

Is It Really a Superfood? Quinoa and The Effects on Cardiovascular Risk Factors

Cetin Sanlialp Sara^{*,†,1}, Günay Seyda²

¹Department of Cardiology, Servergazi State Hospital, Denizli, Turkey

²Department of Cardiology, Bahçelievler State Hospital, Istanbul

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ABSTRACT

Quinoa (*Chenopodium Quinoa* Willd.) is a psudocereal plant which has been consumed for 5000 years. It has attracted the attention all over the world because of its adaptability to all climate conditions and its biological, nutritional importance. The year of 2013 was declared international quinoa year due to the fact that it is an old plant that contributes to world food security. Quinoa has rich nutritional value from protein, essential aminoacid, minerals and vitamins. Also it contains saponins, phytosterols, phytoecdysteroids, phenolics that provides its biological activities. These components may positively affect on health such as metabolic, gastrointestinal and cardiac influences but nowadays there are limited studies on human health. In this review, the cardiovascular effects of quinoa will be mentioned.

Key words: antioxidant–biological activities–cardiovascular effects–quinoa–nutritional value

1 INTRODUCTION

Quinoa (*Chenopodium Quinoa* Willd.) is a plant which belongs to Chenopodiaceae family. Quinoa has been grown in the Andean region for 5000 years [1]. Nowadays it is mainly grown in Peru, Bolivia, Ecuador, Argentina, Chile and Coloumbia [2]. It has been introduced in Europe, North America and Africa since last years because of adapting different types of soil and climatic conditions [3]. Quinoa has been produced in Turkey since 2010 and its production became commercial size in 2015 [4].

In the far east quinoa is also known as “functional food”. “Functional food” term was originated in Japan in the 1980s. Food scientists submitted evidence that their foods had “advantageous physiological effects.” Approved foods then acquired special FOSHU or Food for Specific Health Uses labels. Subsequent countries and scientific organizations attempted to create their own definitions of functional food. This bred high sales but confusion among the public as to the meaning of functional food. The Functional Food Center (FFC) defines “functional food” as natural or processed foods that contains known or unknown biologically-active compounds; the foods, in defined, effective, and non-toxic amounts, provide a clinically proven and documented

health benefit for the prevention, management, or treatment of chronic disease. This definition is unique because of its acknowledgement of “bioactive compounds” or biochemical molecules that improve health through physiological mechanisms. Also, this definition notes that bioactive compounds must be taken in non-toxic amounts because bioactive compounds have upper limits before they become dangerous [5].

Quinoa can be used in different foods such as bread, cookies, biscuit etc. and can be fermented to make beer [6, 7]. Also, quinoa does not include gluten so it is a valuable dietary source for people with gluten sensitivity and celiac diseases [1].

Quinoa has high nutritional and functional content that is associated with high protein, fats, vitamins and minerals [8]. It contains average %15 protein and its protein components are higher than other grains. Its main included proteins are albumin(35%) and globulins (37%). It provides all essential aminoacids [3]. Its major saturated fatty acid is palmitic acid and linoleic acid. Alpha- linoleic acid represent 88% of total fatty acid as unsaturated fatty acids [9]. Its vitamin contents’ such as riboflavin (B₂), pyridoxine (B₆), vitamin E and vitamin C, folic acid are more than other grains⁽²⁾. It contains high quantity calcium, magnesium, iron and zinc. Also magnesium, calcium and potassium are found in bioavailable forms in it [10]. (Table 1)

* Corresponding author.

† Email: saracetin@hotmail.com.tr.

The phytochemicals stored in quinoa are saponins, phytosterols, phytoecdysteroids and betalains. Saponins' structure has steroids or triterpenoid aglycone [11]. Quinoa seeds have most types of saponin chemical structures. Today, it has been reported that quinoa seeds include 68 new types of saponin [12]. Saponins are found as cholesterol complexes and other sterols contents of cell membranes [13]. Saponins provide antifungal, anticancer, hypocholesterolemic, hypoglycemic, antithrombotic, diuretic and anti-inflammatory activities [14]. The components of phytosterols in quinoa seeds are β - sitosterol, campesterol and stigmasterol. The phytosterols are found in more quinoa than other grains [15]. Phytosterols are structurally similar to cholesterol. It blocks cholesterol's intestinal absorption and decreases atherogenic lipoprotein production. Phytoecdysteroids have potential pharmacological and metabolic effects in mammals [3]. Phytoecdysteroids' bioactivities are antidiabetic, immunomodulatory, antidepressive, antioxidant, hepatoprotective and neuroprotective. Quinoa seeds has at least 13 different phytoecdysteroids and 20HE is the most found in these. 20HE can be used for oral or topical sex hormone supplementation because of its low toxicity [16]. It has been demonstrated that 20HE provides reducing adiposity, lowered blood glucose levels in obesity [17]. When quinoa compared among other plants for phytoecdysteroid contents' levels, its seeds contain nearly 10 times more 20HE than spinach and 25 times more than bitter [16, 18, 19]. (Table 2)

