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Physicochemical properties of quinoa (*Chenopodium quinoa* Willd) flakes and corn (*Zea mays* L) flakes

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Abstract

Quinoa (*Chenopodium quinoa* Willd) is native to South America and Maize (*Zea mays* L) is widely cultivated in American and Asian countries. Quinoa is good source of gluten free diet which cannot digest gluten in their intestine. Quinoa is considered as a complete food, quinoa flakes and corn flakes provides a potent amount of fat, protein, carbohydrates and energy along with SFA, MUFA, PUFA, ash and moisture. Quinoa flakes provides a rich amount of Fe, Zn, Ca, Mg, Na, K, P, Cu and Mn. Quinoa flakes and corn flakes were provide a significant amount of vitamin B1, B2, B3 and C which were 0.34, 0.40, 1.11, 5.02 (mg/100g) and 0.89, 1.07, 3.57, 10.21(mg/100g) respectively. Both are considered as rich source of macronutrients and micronutrients. So as concluding remark quinoa flakes and corn flakes both are good cardiovascular health, brain health and human body.

Keywords: Gluten free, fat, moisture, protein, carbohydrate, saturated fatty acids, mono unsaturated fatty acids, poly unsaturated fatty acids, vitamins, minerals, macronutrients, micronutrients, cardiovascular health, brain health

Introduction

Quinoa (pseudo-cereals) is one of the oldest crops in the Andean Region, with approximately 7000 years of cultivation history, great cultures like the Incas and Tiahuanacu had domesticated and conserved this ancient crop (Jacobsen, 2003) [18]. Botanically, quinoa belongs to the class Dicotyledoneae, family Chenopodiaceae, genus *Chenopodium*, and species *quinoa*. The full name is *Chenopodium quinoa* Willd (Nisar M. *et al.*, 2017) [26]. The *Chenopodium* genus is found worldwide, with approximately 250 species identified. It is a granifer species native to South America and domesticated by the people inhabiting the Andes, mainly in Peru and Bolivia, for thousands of years (Filho AMM. *et al.*, 2017) [15]. It is a very interesting food due to its complete nutritional characteristics (Nisar M. *et al.*, 2017) [26]. Quinoa is a complete food with high-nutritional value due mainly to Rich in protein and with an extraordinary balance of essential amino acids, it was considered a sacred plant by those people (Spehar and Santos, 2002) [35], (Spehar, 2006) [33], (Spehar, 2007) [34], (Farro, 2008) [14], (Jancurová *et al.*, 2009) [19].

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, and it is also considered an option to solve human nutrition problems (FAO, 2011) [13]. It is a plant that stands out for its good nutritional value and, above all, by the considerable resistance to weather climate and soil conditions. The edible parts involve leaves and grains, the latter being the most economically and scientifically explored (Spehar, 2006) [33], (Farro, 2008) [14]. Despite having cereal characteristics, as it does not belong to the Gramineae family and owns botanical aspects such as the presence of panicle-type inflorescence and exceptional nutritional balance because of their peculiar composition such as protein and lipids, high protein content (Filho AMM. *et al.*, 2017) [15] sulfur amino acids and lysine and the minor components (Sharma *et al.* 2015) [31], it is designated as a pseudo-cereal or pseudo-grain and even an oleaginous "pseudoseed" (Farro, 2008) [14], (Vega- Gálvez *et al.*, 2010) [39], (Repo-Carrasco-Valencia and Serna, 2011) [28].

Quinoa is highly nutritious contains a high content of health beneficial outstanding protein quality and wide range of minerals, vitamins, phytochemicals, including amino acids, fiber, polyunsaturated fatty acids, saponins, phytosterols, phytoecdysteroids, phenolics, betalains

and glycine betaine (Graf *et al.*, 2015) [16]. It overcomes cereals in the level of lipids, proteins, dietary fibers, vitamins B1, B2, B6, C, E and minerals, especially calcium, phosphorus, iron and zinc. Quinoa is an excellent example of 'functional food' that aims at lowering the risk of various diseases (Nisar M. *et al.*, 2017) [26].

