IJFANS
International Journal of Food And Nutritional Sciences

Volume 7, Issue 1, January 2018, www.ijfans.com e-ISSN: 2320-7876

INTERNATIONAL JOURNAL OF FOOD AND NUTRITIONAL SCIENCES

IMPACT FACTOR ~ 1.021

Official Journal of IIFANS

IJFANS International Journal of Food and Nutritional Science

e-ISSN 2320 -7876 www.ijfans.com
Vol. 7, No. 1, January 2018

Research Paper ***Open Access***

QUINOA (Chenopodium quinoa Willd.) – THE FORGOTTEN GOLDEN GRAIN

Jyoti Goyat[1]* and Chanu Handa[2]

*Corresponding Author: Jyoti Goyat, ✉ jyotirajbarman@gmail.com

Received on: 26th March, 2017 Accepted on: 21st August, 2017

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. This grain has attracted scientific community for its high nutritional value as it is quantitatively rich in proteins, dietary fiber, poly-unsaturated fatty acids, vitamins, minerals and natural antioxidants such as phenols and flavanoids. Also absence of gluten has made it an important and healthy food option for celiac patients. Its anti-inflammatory functions may be proved helpful in preventing metabolic disorders such as cardiovascular diseases (CVD's), diabetes, cancer, hypertension and obesity. This review presents a comprehensive and up-to date information regarding the origin, structure, functional and nutritional composition. It also draws light on its health implications. This is systematic literature review with no meta-analysis. Scientific research and review papers were collected via several electronic databases such as Medline (Pub-Med Version), NLIST (Programme of INF LBNET) and DELNET (Developing library network) under the keywords "*Quinoa*", "*Chenopodium quinoa Willd*.", "Chenopodaceae", "Functional foods", "pseudocereal", "Hypertension", "Origin", "Dicotyledonous", "Hyperglycemia", "Cardiovascular risk", "Triglycerides", Omega-3 fatty acids", "Nutraceutical", "Dietary fiber", "Fatty acids", "Functions", "Viscosity", "Mucilage", "Antioxidants", "Phenolic compounds", "Viscosity", "Morphology", "Applications", "Gelling", "Plasma levels", "Clinical trials", "Insulin Resistance".

Keywords: Quinoa, Functional food, Anti-inflammatory, Antioxidant, Metabolic disorders, Celiac disease

INTRODUCTION

Quinoa (*Chenopodium quinoa* Willd.) is a pseudocereal which belongs to the goosefoot family (*Chenopodaceae*) and native to South America. For thousands of years, quinoa was used by Andes domestically in Peru and Bolivia. Also quinoa is known in the Andes by the name "*Chisaya mama"* which means and called as Mother of all grains by Incas as it was an important staple food for them [1, 2, 3]. Nowadays, it is cultivated in the South America, USA, China, Europe, Canada and India. The main producing countries are Bolivia, Peru, Ecuador and Chile [4, 5]. Quinoa is finding its way in India also under the "Project Anantha" in which quinoa was grown successfully at Hyderabad and Ananthapuramu district of Andhra Pradesh. It is also found in Himalayan region [6].

The United Nations General Assembly declared 2013 as "The International Year of the Quinoa" in recognition of ancestral practices of the Andean people, who have preserved quinoa as food for present and future generation through knowledge [6].

National Aeronautics and Space Administration (NASA) integrated quinoa in the diet of astronauts and considered it as a new crop for Controlled Ecological Life Support System (CELSS) because of its balanced and unique amino acid composition [7, 8].

[1] Ph.D. Research Scholar, Amity University, Sector - 125, Noida, UP, India.

[2] Assistant Professor (II), Amity Institute of Food Technology, Amity University, Noida, UP, India.

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. These seeds are rich in dietary fiber, minerals, vitamins and natural antioxidants. Quinoa also contains some anti-nutritional factors such as saponins which are known for its bitterness and toxicity; saponins are present in the pericarp of the seed and can be removed through dehulling/ polishing or washing [9, 10, 3].

STRUCTURE AND MORPHOLOGY

Quinoa is a dicot, stress tolerant annual herbaceous crop usually about 1-2 m high at altitudes of 2500-4000 m [11]. It is morphologically and systematically different from other cereal grains (monocot) like rice, wheat etc. therefore coined as pseudo cereal [12].

