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Quinoa (*Chenopodium quinoa Willd.*): A Nutritional Healthy Grain

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Abstract : Quinoa (Chenopodium quinoa Willd.), which is considered a pseudo-cereal or pseudo-grain, it is highly nutritious due to its outstanding protein quality and wide range of minerals and vitamins. It has been recognized as a complete food due to its protein quality. It has remarkable nutritional properties; not only from its protein content (15%) but also from its great amino acid balance. The Quinoa grain protein is rich in amino acids like lysine and methionine that are deficient in cereal proteins. The grain is used to make flour, soup, breakfast, cereal and alcohol, while the flour is utilized in making biscuits, bread and processed food. Quinoa starch having small grains and high viscosity can be exploited for various industrial applications. It is also been found to contain compounds like phytosterols, and Flavonoids with possible nutraceutical benefits. Quinoa starch has some functional (technological) properties like solubility, good water-holding capacity (WHC), gelation, emulsifying, and foaming that allow diversified uses. Besides, it has been considered an oil crop, with an interesting proportion of omega-6 and notable vitamin E content. Quinoa starch has physicochemical properties (such as viscosity, freeze stability) which give it functional properties with novel uses. Quinoa has a high nutritional value and has recently been used as a novel functional food Because of all these properties. Quinoa's ability to produce high-protein grains under ecologically extreme conditions makes it important for the diversification of future agricultural systems, especially in high-altitude area of the Himalayas and North Indian Plains. The healthy lifestyle and appropriate nutrition are stressed nowadays. New foodstuffs are still investigated with the aim to improve the diet and conduce to a better health state of the population. Pseudo cereals (amaranth, buckwheat, and quinoa) are convenient for this purpose. Their high nutritious and dietary quality meets the demands of the food industry and consumers.

Keywords: quinoa; essential amino acids; nutrition quality

INTRODUCTION

Quinoa is considered as pseudo-cereals crop, it is a broad leaf plant with starchy dicotyledonous seed and therefore not a cereal. Quinoa is used like the cereal foods, it is also an important ingredient source for the functional food industry. Quinoa grains have an established excellent nutritional food quality and was also called ''the mother grain'' this seed was the major crop of the pre-Columbian cultures in Latin America. Later, after the arrival of the Spaniards, quinoa cultivation was almost eliminated and only remained in the farmers' traditions

Botanically, quinoa belongs to the class Dicotyledoneae, family Chenopodiaceae, genus Chenopodium, and species quinoa. The full name is *Chenopodium quinoa Willd*. Quinoa is a very interesting food due to its complete nutritional characteristics. Quinoa is grown in South America, it is also cultivated in the USA (Colorado and California), China, Europe, Canada, and India. It is also cultivated experimentally in Finland and the UK. Increasing amounts are being exported to the developed world like Europe and the USA. In Europe quinoa was introduced in England in the 1970s, and later research projects focused on

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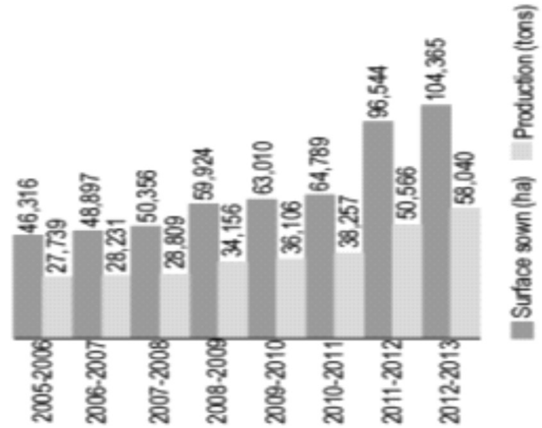
its production for humans and/or as a fodder crop. Currently Quinoa is produced in Bolivia, Peru, and Ecuador and Chile. Almost all quinoa seed (QS) is exported to Europe and the USA.

HISTORICAL BACKGROUND

Quinoa is one of the oldest crops in the Andean Region, with approximately 7000 years of cultivation history, grate cultures like the Incas and Tiahuanacu had domesticated and conserved this ancient crop, Jacobsen (2003) Archaeological findings in Peru and Argentina indicate presence of quinoa seeds around the beginning of the Christian era, Heisser and Nelson (1974), Quinoa seeds were also found in indigenous graves of Tarapaca, Calama, Tiltel and Quillagua Bollaerd and Latcham, as cited by Cardenas (1944),. Quinoa was widely cultivated by pre-Columbian cultures and its grains have been used in the diet of inhabitants of the valleys, and in drier areas (350 mm rain fall) with higher altitudes (above 3500 m) and colder temperatures (average 12 º C) such as the Altiplano. Although Quinoa is a fully domesticated species, its seed still contain saponin, removal of toxic saponins is necessary before they can be consumed (Mujica, 1992; Heisser and Nelson, 1974). Spanish conquest of region and an introduction of cereals such as barley and wheat resulted marginalization and replacement of Quinoa crop (Mujica, 1992; Jacobsen and Stolen, 1993). It went unnoticed among the urban population of the region for mainly economic and social reasons, still the crop never lost among the Andean people. It was also noted that during the 80's, European and the United States market were opened for food products. The expansion of these food consumer markets in the search for new foods linked to ancient cultures helped to transform quinoa from a subsistence crop to a product of export potential. Risi (1997)

