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Influence of germination on chemical and nutritional properties of Barley flour

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Abstract

This study was proposed for effect of germination on chemical and nutritional characteristics of barley flour were investigated. Germination of barley grains was done at 25 ± 3 °C, kept for 72 hours further germinated seeds were dried at 55- 60 °C and milled to obtained flour. The germinated and non-germinated barley flour were comparatively evaluated for chemical, mineral and nutritional composition. Results obtained for protein and fiber content varied significantly was found to be 14.87%, 12.69% and 3.28%, 1.74% for germinated and non-germinated barley flour respectively. Mineral composition of germinated and non-germinated barley flour showed that calcium content was 130 and 110 mg/100g, phosphorus 500 and 320mg/100g, magnesium 180 and 160mg/100g respectively. Further the nutritional properties indicated that antioxidant activity and total flavonoids shown to increase for germinated flour. Therefore, germination can improve the nutritional value and stability of barley flour.

Keywords: Barley flour, germination, nutritional properties, chemical composition

Introduction

Germination of cereals has been used for centuries to soften the kernel structure, to increase nutrient content and availability; to decrease the content of antinutritive compounds, and to add new flavors without knowing the biochemistry behind these phenomena. Barley malting is the most widely known controlled germination process, used to produce malt for brewing purposes and food applications (Norja *et al.*, 2004) [1]. Barley is a cereal grain derived from the annual grass *Hordeum vulgare*. It has many uses; serves as a major animal fodder, as base malt for beer and certain distilled, and as a component of various health foods. It is used in soups and stews, and in barley bread of various cultures. Barley like wheat and rye contains gluten. In a 2017 ranking of cereal crops in the world, barley was fourth in terms of quantity produced around 148.03 million tons (FAOSTAT, 2017) [2] and fifth based on estimated land area harvested per year and occupies about 9.4% of the total world area under cereal production (Zhou, 2010) [3].

Nearly 85% of the current world barley production was used for feeding animals and most of the rest for malting industry. Consequently, barley was transformed into the human food supply system, indirectly (Fischbeck, 2002) [4]. The various barley (*Hordeum vulgare*) cultivars, hull-less barley has recently been receiving considerable research attention concerning the development of functional food, as it is an excellent source of both soluble and insoluble fibre. Hull-less (or 'naked') barley (*Hordeum vulgare* L. var. nudum Hook. f.) is a form of domesticated barley, in which, unlike hulled barleys but similarly to wheat (*Triticum aestivum*), the lemma and palea (hull) are nonadherent to the caryopsis. The total β -glucan content of hull-less barley is higher than that of hulled barley genotypes; whereas the insoluble dietary fibre content is lower (Xue *et al.*, 1997; Blandino *et al.*, 2015) [5, 6].

Germination, a complex process causing physical, chemical and structural changes in grains, has been identified as an inexpensive and effective technology for improving cereal quality. The germination process is characterized by the growth of the embryo of the grain, manifested by the rootlets growth and increase modification of the contents of the endosperm (de Pinho Ferreira Guine & dos Reis Correia, 2013) [7]. Germination of grain commences with the uptake of water. Once germination is initiated, the predominant endosperm reserves, starch, cell wall, and storage proteins, are mobilized by the action of hydrolytic enzymes, which are synthesized in the aleurone layer and in the scutellum and secreted into the starchy endosperm of germinating grains (Lu, Lim, & Yu, 1998; Shaik *et al.*, 2014) [8, 9]. Germinated cereal grains also show higher total phenolic content and antioxidant activity than those of un-germinated rice, wheat and oat. The germination process improves the nutritional quality of cereal. During the process of germination, significant changes in the biochemical, nutritional, and sensory characteristics of cereals occur due to degradation of reserve materials as used for respiration

and synthesis of new cell constituents for developing embryo in the seed (Danisova *et al.*, 1995; Sharma, Saxena, & Riar, 2016) ^[10, 11]. As compared to un-germinated seed, germinated seeds contain high protein, low unsaturated fatty acids, low carbohydrate, and mineral content (Narsih, 2012; Sharma, Saxena, & Riar, 2016) ^[12, 11].

In the present work, interest was centered on the amino acid metabolism associated with the mobilization of the proteins of the grain during germination. The germination of a grain or seed is a chain of events that commences when viable, dry seeds imbibe water, and terminates with the elongation of the embryonic axis. Upon imbibitions, the quiescent seed rapidly resumes metabolic activity, including respiration, enzyme and organelle activity, and RNA and protein synthesis. Enzymes are synthesized to degrade storage macromolecules. These reactions lead to structural modification and development of new compounds, many of which have high bioactivity and can increase the nutritional value and stability of grains. Furthermore, many of the developed compounds are flavor precursors participating in the formation of palatable malt flavor (Warle *et al.*, 2015) ^[13].