Quinoa seeds consist of pericarp, endosperm and perisperm. Developing embryo is found in the perisperm instead of starchy endosperm as found in cereals. Seeds of pseudocereals are comparatively smaller than the cereals [13, 9].

Seeds of quinoa are flat, oval or round shaped and about 1.5 mm to 4 mm in diameter. The quinoa seeds may germinate in few hours after coming in contact with moisture. If sown deeply in the soil, roots may go up to 30 cm in depth. Its Stem may grow straight or branched with cyndrical shape of 3.5 cm in diameter [14, 15]. Depending upon the variety of seeds color may vary from white to grey and black, or can be red or yellow [16].

Quinoa seeds can be used domestically in the roasted form, flour or sprouts for baked goods, soups, salads and bars, etc. [17].

NUTRITIONAL COMPOSITION

The nutrient composition of quinoa seeds have been studied and assessed by many researchers and organizations. QS are rich in protein content, essential amino acids, dietary fiber, fat, minerals, vitamins and natural antioxidants, also present some anti-nutritional factors in the pericarp but can be removed easily through washing [18, 3]. Table 1 [19] gives detailed macro nutrient composition of quinoa seeds.

Protein

Quinoa has a high biological value protein content which varies from 12.9% to 16.5% [17]. According to United States Department of Agriculture (USDA) total protein content of quinoa is higher than that of rice (7.13 g/100 g), wheat (13.21 g/100 g), corn (9.42 g/100 g), Sorghum (10.62 g/100 g) and barley (12.48 g/100 g). Limiting amino acids such as lysine (4.8 g/100 g protein) and threonine (3.7 g/100 g protein) are present in high amount in quinoa protein as compared to other cereal grains [21, 22]. Quinoa protein can meet over 100% of the daily recommended intake of essential amino acids for adult population as recommended by Food and Agriculture Organization (FAO)/World Health organization (WHO) [9, 15]. Essential amino acid profile of quinoa is similar to that of milk protein "casein". All the essential amino acids are present in quinoa in a good amount [17]. Refer Table 2 for the detailed amino acid composition of quinoa given by USDA.

Dietary Fiber

Fiber is one of the important components of healthy diet. Intake of adequate amount of dietary fiber is associated with the prevention of cardiovascular diseases like stroke, myocardial infarction, vascular diseases, obesity,

Table 1: Comparison of the Mean Nutritional Composition of Quinoa Seeds with Other Grains

Nutrients amount per 100 g	Grains/Seeds						
	Quinoa seed	Wheat	Barley	Rice	Oats*	Sorghum	Corn
Moisture (g)	13.28	10.74	9.44	11.62	8.22	12.40	10.37
Energy (Kcal)	368	340	354	365	374	329	365
Carbohydrate (by difference; g)	64.16	71.97	73.48	79.95	66.27	72.09	74.26
Protein (g)	14.12	13.21	12.48	7.13	13.6	10.62	9.42
Fat (g)	6.07	2.50	2.30	0.66	7.6	3.46	4.74

*Source: USDA National Nutrient Database for Standard Reference Release 28 Slightly Revised May, 2016 [19] and *NIN, Nutritive Value of Indian Foods [20]*

Table 2: Amino Acid Compositions of Quinoa Seeds

Amino acids (g/100g)		Amino acids (g/100g)	
Tryptophan	0.16	Phenylalanine	0.59
Threonine	0.42	Tyrosine	0.27
Isoleucine	0.50	Valine	0.59
Leucine	0.84	Arginine	1.09
Lysine	0.77	Histidine	0.41
Methionine	0.30	Alanine	0.59
Cystine	0.20	Aspartic acid	1.13
Glycine	0.69	Glutamic acid	1.86
Proline	0.77	Serine	0.57

Source: USDA National Nutrient Database for Standard Reference Release 28 Slightly Revised May, 2016 [19]

Table 3: Fatty Acid Compositions of Quinoa Seeds

Total saturated Fatty acid (g/100g)	0.706	Total Monounsaturated (g/100g)	1.613	Total polyunsaturated fatty acid (g/100g)	3.292
16:0	0.60	18:1	1.420	18:2	2.977
18:0	0.037	20:1	0.093	18:3	0.260
20:0	0.03	22:1	0.083		
22:0	0.03	24:1	0.017		
24:0	0.01				

