Critical Review on Nutritional Profile of Quinoa Seeds

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Abstract
Nutraceutical is a term, formulated from “nutrition” and “pharmaceutical” by Stephen De Felice in 1989. He termed it as “food or parts of food that provide medical or health benefits including the prevention and treatment of diseases.” Such products may include herbal products, dietary supplements, isolated nutrients, processed food items, and genetically designed food products. One of such drugs is quinoa seeds which have been used as a nutraceutical since long time due to its rich nutritional profile and pharmacological activities. Quinoa seeds have reported to have all kinds of macronutrients and micronutrients such as protein, carbohydrates, lipids, vitamins, minerals, and other essential nutrients. And, its recommended by modern and traditional healers to include in the diet in order to complete the daily requirements of nutrition. Therefore, present review describes about the background, geographical sources, cultivation, macroscopy, microscopy, chemical constituents, nutritional profile, and pharmacological activities of the quinoa seeds.

Keywords: Nutraceutical, Nutritional Profile, Quinoa Seeds

INTRODUCTION
Nutraceutical is a term, formulated from “nutrition” and “pharmaceutical” by Stephen De Felice in 1989. He termed it as “food or parts of food that provide medical or health benefits including the prevention and treatment of diseases.” Such products may include herbal products, dietary supplements, isolated nutrients, processed food items, and genetically designed food products. Chiefly, neutraceuticals contains in them both macronutrients and micronutrients such as protein, carbohydrates, lipids, vitamins, minerals, and other essential nutrients. Marketed nutraceutical products are available in concentrated forms of pills, capsules, powders, and extracts from a single or multiple compound. Hippocrates, known as the father of medicine, believed that food is a medicine wherein Ayurveda has already proclaimed that food is the greatest medicine. Nutraceuticals and dietary supplements are functional foods, which helps in improving the health and management of diseases. Nutraceuticals are utilized for decades worldwide for improving the development of the body. They are advantageous due to the presence of natural sources and polyherbal combinations in them. The pharmaceutical industries in India are nowadays rapidly growing in the field of nutraceuticals with the analysis showing that the market earned $1,480 million in 2011, grown to $2,731 million in 2016 and is predicted to scale up to $250 billion by 2018. The global market of nutraceuticals was 142.1 billion USD in 2011 and as represented by a CAGR there will be a robust growth of 11.95% during 2018 - 2023.
has reported a growth in the market of nutraceuticals with a capital of 6.3%. The increasing demand leads to the new scope of research and drug development in the field of nutraceuticals. Furthermore, Ayurveda has a great probability to render established and time-tested drugs to develop into well define nutraceuticals. A few examples like Liquorice, Ginseng, Asparagus, Quinoa, Spinach, etc. can be used as nutraceuticals. Present review describes about the background, geographical sources, cultivation, macroscopy, microscopy, chemical constituents, nutritional profile, and pharmacological activities of the quinoa seeds.

**Historical background**

Quinoa has proved to be an important source of food in the Andean province since the period of 3000 B.C. [18] It has been prominently used by the Incas community after maize. However, after the Spaniards conquered the region in the year 1532, supplementary crops like potato and barley were introduced relegating the use of Quinoa. [18] Due to the erratic condition of green revolution and conditions like droughts led to the destruction of these crops. It was then, the native crop Quinoa was once again introduced and used in the forefront due to its stress tolerant trait.

**Taxonomical Classification** [16]

- **Kingdom**: Plantae
- **Subkingdom**: Tracheobionta
- **Subdivision**: Spermatophyta
- **Division**: Magnoliophyta
- **Class**: Magnoliopsida
- **Subclass**: Caryophyllidae
- **Order**: Caryophyllales
- **Family**: Chenopodiaceae/Amranthaceae
- **Genus**: Chenopodium L.
- **Species**: quinoa
Vernacular Names [17]

English : Quinoa
Finnish : Kvinoa
German : Reismelde

Geographical Source/ Distribution

Quinoa is widely grown in the Southern American region, at an altitude of 3800m and with latitudes ranging from 20° N in Columbia to 40° S in Chile. Its distribution starts at Nariño to other countries such as Northern Argentina, Ecuador, and Peru. The crop has gained popularity in continents like North America, Europe and Africa. Lately, the crop has been introduced in Asia. [18]