POTENTIAL CONTRIBUTION OF QUINOA TO FOOD SECURITY AND SOVEREIGNTY

Availability, Access, Consumption and Biological utilization are the four pillars of food security. In these context; aspects like exceptional nutritional quality, genetic variability, adaptability to adverse climate and soil conditions, and **low production cost** constitutes quinoa as a strategic crop with potential contributor to food security and sovereignty. Quinoa is a grain with intrinsic outstanding characteristics: wide **genetic variability**. Quinoa adapts to desert, hot and dry climates. This crop can grow with relative humidity from 40% to 88%, and survive with temperatures from -4°C to 38°C. It is resistant to low soil moisture, and can produce acceptable yields even with precipitations from 100 to 200 mm. Due to its **ability to adapt** to adverse climate and soil conditions where other crops are unable to grow, harvest can be obtained at altitudes from sea level to 4000 m (high Andean plateau, 'salares', 'Andean plateau', inter-Andean valleys, 'yungas', sea level). The cultivation of quinoa provides an alternative for countries with limited food production. Quinoa



Source: Data provided by SISPAM (2013)

Figure 1: Production of Quinoa and surface sowed (metric tons per hector)

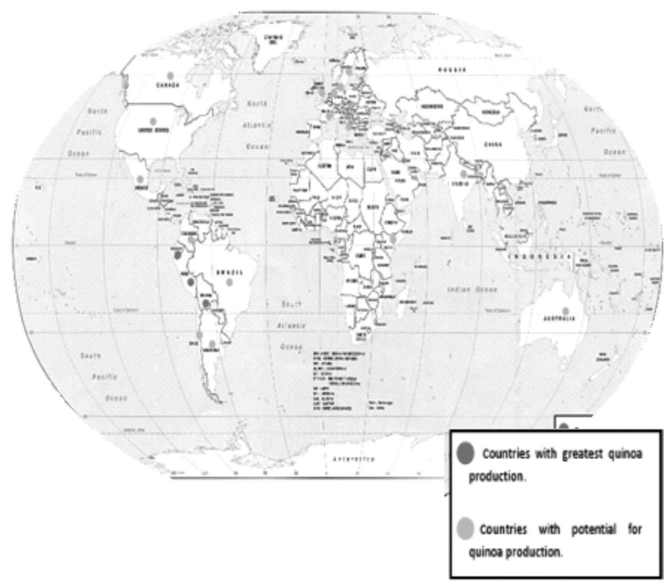


Figure 2: Geographic distribution of world quinoa production

has potential agronomic importance because it can adapt to produce high yields under adverse conditions and contribute to food security in different regions worldwide (Wilson, 1985).

Quinoa is a complete food with high-nutritional value due mainly to its high content of good quality protein. Besides protein content, many studies have been made of their lipids, starch, minerals and saponin (Quinoa contain minerals and vitamins like vitamin B, vitamin C and vitamin E). In 1996, quinoa was catalogued by FAO as one of the most promising crops for the humanity, not only for its great properties and its multiple uses, but also because it is considered an option to solve human nutrition problems (FAO, 2011).

Bolivia and Per!u are the biggest exporters of Quinoa with 88% of the worldwide production, followed by the United States of America with 6% (Brenes *et al.*, 2001) In Argentina production is usually used for domestic consumption as seed or flour.

PHYSICAL PROPERTIES OF QUINOA

The physical, gravimetric, frictional and aerodynamic properties of seeds are useful for designing different postharvest processes like cleaning, classification, transport, aeration, drying and storage. Vilche C.; Gely M.; Santalla E. (2003); determined these properties of quinoa seed samples having moisture contents varying from 4.6 % to 25.8 % d. b. At an average moisture content of 15% length of quinoa seed varied from 1.7 to 2 mm in 72 5% grains while 27.4 % seeds were of more than 2 mm size. Other properties are tabulated as below.