Source: USDA National Nutrient Database for Standard Reference Release 28 Slightly Revised May, 2016 [19]

hypertension, hyperglycemia, and hyperlipidemia. Dietary fibers cannot be digested and absorbed by the small intestine but get fermented in the large intestine. On the basis of their physico-chemical properties and functions, dietary fibers are classified in two forms-insoluble fibers which exhibit bulking action and soluble dietary fibers which get fermented partially/completely in the colon [23]. Total dietary fiber content varies from 13% to 16% in four different varieties of raw quinoa. Most of the dietary fiber was insoluble, with a range of 12.0 to 14.4 grams compared to 1.4 to 1.6 grams of soluble fiber per 100 grams dry weight. Extrusion process increases the amount of soluble fiber because of high shear pressure and temperature conditions [18]. Similar to quinoa's total protein value, its dietary fiber value is generally higher than that of most grains. But lower than that of legumes. Quinoa contains higher dietary fiber content than rice (1.3 g/100 g) and sorghum (6.7 g/100 g) but less than of wheat (10.7 g/100 g) and barley (17.3 g/100 g) [19].

Total Fats

The oil content of quinoa seeds varies from 2% to 10% and rich in essential fatty acids such as linoleic and alpha-linolenic acid [15]. Quinoa contains higher amount of good quality fat than wheat, barley, rice and corn [19].

Quinoa seeds oil contains 89.4% unsaturated fatty acids and 54.2% to 58.3% polyunsaturated fatty acids (PUFAs) [24]. Ratio of Omega-6/Omega-3 in quinoa seed oil is 6/1 which is a recommended ratio [24, 25]. PUFA showed positive effects on the cardiovascular diseases and insulin sensitivity [26, 9]. Refer Table 3 for the detailed composition of fatty acids present in quinoa seeds. Quinoa's fatty acids have been shown to maintain their quality because of quinoa's naturally high value of vitamin E, which acts as a natural antioxidant [27].

Minerals and Vitamins

Quinoa seeds are rich in micronutrients. Main minerals

Table 4: Mineral Compositions of Quinoa Seeds

	Minerals (mg/100g)						
References	**Ca**	**P**	**Mg**	**Fe**	**Zn**	**K**	**Cu**
USDA (2016) [19]	47	457	19	4.57	3.10	563	0.59
Palombini et al. (2013) [28]	108.41	45.86	298.24	10.28	n.d.	935.70	1.55
Nascimento et al.(2014)[29]	44	468	197	5.46	2.93	664	0.59
Ogungbenle (2003)[26]	86.0	22.0	232.0	2.6	3.8	714.0	7.5
Konishi et.al (2004) [30]	86.3	411	502	15	4	732	n.r.

Note: n.d - not determined; n.r - not reported.

present in quinoa are Iron, Copper, Sodium, Potassium, Phosphorus, calcium and zinc. Minerals are inorganic and not synthesized in the body of human beings. Diet deficit in minerals may produce imbalance in health and alter vital functions of body [15].

Mineral composition of quinoa has been studied by different researchers and organizations. Variations in values may depend on the variety of seeds and farming practices. Table 4 [19, 26, 28, 29, 30] shows mineral composition of quinoa studied by different researchers.

Quinoa is also rich in vitamins. They are divided into two on the basis of their solubility such as water soluble and fat soluble. They are not synthesized by the body. Quinoa contains appreciable amount of vitamins especially Vitamin-B and Vitamin-E [15]. Quinoa contains significant amount of pyridoxine (B6) and folic acid, whose values in 100 g can meet the needs of children and adults. The contents in 100 g of riboflavin contribute with 80% of the daily needs of children and 40% of adults [9]. Quinoa is a good source of vitamin-E which is a natural antioxidant and

Table 5: Concentrations of Vitamins in Quinoa and Other Cereals

Vitamins (mg/100gm)	Quinoa (uncooked)	Wheat	Rice
Thiamine (B_1)	0.36	0.50	0.58
Riboflavin (B2)	0.32	0.17	0.04
Niacin	1.52	4.96	4.19
Pyridoxine(B6)	0.49	0.41	0.16
Pantothenic acid	0.77	0.60	1.01
Ascorbic acid(C)	0.0	0.0	0.0
Total folates (ug/100g)	184	44	231
Alpha tocopherol (E)	2.44	0.71	0.11
Vitamin-A(IU)	14	9	0

Source: USDA National Nutrient Database for Standard Reference Release 28 Slightly Revised May, 2016 [19]

higher than wheat when compared [9, 25]. Table 5 shows concentrations of vitamin contents of quinoa seeds with other cereal grains.

