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Studies on standardization of malting process for quinoa seeds (*Chenopodium quinoa*)

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Abstract
Quinoa seed (*Chenopodium quinoa* willd) has since maintained buzz as one of the most popular healthy food trends, including low and gluten-free diet plans. Now a days most of peoples preferred to gluten-free food products quinoa is good source of protein and fibre content. Pseudocereals also contain some anti-nutritional factors which interfere minerals and protein availability. Hence in present investigation efforts were made to standardization the malting procedure of quinoa seeds and assess its nutritional and mineral properties, malt obtained by 4, 8 and 12 h soaking at room temperature and 12, 24 and 48 h sprouting period in sprout maker box at the place of room temperature considered as standardized malting processing for present study as there malting conditions gave highest amount of malt yield of 84.42% steeped for the period 12 h and 24 h sprouting period and also highest hydration capacity and swelling capacity of quinoa seeds during soaking period 12 h and 8 h is superior results than the other soaking period.

Keywords: *Chenopodium quinoa*, steeping, germination, functional properties, yield

Introduction
Malting seeds increases their nutritional content by inducing hydrolytic activity. Local types of fingermillet and mungbean were chosen to assess nutritional changes during the malting process. Fingermillet and mungbean seeds were steeped in boiled cool water (w/v=1:2) for 6 hours at room temperature (30 °C) and germinated for 12, 24, and 36 hours, respectively. Germination was inhibited at various time intervals by drying in sunshine. The raw and malted seeds of fingermillet and mungbean were crushed into fine flour and their proximate composition was determined. The results showed that there was a significant increase (p0.05) in reducing sugar and free amino acid content, a significant decrease (p0.05) in total protein, and no substantial improvement (p>0.05) in moisture, total fat, crude fiber, ash, and total sugar content during malted grain both of fingermillet and mungbean for 36 hours. (Banusha & Vasantharuba, 2013) [4].

Quinoa (*Chenopodium quinoa* Willd.) is a member of the *Chenopodiaceae* family, which includes spinach and beet. There are approximately 250 species of this family worldwide, and it is an epidemics plant unique to South America. It was, however, domesticated thousands of years ago by humans living in the Andes, mainly in Peru and Bolivia. The earliest quinoa remnants discovered date back to 5000 BC. While different local languages use different names for quinoa, such as supha, suba, jupha, and dahue, it is known as quinua and quinoa in Bolivia, Peru, Ecuador, Argentina, and Chile. People have consumed it as a holy plant due to its high protein content and incredible balance of essential amino acids (Maradini Filho *et al*., 2017) [11].

Its high nutritional value attracts attention, but more importantly, it is highly resistant to weather, climate, and soil conditions. While both its seeds and leaves are eatable, it is the seeds that have received the most attention in terms of economic and scientific research. Which has grain-like properties, it is classified as a pseudo-cereal or even a pseudo-seed because it does not belong to the Gramineae family, has botanical traits such as cluster-type inflorescence, and has a balance of proteins and lipids as well as a nutritional quality (sulfur amino acids and lysine) (VegaGalvez *et al*., 2010; Repo-Carrasco-Valencia *et al*., 2010) [18, 14].

Quinoa's main carbohydrate component is starch, which accounts for 52%, 69% of its total weight. Its total diet fiber content is comparable to that of grain products (7%e9.7%), while its soluble fiber content is estimated to be in the 1.3%e6.1% range. Quinoa contains sugar by about 3%. It mostly contains maltose, D-galactose, and D-ribose in addition to low levels of fructose and glucose (Abugoch, 2009) [1].

Malting is the regulated process of germination of cereal grains or pulse seeds. (Briggs, 1998) [6]. During this process, the grains produce enzymes such as diastatic enzymes, which are necessary to convert starch into sugars such as monosaccharides like glucose or fructose and disaccharides like sucrose or maltose. It also produces other enzymes, such as proteases, which degrade the proteins in grains. Furthermore, malting improves grain quality by removing unwanted components such as antinutritional elements. (Verma *et al*., 2012) [19].