Table 1: Physical Properties of Quinoa seeds

Property		*Moisture 4.6% d.b.*	*Moisture 25 % d.b.*
Gravimetric	1000 Seed Mass	2.53 g	3.11 g
	True Density	928 kg / m^3	1188 kg / m^3
	Bulk Density	747 kg / m^3	667 kg / m^3
	Bed Porosity	0.19	0.44
Frictional	Angle of repose	18 ^{0}	25 ^{0}
	Static coefficient of friction	0.14	0.27
Aerodynamic	Terminal Velocity	0.6 m/s	1.02 m/s

Source: Vilche C.; Gely M.; Santalla E. (2003)

CHEMICAL AND NUTRITIONAL PROPERTIES OF QUINOA

The extensive literature is available on Quinoa covering aspects like proximate composition of reserves, chemical characterization of proteins, fatty acid composition of the oils, mineral content and functional and nutritional values. Proximate composition of four different Quinoa varieties cultivated in Andean region viz. Blanca de Juli, Kcancolla, La Molina 89 and Sajama of was determined by Valencia (2011) results of their analysis is presented in Table No 2.

Table 2: Proximate composition of four quinoa varieties (% dry basis)

Component	*Blanca de Juli*	*Kcancolla*	*La Molina 89*	*Sajama*
Moisture	11.39	10.78	12.03	12.62
Ash	3.38	3.52	5.46	3.04
Protein	13.96	15.17	15.47	14.53
Crude fat	5.51	5.77	6.85	4.69
Crude fiber	2.00	3.07	3.38	1.92
Carbohydrates	75.15	72.47	68.84	75.82

Source: All data are the means of 2 replicates. All contents g.100 g–1 dry weight except moisture g.100 g–1 fresh weight Source: Repo-Carrasco-Valencia; Serna (2011)

The proximate composition of instant flour produced from quinoa by extrusion cooking has shown the composition as: moisture 4.8%, protein 12.2%, lipids 5.6%, ash 2.3%, total carbohydrate 74.9%, and fibre 4.1%. (Ascheri *et al.* 2002).

Quinoa flour is low in gluten due the low contents of prolamines and glutamines. It is usually used to enhance baking flours in the preparation of biscuits, noodles, and pastries, and for the preparation of baked foods to maintain the moisture and give an agreeable flavour (Vilche *et al.* 2003). Nutrient content of Quinoa and other staple foods is compared in Table 3.

Besides nutritive components Quinoa seed pericarp contains saponins, which are toxic and bitter tasting constituents, making it necessary to eliminate before eating or processing for the manufacture of food products. Biopolymers are also found in specific parts of the grains, starch occupy the cells of the perisperm, while lipid bodies, protein bodies with globoid crystals of phytin, and proplastids with deposits of

Table 3: Nutritional composition of quinoa compared with other staple foods (%)

Compo-nents (%)	*Quinoa*	*Meat*	*Eggs*	*Cheese*	*Cows Milk*	*Human Milk*
Proteins	13.00	30.00	14.00	18.00	3.50	1.80
Fats	6.10	50.00	3.20		3.50	3.50
Carbohy-drates	71					
Sugar					4.70	7.50
Iron	5.20	2.20	3.20		2.50	
Calories per 100 g	350	431	200	24	60	80

Sourse: Agrifood Report, 2009, MDRT-BOLIVIA

phytoferritin are the storage components of the endosperm and embryo tissues, Valencia-Chamorro (2003).

PROTEINS CONTENTS IN QUINOA

The mean protein content reported in the literature for Quinoa seed is 16.3% on dry basis (db). Protein content of Quinoa seeds is higher than that of barley (11% db), rice (7.5% db), or corn (13.4% db), and is comparable to that of wheat (15.4% db) .Quinoa seed contain relatively less proteins when compared to legume seeds (Table 2). The nutritional value of quinoa protein is comparable to that of milk protein (Koziol , 1992;Ranhotra *et al.*, 1993). The protein efficiency ratio (PER) in raw de-bittered quinoa is 78–93% that of casein. These figures increase when quinoa is cooked, and become 102–105% those of casein (Valencia-Chamorro 2003).