Antioxidants: Phenolic Compounds and Flavanoids

Foods rich in fiber are often an important source of vitamins, minerals, phytochemicals, natural antioxidants and other micronutrients. Quinoa has higher antioxidant activity than some other cereal grains [31]. Quinoa seeds contain both phenols and flavanoids. Phenolic compounds are secondary plant metabolites which can prevent several degenerative disorders. The main phenols found in seeds and sprouts of quinoa are gallic acid, p-Hydroxybenzoic acid, vanillic acid, pcoumaric acid, caffeic acid and cinnamic acid [32]. Quinoa is a rich source of flavanoids which consist mainly of quercetin and kaempferol [33]. Flavanoids content varies from 36.2 to 144.3 mg/100 g [18]. Researchers have studied six diverse sources of seeds from Chile and found them to be the good source of Total Phenolic Contents (TPC) and Total Flavonoid Contents (TFC) ranged from 3.71 to16.55 mg GA/100 g d.m. and 7.77 to 14.37 mg QE/100 g d.m., respectively [34]. Quinoa seeds are found to be both bitter and sweet. Bitterness is due to the presence of saponins and can be removed by washing. The antioxidant activity of bitter quinoa seeds is mainly due to the presence of phenols and flavanoids while of sweet quinoa seeds is due to phenolic, flavanoids and carotenoids compounds. Antioxidant activity of bitter quinoa seeds was higher than that of sweet quinoa seeds and in both cases it decreased after cooking [35]. Antioxidant activity and antioxidant compounds are affected by two bioprocesses such as germination and fermentation. Germination is found to increase the ascorbic acid and total tocopherols amount of quinoa seeds whereas on fermentation the amounts of the compounds are found to be decreased. Phenolic compounds and antioxidant capacity of quinoa is found to be increased by germination [36].

APPLICATIONS IN FOOD INDUSTRY

With the increasing awareness and consciousness about health and food, consumers demand in the market or food industry for the foods with additional benefits to common nutrients has also increased [37]. Quinoa contains good amount of dietary fiber, high biological-value protein, essential fatty acids, vitamins, minerals and natural antioxidants [3]. For the development of any food product, it is important to study the functional properties of its food biopolymers as the technological properties of any food for formulation are directly dependent on the use of its biopolymers. Refer Table 6 for the functional properties of quinoa seeds. Functional properties are related to the water interactions and polymer interactions. Quinoa possesses many functional properties which can be used in the food industry for the preparation and manufacture of food products (cookies, muffins, cakes, breads, snacks, pasta, beverages, breakfast cereals, bars, soups, sauces, beer, diet supplements and extrudates) [9, 3]. Quinoa has favorably good water and oil holding capacity which makes it more potential for human food and drink formulations [26].

Quinoa has been used by the researchers for the development of various food products due to its wider acceptability and rich nutrient contents.

Brito *et al.* (2014) developed gluten free quinoa based cookies [Quinoa flour (30%), Quinoa flakes (25%) and 45% corn starch] for celiac patients and found them sensory acceptable considering their color, hardness and specific volume with high dietary fiber (11 g/110 g), good

Table 6: Functional Properties of Quinoa [9]

Components	Functional properties
Flour	Solubility, WHC, OHC, Emulsifying and Foaming Capacity, Gelation
Protein Concentrates and Isolates	Solubility, WHC, WIC, Emulsifying and Foaming Capacity
Starch	Water Absorption Power, Solubility, Freeze Thaw Stability, Viscosity, Water Binding Capacity

Note: WHC: Water holding capacity, OHC: Oil holding capacity, WIC: Water imbibing capacity.

source of essential amino acids, linolenic acids and some minerals [38].

Breads also prepared by the researchers, in which they have studied physical properties of dough and the bread quality by substituting 10% wheat flour by germinated quinoa flour. They have prepared 3 samples by substituting 10% wheat flour by germinated quinoa flour (24 hour, 48 hour, 72 hour incubation time) with one control (10% wheat flour substituted by non-germinated quinoa flour). Researchers found that 24 hour germinated quinoa samples are best suited for bread making as its loaf volume was largest among all which is directly related to high inner gas production followed by control. Even the stability time and valorimeter value was found to be higher in the control and 24 hour germinated quinoa as compared to 48 hour and 72 hour sample [39].

