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# EFFECT OF GERMINATION ON NUTRITIONAL QUALITY OF BARLEY

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## ABSTRACT

The Barley grains were germinated under controlled conditions and their soaking and germination time was finalized for best results. The ungerminated and germinated flour was evaluated for its nutritional and physicochemical properties.It was found that the germination of barley grains reduced the carbohydrate content from 72.02 to 61.06 (%), starch 59.56 to 56.32 (%), amylopectin 43.48 to 38.32 (%), ash content 1.59 to 1.39 (%), fat 7 to 5 (%), falling number 240 to 80 (%) and oil binding capacity 3.55 to 3.21 (%) respectively. The germination of grains increased the moisture content from 9.6 to 11.2 (%), total sugar 9.03 to 12.98 (%), reducing sugar 2.82 to 4.73(%), non-reducing sugar 6.21 to 8.25 (%), protein content 11.25 to 13.85 (%), amylose content 16.08 to 18.02 (%), water absorption capacity 195.6 to 236.4 (%), particle size 0.05 to 0.056 (μm) and water solubility index 16 **to** 26.8 (%) respectively. So, the present study revealed that germination significantly affects the nutritional and physicochemical properties of barley.

**Key words:** Barley, Germination, Physicochemical properties.

## 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). 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 2007 ranking of cereal crops in the world, barley was fourth both in terms of quantity produced (136 million tons) and in the area of cultivation 566,000 km² (FAOSTAT, 2009).

In the present work, interest was centered on the amino acid metabolism associated with the mobilization of the proteins of the grain during germination (Yemm and Glutamine, 1949). 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 (Bewley *et.al.,* 1994). 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.

Barley is cheaply and easily available in the market and it has high nutritional and medicinal value since it contains a large number of micronutrients. Hence, germination of seeds is one of the best methods to be utilized in the improvement of the nutritional profile of the seed grains and which will be used for the development of various food products, and as in the present scenario people is more health conscious. So, the germination of cereals is important both from nutritional as well as functional point of view. Germination not only improves the bioavailability of the various minerals, vitamins and dietary fibers along with the nutritional profile of the seed grains, but also reduces some anti nutritional factors which reflects the beauty of this method.

## MATERIAL AND METHODS

### PROCUREMENT OF RAW MATERIAL

Freshly harvested good quality raw materials of barley was procured from the local market of Sangrur, Punjab and cleaned in the unit operation laboratory by using instruments like aspirator, grader etc. and also by manual observation.

### GERMINATION OF GRAINS

Germination of barley seeds was carried out as per the method described by (Arora *et.al*., 2009).

| Samples (%) | Ungerminated Barley Flour | Germinated Barley Flour |
|---|---|---|
| **Moisture** | 9.6±0.27$^{a}$ | 11.2±0.27$^{b}$ |
| **Ash** | 1.59±0.21$^{b}$ | 1.39±0.26$^{a}$ |
| **Crude fiber** | 3.58±0.25$^{a}$ | 5.61±0.20$^{b}$ |
| **Carbohydrate** | 72.02±0.28$^{b}$ | 61.06±0.29$^{a}$ |
| **Total sugar** | 9.03±0.24$^{a}$ | 12.98±0.26$^{b}$ |
| **Reducing sugar** | 2.82±0.18$^{a}$ | 4.73±0.19$^{b}$ |
| **Non-reducing** | 6.21±0.20$^{a}$ | 8.25±0.19$^{b}$ |
| **Starch** | 59.56±0.30$^{b}$ | 56.32±0.28$^{a}$ |
| **Amylose** | 16.08±0.20$^{a}$ | 18.02±0.29$^{b}$ |
| **Amylopectin** | 43.48±0.28$^{b}$ | 38.30±0.22$^{a}$ |
| **Protein** | 11.25±0.24$^{a}$ | 13.85±0.20$^{b}$ |
| **Falling Number** | 240±0.31$^{b}$ | 80±0.29$^{a}$ |
| **Fat** | 7±0.10$^{b}$ | 5±0.11$^{a}$ |

## COMPARATIVE CHEMICAL (PROXIMATE) ANALYSIS OF GERMINATED AND UNGERMINATED BARLEY FLOUR

The chemical analysis of germinated and ungerminated seeds was carried out and the moisture content, Ash content, total carbohydrate content, reducing sugar, Starch content, Protein estimation, Amylose content, Estimation of Crude Fibre and Fat content was done as the protocol given by AOAC, 2012.

## PHYSICAL CHARACTERISTICS OF FLOURS OF GERMINATED AND UNGERMINATED GRAINS OF BARLEY

In the same way the physical characteristics were determined for germinated and ungerminated flour Barley. The Water binding capacity, Oil binding capacity was determined using the method described by Yamazaki, 1958 and the Water Solubility Index by Iwe, 1998.

