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Quinoa's (*Chenopodium quinoa* Willd.) Nutraceutical Properties and Traditional Lore

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ABSTRACT

Quinoa, the ancient Andean grain, has evolved into a superfood celebrated for its medicinal and nutraceutical properties. Rooted in the cultural heritage of indigenous communities like the Quechua and Aymara, quinoa's history reaches back to 5000 B.C., and it was esteemed by the Incas as the "Mother Grain." Today, its cultivation is prominent in countries such as Ecuador, Peru and Bolivia, its worldwide presence keeps growing. Quinoa's remarkable versatility and nutrient density make it a valuable agricultural resource. Thriving in challenging environments, from high altitudes to freezing climates, it offers a wide array of health benefits. Abundant in protein, carbohydrates, dietary fiber, essential minerals, and vitamins, quinoa stands as a comprehensive source of vital nutrients. Notably, its amino acid profile, featuring high lysine and methionine levels, sets it apart, and its gluten-free nature accommodates various dietary preferences. Quinoa's phytochemical composition comprises polyphenols, flavonoids and saponins. While saponins may introduce a hint of bitterness, they also harbour potential health advantages, including anti-fungal properties. Its rich mineral content, notably iron, calcium, and phosphorus, enhances its nutritional value. Additionally, quinoa provides essential vitamins such as B6, folic acid, biotin, and vitamin E, surpassing conventional cereal grains in these aspects. Quinoa is a versatile and nutritious grain, offering a unique blend of attributes that confer a multitude of health benefits. Beyond being a core ingredient in the Andean diet, it holds promise as a valuable food source with medicinal and nutraceutical potential, enriching global agriculture and nutrition.

Keywords Quinoa, Ancient grain, Medicinal, Nutraceutical, Orthomolecular, Anti-aging.

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INTRODUCTION

The traditional nutraceutical knowledge of the original peoples has been described as a rich and cumulative repository of wisdom, information, and beliefs that evolves through adaptive processes and is culturally passed down over successive generations. Indigenous communities such as the Quechua, Aymara, and other Andean groups cultivate and utilize

a diverse range of functional foods including grains, tubers, roots, fruits, aromatics and medicinal plants. These foods not only help them maintain good health in challenging high-altitude and inter-Andean valley conditions but are also produced using traditional farming, processing, and preparation techniques, ensuring they receive proper nutrition and preserve their well-being. Quinoa, an ancient Andean grain crop, has garnered global attention in recent years due to its exceptional nutritional and functional properties. It has drawn interest for potential pharmaceutical applications (as noted in studies by Bhargava *et al.* 2006a, Hirose *et al.* 2010, Vega Gálvez *et al.* 2010) and its ability to thrive in adverse environmental conditions such as soil salinity, extreme pH levels, drought, and frost (as demonstrated in studies by Jacobsen *et al.* 2003, Fuentes and Bhargava 2011).

Origin

Quinoa's cultivation can be dated to around 5000 B.C. and it first emerged in the elevated areas of the Andes as documented by Pearsall (1992). The Incas highly regarded quinoa, affectionately calling it the "Mother Grain" or "Chisiya mama" in their native Quenchua language. According to statistics provided by the Food and Agriculture Organization (FAO), the top quinoa-producing nations include Ecuador, Peru and Bolivia.

Area and distribution

Cultivated (World)– Area (188.9 thousand hectares), production of 175 thousand tons (Chura *et al.* 2020).

Cultivated (India)- Area (440 hectares), yield (1053 tonnes).

In India, the states of Andhra Pradesh and Uttarakhand have emerged as primary cultivators of quinoa. In 2013, Uttarakhand entered into a horticulture research agreement with Peru to cultivate quinoa within the state (Kumar *et al.* 2022). World wide spread of Quinoa has undergone a significant transformation over the past century. Originally cultivated in just six countries, quinoa is now grown in over 120 countries worldwide. This expansion has been promotional efforts. This changing landscape introduces fresh n spurred by growing interest, advancements in market development, research initiatives, and rivals in the Andean region, which has conventionally been the epicenter of Quinoa production, encompassing both conventional and classic farming system. Some core transformations in this new context include fluctuating yield and limited technological adoption.

Morphology

Quinoa is a yearly, herbaceous plant with two cotyledons, typically reaching a height of 1-2 meters (Franc and Martina 2006). The seed is, in fact, a fruit, exhibiting various hues (green, yellow, red or purple) and physical characteristics based on its specific variety (Koziol *et al.* 1993).

Characteristics

•Salt-tolerant (Halophytes).

•Resilient to arid conditions (Drought-resistant).

