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The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; SP-11(7): 1106-1110

www.thepharmajournal.com
Received: 06-04-2022
Accepted: 10-05-2022

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Application of quinoa seeds in food industry

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Abstract
Quinoa (*Chenopodium quinoa* Wild.) is a Chenopodiaceae plant species that originated in the Andean region and can adapt to a variety of soil and climatic conditions. Last 5,000-7,000 years, humans have been cultivating and eating quinoa. Quinoa has been dubbed "one of the grains of the twenty-first century" due to its resistance to extreme environmental circumstances as well as its nutritional and biological qualities. Quinoa was significant to pre-Columbian Andean civilizations because the Incas saw it as a divine gift. Quinoa are well-known for their high nutritional content and potential health advantages. It is a high-nutrition pseudo grain that is high in proteins, lipids, fibre, vitamins, and minerals, as well as having an exceptional balance of vital amino acids. Quinoa has been shown to have significant beneficial impacts on human metabolic, cardiovascular and gastrointestinal health They have a high protein content with all essential amino acids. Quinoa also has a lot of phytochemicals like saponins, phytosterols and phytoecdysteroids. Despite its health benefits, quinoa is not widely consumed for a variety of reasons. We believe more research is needed to provide more information about quinoa.

Keywords: Quinoa, quinoa flour, downy mildew, nutritional composition

Introduction
Quinoa grains which is also known as *Chenopodium quinoa* Wild. It is a South American annual plant that grows in abundance. Quinoa's nutritious value was rediscovered during the second half of the twentieth century, leading to a resurgence in its production after centuries of neglect. Domestication is supposed to have began around 7000 years ago in the Andean region. Quinoa has remained a staple diet for Andean indigenous peoples for millennia. Quinoa was shunned as "Indian food" after the Spanish invasion, yet it has persisted despite the introduction of Old-World species. (Brazile D *et al*., 2016) [3]. They have a high protein content (12-20%) (all essential amino acids are highly bioavailable, and they are especially high in lysine and methionine), but they also have a lot of carbohydrates (low glycemic index), dietary fibre (10%), oil (6-7%, high in unsaturated fatty acids) and minerals (magnesium, zinc, iron, potassium and phosphorus). (Sezgin *et al*., 2019) [25]

Chenopodium quinoa Wild's is the botanical name of quinoa, and it is a member of the Goosefoot family "Chenopodiaceae", which contains Swiss chard (*Beta* sp.), spinach (*Spinacia oleracea*), and Lamb's quarters Quinoa is a dicot plant that can reach a height of 1 to 3 metres and is classified as a pseudo-cereal, rather than a true grain. The seeds are round and flat, measuring 1.5-4.0 mm in diameter and range in colour from white to grey to black, with golden undertones. Quinoa comes in 250 different types and is sold all over the world. Plant and fruit colour, as well as plant shape, are used to classify it. This grain can now be planted across Europe, North America, Asia and Africa. In 1993, the European Community authorised the initiative "Quinoa: a versatile crop for the European Community" (Bastidas, E.G *et al*., 2016) [2].

Quinoa was first classified based on the colour of the plant and its fruits. Following that, it was based on the plant's morphological kinds. Despite the great range of variations, quinoa is considered a single species. Quinoa and maize, has been categorised as a race for practical reasons. Quinoa from Ecuador, Peru and Bolivia has been divided into 17 races, Valencia-Chamorro (2003) [29] identified two forms of inflorescence:
1. Glomerulates-glomeruli are tiny clusters of flowers that emerge from tertiary axis.
2. Glomeruli in Amaranthiformes are primarily derived from secondary axes.

Quinoa may be found growing at altitudes ranging from sea level to the Andean mountains. As a result, one of the most useful classifications is one that defines five ecotypes: valley, subtropical, salar and antiplanic (Valencia-Chamorro, S.A *et al*., 2003) [29]. Saponins (0.1-5%), phytic acid (1.05-1.35%) and protease inhibitors are all anti-nutritional agents found in quinoa. These elements may have a negative impact on quinoa products' nutritional, sensory, and quality characteristics. Quinoa contains bioactive substances such phenolic compounds, flavonoids, and carotenoids, which are important antioxidants in the diet and give important health advantages. (Wu, G *et al*., 2015) [33]. The seeds have been eaten like rice, in soups, puffed into breakfast cereals, and milled into flour for toasted and baked items (cookies, breads, biscuits, noodles, flakes, tortillas, and pancakes). (Bhargava *et al*., 2016). Quinoa is now grown in Argentina, Bolivia, Chile, Colombia, Ecuador and Peru at altitudes ranging from sea level to 4500 metres. (Vega-Gálvez *et al*., 2010) [31] Quinoa is a gluten-free food that is good for vegetarians, health-conscious people, athletes, the elderly, and persons with celiac disease, in addition to helping to battle malnutrition in underdeveloped nations. (Li, G., and Zhu, F. 2018) [15].

