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The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(6): 642-645

www.thepharmajournal.com
Received: 19-04-2021
Accepted: 27-05-2021

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Studies physico-chemical properties of Quinoa (*Chenopodium quinoa* willd.) seed

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Abstract
The present research was carried out to evaluate the physico-chemical properties of quinoa seeds. Physical properties such as colour, shape, thousand kernel weight, bulk density, true density, porosity and angle of repose were determined. Chemical/proximate composition of the quinoa seeds was analyzed for the parameters such as moisture, fat, carbohydrate, protein, crude fibre, and ash. Obtained result found that the quinoa seeds having the good nutritional profile with carbohydrate (61.12±0.31%), protein (15.24±0.25%) and fat (6.1±0.58%). Quinoa seeds were also found to be good source of minerals such as potassium (731.6±0.70mg), magnesium (501.3±0.97mg), phosphorus (410.8±0.80mg) and calcium (86.7±.070mg). Quinoa seeds were to be utilized in development of different food products to enhance nutritional and health benefits.

Keywords: Quinoa, physical, chemical, composition, nutritional

Introduction
Quinoa was first cultivated over 5000 years ago and due to its nutritional content and health benefits it is known as "the mother of all grains". It was staple food for the Incas region people and still a prominent food source for their indigenous descendants. It is widely consumed in the highlands of the andes in South America, quinoa has attained popularity as health food in North America, Europe, Australia, Japan and India (Singh *et al*., 2016) [16]. The world's main producers are Bolivia, Peru and the United States. In 2008, these two countries accounted for 92% of quinoa produced in the world. In India, Andhra Pradesh and Uttrakhand are emerging as the main cultivators of quinoa. In 2013, Uttrakhand signed a horticulture research agreement with Peru to grow quinoa in the state and research institutes in Andhra Pradesh have successfully developed local varieties of the crop.

Quinoa (*Chenopodium quinoa* Willd.) is considered as pseudo-cereals crop, it is a broad leaf plant with starchy dicotyledonous seed and therefore not a cereal. Quinoa grains have an established excellent nutritional food quality and also known as "the mother grain". Botanically, quinoa belongs to the class *Dicotyledoneae*, family *Chenopodiaceae*, genus *Chenopodium*, and species *quinoa*. The full name is *Chenopodium quinoa* Willd. (Sharma *et al*., 2015) [15]. Quinoa are round and flattened and they may measure from about 1.5 mm in diameter to 4 mm; about 350 seeds weigh 1 g. Seed size and color are variable. Seed colors go from white to grey and black, potentially having tones of yellow, rose, red and purple and violet, often with very colorful mixes in the same panicule, where black is dominant over red and yellow, which in turn are dominant to white seed color It is a very interesting food due to its complete nutritional characteristics.

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 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 and it is also considered an option to solve human nutrition problems (FAO, 2011). Quinoa is considered one of the best plant origin protein sources, as its protein levels are similar to those found in milk and higher than those present in cereals such as wheat, rice and maize.

Physical properties of quinoa such as thousand kernel weight of quinoa 2.5 to 3.1 g, density 928 to 1188 kg/m3, porosity 0.19 to 0144 per cent, angle of repose 18 to 258^0 and terminal velocity of quinoa was 0.6 to 1.02 m/s. (Mohammaad *et al*., 2017) [9].

The protein quantity and quality of quinoa are generally superior to those of cereal grains such as wheat, rice and barley and maize while offering gluten-free property and high digestibility.

Quinoa has a higher total protein content (12.9 per cent to 16.5 per cent) than barley (10.8 per cent to 11.0 per cent), oat (11.6 per cent), rice (7.5 per cent to 9.1 per cent), and maize (10.2 per cent to 13.4 per cent) and a total protein content equal to that of wheat (14.3 per cent to 15.4 per cent) (Comai *et al.*, 2007 and Peiretti *et al*., 2013) [2, 11].