•Adaptable to varying day lengths (Photoperiod-resilient).
•Thrive at different elevations (ranging from sea level to altitudes of 4000 m).

•Capable of withstanding freezing temperatures (Frost-resistant, enduring -8°C for up to 4 hrs).

This 'precious grain' presents an effective solution for addressing food insecurity, especially in arid and isolated regions where other crops cannot be cultivated (Jacobsen *et al.* 2003, Fuentes and Bhargava 2011).

Quinoa seeds possess distinctive structural characteristics

Quinoa seeds exhibit a disk-shaped morphology, as described by Imelda. They possess a flat equatorial band encircling the outer edge. Unlike traditional cereals, quinoa stores its nutrients primarily in the perisperm rather than the endosperm, earning it the designation of a pseudo-cereal. The embryo, which envelops the perisperm is dicotyledonous and constitutes a component of the seed's bran fraction. In

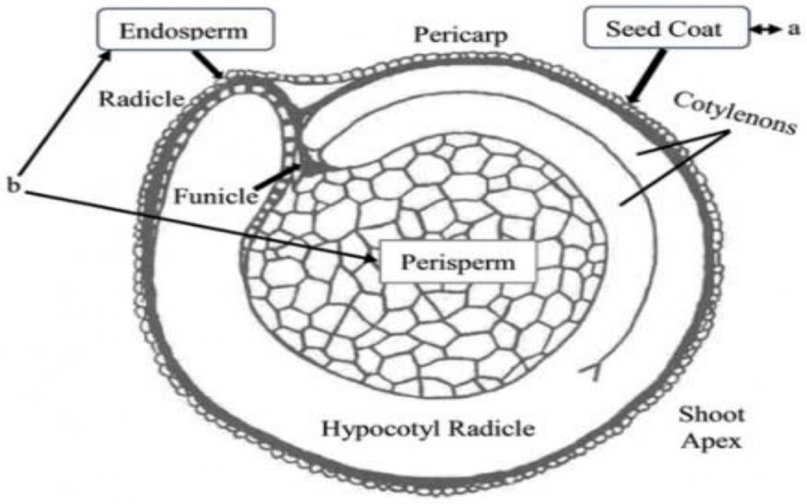

Fig. 1. Median longitudinal section of the quinoa grain.

accordance with the findings of Imelda, quinoa seeds possess food reserves in various areas, including the perisperm, embryo, and endosperm as shown in Fig. 1.

Quinoa is hailed as a superfood owing to its exceptional nutritional profile

Quinoa has garnered a reputation as a superfood owing to its remarkable nutritional composition. Researchers have shown great interest in quinoa due to its well-balanced array of essential nutrients, including carbohydrates (comprising 77.6% of its composition), protein (making up 12.9%), and an amino acid profile that features high levels of lysine and methionine. Furthermore, quinoa contains lipids at a rate of 6.5% and is abundant in dietary fiber, as documented in studies by Ruales and Nair (1994).

Additionally, quinoa boasts a rich mineral content, with substantial amounts of Potassium (K), Phosphorus (P), Magnesium (Mg), Calcium (Ca) and Iron (Fe), far exceeding the levels found in typical cereal grains. This remarkable mineral profile has been highlighted by various researchers.

a) ***Anti-carcinogenic*** **:** Quinoa contains antioxidants and phytonutrients that may help minimized the likelihood of specific cancers.

b) ***Anti-diabetes*** **:** Its low glycemic index and high fiber content can assist in blood sugar management, making it a favourable choice for those with diabetes.

c) ***Anti-inflammatory*** **:** Quinoa's nutrients and antioxidants may help combat inflammation in the body, potentially lowering the risk of chronic diseases.

d) ***Anti-hypertension*** **:** The potassium and magnesium content in quinoa can contribute to lower blood pressure levels.

e) ***Anti-aging*** **:** Quinoa is rich in antioxidants like vitamin E and selenium, which can help protect the skin and body from premature aging.

f) ***Obesity*** **:** Its high fiber and protein content can promote a feeling of fullness, aiding in weight management.

g) ***Cardiovascular health*** **:** Quinoa's heart-healthy nutrients, such as fiber and omega-3 fatty acids, may reduce the risk of heart disease.

h) ***Gluten-free*** **:** Quinoa is naturally gluten-free, making it suitable for individuals with gluten sensi-

tivity or celiac disease.

i) ***Immune health*** **:** It contains vitamins and minerals like zinc and vitamin C, which can support a robust immune system.

j) Incorporating quinoa into your diet can contribute to these health benefits and provide a nutritious addition to your meals.