Schumacher *et al.* (2010) developed a dark chocolate with the addition of toasted quinoa at 12%, 16% or 20% levels of incorporation and revealed that dark chocolate with 20% quinoa helps in increasing the protein content, essential amino acids and vitamin E content by 9%. A slight reduction was noticed in polyphenols quantity (23.5¼ mol to 18¼ mol pirocatechin/gram). All the three formulas of dark chocolate showed an index of acceptance above 70% [40].

Sweet porridge, vegetable porridge, fruit *chat* and cutlets using quinoa grain were developed by a group of researchers and reported to be highly acceptable when tasted by 10 trained panels using a 9-point hedonic rating scale. All the developed products were found to be highly proteinaceous and rich in lysine (11.45-19.78 g/100 g) which is a limiting amino acid in cereals [41].

Kahlon *et al.* (2016) developed and organoleptically evaluated four kinds of quinoa gluten-free whole grain snacks. They found all the four snacks desirably acceptable at the index of acceptance and suggested them as a good food choice for vegetarians and those hypersensitive to gluten [42].

HEALTH BENEFITS

Several animal and human studies have been conducted to study the effect of consuming quinoa grain on health and it is found to have numerous health benefits.

Zevallos *et al.* (2014) conducted a clinical trial on 19 celiac patients, where the patients were advised to take 50 g cooked quinoa per day for 6 weeks. All the gastrointestinal parameters were found to be improved after following the quinoa diet and a small decrease in total cholesterol, Low-Density Lipoprotein (LDL), High-Density Lipoprotein (HDL) and triglyceride were also noted. This study concluded that quinoa is safe for consumption for celiac patients [43]. 35 postmenopausal women with excess weight were given 25 g Quinoa Flakes (QF) per day for 4 weeks and found that QF consumption has increased the protein and dietary fiber intake. Also reduction was seen in triglycerides, cholesterol, Low-Density Lipoproteins (LDL), Thiobarbituric acid reactive substances (TBARS) whereas an increase in glutathione was noticed [44]. It was noted that, quinoa cereal bar has reduced triglyceride, cholesterol and low-density lipoprotein levels when taken for 30 days by 22 students aged 18 to 45 years. Quinoa intake may reduce risk of developing cardiovascular disease [45].

A critical evaluation of animal model studies was conducted by Simnadis with colleagues (2015) on more than 10 animal studies and stated that quinoa consumption reported to decreased weight gain, improved lipid profile and also improved capacity to respond to oxidative stress [46]. Quinoa was intervened to twenty four male Wistar rats for 5 weeks and researchers reported a reduced concentration of plasma cholesterol. Also a significant reduction in glucose levels was noticed [47].

CONCLUSION

Quinoa (*Chenopodium quinoa Willd.*), a pseudocereal is an ancient Andean grain also known as wonder golden grain. Quinoa has exceptionally good nutritional values. Quinoa is rich in high biological value protein, dietary fiber 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 has good functional properties such as solubility, water holding capacity, oil holding capacity, foaming agent and emulsifying agent which makes it promising future cultivar

for novel uses. Quinoa may prove beneficial in reducing cholesterol, triglycerides and hyperglycemia in humans. All above properties prove the potential of quinoa to become an important industrial and food crop of the 21st century. There is a scope of further research in India or in the world as it is very wide topic and need to be studied carefully and thoroughly in respect of developing food products and to prove its health implications.