Functional properties are given also by minerals, vitamins, fatty acids and antioxidants that can make a strong contribution to human nutrition, particularly to protect cell membranes, with proven good results in brain neuronal functions (Alvez *et al.*, 2010) [6].

The absence of gliadins (gluten-forming proteins present in wheat) and protein fractions corresponding to gliadin (found in oats, barley, rye and malt) makes quinoa appropriate for the preparation of food products popularly referred to as "gluten-free", important aspects that enable greater variety and supply of more nutritious food, suitable for patients with celiac disease (Almeida & Sá, 2009) [2], (Borges *et al.*, 2010) [9]. The gluten-induced autoimmune intestinal enteropathy, or celiac disease, is a type of food intolerance in genetically susceptible individuals, associated specifically to products containing gluten such as wheat, rye, barley, oats and triticale. It is characterized by chronic inflammation of the mucosa of the small intestine, which can result in partial or total intestinal villous atrophy years (Filho AMM., *et al.*, 2017) [15]. Studies worldwide have shown that the prevalence of this disease is considerably higher than previously supposed, ranging from 1:100 to 1:300 individuals in the healthy adult population of most part of the world (Borges *et al.*, 2003) [11], (Bicudo, 2010) [8].

Maize (*Zea mays* L), also known as corn, belongs to the family Poaceae. *Zea* is an ancient Greek word which means "sustaining life" and *Mays* is a word from Taino language meaning "life giver." The word "maize" is from the Spanish connotation "maiz" which is the best way of describing the plant. Various other synonyms like zea, silk maize, makka, barajovar, etc. are used to recognize the plant (Kumar & Jhariya, 2013) [22]. Maize (*Zea mays* L) is one of the most versatile emerging crops having wider adaptability under varied agricultural and climatic conditions. Maize or corn (*Zea mays* L.) is an important annual cereal crop of the world. It is considered as a staple food in many parts of the world (Sandhu, Singh, and Malhi, 2007) [29]. Corn is universal crop grown in the developed and developing countries. It is third most important cereal crop of the world next to wheat and paddy (Priya and Verma, 2010) [27]. In 17th century maize was introduced to India. The world production of maize was 967 million metric tons (MMT) and in India its production was 23 MMT in 2013–14 (India maize summit, 2014) [17]. Due to its highest yield potential among the cereals it is known globally as queen of cereals.

Globally, maize is known as queen of cereals because it has the highest genetic yield potential among the cereals. It is widely cultivated throughout the world and enormous quantity of maize is produced each year than any other grain. The United States produces 40% of the world's harvest (Sangamithra, *et al.*, 2016) [30]. It is known as mother grain of Americans and it is the driver of the US economy (Shah *et al.*, 2016) [36]. Other major maize producing countries are China, Brazil, Mexico, Indonesia, India, France and Argentina. In India, maize is the third most important food crops after rice and wheat. The major producers of maize in the country are Uttar Pradesh, Bihar, Rajasthan, Madhya Pradesh, Punjab, Haryana, Maharashtra, Andhra Pradesh, Himachal Pradesh, West Bengal, Karnataka, and Jammu and Kashmir, jointly

accounting for over 95% of the national maize production (Milind & Isha, 2013) [24]. This together contributes nearly 9% in the national food basket and more than Rs. 100 billion to the agricultural GDP at current prices apart from generating employment to over 100 million man-days at the farm and downstream agricultural and industrial sectors (Sangamithra, *et al.*, 2016) [30].