## VISCOSITY OF FLOURS

The Brookfield rotational Viscometer (Model LVT2, Brookfield Engineering Lab, Stoughton, Mass, USA) has been successfully applied to analyze rheology of pastes, colloidal suspensions and solutions (Sikdar *et.al.,* 1979). Apparent viscosity ($\mu_a$) of flours of germinated and ungerminated grains of barley was determined using Brookfield Viscometer with spindle No.1 at room temperature at different rpm (6, 12, 30 and 60). Flour samples were taken about 200ml in 250ml beaker and apparent viscosity ($\mu_a$) in mPa·s was calculated by multiplying the dial reading at different rpm (6, 12, 30 and 60) of the Brookfield Viscometer with the factors (10, 5, 2, and 1), respectively, as described in the manual of LVT Brookfield viscometer.

## FALLING NUMBER

Moisture test on a barley sample selected and ground was performed. 7 g ground sample, based on a 14% moisture basis, is used for the falling number test. Distilled water added to the ground sample in a falling number test tube. The ground barley and water mixture is thoroughly shaken, forming slurry. A stirrer is placed in each falling number tube. Tubes containing slurry are immersed in the boiling water-bath of the falling number apparatus. The slurry is stirred with the stirrer for 60 Sec. Then stirrer is allowed to drop by its own weight through the ground flour of barley and water slurry. The total time in seconds it takes the stirrer to reach the bottom including the 60 seconds, stirring time is the falling number result, which reflects the sprout damage in the sample. The falling number reading is then recorded.

## RESULTS AND DISCUSSION

The chemical and physical parameters which were observed for germinated and ungerminated barley flour (Table.1).

**Table 1: Chemical composition of ungerminated and germinated flours of barley**

Values are mean of 3 determination ± S.D. a to e character show significant difference in each row (P≤ 0.05)U= ungerminated; G= Germinated

**Table 2: Physical (flour) properties ungerminated and germinated flours of Barley**

| Samples | Barley (u) | Barley (g) |
|---|---|---|
| **Particle size (µm)** | 0.05 | 0.056 |
| **WAI (%)** | 195.6 | 236.4 |
| **WSI (%)** | 16 | 26.8 |
| **OAC (%)** | 3.55 | 3.21 |
| **Viscosity (cP)** | 35 | 24 |
| **Colour (Yellow)** | 1.5 | 1.6 |
| **Colour (Red)** | 1.1 | 1.1 |
| **Colour (Blue)** | 0.6 | 0.6 |
| **Colour (TCU)** | 7 | 7.1 |

Samples in duplicate were taken and average values are reported
u= ungerminated, g=germinated

The moisture content of ungerminated and germinated flour samples of barley varied between 9.6 % to 11.2 % (wb) as shown in (Table 1) means moisture content was increased after germination similar to the results were reported by Khatoon, and Prakash, (2006) in germinated legumes. As germination proceeds, legumes took up water from the surroundings in order for the metabolic process to commence. Dry legumes absorb water rapidly, influenced by the structure of the legume. The increase in water uptake with time is due to the increasing number of cells within the seed becoming hydrated (Nonogaki *et.al.,* 2010).

Ash content of ungerminated barley flour decreased from 1.59 % to 1.39 % (wb) during germination as shown in (Table.1) Ash content was significantly decreased in germinated barley, parallel to observations of Ohtsubo, et.al., 2005, Khatoon and Prakash, 2006; Nazni et.al., (2010) and Hahm et.al. (2008). The decrease in ash content represents loss in minerals due to rootlet and washing of the barley in water to reduce the sour smell during the period of germination (Tatsadjieu *et.al.,* 2004).

The soaking, germination and heating treatments given to barley grains decreased the total carbohydrate contents 72.02 % to 61.06 % in germinated flour of barley (Table.1), due to the active respiration process during soaking and germination. On the other hand, soaking, germination and heating increased the reducing from 2.72% to 4.83%, non-reducing 6.21 % to 8.25 % and total sugars 9.03 % to 12.98 % due to activities of α-amylase and β-amylase enzymes, which increase with soaking and subsequent germination. Srivastava *et.al.,* (1988) also reported an increase in amylase activity during soaking and subsequent germination of pigeon pea.

The protein and fat content as affected by soaking, germination and heating of barley had an increasing effect on protein content 11.25 % to 13.85 %. Khader, (1983) also reported increase in protein content after germination. The fat content in the present study decreased from 7 % to 5 % after soaking, germination (96hrs) and heating. Similar results of decrease in fat content after soaking, prolonged germination and heating are reported by Khader, 1983 and Mostafa and Rahma, 1987. Similarly the results of soaking, germination and heating of soybean related to decrease in fat and an increase in protein are in agreement with those of Dogra et.al., (2001).

Crude fibre was increased in germinated barley from 3.58 % to 5.61 % (Table 1). In germinated rice, the amount of crude fibre was contributed by the presence of bran layer, an outer layer of rice that contained fibre. A study by Azizah *et.al.,* (1997) demonstrated that crude fibre was decreased in soaked peanut and mung bean, but conversely increased in soaked rice and soybean. This indicates that germination process affects the level of crude fibre during the period of soaking before the actual phase of germination.