REFERENCES

- Abogoch James L E (2009), "Quinoa (*Chenopodium quinoa Willd.*): Composition, Chemistry, Nutritional and Functional Properties", *Advances in Food and Nutrition Research*, Vol. 58, ISSN: 1043-4526, DOI: 10.1016/4526(09)58001-1.
- Alvarez-Jubete L, Arendt E K and Gallagher E (2010a), "Nutitive Value of Psuedocereals and Their Increasing Use as Functional Gluten-Free Ingredients", *Trends in Food Science & Technology*, Vol. 21, No. 2, pp. 106-113.
- Alvarez-Jubete L, Wijngaard H, Arendt E K and Gallagher E (2010b), "Polyphenol Composition and *in vitro* Antioxidant Activity of Amaranth, Quinoa, Buchwheat and Wheat as Affected by Sprouting and Baking", *Journal of Food Chemistry*, Vol. 119, No. 2, pp. 770-778.
- Anderson J W, Baird P, Davis R H, Ferreri S, Knudtson M and Koraym A (2009), "Health Benefits of Dietary Fiber", *Nutrition Reviews*, Vol. 67, No. 4, pp. 188-205.
- Arneja I, Tanwar B and Chauhan A (2015), "Nutritional Composition and Health Benefits of Golden Grain of 21st Century, Quinoa (*Chenopodium quinoa Willd.*): A Review", *Pakistan Journal of Nutrition*, Vol. 14, No. 12, pp. 1034-1040, ISSN 1680-5194.
- Bavec F and Bavec M (2006), "Organic Production and Use of Alternative Crops", pp. 65-107, CRC Press.
- Bhathal S K, Kaur N and Grover K (2015), "Organoleptic and Nutritional Evaluation of Gluten Free Products from Quinoa (*Chenopodium quinoa*) Grain", *International Journal of Food and Nutritional Sciences*, Vol. 4, No. 4.
- Bhathal S, Grover K and Gill N (2015), "Quinoa—A Treasure Trove Nutrients", *J. Nutr. Res.*, Vol. 3, No. 1, pp. 45-49, ISSN: 2348-1064.
- Brito I L, Evandro L D S, Felex S S, Madruga M S, Yamashita F and Magnani M (2014), "Nutritional and Sensory Characteristics of Gluten-Free Experimental Mixture Design", *Journal of Food Science and Technology*, doi: 10.1007/s13197-014-1659-1.
- Brittany L Graf, Patricio Rojas-Silva, Leone E Rojo, Jose Delatorre-Herrera, Manuel E Baldeon and IIya Raskin (2015), "Innovations in Health Value and Functional Food Development of Quinoa (*Chenopodium quinoa Willd.*)", *Comprehensive Reviews in Food Science and Food Safety*, doi: 10.1111/1541-4337.12135.
- Carciochi R A, Alessandro L G, Vandendriessche P and Chollet S (2016), "Effect of Germination and Fermentation Process on the Antioxidant Compounds of Quinoa Seeds", *Plant Foods Hum. Nutr.*, doi: 10.1007/s11130-016-0567-0.
- Carrasco E and Soto J (2010), "Importance of Andean Grains", in Rojas W *et al.* (Eds.), *Andean Grains, Progress Achievements and Experiences in Quinoa, Amaranth Canahua and Bolivia*, Biodiversity International, Rome, Italy.
- De Carvalho F G, Ovidio P P, Padovan G J, Jordao A A, Marchini J S and Navarro A M (2014), "Metabolic Parameters of Postmenopausal Women After Quinoa or Corn Flakes Intake—A Prospective and Double-Blind Study", *Int J Food Sci Nutr.*, Vol. 65, No. 3, pp. 380-385.
- Dini I, Tenore G C and Dini A (2010), "Antioxidant Compound, Content and Antioxidant Activity Before and After Cooking in Sweet and Bitter *Chenopodium quinoa* Seeds", *Food Science & Tech.*, Vol. 43, pp. 447-451.
- Falguera V, Aliguer N and Falguera M (2012), "An Integrated Appoarch to Current Trends in Food Composition: Moving Toward Functional and Organic Products", *Food Control.*, Vol. 26, pp. 274-281.
- Farinazzi-Machado F M V, Barbalho S M, Oshiiwa M, Goulart R and Pessan Junior O (2012), "Use of Cereal Bars with Quinoa (*Chenopodium quinoa Willd.*) to Reduce Risk Factors Related to Cardiovascular Diseases", *Food Sci. and Tech.*, Vol. 32, No. 3, pp. 239-244.
- Filho A M, Pirozi M R, Borges J T, Pinheiro H M, Chaves J B and Coimbra J S (2015), "Quinoa: Nutitional, Functional and Antinutritional Aspects", *Critical Reviews in Food Science and Nutrition*, DOI: 10.1080/10408398.2014.1001811.