Malted grains have a high protein, fiber, and unsaturated fatty acid content while being low in carbohydrate. By enhancing the activities of hydrolytic enzymes such as amylase and protease, malted legumes increased the levels of total proteins (prolamins and lysine), fat, essential amino acids, total sugars, B-group vitamins, and starch digestibility. (Dipnaik and Bathere, 2017) [18].

Materials and Methods

Quinoa seeds: Good quality raw materials, such as quinoa seeds, were obtained from the Seed Technology Research Unit at Vasantrao Naik Marathwada Krushi Vidyapeeth, Parbhani.

Processing equipments and chemicals

Processing equipments used in present investigation were of analytical grade. The processing equipments *viz.*, Cabinet dryer (For drying of germinated quinoa grains), Weighing balance (For weighed quinoa seeds), Sprout maker box, Brookfield Viscometer (LVDV-E) (For measuring viscosity of quinoa seeds), Sieve analyzer (For obtaining equal particle size), Grinder (Krupa mill), etc. were obtained from Department of Food Process Technology, College of Food Technology, V. N. M. K. V., Parbhani (MS) India.

Malting of quinoa seeds

Process standardization of malting process for quinoa seeds is summarized (Fig. 1).

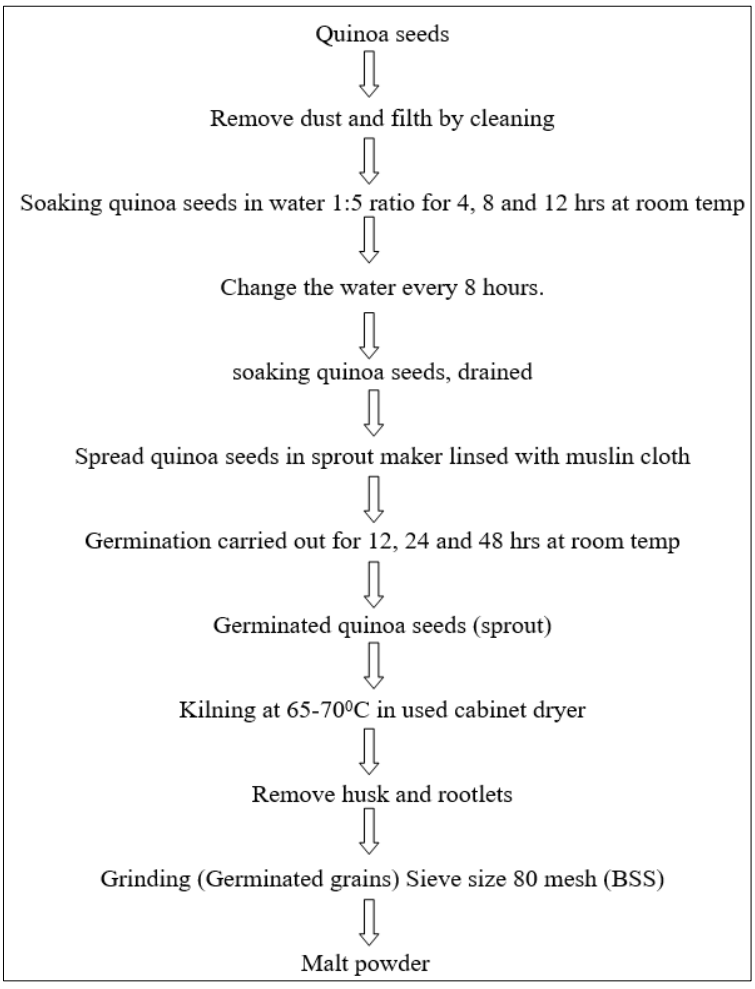

Fig 1: Flow sheet for the malting process standardization of quinoa seeds

Steeping/Soaking

Weighed quinoa seeds was steeped in 1:5 ratio with water for 4, 8 and 12 h. Every sample was steeped in triplicate to standardize steeping and sprouting period. Water was changed after every 8 h.