Table 2. Chemical composition of quinoa and some cereals and legumes (g/100 g dry wt) (Valencia-Chamorro 2003)

Components	*Quinoa*	*Barley*	*Maize*	*Rice*	*Wheat*	*Bean*	*Lupine*	*Soya*
Protein	16.5	10.8	10.22	7.6	14.3	28.0	39.1	36.1
Fat	6.3	1.9	4.7	2.2	2.3	1.1	7.0	18.9
Fibre	3.8	4.4	2.3	6.4	2.8	5.0	14.6	5.6
Ash	3.8	2.2	11.7	3.4	2.2	4.7	4.0	5.3
Carbohydrates	69.0	80.7	81.1	80.4	78.4	61.2	35.3	34.1
kcal/100 g[a]	399	383	408	372	392	367	361	451

kcal/100 g: 4× (% protein + carbohydrates) + 9× (% fat); [b]Kent (1963), Koziol (1992)

Lysine is a limiting amino acid in most cereal grains. Amino acid composition of quinoa has been studied by Koziol (1992), essential amino acid balance in quinoa seed protein is excellent because of its higher lysine (5.1–6.4%) and methionine (0.4–1%) contents than cereals and legume proteins. Quinoa proteins have higher histidine content than Maize, Rice and wheat proteins. (Table 3).

Methionine plus cystine content of quinoa is also adequate for children (2–12 years old) and adults. According to the FAO/WHO suggested requirements for a 10-year-old children, Quinoa protein have adequate levels of aromatic amino acids (phenylalanine and tyrosine) and similarly in histidine, isoleucine, threonine, phenylalanine, tyrosine, and valine contents. By comparison, lysine and leucine in QPs are limiting amino acids for 2–5-year-old infants or children, while all the essential amino acids of this protein are sufficient according to FAO/WHO. (Table 3).

Table 3: Essential amino acids in quinoa and other foods (g/100 g protein) (Koziol 1992)

	Quinoa	*Maize*	*Rice*	*Wheat*	*Bean*	*Milk*	*FAO[a]*
Histidine	3.2	2.6	2.1	2.0	3.1	2.7	2.6
Isoleucine	4.9	4.0	4.1	4.2	4.5	10.0	4.6
Leucine	6.6	12.5	8.2	6.8	8.1	6.5	9.3
Lysine	6.0	2.9	3.8	2.6	7.0	7.9	6.6
Methionine[b]	5.3	4.0	3.6	3.7	1.2	2.5	4.2
Phenylalanine[c]	6.9	8.6	10.5	8.2	5.4	1.4	7.2
Threonine	3.7	3.8	3.8	2.8	3.9	4.7	4.3
Tryptophan	0.9	0.7	1.1	1.2	1.1	1.4	1.7
Valline	4.5	5.0	6.1	4.4	5.0	7.0	5.5

[a]as reported by Koziol (1992); [b]methionine + cystine; [c] Phenylalanine + tyrosine; FAO

CARBOHYDRATES CONTENTS IN QUINOA

Carbohydrates are the major portions of Quinoa seed dry matters; it comprises Starch and Dietary fibers as major components. Carbohydrates content in Quinoa seeds vary from 67% to 74% of the dry matter; out of it starch makes up about 55–65%. In quinoa seeds primarily starch compound is located in perisperm as simple units or as spherical aggregates having very small grain size, less than 3 μm (Wolf *et al.*, 1950; Atwell *et al.*, 1983). When compared for its amylose content, Quinoa starch contain 11% amylose which is less than other cereals like rice (17%), wheat (22%), or barley (26%)

Gelatinization temperature of Quinoa starch is relatively low, 57 – 64°C (Atwell *et al.*, 1983). Quinoa starch exhibits higher viscosity than wheat starch, but it is not as high as corn starch (Ahamed *et al.*, 1996). Like *waxy* corn starch Quinoa starch has superior freeze-thaw stability to normal corn starch (Ahamed *et al.*, 1996). Other carbohydrates found are pentosans (2.9–3.6%), disaccharides (2.3%), crude fiber (2.5–3.9%), and monosaccharides (2%) (Valencia-Chamorro 2003).

FAT CONTENTS IN QUINOA

Quinoa contains 2% to 9 % fat (Cardoza and Tapia, 1979; Romero, 1981), average oil content is around 6% USDA (2005) it can be considered as a pseudo-oil crop. These percentages are roughly similar to fat content of corn, but it is much less than soybean (20-25% oil). Quinoa, Corn and Soya oils exhibit similar fatty acid compositions (Koziol, 1991). As with soybean and most cereals, linoleic acid is the predominate fatty acid, similarly Quinoa is a rich source of essential fatty acids like linolenic (18:2n-6: 52%) and linolenic (18:3n-6: 40%) (Valencia-Chamorro 2003). The overall fatty acid composition of the whole quinoa seeds was similar to other cereal grains, with linoleic, oleic, and palmitic acids as the major acids present (Przybylski *et al.* 1994).