Quinoa is rich in fiber and minerals, apart from having a sufficient quantity of carbohydrates (52-69%), proteins (13.8-16.5%) and fat (2.0-9.5%). (Semra and Nevin, 2016) [14]. Quinoa is high in fiber. Its fiber content can help to lower cholesterol levels, reduce blood sugar levels and increase fullness. Digestion is stimulated by fiber that requires bile acids which are made partially with cholesterol. People who are on a gluten free diet have been suggested for the incorporation of quinoa to improve their polyphenol content as compare with other gluten free ingredient. (Sanju *et al*., 2020)

It is stated that quinoa may benefit high risk group consumers, such as children, the elderly, high performance sports people, individuals with lactose intolerance, women prone to osteoporosis, people with anemia, diabetes, dyslipidemia, obesity and celiec disease due to its properties including a high nutritional value, therapeutic features and gluten free content (Naga *et al.*, 2019)

Considering the problem like malnutrition, celiac disease and diabetic mellitus it is hypothesized that pseudo-cereal such as quinoa would have better utility in being part of human diet and found to be good way to convey such nutritious grain in human diet.

For the preparation of quinoa value added product, determination of its physic-chemical properties will help in enhancing the quality of product.

Materials and Methods

The present investigation was carried out in Department of Food Process Technology, College of Food Technology, VNMKV, Parbhani during year 2020-21.

Materials

Good quality quinoa seeds were procured from Seed Technology Research Unit, VNMKV, Parbhani. Chemicals used in this investigation were of analytical grade. They were obtained from Department of Food Process Technology, College of Food Technology, VNMKV, Parbhani.

Methods

Physical characteristics of quinoa seeds

The quinoa seeds are subjected to physical analysis of, thousand kernel weight, true density, bulk density, porosity and angle of repose. It confirm that the quality of quinoa seeds.

Thousand kernel weight

One thousand grains were counted and weighed by a digital weighing balance in three replication and mean value was recorded.

Bulk density

Twenty five gram of sound grains was weighed on the digital weighing balance and filled into the measuring cylinder earlier filled with reference solution of hexane. The increase in the level of liquid was measured after adding the grains. It is bulk density represented in kg/m^3 (Dutta *et al.*, 1988) [3].

$$\text{Bulk Density } (\rho) = \frac{\text{Weight of grains}}{\text{Volume displayed}}$$

True density

The true density defined as the ratio of the mass of the sample of seeds to the solid volume occupied by the sample, was determined using an electronic balance reading to 0.0001 g and a pycnometer (50±0.1 ml) (liquid displacement method). Toluene was used instead of water because it is absorbed by grains to a lesser extent. Due to the short duration of the experiment, Toluene absorption was found to be negligible and therefore seeds were not coated for its absorption prevention.

Porosity

The porosity (e) of the bulk seed was defined as the fractions of the space in the bulk grain that is not occupied by the grain. The porosity was calculated using formula

Porosity (%) = (True density-Bulk density) × 100 / True density

Angle of repose

It is the steepest angle between the base and slope of cone formed on a free vertical fall of grain mass to a horizontal plane when material is free falling or sliding. It was determined by making a circular pile of the grains freely falling. The height of the pile was taken (h) and its radius (r) was measured. Angle of repose was determined using a method described by (Mohsenin N.N., 1986) [10].

Angle of Repose (θ) = $\tan^{-1}$ (h/r)

Proximate composition of quinoa seeds

Raw materials such as quinoa seeds were analyzed for proximate composition including moisture, fat, protein, total carbohydrate, crude fiber, ash and mineral composition was carried out as per the methods given by AOAC, 2005 [1].

Determination of minerals composition of quinoa seed

Two grams of defatted sample was weighed and heated at 550ºC. Then, the obtained ash was digested with concentrated Hydrochloric acid (HCL) on hot plate. The digested material was then filtered using whatman No. 42 filter paper and the final volume made to 100ml with distilled water that was further used for analysis with respects to iron, calcium, potassium, contents by using methods (Ranganna S., 1986) [12].

Results and Discussion

Physical properties of quinoa seeds

The understanding of physical quality attributes is critical in designing end product and its use, different individual grains have different physical characteristics that may dictate end product quality and application. Physical properties of kernel such as size, shape and weight play important role in the efficiency of milling in terms of flour yield, colour, chemical composition and acceptability. Physical characteristics of the selected quinoa genotypes *viz*., 1000 kernel weight, true density, bulk density and angle of repose were studied. The results pertaining to physical properties of quinoa seeds are presented in Table 1.