Quinoa (*Chenopodium quinoa* Wild.) is a dicotyledonous herbaceous plant that is both medicinal and tasty. Quinoa's excellent nutritional value originates from its well-balanced protein, amino acid, fibre, mineral, and trace component composition (for instance vitamins and antioxidants) (Vidueiros, S.M *et al*., 2015) [28] Quinoa has been pushed as an alternative agricultural crop and marketed as a superfood, to the point where numerous studies have lately described quinoa as a significant resource for the development of functional foods. Agriculture and Food Policy Quinoa has been named as one of the crops that will provide food security in the twenty-first century by the Food and Agriculture Organization (FAO). Quinoa has been designated as the International Year of Quinoa in 2013. (Montemurro, M *et al*., 2019) [20] Quinoa is a plant species in the Polygonaceae family with a nutritional profile comparable to grass seeds; because the seed is too small to mill to separate the anatomical components, quinoa is classified as a whole grain (Van Der Kamp *et al*., 2021) [30] Quinoa is a good source of gluten-free protein, which has a well-balanced amino acid profile when compared to other cereals; lipids rich in unsaturated fats; dietary fibre; and minerals and phytochemicals, in addition to a high starchy carbohydrate content. This suggests that quinoa could be a gluten-free alternative to traditional cereals. (Li, L and, Lietz, G., 2018) [16]. This crop is a high-nutritive natural food resource that is evolving into a high-quality food for current and future human generations' health and food security. The purpose of this review article is to educate readers on the use of quinoa in the food industry.

Nutritional composition

Quinoa is a nutritious food because it includes a wide range of nutrients and, when coupled with other foods, may make up a healthy diet. Quinoa is known for being high in protein. As shown in the table, quinoa has a higher protein level than most grains but a lower protein content than most other plant foods. Legumes. Quinoa has a good balance of necessary amino acid levels when compared to other plant meals. Finally, quinoa is an excellent source of calories and dietary fibre, as well as minerals such as iron and zinc. Quinoa has a unique amino acid, carbohydrate, lipid and micronutrient composition, with nutritional levels that are often higher than those seen in other grains. Cereal-based items Though there has been a lot of focus on quinoa's health benefits, Quinoa's secondary metabolites may contribute to the maintenance of human health and wellness, as well as its macro-and micronutrient profiles. Triterpenoids (saponins, phytosterols, and phytoecdysteroids), phenolics, betalains and glycine betain are among the secondary metabolites found in quinoa. (Graf, B.L *et al*., 2015) [13].

Table 1: Nutrient contents of quinoa and selected food, pre 100 grams dry weight

SL. No.	Components	Amount
1.	Energy (kcal/100g)	399
2.	Protein (g/100g)	16.5
3.	Fat (g/100g)	6.3
4.	Total carbohydrates (g/100g)	69
5.	Iron (mg/100g)	13.2
6.	Zinc (mg/100g)	4.4

Quinoa has a wide range of traditional and nontraditional applications, as well as value-added industrial innovations that are now commercially available, such as ready-to-eat cereals, pasta, granola bars, and breads. The entire grain can be boiled and combined with other foods in a meal, such as in a soup or ground into flour for use in breads and other baked goods. Beverages and a variety of other foods.