Lipids isolated from quinoa seed and seed fractions were characterized for lipid classes and fatty acid composition by Przybylski, when analyzed it was found that Quinoa seed lipids contained the largest amount of neutral lipids among other seed fractions. Higher amounts of FFA were detected in the whole quinoa seed and hull 18.9% and 15.4% of total lipids respectively. 50 % of neutral lipids were triglycerides; Diglycerides contributed 20% of the neutral lipid fractions and were present in the whole seed. Among the Phospholipids lysophosphatidyl ethanolamine was 45% and Phosphatidyl choline was 12% of whole seed phospholipids. (Przybylski *et al.* 1994).

Table 4: Oil Quality of Quinoa and Common Cereal Grains (values expressed as percent of total oil)

	Quinoa	*Wheat*	*Barley*	*Rice*	*Corn*
Predominate acid	18:2	18:2	18:2	18:1	18:2
Saturated	13%	23%	26%	32%	16%
Monounsatu-rated	34%	22%	16%	37%	31%
Polyunsatu-rated	53%	55%	58%	31%	53%

Source: USDA, 2005

MINERALS IN QUINOA

Quinoa is a good source of minerals; When compared with common staple foods like barley, oats, rice, corn, or wheat Quinoa seeds contain high quality proteins, higher levels of energy, calcium, phosphorus, iron, fiber, and B-vitamins. (Dini *et al.* 2005). Comparative data of mineral content of quinoa seeds is presented in Table 5. Koziol (1992)

Larger amounts of calcium (874 mg/kg), phos-phorus (5.3 g/kg), magnesium (2.6 mg/100 g), iron (81 mg/kg), zinc (36 mg/kg), potassium (12 g/kg), and copper (10 mg/kg) than most of the common cereal grains were also repored by Ruales & Nair (1993).

Table 5: Mineral composition (mg/kg d w) in quinoa and some cereals (Koziol 1992)

Minerals	*Quinoa*	*Wheat*	*Rice*	*Barley*
Ca	1487	503	69	430
Mg	2496	1694	735	1291
K	9267	5783	1183	5028
P	3837	4677	1378	3873
Fe	132	38	7	32
Cu	51	7	2	3
Zn	44	47	6	35

Polishing and washing of seeds reduce mineral content to some extent, reduction of 12–

15% in iron, zinc, and potassium, 27% in copper and 3% in magnesium were reported.

VITAMINS CONTENTS IN QUINOVA

Range of Fat soluble vitamins like Vitamin A, Vitamin E and water soluble vitamins as Thiamin, Riboflavin, Niacin and Ascorbic acid was quantified by Ruals et al (1992) and it is expressed in Table 6. Quinoa is considered as a good source of vitamins like thiamin (0.4 mg/100 g), folic acid (78.1 mg/100 g), and vitamin C (16.4 mg/100 g). The process of saponins removal from the seeds reduces the vitamin and mineral contents to some extent. The loss is significant (P < 0.001) in the case of potassium and considerable also in the case of iron and manganese (P < 0.01). Ruales & Nair (1993).

Table 6: Vitamin content of Quinoa grain (mg/100g dry matter)

Vitamins	*Range*
Vitamin A(carotenes)	0.12-0.53
Vitamin E	4.60-5.90
Thiamine	0.05-0.60
Riboflavin	0.20-0.46
Niacin	0.16-1.60
Ascorbic Acid	0.00-8.50

Ruales *et al.*, 1992, cited by Ayala *et al.*, 2004

SAPONINS AND ANTINUTRIENTS IN QUINOA

Bitter Saponins and phytic acid are the main disadvantageous factors present in quinoa seeds. Other inhibitors, trypsin inhibitor and tannins, are present in low levels.

Saponins : Saponins are known to be antimicrobial, to inhibit mould, and to protect plants from insect attack. Saponins may be considered a part of plants' defence systems, and as such have been included in a large group of protective molecules found in plants (Morrissey & Osbourn, 1999). The pericarp, an outer layer of quinoa seed contains saponins.

Saponins are glycosylated secondary metabolites that impart a bitter taste. Saponins consist of hydrophilic carbohydrate chain attached to a triterpene agycone called as sapogenins (Wink 2004). According to the nature of the sapogenin moiety, they are conjugated with hexoses, pentoses, or uronic acids. The sapogenins are steroids (C27) or triterpenoids (C30) (Valen-cia-Chamorro 2003). Saponins in quinoa are basically glycosidic triterpenoids with glucose constituting about 80% of the weight. Monodesmosidic saponins are with one carbohydrate chains, and bidesmosidic saponins carry two carbohydrate chains. The amount of saponins present depends on the variety of quinoa. Sensory evaluation of quinoa indicate threshold level of saponins at 0.11 g per 100 g. Varieties having equal or less saponins are considered as sweet varieties. Quinoa contains saponins in the amount from 0.1% to 5%. It is higher in bitter-flavour varieties than in sweet (low-saponins) varieties (Valencia-Chamorro 2003).

