EFFECT OF BARLEY β-GLUCAN ON SENSORY CHARACTERISTICS OF BREAD

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β- glucan is a fibrous polysaccharide having proven functional and medicinal properties. Increased consumption of this polysaccharide in food may prevent health related problems such as diabetes, diverticulosis, colon cancer and piles. In this study β-glucan was extracted from barley by hot water extraction technique and was incorporated into bread at various concentrations. Hot water extraction technique yielded an elevated recovery of 83.48 %. Wheat flour used for bread preparation was comprised 0.44% ash, 1.31% crude fat, 0.21%, crude fiber and 12.1% protein. External and internal characteristics of bread were evaluated through organoleptic technique. All the internal and external parameters were improved with increasing concentration of β-glucan. Storage of bread also showed its influence on volume, aroma, taste, mastication, and texture of bread. Overall, incorporation of β-glucan revealed a great prospective for the manufacturing of bread.
Keywords: Barley, β-glucan, bread, sensory characteristics, storage

INTRODUCTION

Barley is distinctive among cereal crops because of its high concentration of dietary fiber, particularly mixed linked (1→ 3) (1→ 4) - β -D glucans. This material is a valuable industrial hydrocolloid and can be extracted from the endosperm of barley grains. The β-glucan from barley (*Hordeum vulgare*) grains has been shown to have an important influence on human glycemic control. Incorporation of β-glucan directly into foods imparts neutraceutical properties to food and resulted in reduction of postprandial blood glucose (Wood and others 1990; Wood 1993). Neutraceuticals are defined as any substance that is a food or part of a food that provides medical and/or health benefits. (Defelice, 1995) Additionally barley flour enriched with β-glucan has been shown to have physiological effects comparable to other isolated fibers, such as guar gum, psyllium, and pectins (Knuckles *et al.*, 1997). Previous studies have established the positive association between intake of dietary fiber and decreased risk of several diseases such as colorectal or cardiovascular diseases cancer (Peters *et al.*, 2003). Adequate fiber intake has also been shown to improve glucose/insulin metabolism and lower plasma lipid concentrations in type 2 diabetes patients (Chandalia, 2000).

Dietary fiber can be classified in to two groups according to their solubility. These are soluble and insoluble dietary fibers. Bread is considered a good source of carbohydrates but it is a poor source of dietary fiber, containing typically less than 2.5% of dietary fiber, at the same time soluble portion of dietary fiber is also insufficient (FOB, 2003). Soluble fiber is known for its hypocholesterolemic effect and insoluble fiber is known for reduction in the risk of colon cancer. β-Glucan is accredited for reduction in the risk of colon cancer and is known to reduce the absorption of glucose in the digestive system (Pomeranz, 1988; Potty,1996). Owing to benefit effects of dietary fiber many researchers had prepared high fiber bread from various sources (Laurikainen *et al.*, 1998; Pomeranz *et al.*, 1977; Sidhu *et al.*, 1999; Wang *et al.*, 2002). FDA (Food and Drug Administration) has acknowledged the use of β-glucan in food and recommended a daily intake of 3g β-glucan for achieving the health benefits.

Apart from numerous health benefits, β-glucan also has a strong positive affect on bread properties. Knuckles *et al.*, (1997) reported that β-glucan enriched barley fraction increased water absorption in bread. Hydrocolloids work by bringing about structural changes in main components of wheat flour systems during bread making steps and bread storage (Appelqvist & Debet, 1997). This resulted in alteration in technological quality of doughs and breads (Armero & Collar, 1996, 1997). Hydrocolloids also influence bread making performance and keep ability of stored breads (Armero & Collar, 1998; Davidou *et al.*, 1996). Previous study by Urlacher and Dalbe (1992) has shown that xanthan gum, at low concentrations provides storage stability and water binding capacity to bread. Pleasantness of food is one of the key factors affecting food choice (Arvola *et al.*, 1999) and its importance dominates health issues (Glanz *et al.*, 1998, Tepper and Trail 1998). Sensory characteristics determine the use of neutraceutical products (Cardello and Schutz 2003). Consumers make no compromise between poor taste and health effects (Tuorila and Cardello, 2002).

The aim of this study was to extract β-glucan from local cultivar, and to study how various concentration of barley β-glucan affect the perceived sensory characteristics of bread. In addition, effect of storage on sensory characteristics of β-glucan containing bread was also investigated.