The starch content of barley decreased from 59.56 % to 56.32 % during soaking, germination (96 hrs) and heating (Table 1). The increased α- amylase and β-amylase activities correspond with the decrease in the starch content during germination the amylolitic enzymes generated transform starch into fermentable sugar, increase in amylose content from 16.08% to 18.02% and decrease in amylopectin from 43.48 % to 38.30 % in germinated barley flour and these results are in agreement with those of Sharma et.al., (2007). Palmer *et.al.,* (1989) reported that the germination of cereal grains caused extensive changes in the structure and composition of major macromolecular components of the grains. Since gelatinization rates are related to starch composition and structure, the extent of starch modification during grain germination may influence rates of gelatinization. Therefore, the small increase in gelatinization rates for starches from the out-of-steep through to the four days germinated grains at 50°C assay temperature may suggest small improvements in starch degradability due possibly to differences in the degree of modification of starch structure and composition.

The Pertson Falling Number apparatus was designed to assess the gelatinization of starch and its subsequent hydrolysis by alpha amylase. The ability of a barley grain to convert its own starch to low molecular weight sugars increases during the germination period due to the production of α and β-amylases. While starch contributes a very high viscosity to ungerminated grain flour, the low molecular weight sugars contribute far less in germinated flour. The Pertson Falling Number apparatus measures this viscosity and assesses the ease with which starch can be converted to sugars during germination. (Table 1) shows the effect of germination on the Falling Number assessment of barley flour of germinated and ungerminated grains. No exogenous enzymes were added to these experiments so that at casting the grain was not able to convert its own starch content to sugars. Thus, during the soaking, germination and heating stage the starch was gelatinized but without endogenous amylases present, and with the endosperm almost totally unmodified, the plunger was not able to fall through the slurry. After 12 hrs soaking, 96 hrs germination and heating treatment, there was sufficient modification to the grain with sufficient enzyme activity to convert the starch, and the plunger was able to fall quite rapidly through the gelatinized starch. After 96 hrs germination coinciding with considerable modification of the endosperm and development of enzyme potential, the Falling Number was reduced to a minimum level i.e from 240 to 80. The changes associated with germination are important for improving the nutritional value of the barley grain flour, and clearly it is possible to measure these changes with the Pertson Falling Number apparatus. These results are in agreement with results obtained through the study by Best *et.al.,* (1991) .

**CHANGES IN PHYSICOCHEMICAL PROPERTIES**

The particle size of the ungerminated flours of barley was increased after germination than ungerminated grains flour (Table 2) also the WAI of ungerminated grains flour of Barley increased from 195.8 % to 236.4 %after soaking (12 hrs), germination (96 hrs) and heating.The WAI of germinated grainsincreased due increased protein content during germination since protein was increased the protein structure hold maximum water by binding water molecules in its structure. Therefore, WSI was increased after germination; these results are in agreement with the results obtained by (Cira-Chavez *et.al.,* 2009).

The WSI (water solubility index) of ungerminated flour of barley increased from 16 % to 26.8 %after soaking (12 hrs), germination(96 hrs) and heating of grains flour, with the fact that during the germination process the carbohydrate content decreased as a result of hydrolysis by the amylase enzymes. The increased in WSI with germination was significantas germination can be used to increase the amount of soluble materials, such as starch and amino acids, which can be easily digested (Pelembe *et.al.,* 2004).

OAC (Oil Absorption Capacity) of ungerminated grain flours of barley was decreased after 12 hrs soaking, 96 hrs germination and heating, from 3.55 % to 3.21 %. In faba-bean flour protein content increased, WAI increased and OAC decreased after the germination same trend was observed by Rahma, (1998). Viscosity determination of germinated flourof barley was 35 cP to 24 cP (Table 2). The decrease in the viscosity of the flour was due to the action on the starch by hydrolyzing enzymes that were produced during germination. Starch breakdown proceeds by the combined actions of α-amylase, debranching enzyme (pullulanase like enzyme), β-amylase and α-glucosidase in germinated cereal seeds (Zeeman et.al., 2007 and Sumathi *et.al.*, 1995). Reported lower viscosities in malted legumes with corresponding increased in amylase activity.

Color of flours of ungerminated and germinated grains of barley was measured by using Lovibond Tintometer indicated that TCU (total color units) of ungerminated flour increased slightly from 7 to 7.1 and yellowness increased from 1.5 to 1.6 of barley flour after 12 hrs soaking, 96 hrs germination and heating

## CONCLUSION

In the present study germination of barley was carried out under the controlled conditions of soaking, germination and heating. Finally the best results were obtained at 12hrs soaking time and 96 hrs germination time. Germinated grains were heated to stop the enzyme activities and to maintain the moisture content and finally the germinated grains were ground into two types of flour having 60 mesh size particles and 25 mesh size particles. The fine flour of 60 mesh-size was evaluated for its chemical (proximate) composition like moisture content, ash content, carbohydrate, total sugar, reducing sugar, non-reducing sugar, starch, amylose, amylopectin, protein, fat and falling number, and also physiochemical properties like colour, water absorption index, water solubility index, oil binding capacity and particle size. It was observed that chemical composition and physicochemical properties were significantly affected upon soaking (12hrs), germination (96 hrs) and heating to grains of barley.

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