Materials and Methods

Barley grains were procured from Parbhani local market and were analyzed for the nutrients namely moisture, protein, fat, ash, crude fibre and minerals viz., calcium, phosphorus, iron and zinc, etc (AOAC, 2005) ^[14], total phenolic content, antioxidant activity and total flavonoids content. Carbohydrate content of samples was computed by difference method (Ranganna 1996) ^[15]. Nutrients were analyzed in duplicate and results were expressed on dry weight basis.

Preparation of sample

Germination of grain

Washed the grain with 0.7% sodium hypochlorite, soaked in distilled water at room temperature for 12 hours (1 part of grain: 4 parts of water). The water drained off and the grain transferred and spread on trays which were covered by muslin cloths. The muslin cloths allowed oxygen to enter for the germinated grain while minimizing contamination. The grain germinated at 25±3 °C, for 72 hours and grain sprayed daily with distilled water in order to maintain an adequate hydration level. The grains weighed prior to soaking, and after soaking before the germination operation. The germinated seeds were dried at 55- 60 °C; milled to obtained grain sprout flour and stored in refrigerator (Juana *et al.* 2005) ^[16].

Analytical Methods

Proximate Analysis

Different chemical properties of samples were analyzed for moisture content, ash, fat, protein and total carbohydrate. All the determinations were done in triplicate and the results were expressed as the average value.

Moisture content

Moisture content was determined adopting AOAC (2005)^[14] method as following:

$$\% \text{ Moisture content} = \frac{\text{Loss in weight}}{\text{Weight of sample}} \times 100$$

Ash

Drying the sample at 100 °C and churned over an electric heater. It was then ashes in muffle furnace at 550 °C for 5 hrs. It was calculated using the following formula:

$$\% \text{ Ash content} = \frac{\text{AW}}{\text{IW}} \times 100$$

Where, AW = Weight of Ash and IW= Initial weight of dry matter

Fat

AOAC (2005) ^[14] method using soxhlet apparatus was used to determined crude fat content of the sample. The percent of crude fat was expressed as follows:

$$\% \text{ Crude Fat} = \frac{\text{Weight of dried ether soluble material}}{\text{Weight of sample}} \times 100$$

Protein

Protein content was determined using AOAC (2005) ^[14] method. Percentage of nitrogen and protein calculated by the following equation:

$$\% \text{ Nitrogen} = \frac{\text{T}_S - \text{T}_B \times \text{Normality of acid} \times 0.014}{\text{Weight of sample}} \times 100$$

Where, Ts = Titre volume of the sample (ml), TB = Titre volume of Blank (ml), 0.014= M eq. of N₂.

% Protein = Nitrogen × 6.25

Total carbohydrate

Total carbohydrate content of the samples was determined as total carbohydrate by difference, that is by subtracting the measured protein, fat, ash and moisture from 100 phenol sulphuric acid method as given by AOAC (2005) ^[14].

Determination of minerals

Two grams of sample was weighed and heated at 550 °C. Then the ashes were dissolved with 100 ml 1M HCl. Dissolved ash was analyzed for zinc, iron, calcium, potassium, sodium and magnesium contents by using methods of AOAC (2005) ^[14].

Nutritional composition analysis

Total phenolic content (TPC)

The total phenolic content was determined according to the Folin-Ciocalteu spectrophotometric method explained by Gao *et al.* (2002) ^[17]. The results were expressed as mg of ferulic acid equivalents per gram of sample.

Antioxidant activity (AOA)

Antioxidant activity will be measured using a modified version of the method described by Williams *et al.* (1995) ^[18]. Antioxidant activity was calculated as % discoloration.

$$\% \text{ Antioxidant activity} = (1 - (\text{A of sample } t=30 / \text{A of control } t=0)) \times 100$$

Total flavonoids content (TFC)

The total flavonoids content will be determined as described by Jia, *et al.* (1998) [19]. Catechin was used as standard and results were reported as miligram catechin equivalents/g of sample.

Results and Discussion

Physical properties of Barley grain

Various physical properties of barley grain were determined, and results obtained are presented in Table 1.