Protein

Quinoa is renowned for its high protein content. According to Koziol (1992), the protein content in quinoa grains varies from 13.8 to 16.5%, with an average of approximately 15%. Sweet quinoa varieties, which contain fewer saponins has documented to have a protein content of 14.8%, while bitter quinoa varieties, which have higher saponin levels, contain around 15.7% protein (Wright *et al.* 2002). In a study in 1963, four different quinoa genotypes were examined, revealing a protein range of 12.9 to 15.1%. Quinoa's lysine content is notably double that of wheat, making it a valuable source of this essential amino acid. Moreover, quinoa stands out for its elevated levels of sulfur- containing amino acids, cystine, and methionine, which are found in concentrations that are unusually high compared to other plant-based sources. This heightened amino acid profile may be attributed to the volcanic soil where quinoa originates (Schlick and Bubenheim 1996). Quinoa flour is considered low in gluten due to its low prolamine and glutamine contents. This gluten profile makes quinoa a suitable dietary choice for individuals with celiac disease, as it can be consumed without triggering adverse gluten-related reactions.

Carbohydrates

Starch is the predominant carbohydrate found in quinoa, primarily located in the perisperm. It constitutes approximately 58.1 to 64.2% of the dry matter of quinoa, of which 11% is composed of amylose, as reported by Repo-Carrasco *et al.* (2010). Quinoa starch granules are smaller in size compared to those found in common cereals, and they have a polygonal shape with a diameter of about 2 µm. This unique starch composition, rich in amylopectin, imparts excellent freeze-thaw stability to quinoa. Consequently, it serves as an ideal thickening agent in frozen foods and various other applications where resistance to retrogradation, or the reformation of starch crystals, is desired. This characteristic makes quinoa starch particularly valuable in maintaining the texture and quality of food products during freezing and subsequent thawing, as highlighted by research from Berghofer and Schoenlechner (2002), Ahamed *et al.* (1998).

Fat

Fat in quinoa is predominantly found in the germ of the seed. Quinoa's fat content is greater than that of maize, varying from 1.8 to 9.5% with an average 5.0 to 7.2% Koziol (1992). Dini *et al.* (1992) reported a total lipid content of 14.5% in quinoa, with about 70% of these lipids being unsaturated fatty acids, particularly linoleic acid and oleic acid, which make up 38.9% and 27.7%, respectively. Linoleic acid is the most abundant polyunsaturated fatty acid in quinoa, constituting 52% of the total fatty acids. The presence of vitamine E in quinoa serves as a natural antioxidant, safeguarding all the fatty acids contained in it. Quinoa's n-6/n-3 ratio is 6.2, falling within recommended values according to Alvarez-Jubete *et al.* (2010). This balance of fatty acids contributes to its overall nutritional quality.

Nutritional composition

Minerals

Minerals in quinoa are primarily concentrated in the outer bran layers and their concentrations surpass those typically found in most grain crops. In particular, quinoa boasts higher levels of iron (81 mg/kg), calcium (874 mg/kg), and phosphorus compared to maize and barley. Phosphorus, potassium and magnesium are predominantly located in the embryo of quinoa, while calcium (Ca) and phosphorus (P) in the pericarp are associated with the pectic compounds of the cell wall, as noted in the study by Konishi *et al.* (2004). Sulfur is spred throughout the embryo of quinoa evenly. Furthermore, iron in quinoa has been documented as highly soluble, potentially making it more easily available for populations dealing with

iron-deficiency anaemia, as suggested by Valencia *et al.* (1999). These rich mineral contents contribute to quinoa's nutritional content and its possibilities individuals seeking to increase their dietary intake of essential minerals.

Vitamins

Vitamins are vital micronutrients that organisms require in small quantities. According to Koziol (1992), quinoa stands out with significantly higher vitamin content when compared to common cereals like rice, barley, and wheat/ In a 100 g edible portion of quinoa, you can find 0.20 mg of vitamin B6, 0.61 mg of pantothenic acid, 23.5 g of folic acid, and 7.1 g of biotin, as documented by Bhargava *et al.* (2006b). Quinoa's antioxidant properties are further enhanced by the presence of a substantial amount of alpha-tocopherol (vitamin E). Additionally, quinoa boasts higher beta-carotene concentrations (0.39 mg/100 g dry weight) in comparison to cereals like wheat (0.02 mg/100 g dry weight) and barley (0.01 mg/100 g dry weight), as highlighted by Koziol (1992). Recent research by Schoenlechner *et al.* (2008) has revealed that quinoa contains ten times more folate content (132.7 mg/100 g dm) than wheat. Notably, the bran fractions of quinoa contained an average of 124% of the total folate, while the flour fractions contained an average of 57%. This high folate content makes quinoa-based products such as pasta and cookies an excellent alternative for individuals seeking to increase their folate intake in their die.