The bitter cultivars of quinoa predominantly contain phytolaccagenic acid saponins, a class of saponins generally not found in plants used as human food, while some sweet varieties has no detectable amounts of this class of saponin. (K.G. Ng, K.R. Price.1994). Saponins work as emulsifying agents and tend to foam in aqueous solutions. Saponins form complexes with iron and zinc and therefore may reduce its absorption in gut and considered to be highly toxic but now it has been suggested that those present in food stuff are not toxic may be even beneficial in human diet to some extent. The reduction of plasma cholesterol and bile salt concentrations has been attributed to the presence of certain saponins in the diet.(Valencia-Chamorro 2003).

Phytic acid: Phytic acid (hexa phosphate of inositol) is a complex class of naturally occurring anti-nutritional factor present in plant foods, it affects the digestion and absorption of minerals. It is a major phosphorus storage compound in fruits and vegetables; it is also present in most of the legumes and cereals at the level of 1-3 % on dry weight basis, mostly concentrated in the germ fraction cereal grains. In case of five different varieties of quinoa phytic acid concentration, was reported around 1.18 g/100 g. Phytic acid is located in the external layers as well as in the endosperm of quinoa seeds. (Valencia-Chamorro 2003).

Oxalate: Oxalates is a dicarboxylic acid and is found in the form of soluble salts of potassium and sodium and as insoluble salts of calcium, magnesium and iron. Oxalate is a toxic substance. A high dietary oxalate intake influences mineral and trace element absorption in humans and may lead to calcium oxalate stone formation due to the ability of oxalate to form insoluble complexes with divalent cations in the gastrointestinal tract. Total oxalate content in quinoa ranged from 143 to 232 mg/100 g in roots and nuts, and from 874 to 1959 mg/100 g in leaves and stems (Siener *et al.* 2006)

Trypsin inhibitor: TIA is an anti-nutritional factor is responsible for reduced protein digestibility in human system by interacting with proteolytic enzymes rendering them unavailable for protein digestion. Trypsin inhibitor in eight varieties of quinoa was measured and ranges between 1.36–5.04 TIU/mg, it is lower than in soybean (24.5 TIU/mg). Heat treatment inactivates Trypsin inhibitor (Valencia-Chamorro 2003).

Polyphenols (tannins): In the whole quinoa seeds Valencia-Chamorro (2003) reported small amounts of polyphenols (0.53 g/100 g) which are further reduced after scrubbing and washing with water (0.23 g/100 g). The total phenolics content in quinoa seeds was determined according to the colorimetric Folin–Ciocalteu method with tannic acid as a standard compound (R2 = 0.98, y = 0.0063 + 0.083). A wide range of total phenolics content was found 94.3 ± 3.0 to 148 ± 1.9 mg/g tannic acid equivalent (TAE) of dried samples, with an average of 121 mg/g TAE (R. Yawadio Nsimba *et al.* 2008).

FUNCTIONAL PROPERTIES OF QUINOA

Antioxidant Property: Antioxidant potential of seeds and sprouts of selected pseudocereals Amaranth and quinoa was done by the methods like Ferric Reducing Ability of Plasma (FRAP) assay, ABTS radical scavenging activity and DPPH radical scavenging activity. Total polyphenols and anthocyanins were also determined. The aim of our study was to show the nutritional value of sprout as a good source of antioxidants. Total Antioxidant capacity (TAC) values for quinoa seeds are as FRAP 4.97 in mmol Fe2 + kg^{-1} DW, ABTS 27.19 in mmol trolox kg^{-1} DW, DPPH 38.84 in mmol trolox kg^{-1} DW, Total Anthocyanins 120.4 – ANT mg CGE 100 g^{-1} DW, Total polyphenols –3.75 TP mg GAE g^{-1} DW. . Paweł Pas´ko *et al.* (2009)

Values for sprouts were also measured and found significantly higher indicating Quinoa seeds and sprouts show relatively high antioxidant activity. Quinoa seems to be the better substitute for traditional cereals than amaranth. The results investigation have shown that sprouts have a significantly higher antioxidant activity than seeds, which may be a result of difference in the content of polyphenols, anthocyanins and other compounds and The sprouts of amaranth and quinoa are ‘‘new” vegetables, which can be used in the nutrition of vegans and vegetarians and as a common diet too. Paweł Pas´ko *et al.* (2009).

