread. The clinical history of the patient showed the previous allergic response to quinoa and seasonal rhinitis due to pollen. Skin prick test using ground seeds of quinoa was positive; it showed irritation diameter of 15mm, and in control, it was just 5mm observed whereas fish and bread showed negative results. For further analysis, cooked and raw quinoa protein extract and blood samples of allergic and non-allergic individuals investigated by using immunoblotting. 35 kDa band used for detection, and it showed a positive response towards immunoglobulin E in blood samples of allergic people while no band appear in non-allergic patients (Turkut *et al*., 2016).

## Conclusion

Quinoa recently recognized for its nutritional and health benefits in all over the world. It gained

importance due to the high amount of protein (essential amino acids), fiber, vitamin and minerals in it. It is a good source of minerals and bioactive compounds saponin, betaine and other polyphenols. In context, different studies show positive effects of quinoa on different diseases. Quinoa helps in increasing good cholesterol HDL high-density lipoprotein. It is naturally occurring gluten-free grain which make quinoa ideal for celiac patients as it is easily digestible and well-tolerated. Quinoa is easily absorbable in blood steam due to which it lowers the haemoglobin A1c values in type 2 diabetes patients. The results of the study show that betaine supplements lower the condition of homocystinuria. These supplements also improve the body composition and athletic performances. Quinoa has overall good acceptability and commercial values; consumers appreciate quinoa-based food products. By reviewing different literatures reveals that quinoa is extremely healthy grain. Further study on quinoa consumption should be encouraged and investigate its effects on human health.

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**Conflict of interest**

There is no conflict of interest

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