It provides nutrients, serves as a basic raw material for the production of starch, oil, protein, alcoholic beverages, food sweetener and more recently fuel (Shah, *et al.*, 2015) [37]. In traditional medicine, it is used for relieving diarrhea, dysentery, urinary tract disorders, prostatitis, lithiasis, angina, hypertension, tumor and is pharmacologically exploited for hypoglycemic, anti-inflammatory, antioxidant and diuretic properties. It is found to have β carotene, biotin, and choline (Milind and Isha, 2013) [24]. It also contains vitamin C, vitamin K, vitamin B1 (thiamine), vitamin B2 (niacin), vitamin B3 (riboflavin), vitamin B5 (pantothenic acid), vitamin B6 (pyridoxine), folic acid, selenium, N-p-coumaryl tryptamine, and N-ferrulyl tryptamine (Shah, *et al.*, 2015) [37]. Potassium is a major nutrient present which has a good significance because an average human diet is deficient in it (Kumar & Jhariya, 2013) [22]. Roasted maize kernels are also used as coffee substitute (Breadley, 1992) [7].

The maize is cultivated throughout the year in all states of the country for various purposes in addition to food for human being, it serves as a quality feed for animals, as an ingredient to thousands of industrial products that includes starch, oil, protein, alcoholic beverages, sweeteners, pharmaceutical, cosmetic, plastics, fabrics, gum, package and paper industries etc. It is widely processed into various types of products such as cornmeal, grits, starch, flour, tortillas, snacks, and breakfast cereals. Maize flour is used to make chapatis or flat breads which are eaten mainly in a few Northern states of India (Mehta & Dias, 1999) [23]. Due to increasing attention being drawn towards the development of nutraceuticals, the phytochemical compounds derived from maize and their health properties have recently become the major focus of studies (Shah, *et al.* 2016) [36].

Thus, this work aims to discuss about the major compounds in quinoa flakes and corn flakes and their health-promoting effects, in order to better understand the nutritional and health potential of quinoa and maize and consequently improve its consumption.

Material and Methods

Quinoa and Corn flakes both were collected from local market. Moisture content of quinoa flakes and corn flakes were determined by oven method described in AOAC (1990) [4]. Crude protein was determined by the Kjeldahl nitrogen method described in AOAC (1990) [4]. Fat content was determined by the soxhlet extraction method described in AOAC (1990) [4]. Ash was determined by AOAC (1995) [5] method. A 2g sample was ignited at 600 °C in a muffle furnace for 6 hours. The residue was cooled in a desicator and weighed. Crude fiber was determined by AOAC (1995) [5] method. Carbohydrate and energy were calculated by calculation method Kent (1963) [20], Koziol (1992) [21].

Vitamin A content was determined by the HPLC (AACC, 1995) [3]. Vitamin E (α -tocopherol) content was determined by the high performance liquid chromatography (HPLC)/ fluorescence method described by Miranda *et al.* (2010) [25]. Furthermore, vitamin B1 (thiamine), B2 (riboflavin), B3 (niacin) and B5 (pantothenic acid) were determined by acid and enzymatic hydrolysis, separated with HPLC (AACC,

1995)^[3]. Fatty acids were determined by IS: 548. Mineral elements (Na, K, Ca, Mg, Cu, Mn, Zn, and Fe) were measured with inductively coupled plasma (Spectrophotometer) method (AOAC 1995)^[5].

Statistical Analysis

The entire experiment was replicated three times. All the data were analyzed by excel and results were expressed as mean \pm standard deviation (SD).