Sprouting/Germination

The steeped grains were drained and distributed on a muslin cloth-lined sprout making box. To avoid drying, the sprout producer was placed in room temperature water that was sprinkled on occasion. Germination was timed for 12, 24, and 48 hours.

Kilning/ Drying

The quinoa malt is dried by convection heat treatment to inhibit further germination. The germinated quinoa seeds

were dried in a cabinet dryer at temperatures ranging from 65 °C to 70 °C, and the rootlets were manually removed. The husk was removed by rubbing a pestle on the grain's outer surface, and the malted quinoa seeds were ground using a grinder (Krupa mill) and sieved to obtain particle size of 80 mesh (BSS).

Chemical composition
The moisture, protein, fat, ash, carbohydrates and crude fiber content of the quinoa seed treatments were determined using the methods of (AOAC, 2000) [3]. Total carbohydrates was calculated by the difference methods.

Mineral composition
The conventional procedure specified by Association of Official Chemists was used for mineral content analysis of the samples (AOAC, 2005) [2]. Calcium (Ca), Magnesium (Mg), Potassium (K), Sodium (Na), Iron (Fe), Manganese (Mn) and Zinc (Zn) were determined using Atomic Absorption Spectrophotometer (PERKIN – ELMER, 2380). In ppm, all values were expressed.

Determination of functional properties
Hydration capacity
To determine hydration capacity, by using the formula given by (Thathola *et al*., 2002) [17]. The grain number weighing 100 g of each were counted and transferred to measuring cylinder. To this 100 ml distilled water was added and cylinder was covered with aluminum foil and left for 15 hours at room temperature (25-2 °C). The grains were drained, Superfluous water was removed with filter paper and swollen grains were weighed. Hydration capacity was calculated.

$$Hydration\ capacity\ (\%) = \frac{Weight\ after\ soaking\ -\ Weight\ before\ soaking}{Weight\ of\ seeds} \times 100$$

Swelling capacity
To determine swelling capacity by using the formula given by (Thathola *et al*., 2002) [17]. Grain weighing 100gm were counted and transferred to a measuring cylinder and their volume was recorded. To this 100ml water was added and cylinder was covered with aluminum foil and left for 15 hours at room temperature (25+2 °C). The water was drained and volume of soaked grains was noted in graduated cylinder.

$$Swelling\ Capacity\ (\%) = \frac{Volume\ after\ soaking\ -\ Volume\ before\ soaking}{Weight\ of\ grains} \times 100$$

Malting loss and yield
Malting loss and malt yield were calculated using the difference in grain weight before and after soaking of sprouted grains. (Edney, 2000) [9].

Statistical analysis
The analysis of variance of the data obtained was done by using completely randomized design (CRD) for different treatments as per the methods given by (Panse and Sukhatme, 1967) [13].

Results and Discussion
The results obtained from the presents Investigation are summarized wherever required.

Chemical composition of quinoa seeds
The chemical composition of quinoa seeds such as moisture, protein, fat, carbohydrate, ash and crude fibre were determined and results obtained are summarized in Table 1.

Table 1: Chemical composition of quinoa seeds

Sr. No.	Parameter	% values
1.	Moisture	10.7±0.01
2.	Protein	14.8±0.02
3.	Fibre	5.38±0.02
4.	Fat	6.26±0.03
5.	Carbohydrate	60.2±0.02
6.	Ash	4.12±0.02

*Each value represents of average of three determinations

The data in Table 1. revealed that the quinoa seeds was found to contain a good amount of protein 14.8±0.02 (%) and 5.38±0.02 fibre (%). The moisture, fat, ash and carbohydrate content of quinoa seeds was found to be 10.7±0.01 (%), 6.26±0.03 (%), 4.12±0.02 (%) and 60.2±0.02 (%) content. The results obtained for the chemical composition of quinoa seeds were found similarly to the results reported by **(**Thakur, *et al*., 2021) [16].

Mineral composition of quinoa seeds
The data on the mineral composition of quinoa seeds are presented in Table 2.