- Gopalan C, Rama Sastri B V and Balasubramanian S C (2007), "Nutritive Value of Indian Foods", National Institute of Nutrition, Indian Council of Medical Research, Hyderabad, India.
- Gorinstein S, Lojek A, Ciz M, Pawelzik E, Delgado-Licon E, Medina O J, Moreno M, Salas I A and Goshev I (2008), "Comparison of Composition and Antioxidant Capacity of Some Cereals and Psuedocereals", *International Journal of Food Science & Technology*, Vol. 43, No. 4, pp. 629-637.
- Greg S and David L Bubenheim (xxxx), "Quinoa: An Emerging "New" Crop with Potential for CELSS (NASA) 1993 (NASA-TP-3422), p. 9.
- Jacobsen S E (2003), "The Worldwide Potential for Quinoa (*Chenopodium quinoa Willd*.), *Food Reviews International*, Vol. 19, Nos. 1-2, pp. 167-177, doi: 10.1081/FRI-120018883.
- Jacobsen S E and Stolen O (1993), "Quinoa-Morphology and Phenology and Prospects for its Production as a New Crop in Europe", *Eur. J. Agron*., Vol. 2, pp. 19-29.
- Jacobsen S E, Jorgensen I and Stolen O (2015), "Cultivation of Quinoa (*Chenopodium quinoa*) Under Temperate Climatic Condition in Denmark", *J. Agric. Sci*., Vol. 122, pp. 47-52.
- Kadereit G, Borsch T, Weising K and Freitag H (2003), "Phylogeny of Amaranthaceae and Chenopodiaceae and the Evolution of C4 Photosynthesis", *Int J Plant Sci*., Vol. 164, No. 6, pp. 959-986.
- Kahlon T S, Avena-Bustillos R J and Chiu M M (2016), "Sensory Evaluation of Gluten-Free Quinoa Whole Grain Snacks", *J. Heliyon*., Article No. e00213, http://dx.doi.org/10.1016/j.heliyon.2016.e00213
- Konishi Y, Hirano S, Tsuboi H and Wada M (2004), "Distribution of Minerals in Quinoa (*Chenopodium quinoa Willd*.) Seeds", *Biosci. Biotechnol. Biochem*., Vol. 68, No. 1, pp. 231-234.
- Lopez-Garcia (2007), "Quinoa: A Traditional Andean Crop with New Horizons", *Cereal Foods World*, Doi: 10.1094/CFW-52-1-0088.
- Miranda M, Delatorre-Herrera J, Vega-Galvez A, Jorquera E, Quispe-Fuentes I and Martinez E A (2014), "Antimicrobial Potential and Phytochemical Content of Six Diverse Sources of Quinoa Seeds (*Chenopodium quinoa Willd*.)", *Agricultural Sciences*, Vol. 5, pp. 1015-1024.
- Nascimento A C, Mota C, Coelho I, Gueifao S, Santos M, Matos A S, Gimenez A, Lobo M, Samman N and Castanheira I (2014), "Characterisation of Nutrient Profile of Quinoa (*Chenopodium quinoa*), Amaranth (*Amaranthus causatus*), and Purple Corn (*Zea mays* L.) Consumed in North of Argentina: Proximates, Minerals and Trace Elements", *Journal of Food Chem*., Vol. 148, pp. 420-426, doi: 10.1016/j.foodchem.2013.09.155.
- Ng S, Anderson A, Cokera J and Ondrusa M (2007), "Characterization of Lipid Oxidation Products in Quinoa (*Chenopodium quinoa*)", *Food Chem*., Vol. 101, No. 1, pp. 185-192.
- Nowak V, Du J and Ruth Charrondiere U (2015), "Assessment of the Nutritional Composition of Quinoa (*Chenopodium quinoa Willd*.)", *Food Chemistry*, doi: http://dx.doi.org/10.1016/j.foodchem.2015.02.111.
- Ogungbenle N H (2003), "Nutritionla Evaluation and Functional Properties of Quinoa (*Chenopodium quinoa*) Flour", *International J. of Food Science and Nutrition*, Vol. 54, No. 2, pp. 153-158.
- Palombini S V, Claus T, Maruyama S A, Gohara A K, Souza A H P, Souza N E D, Visentainer J V, Gomes S T M and Matsushita M (2013), "Evaluation of Nutritional Compounds in New Amaranth and Quinoa Cultivars", *Food Science and Technology*, Vol. 33, No. 2, pp. 339-344, doi: http://dx.doi.org/10.1590/20612013005000051.
- Park S H and Morita N (2005), "Dough and Breadmaking Properties of Wheat Flour Substituted by 10% with Germinated Quinoa Flour", *Int. J. Food Sc. and Tech*., Vol. 11, p. 471, Doi: 10.1177/1082013205060766.
- Pasko P, Sajewicz M, Gorinsten S and Zachweijal Z (2008), "Analysis of Selected Phenolic Acids and Flavanoids in Amaranthus Cruentus and Chenopodium Quinoa Seeds and Sprouts by HPLC", *Acta Chromtaographica*, Vol. 20, pp. 661-672.
- Pawel P, Pawel Z, Henryk B, Joanna C and Gorinstein S (2010), "Effect of Quinoa Seeds (*Chenopodium quinoa Willd*.) in Diet on Some Biochemical Parameters and Essential Elements in Blood of High Fructose–Fed Rats", *Plant Foods Human Nutrition*, Vol. 65, pp. 333-338, doi: 10.1007/s11130-010-0197-x.