Results and Discussion

The Quinoa flakes (Table. 1) contains 1.22 g/100g of ash, 5.34 g/100g of moisture, 6.4 g/100g of fat, 14.81 g/100g of protein which is lower than 16.5 g/100g (Jancurova M., 2009)^[19], 1.80 g/100g of crude fiber and 72.18 g/100g of carbohydrates. Quinoa flakes provide 405.97 Kcal/100g of energy which is higher than 399 Kcal/100g (Valencia, 2003)^[38]. Bhathal *et al.*, (2017)^[10] stated that quinoa has crude protein (14.02%), crude fat (5.13%) and total ash (3.83%). Nutritional analysis (Table. 1) of corn flakes presents 2.46 g/100g of ash, 4.64 g/100g of moisture, 1.30 g/100g of fat, 7.38 g/100g of protein which is lower than 16.5 g/100g (Jancurova *et al.*, 2009)^[19], 1.15% of crude fiber and 84.22% of carbohydrates. The amount of energy is provided by corn flakes are 378.12 Kcal/100g which is lower than 408 Kcal/100g (Valencia, 2003)^[38]. Results show that quinoa flakes is higher in nutritional values like fat, protein, crude fiber and energy than corn flakes, so its batter than the corn flakes.

Table 1: Proximate analysis of Quinoa flakes and corn flakes (g/100g)

S. No.	Parameter	Quinoa Flakes	Corn Flakes
1	Ash	1.22 \pm 0.00	2.46 \pm 0.10
2	Moisture	5.34 \pm 0.49	4.64 \pm 0.27
3	Fat	6.45 \pm 0.08	1.30 \pm 0.03
4	Protein	14.81 \pm 0.24	7.38 \pm 0.04
5	Crude Fiber	1.80 \pm 0.19	1.15 \pm 0.11
6	Carbohydrate	72.18 \pm 0.58	84.22 \pm 0.33
7	Energy (Kcal)	405.97 \pm 2.34	378.12 \pm 1.52

The Quinoa flakes (Table. 2) contains 0.86 g/100g of saturated fatty acids, 1.79 g/100g of mono saturated fatty acids and 3.74 g/100g of poly saturated fatty acids. Quinoa flakes provide 6.39 g/100g of total fatty acids. The results provided by the study presented that the cornflakes (Table. 2) contain 0.21 g/100g of saturated fatty acids, 0.34 g/100g of mono saturated fatty acids, and 0.67 g/100g of poly saturated fatty acids. Corn flakes provide 1.28 g/100g of total fatty acids. Results shown that quinoa flakes is higher in fatty acids values like mono saturated fatty acids and poly saturated fatty acids than amount found in corn flakes, so its batter than the corn flakes. Rich amount of mono saturated fatty acids and poly saturated fatty acids is good for cardio vascular health of human.

Table 2: Fatty acid analysis of quinoa flakes and corn flakes (g/100g)

S. No.	Parameter	Quinoa Flakes	Corn Flakes
1	SFA	0.86 \pm 0.13	0.21 \pm 0.01
2	MUFA	1.79 \pm 0.09	0.34 \pm 0.02
3	PUFA	3.74 \pm 0.10	0.67 \pm 0.02
4	TFA	6.39 \pm 0.19	1.28 \pm 0.05

As per results comes in study Quinoa flakes (Table. 3) contains 9.09 mg/100g of iron, 5.61 mg/100g of zinc, 71.32

mg/100g of calcium, 212.08 mg/100g of magnesium, 64.71 mg/100g of sodium, 901.70 mg/100g of potassium, 394.67 mg/100g of phosphorus, 43.96 mg/100g of copper, and 2.72 mg/100g of manganese. Bhathal *et al.*, (2017)^[10] reported that quinoa flour contain calcium (83.33mg/100g), magnesium (202.17mg/100g), zinc (4.23mg/100g).

The results provided by the study presented that the cornflakes (Table. 3) contains 4.02 mg/100g of iron, 0.20 mg/100g of zinc, 20.76 mg/100g of calcium, 12.11 mg/100g of magnesium, 804.89 mg/100g of sodium, 85.64 mg/100g of potassium, 44.53 mg/100g of phosphorus, 0.09 mg/100g of copper, and 0.95 mg/100g of manganese. Abiose and Ikujenlola (2014)^[1] reported that common maize contain iron, zinc, calcium, potassium, magnesium and sodium were 1.10 mg/100g, 11.48 mg/100g, 64.74 mg/100g, 77.23 mg/100g, 141.30 mg/100g, and 61.65 mg/100g respectively.