Cultivation/Harvest and Storage of Quinoa

Quinoa plant can be cultivated on a variety of land having a wide range of pH. [18, 19] The crop can be sowed by providing a spacing of 25-50 cm in between the rows. This will allow easy hoeing of the crop. Cultivation of quinoa in a properly drained and levelled ground is highly recommended. Sowing of The seeds should be sowed in 1-2 cm deep, fine structured, moist seedbed. [18, 19] The drought-tolerant trait of the crop makes it suitable for cultivation in India. The plant attains its maturity stage when it becomes completely dry and sheds its leaves. Traditional techniques using animals for ploughing sticks as well as threshers are utilized for threshing the seeds. The grains collected should be completely dried before its storage. [18, 20]

Macroscopic characters

Quinoa is an annual herb and it is considered a pseudo cereal plant. The crop grows well in India reaching up to 1.5 m in height producing a large number of branches with large leaves.

Stem- The stem is erect bearing alternate variously coloured leaves.

Leaves- The leaves at the top of the plant are lanceolate whereas the leaves below are rhomboidal and exhibit polymorphism.

Roots- The roots possess a well-developed ramified taproot, protecting the whole plant from drought conditions.

Inflorescence- The inflorescence of the plant are in panicles, 15-70 cm in long, which rises above the plant, also on axils of the leaves at the bottom.

Flowers- A unique feature of the plant is the hermaphrodite, which is present along with a female flower.

Fruit- An achene consisting various layers such as a pericarp, an episperm and a perigonium is present in shapes like cylindrical, conical or ellipsoidal.

Seeds- The size and colour of the seeds are variable with the black colour being dominant over red, yellow, and white. [21]
Microscopic Characters of the seeds [22]

The microscopic characters of the seeds consist of the following components.

**Pericarp**- It consists of two layers. The outer layer has large cells, which are papillose in shape while the cells in the inner layer are tangentially stretched. **Seed Coat**- It consists of cells that are double layered. The Exotesta is large and has cells, which are thick whereas the Endotegmen cells are comparatively thin. **Perisperm**- It consists thin-walled uniformly arranged non-living cells. The cells comprise angularly shaped starch grains. A Nuclei along with other organelles are also present. **Endosperm**- The micropylar area in endosperm consists of a single or double cell layer, which has thick hard outer cell walls enveloping the hypocotyl-radicle axis. **Embryo**- Embryonic cells have thin primary cell walls consisting of a hypocotyl-radicle axis bearing a pair of cotyledons, which consists of spongy, palisade tissues, a protoderm, and a procambium.

**Traditional Uses of Quinoa**

Traditionally, Quinoa has been extensively utilized by the native people of South America. Quinoa seeds were consumed comparable to that of rice. Preparations such as soups, breakfast cereal, and flour for baking cookies, bread, biscuits, pasta, flakes, and pancakes were prepared. The leaves of the crop were eaten similarly like the leaves of spinach and quinoa sprouts have been included in salads. The South American natives have also ceremonially used fermented products such as beer and a traditional alcoholic beverage called “chichi.” [23]

Description of some of the traditional preparations eaten by the Altiplano communities. [23]

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Preparation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Quinoa soup</td>
<td>Soup cooked with vegetables and meat.</td>
</tr>
<tr>
<td>2.</td>
<td>Lawa</td>
<td>Semi-thick preparation prepared from flour, limewater, and animal fat.</td>
</tr>
<tr>
<td>3.</td>
<td>Presque</td>
<td>Quinoa grain prepared in water without addition of salt and given along with the milk or the cheese.</td>
</tr>
<tr>
<td>4.</td>
<td>Kispiña</td>
<td>Buns of various shapes and sizes treated with steam.</td>
</tr>
<tr>
<td>5.</td>
<td>Tacti o tactacho</td>
<td>Prepare Doughnut-shaped buns by using flour and llama fat and subjected for the frying</td>
</tr>
<tr>
<td>6.</td>
<td>Mucuna</td>
<td>Steamed quinoa balls cooked from flour filled with seasonings at the center.</td>
</tr>
<tr>
<td>7.</td>
<td>Phiri</td>
<td>Quinoa flour, which is roasted and is slightly damp.</td>
</tr>
<tr>
<td>8.</td>
<td>Phisara</td>
<td>Slightly roasted quinoa grains</td>
</tr>
<tr>
<td>9.</td>
<td>Q’usa</td>
<td>Macerated beverage of Quinoa seeds</td>
</tr>
</tbody>
</table>
10. El Ullphu, Ullphi  
   Sweet cold drink obtained by roasting flour of Quinoa and further diluted with water.