Table 1 tabular representation underscores that quinoa offers a commendable nutritional profile compared to conventional cereal crops. However, it's worth noting that oats, amaranth, and wheat excel in specific nutrient aspects when compared to quinoa.

Phytochemical composition

Polyphenols

According to Paskol *et al.* (2008), quinoa seeds demonstrate an elevated concentration of bioactive polyphenols, which can alter an organism's antioxidant state and protect it from oxidative stress. Quinoa and red amaranth sprouts and seeds both contained gallic acid, which was the predominant phenolic acid present. The seeds and sprouts included p- Hydroxybenzoic acid, vanillic acid, p-coumaric acid, caffeic acid and cinnamic acid respectively. Quinoa has a total phenolic concentration of 60 mg GAE/100 g of grain. According to Alvarez-Jubete *et al.* (2010) quinoa had a lower total phenol level than buckwheat and much greater total phenol content than amaranth.

Flavonoid

According to Repo-Carrasco *et al.* (2010), the flavonoid concentration of quinoa ranges from 36.2 to 144.3 mg/100 g. According to Martinez *et al*. (2009), quinoa from diverse sources contains daidzein and genistein in varying amounts. The amount of flavonoids in quinoa rises by 4.4 times after germination

Table 1. Comparison of quinoa with other common cereal crops (g/kg of edible portion Kcal/ kg). Sources: National nutrient database for standard reference release; USDA, DRI nutrient report.

Grains	Protein	Total lipids	Carbohydrates	Dietary fibers	Minerals	Water	Energy
Quinoa	141.2	60.7	641.6	70.0	12.8	132.8	3680
Amaranth	135.6	70.2	652.5	67.0	14.9	112.9	3710
Oats	168.9	69.0	662.7	106.0	11.9	82.2	3890
Barley	105.0	16.0	745.2	101.0	11.0	121.1	3450
Buckwheat	126.2	31.0	705.9	100.0	14.7	111.5	3350
Rice	133.5	208.5	496.9	210.0	47.6	61.3	3160
Wheat	74.0	12.7	425.3	11.0	5.0	477.5	2140
Daily requirement							
Male adult	56.0	40.0	130.0	38.0	10.2	3.7	2100
Female adult	46.0	40.0	130.0	25.0	10.0	2.7	2100

and after oven drying (Carciochi *et al.* 2014).

Saponins

Quinoa's principal limiting elements, which give it a bitter flavor, are saponins. The seed's epicarp contains saponins that give it a distinctively bitter or astringent flavor. According to Chauhan *et al.* (1992), the hulls contained 40–45% of the saponins. According to Stuardo and Martin (2008), quinoa contains between 0.1 to 5% saponins. According to its saponin concentration, quinoa is categorized as "sweet" (free of or having 0.11% of free saponins) (Martinez *et al.* 2009). Although saponins are sometimes referred to as the "anti-nutrient of quinoa," they may potentially have health-related or therapeutic advantages, Stuardo and Martin (2008), since its association with steroid-containing fungal membranes compromises the stability of the membranes and reported that quinoa saponins had antifungal properties.

CONCLUSION

Quinoa, an ancient grain, has medicinal, nutraceutical, orthomolecular, anti-aging, and anti-stress properties. It is also the Andean people's staple diet and medicine due to its optimum balance of vital amino acids and other nutrients for appropriate development and growth. The research methodology involved over a period of 14 years (2005-2019), there has been extensive exploration and exchange of bilateral and multilateral knowledge in Andean communities. Traditional medicinal applications of quinoa by Andean people include treating fractures, sprains, discoloration's, bruises and strengthening of bones, Quinoa's calcium content is four times higher than that of maize and it contains lithium, which can alleviate anxiety and depression. It is also galatogenic, enhancing milk production in nursing mothers and may help prevent uterine cancer and issues related to menopause due to its phytoestrogens (Daidzein and Cystein). Additionally, quinoa can help prevent osteoporosis and counteract the organic and functional changes associated with estrogen deficiency. It's high biological value protein and balance essential amino acids with fiber constituting 6% of the grain's weight, promotes bowel movement. It is rich in antioxidants like betalains and betaxanthins which supports health and serve as an energy source for muscles, the brain and the nervous system. The amino acid Alanine and Glycine act as brain- calming neurotransmitters and regulates motor functions, while Proline aids in joint repair and injury recovery. It helps combat anaemia due to its iron content and has saponins that prevent polyglobulinemia due to their haemolytic effect. Native varieties and wild relatives of quinoa are used in food, medicine, flavoring, dyes, seasoning, ornamentals and biocides.

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