Antimicrobial Property: Six different varieties of quinoa seeds (Ancovinto, Cancosa, Cahuil, Faro, Regalona and Villarrica) from three distinct geographical zones of Chile (two from each zone) were examined for their antimicrobial properties. Dry ethanol extract of seed was dissolved in water (30.0 mg of extract/mL of distilled water) and used to test inhibition zone against two microorganisms, *Staphylococcus aureus* (ATCC 25923) (Gram-positive) and *Escherichia coli* (ATCC 25922) (Gram-negative), using the disk diffusion assay technique. Extracts of all quinoa samples showed antimicrobial activity in the range of 8.3 -14.8 mm inhibition zone for *E. coli* and 8.5 - 15.0 mm inhibition zone for *S. aureus*. Cancosa seeds had the highest antimicrobial action. Miranda, M. *et al.* (2014).

Pearson’s coefficient correlations between Total Phenolic Content(TPC), Total Flavonoid Content (TFC), Total Saponin Content (TSC) and inhibition zone of all six varieties was done. The relationship between TFC and antimicrobial activities against *E. coli* and *S. aureus* was found moderate (r = 0.60 and 0.43, respectively) but positively significant ($p < 0.05$) for *E. coli*, indicating that flavonoid compounds might contribute to the antimicrobial activities against *E. coli* and *S. aureus.* Miranda, M. *et al.* (2014).

FOOD USE OF QUINOA

Kancolla is a sweet variety of quinoa, used as a food, principally in the same way as wheat and rice. Bitter varieties of quinoa need de-hulling prior to food use so as to remove bitter principles and anti-nutritional factors. Boiled seeds of quinoa can be eaten as a rice replacement, or used to thicken soup or as porridge or as a hot breakfast cereal. Green turned sprouted quinoa seeds can be added to salads. Like popcorns Quinoa seed pops can also be made. Seeds can also be ground and used as flour to mix in bread flour at the level of 10 -13 %, noodles and pasta at the level of 30–40% and biscuits up to 60 %. (Valencia-Chamorro 2003).

Quinoa seeds have been identified for making soups and desserts, pastries, drinks and dry snacks. Following is a brief description of traditional preparations that are made from quinoa in South America.

1. **Quinoa soup:** Not very thick cooked quinoa with meat or dried meat, tubers and vegetables.
2. **Lawa**: A semi thick "Mazamorra" (porridge like preparation) with raw flour, water with lime and animal fat.
3. **P'esque:** Quinoa grain cooked with water, without salt, served with either milk or grated cheese according to the availability of these additions.
4. **Kispiña:** Steamed buns of different shapes and sizes.
5. **Tacti o tactacho:** Fried buns, a kind of doughnut made with flour and llama fat.
6. **Mucuna:** Steam cooked balls made from quinoa flour with seasoning in the centre similar to tamales or humitas.
7. **Phiri:** Roasted and slightly dampened rough quinoa flour.
8. **Phisara:** Lightly roasted and cooked quinoa grain.
9. **Q'usa:** Quinoa chicha, a macerated cold drink
10. **El Ullphu, Ullphi:** Cold drink prepared with roasted quinoa flour diluted in water with sugar added to taste.
11. **Kaswira de quinua:** Flattened bread fried in oil, made with katahui (lime) and white quinoa.
12. **Kaswira de ajara:** Flattened bread fried in oil, made with katahui (lime) and black quinoa or Ajara
13. **K'api kispiña**: Steamed bun, made with quinoa ground in a K `ona and cooked in a clay pot, common in the feast of All Saints.
14. **Turucha quispiña o Polonca:** Large steamed breads, made with katahui and quinoa lightly ground (chama) in a Kona, and cooked in a clay pot.
15. **Mululsito quispiña:** Steamed bread, made with katahui and quinoa flour, cooked in a clay pot,smaller than Kispiñas.
16. **Quichi quispiña:** Steamed and fried bread, made with katahui and quinoa flour, fried in a pan.
17. **Juchacha:** Andean soup based on ground quinoa and katahui, accompanied by roasted barley flour.
18. **Chiwa:** Young leaves of quinoa called **Lliccha** in Quechua and **Chiwa** in Aymara, are used as a vegetable in the preparation of soups and salads. The leaves are rich in vitamins and minerals, especially calcium, phosphorus and iron.

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Reference

Ahamed N.T., Singhal R.S., Kulkarni P.R., Kale D.D, Pal M. (1996): Studies on *Chenopodium quinoa* and Amaranthus paniculatas starch as biodegradable fillers in LDPE films. Carbohydrate Polymers, **31**: 157–160.

Ascheri J.L.R., Spehar C.R., Nascimento R.E. (2002): Comparative chemical characterization of instantaneous flours by extrusion – cooking from quinoa

Atwell, W. A *et al*., 1983 (*Chenopodium quinoa* Willd.), corn and rice. Alimen-taria, **331**: 89–92.