Results show that quinoa flakes is higher in iron, zinc, calcium, magnesium, potassium, phosphorus, copper and manganese. But sodium content found higher in corn flakes. Rich amount of mineral is good for muscle and neurological health of human and also good for heart.

Table 3: (Mineral analysis of Quinoa flakes and corn flakes) mg/100g

S. No.	Parameter	Quinoa Flakes	Corn Flakes
1	Fe	9.09 \pm 0.13	4.02 \pm 0.08
2	Zn	5.62 \pm 0.09	0.20 \pm 0.01
3	Ca	71.32 \pm 1.06	20.76 \pm 0.38
4	Mg	212.08 \pm 2.73	12.11 \pm 0.17
5	Na	64.71 \pm 3.87	804.89 \pm 5.94
6	K	901.70 \pm 9.81	85.64 \pm 0.41
7	P	394.67 \pm 11.02	44.53 \pm 0.52
8	Cu	43.96 \pm 1.39	0.09 \pm 0.03
9	Mn	2.72 \pm 0.12	0.95 \pm 0.05

Quinoa flakes (Table. 3) according to the results it provides 0.41 mg/100g of vitamin A, 0.34 mg/100g of vitamin B1, 0.40 mg/100g of vitamin B2, 1.11 mg/100g of vitamin B3, 0.59 mg/100g of vitamin B5, 5.02 mg/100g of vitamin C and 4.11 mg/100g of vitamin E. Quinoa contain vitamin B1 (0.38 mg/100g dry wt.), B2 (0.39 mg/100g dry wt.), B3 (1.06 mg/100g dry wt.) and vitamin C (4.00 mg/100g dry wt.) (Koziol, 1992)^[21].

The results provided by the study cornflakes (Table. 3) 0.89 mg/100g of Vitamin B1, 1.07 mg/100g of Vitamin B2, 3.57 mg/100g of Vitamin B3, and 10.21 mg/100g of Vitamin C. During the study it is observed that corn flakes do not contain vitamin A, vitamin B5 and vitamin E. According to Shah *et al.*, (2016)^[37] vitamin composition in maize are B1 (0.10 mg/100g), B2 (0.42 mg/100g), and vitamin C (0.12 mg/100g).

Table 4: Vitamin analysis of Quinoa flakes and corn flakes (mg/100g)

S. No.	Parameter	Quinoa Flakes	Corn Flakes
1	Vitamin A	0.41 \pm 0.02	NR
2	Vitamin B1	0.34 \pm 0.02	0.89 \pm 0.01
3	Vitamin B2	0.40 \pm 0.01	1.07 \pm 0.03
4	Vitamin B3	1.11 \pm 0.02	3.57 \pm 0.05
5	Vitamin B5	0.59 \pm 0.02	NR
6	Vitamin C	5.02 \pm 0.10	10.21 \pm 0.17
7	Vitamin E	4.11 \pm 0.17	NR

Conclusion

Thus in light of experimental data and scientific data it may be concluded that quinoa is a very interesting food because of

its nutritional characteristics. It has been recognized as a complete food due to its protein quality. Quinoa is gluten-free, so it can be consumed by people who have celiac disease as well as by those who are allergic to wheat. The oil fraction of the quinoa flakes is of high quality and highly nutritional value. It is also rich in iron, zinc, calcium, magnesium, potassium, phosphorus and provides crude fiber, vitamin A, vitamin E as well as some vitamin B complex along with vitamin C. It is also provide the rich amount of energy. On the other hand corn flakes is good source of macronutrients such as energy, carbohydrate, protein and also transfer rich amount of micronutrients like vitamins and mineral. Corn flakes provide a rich amount of vitamin C and vitamin B1, B2, and B3. So as concluding remark quinoa flakes and corn flakes both are good cardiovascular health, brain health and human body.

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