Phenolics contain hydroxyl groups that provide antioxidant activity [20]. Polyphenols have subgroups and one of them is flavanoids [21]. Its phenolic acid and flavonoids contents provides inhibitors effect on α - glucosidase and pancreatic lipase enzymes [4]. Betanins and isobetanins' effects are similar to phenolics in human health [22]. Some studies showed that the betanins in quinoa provide more antioxidant activities than polyphenols [23].

The effects of quinoa on health

Quinoa may have beneficial effects on high risk groups such as elderly, children, patients with anemia, obesity, dyslipidemia, celiac diseases due to its high proteins, fibers, minerals, vitamins, fatty acids and specially phytochemicals contents [3]. It has antifungal, antiviral, anticancer, hypocholesterolemic, hypoglycemic, antithrombotic, diuretic and anti-inflammatory biological activities that provided by saponins [24]. But the trials of quinoa about human health are still limited [3].

Quinoa effects on cardiovascular risk factors

In a study, the effects of dietary quinoa on parameters for risk of cardiovascular diseases were evaluated after 30 d consumption in twenty-two 18 to 45-year-old students. In this study daily consumption of a quinoa cereal bar for 30 days significantly lowered triglyceride, total cholesterol, and LDL levels. Meanwhile, blood glucose levels, body weight, and blood pressure each decreased, though nonsignificantly. So, quinoa flakes can be used in cereal bars or can be added in food products such as cookies, breakfast cereals, and diet supplements [25]. In China, recent changes to traditional diets, including a dramatic decrease in amounts of whole grains consumed from 104 g/d in 1982 to 24 g/d in 2002

Table 1. The nutritional and bioactive components of quinoa

Contents	Quantity
Proteins	
Total protein	8-22 %
Prolamin	0.5-7 %
Albumin and Globulin	44-77 %
Fatty acids	
Saturated fatty acids	12.3-19 %
Monounsaturated fatty acid	25-28.7 %
Squalene	33.9-58.4 mg / 100 g
Oleic acid	58.3 %
Linoleic acid	90 %
Minerals	
Calcium	874 mg / kg
Iron	81 mg / kg
Vitamins	
Vitamin E	0.59-2.6 mg / 100 g
Vitamin C	16.4 mg / 100 g
Folic Acid	78.1 mg / 100 g
Tiamin	0.4 mg / 100 g
Phytochemicals	
Phytosterols	118 mg / 100 g
Phytoecdysteroids	138-570 g / g
Phenolics	251.5 g / g (dry weight)
Betain	3930-6000 g / g

Table 2. The comparison of plants for phytoecdysteroid contents

Name	Scientific Name	Plant part	Phytoecdysteroid content
Quinoa	Chenopodium quinoa Willd.	Seed	109 to 497 g/g 20HE 138 to 570 g/ phytoecdysteroids
Bit-ter	Dioscorea dumetorum Kunth	Dried rhizome	22 g/g (20)- 5 β , 11 α , 20-trihydroxyecdysone; 266 g/g ajugasterone C; 32 g/g herkesterone
Spinach	Spinacia oleracea L.	Dry leaves	40 g/g 20HE
		Fresh leaves	40 g/g phytoecdysteroids
		Fresh roots and stem	100 g/g phytoecdysteroids
		Fresh whole plants	100 to 200 g/g phytoecdysteroids

may be responsible for the elevated CVD mortality seen in this country [26]. On the other hand, Liangkui Li et al showed that daily consumption of quinoa in this short-term intervention appears to modify glucose response, but has minimal effects on other CVD risk biomarkers [27]. Daily intake of 25 grams of quinoa flakes, not the corn flakes, in postmenopausal women was shown to reduce total cholesterol and LDL-c and to increase in GSH in a prospective and double-blind study [28].

Seeds of quinoa are an excellent source of antioxidants. It has been seen that quinoa reduced oxidative stress by decreasing malondialdehyde in the plasma and increased the activities of antioxidant enzymes such as catalase, erythrocyte superoxide dismutase, plasma glutathione perox-

idase [29]. Despite the wide usage of these chemical-based antioxidant activity assays, they lack the in vivo physiological relevance in pH and temperature, and more importantly in bioavailability, uptake, and metabolism of the antioxidant compounds [30].