Diseases of quinoa

Downy mildew

The most destructive disease of quinoa an ancient Andean grain crop, is downy mildew caused by *Peronospora farinosa*. The illness has been found in all places where quinoa is grown. Despite the disease's widespread and considerable impact on quinoa production, epidemiology, host specialisation, population and resistance of the host plant structure. Downy mildew is indigenous to the Andean region, it poses a constant threat to quinoa production whenever the conditions are right for disease growth. It has a high potential for spread and growth throughout the region, but it does not occur with the same intensity in the various Andean quinoa production zones. Typical symptoms include light or yellow chlorotic lesions on the leaf surface (which produce a reduction in the amount of water in the leaf). Gray-violaceous photosynthetic area of the plant and finally become necrotic) and photosynthetic area of the plant and eventually turn necrotic) sporulating regions on the leaf's underside the lesions are minor and inconspicuous in some cultivars. In some cases, the lesions are small, diffuse and irregular, whereas in others, they are massive, diffuse and irregular. Some cultivars have the lesions change colour from red to purple, indicating a hypersensitive reaction (small necrotic flecks). It has also been noticed. (Danielsen S., *et al.* 2003) [9] Quinoa is afflicted with a number of pathogens that cause diseases such as mildews, damping off, blight, mosaic, and others. Viruses are known to infect the plant, however there have been no instances of serious damage. The most common type of mildew is downy mildew. Even in the most resistant cultivars, this severe disease on quinoa is reported to produce output reductions of 33-58 percent. (Tahmasebi, M., and Firuzkoohi, M. 2017) [27].

Leaf spot

Pseudomonas sp. was recovered from quinoa leaves, stems, petioles, and seeds. This pathogenic bacterium causes dark brown patches and apical necrosis in leaves, and apical necrosis in stems. It causes deep lesions that have a vitreous appearance. The consistency is nice. As a result, *Pseudomonas* sp. causes significant crop damage and loss, resulting in plants with a wide range of traits. Cankers, spots, and a number of other disorders and symptomsrots, blights, and galls. (Foyal and Lisa 2018) [11]. Leaf spot is caused by *Ascochyta hyalospora*. It appears to benefit from hot temperatures. The fungus is spread by seeds, and the initial sign is bright dots on the leaves with an undefined area. Pycnidia can be seen later on, and the leaves get dry and fall off. Leaf spot has now become a major problem in the cultivation of quinoa in China. (Li, J and Zhou, X., 2018)

Brown stem rot

Brown stem rot is caused by *Phoma exigua var. foveata*, a pathogenic fungus. Quinoa brown stem rot was discovered for the first time in the 1974-1975 crop season in the Peruvian plateau. This pathogenic fungus thrives in a chilly, humid environment. Pathogens are mostly found in the stem and inflorescence, and the disease's injured sections were dark brown with a glassy border. *Phoma exigua* is a soil-borne pathogen that thrives in low-temperature, high-humidity environments, which are prevalent in the Andean highlands throughout the growing season. Mechanical harm to the plant is required for pathogenicity testing to be successful. infection. Hailstorms are common in the Andean highlands, causing severe mechanical damage to the plants.

Seed rot and damping off

Rhizoctonia and *Fusarium*-caused root and seedling infections in quinoa. *Rhizoctonia solani* and *Fusarium* spp. *R. solani* displayed symptoms similar to those seen in the field caused by damping off in pathogenicity tests conducted in greenhouses. Because both fungi are soil-borne diseases that affect a variety of other hosts and generate comparable symptoms, the inoculum potential in the soil may be a key element in the disease's ability to cause damage. Seed rot and damping off of quinoa is caused by *Sclerotium rolfsii Sacc. Pythium zingiberum*, a pathogen that causes rhizome rot in ginger, is another possible barrier for quinoa *P. zingiberum* oospores inoculated in the soil produced damping off of quinoa seedlings. Quinoa was more susceptible than C. amaranticolor. *Sclerotium* and *Pythium*-caused seed rot and damping off have not yet been recorded in South America, but they should be regarded potential production restrictions when quinoa is introduced into areas where it is not grown traditionally. (Danielsen S *et al*., 2003) [10]

Application

Breads, biscuits, cookies, crepes, muffins, pancakes and tortillas are just a few of the foods made from the seed. Quinoa has recently gotten a lot of attention.as a treatment for celiac disease, Wheat, rye, and barley are all cereals that can be substituted. Gluten is present in all of them. (Jacobsen, S. E. 2003) [14]. Pseudocereal leaves, which were formerly regarded as a waste product, are edible and can be utilised in salads as well as a great complement for functional foods. (Gawlik-Dziki, U *et al*., 2009) [12] Quinoa saponins have been used to control agricultural pests in a limited number of studies. When employed against Candida albicans, the total saponin fraction of C. quinoa was found to reduce the growth of the fungus marginally and it was recently discovered that the biological activity of quinoa saponins can be increased by treating them with alkali. (Coral and Cusimamani, 2014) [8]. Several South American indigenous peoples, including the Quechua, Aymara, Tiahuancota, Chibcha, and Mapuche, have traditionally consumed quinoa (Bhargava and Srivastava 2013) [5]. The seeds have been used to manufacture toasted and baked foods in the same way that rice has been used in the past (Bhargava and others 2006) [4]. Quinoa seeds can also be fermented to make beer or "chicha", a classic South American ceremonial alcoholic beverage (FAO 2011) [21].