Table 1: Physical Parameters of barley grain

Physical Parameters	Observation
Colour	Tan
Shape	Horseshoe
Length (mm)	9.95
Width (mm)	3.35
Thickness (mm)	2.58
Wt. of 1000 seeds (g)	42.08
True Density (kg/m ³)	940
Bulk density (g/ml)	0.62
Porosity (%)	44

*Each value represents the average of three determinations

The data given in Table 1 revealed Various Physical characteristics of barley. Colour is an important characteristic for determining the visual acceptance. The colour of barley grain was found tan whereas horseshoe in shape. Different dimensional properties like length, width and thickness was measured and found 9.95, 3.35 and 2.58 (mm) respectively. The 1000 kernel weight was reported to 42.08 (g), true density 940 (kg/ m³), bulk density 0.62 (g/ml), porosity 44 (%).

Chemical and mineral composition of non-germinated and germinated barley grain

The data pertaining the influence of the germination on various chemical and mineral composition such as moisture, fat, carbohydrates, protein, ash and crude fiber were determined, and results obtained are illustrated in Table. 2 and Table. 3

Table 2: Proximate composition of barley flour

Chemical Parameters	Mean Value*	
	Non-germinated barley	Germinated barley
Moisture (%)	11.2 ± 0.04	12.51 ± 0.03
Crude Fat (%)	2.75 ± 0.13	2.1 ± 0.10
Total carbohydrates	68.9 ± 0.70	63.79 ± 0.50
Total Protein (%)	12.69 ± 0.20	14.87 ± 0.30
Ash	1.8 ± 0.05	1.56 ± 0.02
Crude Fibre	1.74 ± 0.08	3.28 ± 0.09

*Each value represents the average of three determinations

Results given in above table. 2 indicated that the moisture content of non-germinated and germinated barley flour varied between 11.2 to 12.51% it means moisture content was increased after germination similar to the results were reported by Khatoon, and Prakash, (2006) [20]. The total protein increases after germination from 12.69 to 14.87 same result also reported by Khader, (1983) [21]. Crude fibre were intensively increased with the germination of barley from 1.74 to 3.28%. Table. 2 showed that carbohydrates content, ash and crude fat in barley before and after germination ranged from 68.9 to 63.79, 1.8 to 1.56 and 2.75 to 2.1

respectively. Moreover, Chauhan *et al.* (2015) [22] showed that there was significant difference in carbohydrate content among amaranth before and after germinated flours. The decrease in carbohydrates in germinated grains may be attributed to increase in alpha-amylase activity which breakdown complex carbohydrates into simpler and more absorbable sugars Hung *et al.* (2011) [23].

Table 3: Mineral content of barley flour

Minerals (mg/100g)	Non-germinated barley	Germinated barley
Macro elements		
Calcium (Ca)	110	130
Magnesium (Mg)	160	180
Potassium (K)	300	250
Phosphorus (P)	320	500
Micro elements		
Iron (Fe)	8.70	7.1
Magnesium (Mn)	1.54	1.49
Copper (Cu)	0.68	0.62
Zinc (Zn)	2.92	3.48

*Each value represents the average of three determinations

The mineral composition of barley were analyzed and results revealed that macro-elements such as calcium, magnesium, and phosphorus increased with germination from 110 to 130, 160 to 180 and 500 respectively while potassium reduced in germinated barley from 300 to 250 (mg/100g). The micro elements as iron, magnesium and copper reduced with germination from 8.70 to 7.1, 1.54 to 1.49 and 0.68 to 0.62 respectively. while zinc is increases from 2.92 to 3.48 (mg/100g). Results reported are in close agreement with these findings of Hubner and Arendt (2010) [24].

Nutritional composition of barley flour

Table 4: Nutritional composition of barley flour

S. No	Constituents	Non-germinated Barley flour	Germinated Barley flour
1	Total phenolic content (mg ferulic acid equivalents/g)	2.12	1.85
2	Antioxidant activity (%)	11.37%	14.36%
3	Total flavonoids content (mg catechin equivalents/g)	0.29	0.37

Results given in above table. 4 indicated that the nutritional composition viz., Total phenolic content, Antioxidant activity and Total flavonoids content of barley flour before and after germination were ranged from 2.12 to 1.85 (mg ferulic acid equivalents/g), 11.37 to 14.36% and 0.29 to 0.37 (mg catechin equivalents/g). Results reported are in close agreement with these findings of Lu *et al.* (2007) [25].

Conclusion

In the present study germination of barley was carried out under the controlled conditions of soaking, germination and heating. From the result, it can be concluded that the chemical, mineral and nutritional properties were significantly influenced by the germination process. A significant decrease crude fat, ash and carbohydrate of barley. Moreover, the minerals content, i.e Ca, Mg and P increase by the germination process. Further the nutritional properties indicated that antioxidant activity and total flavonoids shown to increase for germinated flour. Therefore, germination can improve the nutritional value and stability of barley flour.

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