Table 2: Mineral composition of quinoa seeds

Sr. No.	Parameter	(mg/kg)
1.	Calcium (mg/kg)	57.4±0.03
2.	Iron (mg/kg)	14.2±0.03
3.	Zinc (mg/kg)	4.67±0.01
4.	Phosphorus (mg/kg)	452±3.06
5.	Potassium (mg/kg)	1166±0.03
6.	Magnesium (mg/kg)	127±0.13

*Each value represents of average of three determinations

The quinoa seeds was found results such as calcium, iron, zinc, phosphorus, Potassium and magnesium content of quinoa seeds were 57.4±0.03 (mg/kg), 14.2±0.03 (mg/kg), 4.67±0.01 (mg/kg), 452±3.06 (mg/kg), 1166±0.03 (mg/kg), 127±0.13 (mg/kg), respectively. The concentration of calcium, magnesium, phosphorus, potassium, and iron were found much higher than the other inorganic minerals. However, zinc was found very low in concentration. The results obtained on mineral content of quinoa seeds were similarly to the (Miranda, *et al*., 2010) [18].

Effect of malting on functional properties
Various functional properties such as water absorption capacity, swelling capacity, and oil absorption capacity were determined and results is presented in the Table 3.

Table 3: Effect of soaking on functional properties of quinoa seeds

Steeping period (h) RT	Hydration capacity %	Swelling capacity %
4	62.18	65
8	78.4	82
12	80.7	74

RT= Room temperature, h= Hours

The data presented in Table 3. revealed that, the hydration capacity symbolize the ability of a quinoa seeds to associate with water under conditions where water is restrictive and considered to be an index of the capability of absorb and retain water. The hydration capacity of quinoa seeds found to be 62.18% for 4 h soaking period, 78.4% for 8 h soaking period, 80.7% for 12 h soaking period. The swelling capacity of quinoa seeds was found in 65% for 4 h, 82% for 8 h and 74% for 12 h respectively. The functional properties of quinoa seeds were similar results with the (Jain *et al*., 2012) [10].

Effect of malting on malt yield and malting loss

Table 4. The data on malt yield and malting loss of quinoa seeds were calculated and presented in Table 4.

Table 4: Effect of steeping and germination period variation on malt yield and malting loss % of quinoa seeds

Steeping period (h) at room temperature		Germination period (h) at room temperature		
		12	24	48
Malt Yield %	4	82.24	82.22	70.20
	8	82.58	80.56	68.96
	12	81.92	84.42	79.48
Malting Loss %	4	17.76	17.78	29.8
	8	17.42	19.44	31.04
	12	18.08	15.58	20.52

The loss due to germination can be attributed to respiratory activity of quinoa seeds while the increased losses, due to prolonged steeping may be due to faster rate of germination it could also be analysed from the Table 4. that maximum malt yield 84.42% was found in case where the quinoa sample steeped for the period of 12 h with 24 h of germination period and the results were statistically superior to other samples on the basis of observed results it could be stated that variations in germination and steeping periods critically affect the malt yield and direct relation between the steeping and germination periods with reduced in malt yield cannot be correlated. The decrease in malt yield after prolonged germination period may be attributed to more development of rootlets and subsequent removal of rootlets, more respiratory activity (Chinyere, 2007; Bhise *et al*., 1988) [7, 5].

Conclusion

Attempts were made during the current investigation to study the chemical and mineral composition of quinoa seeds and the malting process by varying the steeping and germination periods. Based on the scientific findings of the current investigation, it is possible to conclude that. Quinoa seeds were high in minerals, particularly calcium, potassium, phosphorus, and iron. It also had a high protein and fiber content quinoa seeds contain anti-nutritional factors that interfere with the availability of minerals and protein to the human body. These can be reduced by using a simple processing technique like malting. Malt was obtained by soaking for 4, 8, and 12 hours at room temperature, followed by sprouting for 12, 24, and 48 hours in a sprout maker box. These malting conditions were chosen as the standardized malting procedure for the current study because they provided the highest amount of hydration capacity and moderate yield.

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