Caussette M., Kershaw J.L., Shelton D.R. (1997): Survey of enzyme activities in desaponified quinoa *Chenopodium quinoa* Willd. Food Chemistry, **60**: 587–592.

Comai S., Bertazzo A., Bailoni L., Zancato M., Costa C.V.L., Allegri G. (2007): The content of proteic and nonproteic (free and proteinbound) tryp-tophan in quinoa and cereal flours. Food Chemistry, **100**: 1350–1355.

Dini I., Tenore G.C., Dini A. (2005): Nutritional and antinutritional composition of Kancolla seeds: an in-teresting and underexploited andine food plant. Food Chemistry, **92**: 125–132.

Dini I., Tenore G.C., Dini A. (2004): Phenolic constituents of Kancolla seeds. Food Chemistry, **84**: 163–168.

Dini I., Tenore G.C., Trimarco E., Dini A. (2006) Two novel betaine derivatives from Kancolla seeds (Chenopodiaceae). Food Chemistry, **98**: 209–213.

Jacobsen (2003).

Heisser and Nelson (1974).

Kent N. (1963): Chemical Composition of Cereals. 3rd Ed. Pergamon Press, Oxford: 27–48.

Kim G. Ng, Keith R. Price & G. Roger Fenwick (1994): A TLC method for the analysis of quinoa (Chenopodium quinoa) saponins, Food Chemistry **49**; 311-315.

Koziol M.J. (1992): Chemical composition and nutritional evaluation of quinoa (*Chenopodium quinoa* Willd.) . Journal of Food Composition Analysis, **5**: 35–68.

Matiacevich S.B., Castellión M.L., Maldonado S.B., Buera M.P. (2006): Water-dependent thermal transitions in quinoa embryos. Thermochimica Acta, **448**: 117–122.

Miranda, M., Delatorre-Herrera, J., Vega-Gálvez, A., Jorquera, E., Quispe-Fuentes, I. and Martínez, E.A. (2014) Antimicrobial Potential and Phytochemical Content of Six Diverse Sources of Quinoa Seeds (*Chenopodium quinoa* Willd.). *Agricultural Sciences*, **5**, 1015-1024.

Morrissey JP & Osbourn AE (1999) : Fungal resistance to plant antibiotics as a mechanism of pathogenesis. Microbiological and Molecular Biological Reviews 63, 708–724

Partap T., Galwey, N.W. (1995): Chenopods. *Chenopodium* spp. Promoting the conservation and use of underutilized and neglected crops. 22. IPGRI:63.

Paweł Pas´ko *et al.* (2009): Anthocyanins, total polyphenols and antioxidant activity in amaranth and quinoa seeds and sprouts during their growth Food Chemistry 115, 994–998.

Przybylski R., Chauhan G.S., Eskin N.A.M. (1994): Characterization of quinoa (*Chenopodium quinoa*) lipids. Food Chemistry, **51**: 187–192.

Ranhotra, G. *et al.* Composition and protein nutritional quality of quinoa. **Cereal Chemistry**, v. 70, p. 303-305, 1993.

R. Yawadio Nsimba *et al.* (2008) :Antioxidant activity of various extracts and fractions of Chenopodium quinoa and Amaranthus spp. Seeds. Food Chemistry, **106** : 760–766.

Ruales J., Nair B.M. (1993): Content of fat, vitamins and minerals in quinoa (*Chenopodium quinoa*, Willd) seeds. Food Chemistry, **48**: 131–136.

Siener R., Hönow R., Seidler A., Voss S., Hesse A. (2006): Oxalate contents of species of *Polygonaceae*, *Amaranthaceae* and *Chenopodiaceae* families. Food Chemistry, **98**: 220–224.

Tang H., Watanabe K., Mitsunaga T. (2002): Characterization of storage starches from quinoa, barley and adzuki seeds. Carbohydrate Polymers, **49**: 13–22.

Tari T.A., Annapure US., Singhal R.S., Kulkarni P.R. (2003): Starch-based spherical aggregates: screening of small granule sized starches for entrapment of a model flavouring compound, vanillin. Carbohydrate Polymers, **53**: 45–51.

Tari T.A., Singhal R.S. (2002): Starch-based spherical aggregates: stability of a model flavouring compound, vanillin entrapped therein. Carbohydrate Polymers, **50**: 417–421.

Valencia-Chamorro S.A (2003): Quinoa. In: Cabal-lero B.: Encyclopedia of Food Science and Nutrition. Vol. 8. Academic Press, Amsterdam: 4895–4902.

Vilche C., Gely M., Santalla E. (2003): Physical properties of quinoa seeds. Biosystems Engineering (2003) 86.