Quinoa may inhibit over production of NO. NO acts as a necessary component in the regulation of various physiological functions such as blood pressure, immune response and neural communication under normal physiological conditions [31]. But overproduction of NO can induce tissue damage and is associated with inflammatory diseases including atherosclerosis and hypertension [32, 33]. An inhibitory activity against NO production in LPS-stimulated RAW 264.7 cells was shown in previous studies and these data are related to the higher level of total phenolic content in the ethanolic extracts when compared to the water extract [34]. Also, the secondary metabolite of plants has also been reported to act as excellent anti-inflammatory agent in oxidative stress and inflammation [35]. There is a growing body of epidemiological studies supporting an inverse association between whole grain consumption and risk of several chronic diseases, including cardiovascular diseases [36, 37].

The other effects of quinoa

Antimicrobial and antifungal effects: The quinoa saponin fractions inhibits the growth of *C. Albicans* [38]. The seeds of quinoa have found more effective than Amoxisin against *E. Coli* and *S. Aureus* [39].

Anticancer effects: The phenolic compound of quinoa is related with inhibition of tumor angiogenesis that provides cancer promotion and progression [40]. In a study, it has been showed that the phenolic fraction of quinoa was effect on prostat cancer cells in rats. It is thought that phenolic components of quinoa may be beneficial by providing intracellular signaling associated with oxidative stress and reactive oxygen radicals [41].

Celiac diseases: Quinoa does not include gluten content so it is tolerated by celiac patients. In a study, 50 g quinoa was given 19 patients with celiac disease everyday for 6 weeks and the end of the study; serology, gastrointestinal parameters of patients were evaluated. The study findings showed the patients gastrointestinal parameters' were normal after use quinoa and the structure of villus returned normal size and length [42].

Increase of IGF-1: In a study, 100 g quinoa added baby foods twice a day in Ecuador. The babies fed with quinoa have high IGF-1 levels in their plasma when compared with control group. It can reflect that quinoa can prevent the malnutrition in infants [43].

Weight losing effects: The high fatty diet with 20-hydroxyecdysone (20HE) riched by quinoa may provide the absorption of lipids, increasing glucose oxidation/mitochondrial oxidative phosphorylation and spending energy [44].

Gastrointestinal benefits: It has been showed that the arabinan and pectin isolated by quinoa made smaller the gastric lesions in rats. According to this study' results, the quinoa may increase the mucosal synthesis or the capacity to bind to the superficial mucosa and may cover the surface of gastric mucosa [45]. (Tables 3 and 4)

Table 3. The non- cardiac benefits of quinoa

Quinoa inhibits the proliferation of bacterias and fungals.
Quinoa inhibits the releasing of IL-6 and IL-1 β .
Quinoa have anticancerogenic and antioxidative effects.
Quinoa provide losing weight and increases the insulin sensitivities.
Quinoa increase the plasma levels of IGF-1.
Quinoa improve the gastric parameters and the structure of villus in celiac patients.
Quinoa have gastroprotective activity.

Table 4. The benefits of quinoa on cardiovascular risk factors

Quinoa decreases the blood glucose levels.
Quinoa edits the blood pressure.
Quinoa lowers total cholesterol, triglyceride and LDL levels.
Quinoa inhibits over production of NO that causes tissue damage so it can prevent chronic inflammatory diseases including atherosclerosis.

The side effects of quinoa

There are few case-reports about the allergic reactions due to quinoa. One of them was a 38-year-old female patient with eosinophilic esophagitis caused by quinoa and her skin prick test was positive for quinoa [46]. Others of them were a 29-year-old woman that has urticaria and angioedema in the lips after eating quinoa salad [47] and another case was a 52-year-old male diagnosed with quinoa allergy reported [48].

2 CONCLUSION

Quinoa has rich nutritional value and functional various biological activities that are provided by phytochemical composition. Despite more studies in invitro environments about quinoa, the studies on humans are unfortunately limited. The effect of food processing on the bioaccessibility, bioavailability and bioactivity of phytochemicals in quinoa seeds has not well studied yet. New varieties rich in these bioactive components and incorporation into functional foods are also important areas of future research. Further investigation is necessary to validate the effect of the components in quinoa on potential CVD preventing benefits in humans.

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Conflicts of interest

There are no conflicts of interest.

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AUTHOR BIOGRAPHY

Cetin Sanlialp Sara Department of Cardiology, Servergazi State Hospital, Denizli, Turkey

Günay Seyda Department of Cardiology, Bahçelievler State Hospital, Istanbul