Only one study on the sensory analysis of quinoa grains has been found. The study's findings revealed a wide range of sensory properties. For instance, a green scent or a solid texture. Positive features included crunchiness, while negative qualities included Pasty, sticky, and cohesive were all undesirable characteristics. Preference appeared to be influenced not just by sensory characteristics but also by other factors. quinoa, as well as the consumer's familiarity with the grain. Those whose diets comprised of 750-1000 grammes of organic foods per kilogramme of body weight. Those who ate all quinoa varieties scored much higher than those who didn't. 0-250 g kg1. (Wu G *et al*., 2017) [34]. Quinoa has been used as a partial substitute for wheat or rice flour in bread baking in various proportions. Whole quinoa seeds, flakes, or flour have traditionally been used to make quinoa-enriched bread. Wheat-based bread containing up to 200 g kg1 of dehulled and washed quinoa seeds was considered to be totally acceptable to the taste, with a very good scent and flavour, despite a slightly bitter taste. (Suárez-Estrella, D *et al*., 2018) [26].

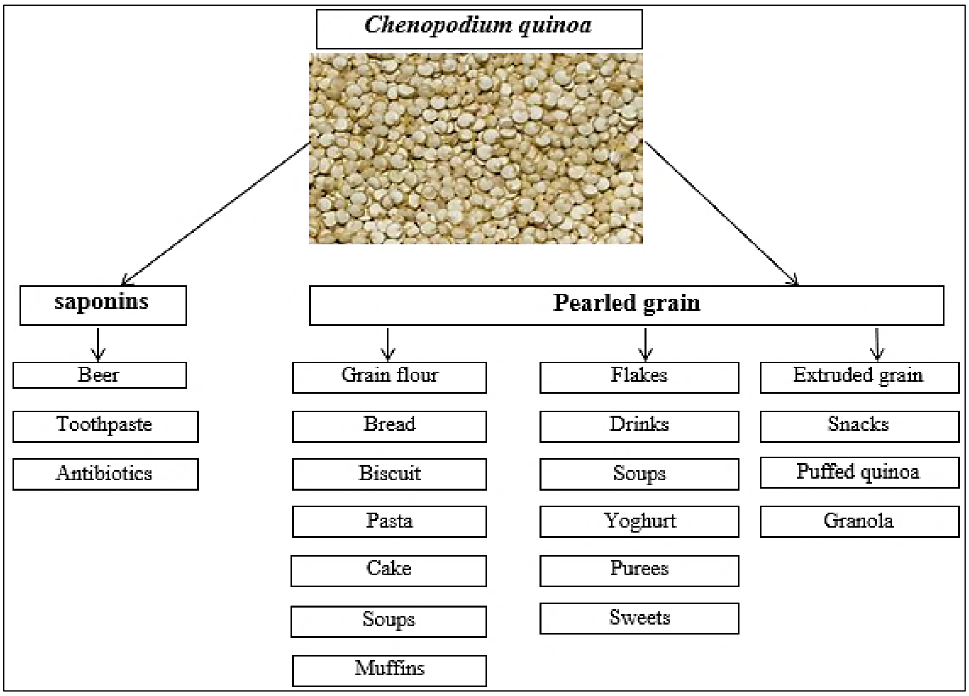
Utilization and effects of various quinoa-based products