11. Kaswira de quinua  
   Flat bread fried with white quinoa and lime.

12. Kaswira de ajara  
   Flat bread made from lime and ajara fried in oil.

13. K’api kispiña  
   Buns steamed in clay pots, it is commonly prepared in the All Saints feast.

14. Turucha quispiña o Polonca  
   Steamed breads prepared in clay pots using lightly ground quinoa.

15. Mululsito quispiña  
   Steamed breads smaller than Kispiñas are made from quinoa flour, which are processed in mud pots.

16. Mululsito quispiña  
   Bread made with quinoa flour are steamed and fried.

17. Juchacha  
   Andean soup mixed with barley flour that has been roasted.

18. Chiwa  
   Soups and salads prepared by the leaves of Quinoa.

**Table 1 Traditional uses of quinoa seeds**

**Chemical composition and nutritional profile of Chenopodium quinoa** [24]

<table>
<thead>
<tr>
<th>Chemical Constituents</th>
<th>Quantity (gm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein</td>
<td>16.5</td>
</tr>
<tr>
<td>Fat</td>
<td>6.3</td>
</tr>
<tr>
<td>Fiber</td>
<td>3.8</td>
</tr>
<tr>
<td>Ash</td>
<td>69.0</td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>3.8</td>
</tr>
</tbody>
</table>

**Table 2 Chemical composition of Chenopodium quinoa**

**Essential amino acids present in Chenopodium quinoa** [24]

<table>
<thead>
<tr>
<th>Essential amino acids</th>
<th>Quantity (gm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Histidine</td>
<td>3.2</td>
</tr>
<tr>
<td>Isoleucine</td>
<td>4.9</td>
</tr>
<tr>
<td>Leucine</td>
<td>6.6</td>
</tr>
<tr>
<td>Lycine</td>
<td>6</td>
</tr>
<tr>
<td>Methionine</td>
<td>5.3</td>
</tr>
<tr>
<td>Phenylalanine</td>
<td>6.9</td>
</tr>
<tr>
<td>---------------</td>
<td>-----</td>
</tr>
<tr>
<td>Threonine</td>
<td>3.7</td>
</tr>
<tr>
<td>Tryptophan</td>
<td>0.9</td>
</tr>
<tr>
<td>Valline</td>
<td>4.5</td>
</tr>
</tbody>
</table>

Table 3 Essential amino acids in *Chenopodium quinoa*

Mineral composition in *Chenopodium quinoa* [24]

<table>
<thead>
<tr>
<th>Minerals</th>
<th>Quantity (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium</td>
<td>1487</td>
</tr>
<tr>
<td>Magnesium</td>
<td>2496</td>
</tr>
<tr>
<td>Potassium</td>
<td>9267</td>
</tr>
<tr>
<td>Iron</td>
<td>3837</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>132</td>
</tr>
<tr>
<td>Copper</td>
<td>51</td>
</tr>
<tr>
<td>Zinc</td>
<td>44</td>
</tr>
</tbody>
</table>

Table 4 Mineral composition in *Chenopodium quinoa*

Vitamin concentrations in *Chenopodium quinoa* (mg/100g dry wt.) [24]

<table>
<thead>
<tr>
<th>Vitamins</th>
<th>Quantity (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1-Thiamine</td>
<td>0.38</td>
</tr>
<tr>
<td>B2-Riboflavin</td>
<td>0.39</td>
</tr>
<tr>
<td>B3- Niacin</td>
<td>1.06</td>
</tr>
<tr>
<td>C- Ascorbic acid</td>
<td>4.00</td>
</tr>
<tr>
<td>Alpha Tocopherol</td>
<td>5.37</td>
</tr>
<tr>
<td>Beta Carotene</td>
<td>0.39</td>
</tr>
</tbody>
</table>

Table 5 Vitamin concentrations in *Chenopodium quinoa*
Reported Pharmacological activity of *Chenopodium quinoa* [25, 26, 27, 28, 29]

**Fig. 2** Reported pharmacological activity of *Chenopodium quinoa*

**Conclusion:**
Nutraceuticals are the functional food which complete the daily requirements of macronutrients and micronutrients which can not be completed by the routine diet. Increasing demand of nutraceuticals leads to launch of new products in the market. However, quinoa seeds are capable to complete the criteria of the nutraceutical due to the rich nutritional profile. Present review covers its traditional and modern application as nutraceutical. However, further studies are required to accept quinoa seeds as nutraceutical with a better dosage form.

**REFERENCE**

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