- Repo-Carrasco-Valencia R A M and Serena L A (2011), "Quinoa (*Chenopodium quinoa Willd*.) as a Source of Dietary Fiber and Other Functional Components", *Food Science and Technology*, Vol. 31, No. 1, pp. 225-230.
- Repo-Carrasco-Valencia R A-M, Espinoza C and Jacobsen S E (2003), "Nutritional Value and Use of the Andean Crops Quinoa (*Chenopodium quinoa*) and Kaniwa (*Chenopodium pallidicaule*)", *Food Reviews International*, Vol. 19, Nos. 1-2, pp. 179-189, Doi: 10.1081/FRI-120018884.
- Schumacher B A, Brandelli A, Macedo C F, Pieta L, Klug V T, Jong V (2010), "Chemical and Sensory Evaluation of Dark Chocolate with Addition of Quinoa (*Chenopodium quinoa Willd*.)", *Journal of Food Science Technology*, Vol. 47, No. 2, pp. 202-206.
- Simnadis T G, Tapsell C L and Beck E J (2015), "Physiological Effects Associated with Quinoa Consumption and Implications for Research Involving Human: A Review", *Plant Foods Human Nutrition*, Vol. 70, pp. 238-249, doi: 10.1007/s11130-015-0506-5.
- Tang Y, Li X, Chen P X, Zhang B, Hernandez M, Zhang H, Marcone M F, Liu R and Tsao R (2015), "Characterisation of Fatty Acid, Carotenoid, Tocopherol/Tocotrienol Compositions and Antioxidant Activities in Seeds of Three Chenopodium Quinoa Willd, Genotypes", *Food Chem.*, Vol. 174, pp. 502-508.
- Taylor J R N and Parker M L (2002), "Quinoa", in P S Belton and J R N Taylor (Eds.), *Pseudocereals and Less Common Cereals: Grain Properties and Utilization*, Springer-Verlag, Berlin.
- USDA National Nutrient Database for Standard Reference Release 28 Slightly Revised May, 2016 [cited January 11, 2017], available from: https://ndb.nal.usda.gov/ndb/search/list
- Valcarcel-Yamani B and Caetano da Silva Lannes S (2012), "Applications of Quinoa (*Chenopodium quinoa Willd*.) and Amaranth (*Amaranthus spp*.) and their Influence in the Nutritional Value of Cereal Based Foods", *Food Public Health*, Vol. 2, No. 6, pp. 265-275.
- Valencia-Chamorro S A (2003), "Quinoa", in: Caballero B (Ed.), *Encyclopedia of Food and Nutrition*, pp. 4895-4902, Academic Press, Amsterdam.
- Vega-Galvez A V, Miranda M, Vergara J, Uribe E, Puente L and Martinez E A (2010), "Nutrition Facts and Functional Potential of Quinoa (*Chenopodium quinoa Willd*.), An Ancient Andean Grain: A Review", *Journal of the Science Food and Agriculture*, Vol. 90, pp. 2541-2547, Doi: 10.1002/jsfa.4158.
- Zevallos V F, Herencia L I, Chang F, Donnelly S, Ellis H J and Ciclitira P J (2014), "Gastrointestinal Effects of Eating Quinoa (*Chenopodium quinoa Willd*.) in Celiac Patients", *Am. J. Gastroenterol*., Vol. 109, pp. 270-278.


IJFANS
International Journal of Food
And Nutritional Sciences