Sl. No.	Product	Amount in percentage	Effect	References
1.	Grain	100%	Antioxidant activity, as well as the prevention of diseases linked to free radical damage.	(Yael, B *et al*., 2012) [35]
2.	Bread	Various percentage from 0-20% germinated	Lower volume and sensory acceptability of the loaf. Bread of good quality at a maximum of 10%	(Rodriguez-Sandoval, *et al*., 2012) [22]
3.	Pasta	Different percentage of quinoa flour	Good lysine and methionine content, and a consumer taste panel approved it.	(Caperuto, L.C., *et al*., 2001) [7]
4.	Cookies	0-50% of quinoa flour	Minerals, ash, crude protein, crude fat, total phenolic content, phytic acid, and total phenolic content have all increased.	(Demir, M.K., and Kılınç, M. 2017) [10]
5.	Cakes	Roasted and non-roasted quinoa flours (79%)	Increased shelf life and limit starch retrogradation.	(Rothschild, J *et al*., 2015) [23]
6.	Cereal bars	Less than 85%	*In vivo* assay (30 days): reduced blood pressure and body weight	(Chillo, S *et al*., 2008) [6]
7.	Quinoa Yoghurt like beverage	Fermentation-35%	Free amino acids and GABA concentrations, polyphenols and antioxidants, protein digestibility, and starch hydrolysis index are all higher.	(Lorusso, A *et al*., 2018) [18]
8.	Muffins	30% and 50%	Protein, fibre, and minerals (magnesium, potassium and zinc) concentrations are higher. At 50%, there is a high level of acceptability.	(Baker, M.G *et al*., 2013) [1]

There is a scarcity of information on the effect of quinoa on the sensory properties of pasta products. Corn-based pasta with 100 g kg1 quinoa flour was somewhat popular, with 70% of respondents saying they would probably or definitely buy it. 48 A similar quinoa enrichment resulted in a product with lesser firmness than the control (1000 g kg1 amaranth), but equivalent adhesiveness and bulkiness. (Chillo, S *et al*., 2018) When compared to previous gluten-free formulations, the acceptance of the quinoa-based product with chickpea or soy flour was high. (Mastromatteo, M *et al*., 2012) [19]. Several studies have looked at the effect of quinoa on cookie acceptability, with mixed results, whether the cookies were wheat-based or gluten-free. Low levels of quinoa enrichment (100 g kg 1) had no effect on the sensory acceptability of cookies prepared predominantly from wheat flour, as expected, while a somewhat greater level of substitution (150 g kg 1) affected flavour, taste and overall acceptability. (Watanabe, K *et al*., 2014) [32].

Quinoa was also utilised to make muffins, with a 30 percent to 50 percent substitution rate for rice flour. The higher concentration of proteins, fibre, and minerals in the GF product confirmed that the nutritional quality of the GF product had improved. In the volume and textural analysis parameters, no significant differences were identified, although muffins manufactured with 50% quinoa flour had a greater acceptance in a sensory study. (Baker, M.G *et al*., 2013) [1]. To make a GF, sweet product, quinoa flour was used to make cakes. The quinoa flour used in the recipe had a percentage of 79 percent (on a flour basis). Quinoa grains were likewise roasted (170 °C) before milling, with varying process periods (15, 30 and 45 minutes), as previously stated, and the flours used in bread-making saw ideal outcomes. (Bastidas, E.G *et al*., 2016) [2].

A precooked slurry of drum-dried quinoa flour is used to make an infant food product After 15 days, they discovered an increase in insulin-like growth factor-1 (IGF-1) in the plasma of children who consumed a supplemental portion of 2 100 g of the infant food product, whereas the control group showed no difference. (Ruales, J *et al*., 2002) [24]. Quinoa was also used to make beverages that tasted like yoghurt. The use of the probiotic strain Lactobacillus rhamnosus SP1 as the starter increased significantly the nutritional indexes (chemical score, protein efficiency ratio, EAA index, and biological value) of a previously gelatinized mixture of quinoa flour and water fermented by the exopolysaccharides (EPS)-producing strain Weissella confusa DSM 20194 caused an increase in the viscosity of the beverage. Fermentation also enhanced free amino acid and aminobutyric acid (GABA) concentrations.



Application of quinoa in food industry

Conclusion

Quinoa has a wide range of conventional and unorthodox uses, as well as value-added industrial inventions such ready-to-eat cereals, pasta, granola bars, and breads that are now commercially available. The whole grain can be boiled and mixed with other ingredients in a meal, such as a soup, or crushed into flour for breads and other baked items. beverages, as well as a wide range of other items. Quinoa is a high-protein, high-carbohydrate, high-mineral, maltose, and D-xylose food. The water and oil absorptions were both excellent, indicating that it might be used in human food and drink compositions. Based on the demonstration it is understood that quinoa has been widely used in food industry. Which is highly nutritional and healthy for daily base human intake.

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