Table 1: Physical Parameters of raw quinoa seeds

Physical Parameters	Observation
Colour	Cream white
Shape	Circular
1000 kernel weight (g)	2.32±0.16
Bulk density (kg/m^3)	601.3±0.30
True density (kg/m^3)	873.6±0.50
Porosity (%)	31.05±0.54
Angle of repose (^{0})	31.4±0.33

*Each value represents the average of three determinations

The physical properties of quinoa seeds investigated and the result are presented in the Table 1. The data revealed that the quinoa is circular in shape and cream white in colour. Thousand kernel weight of quinoa seeds were 2.32±0.16g. The bulk density and true density of quinoa seeds were 601.3±0.30 kg/m^3 and 873.6±0.50 kg/m^3 respectively. The porosity of quinoa seeds was 31.05±0.54 per cent. The angle of repose of quinoa seeds was 31.4±0.33^0. The results of quinoa seeds for physical properties were to close resemblance with the results reported by Vilche *et al*. (2003) [17].

Chemical and mineral composition of quinoa seeds

Data pertaining to various chemical properties like moisture, fat, carbohydrate, proteins, ash and crude fiber were investigated and results obtained and depicted in Table 2.

Table 2: Proximate composition of raw quinoa seeds

Chemical Parameters	Mean Value (%)
Moisture	9.8±0.70
Total Fat	6.1±0.58
Total carbohydrates	61.12±0.31
Total Protein	15.24±0.25
Ash	3±0.32
Crude Fiber	4.74±0.77

*Each value represents the average of three determinations

The data indicated in Table 2. Conclude that the quinoa seeds contain 61.12±0.31 percent carbohydrate, 15.24±0.25 percent protein and 6.1±0.58 percent crude fat. The ash content of quinoa seeds was about 3±0.32 percent. Quinoa seeds contain fair amount of crude fiber 4.74±0.77 percent. Moisture 9.8±0.70 percent content of quinoa seeds is an indicative of used dried seed. The obtained results for the proximate composition of quinoa seeds flour were found similar to findings of results of Maradini-filho (2017) [8] and Galvez *et al.* (2010) [5].

Mineral composition of quinoa seeds

Minerals are inorganic elements needed by the body as structural component and regulators of body processes. The results given with respect to various minerals such as calcium, phosphorus, magnesium, iron and potassium were determined and accordingly results presented in Table 3.

Table 3: Mineral content of raw quinoa seeds

Minerals	Average value (mg/100g)
Calcium	86.7±.070
Phosphorus	410.8±0.80
Magnesium	501.3±0.97
Iron	15.5±0.80
Potassium	731.6±0.70

*Each value is an average of three determinations

It is seen from the Table 3. that the mineral content of quinoa seeds was evaluated and found that the potassium content of quinoa seeds is found to be highest (731.6 mg) than the rest of the minerals. Moreover, calcium content is 86.7 mg/100g, phosphorus 410.8 mg/100g, magnesium 501.3 mg/100g and iron content is 15.5 mg/100g respectively. The study showed that quinoa seeds are good source of potassium, calcium, phosphorus, magnesium and iron. Similar results were obtained with Arneja *et al*., (2015) [6].

Conclusion

Physical properties of quinoa seeds will help in designing the machinery, processing and milling operations. The proximate composition of quinoa seeds showed that it was a complete food with a good nutritional profile. A quinoa seeds were found to be good source of minerals. Finally it can be concluded that evaluating physico-chemical characteristics of quinoa seeds was found to be critical for the design and production of process machinery as well as the development of good nutritional quality products based on its nutritional content.

Acknowledgement

Authors are thankful to Dr. U. M. Khodke, ADP, College of Food Technology, VNMKV, Parbhani for constant encouragement and support. Authors are also thankful to Mr. Eknath Shinde (PhD Scholar) for constant support and guidance.

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