MATERIALS AND METHODS

Sample material and ingredients

Covered barley of cultivar Jau-87 was obtained from Ayub Agricultural Research Institute, Faisalabad. Whole barley was milled in a high-speed electric mill equipped with 0.50 mm screen. A commercial wheat flour, salt, sugar, shortening was procured from local market. Powdered yeast was purchased from a scientific store. All other chemicals, reagents and solvents used in the present study were of analytical grade and these were obtained from reputed companies.

β-glucan extraction

β-Glucan was extracted from whole barley flour by adopting hot water extraction. A schematic outline of the extraction and purification protocol is presented in Figure 1.

Chemical analysis

The chemical parameters of the flours, including moisture content, ash, crude fat and crude fiber were determined using standard methods 44-16 , 08-01, 46-10, 32-10 respectively (AACC, 2000). The nitrogen content in flour samples was determined by Kjeldahl's method as described in AACC (2000) Method No. 46-10 and a conversion factor of 5.7 was used for calculating the protein content.
Total β-glucan content in flour samples was determined by employing Megazyme assay kit (Megazyme International Ireland Ltd. Wicklow, Ireland) as outlined by McCleary and Holmes (1985). β-Glucan contents of gums were reported on moisture free basis.

Bread baking

The bread baking was carried out by straight dough method 10-10B of AACC (2000), according to the following formula given in Table 1. The ingredients were mixed for 5 minutes in a Hobart A-200 Mixer to form dough and allowed to ferment at 86 °F (30 °C) and 75% R.H. for 180 minutes. First and second punch was carried out after 120 and 150 minutes, respectively. The dough was moulded and panned into 100 g test pans, and final proofing was done for 45

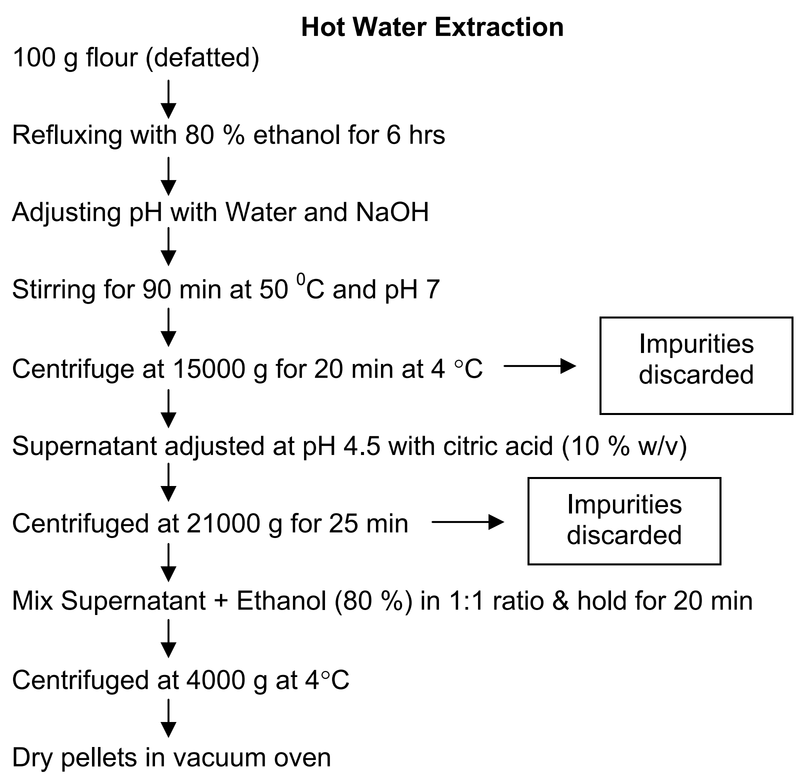

Figure 1. Extraction and purification schemes of β-glucan from barley flour

minutes at 95 °F (35 °C) with 85 % R.H. The bread was baked at 450 °F (232 °C) for 25 minutes.

Table 1. Formulation of bread

Ingredient	Bakers %
Flour	100
Yeast	001
Salt	001
Sugar	003
Shortening	005
β-glucan	0,1, 2, 3, 4 and 5
Water	According to water absorption

Sensory evaluation

Bread quality evaluation was performed by organoleptic assessment tests through hedonic score system according to the method described by Matz (1972). Panelists were selected from post graduate students, and teaching members of the Food Science and Technology Department .All the members of panel were experienced and well familiar with hedonic scale test system. They then scored different sensory attributes, such as volume, color of crust, symmetry of form, evenness of bake, character of crust and internal characteristics like grain, color of crumb, aroma, taste and texture associated with (control and treated) bread samples at regular intervals.

Statistical analysis

The data obtained for each parameter was subjected to statistical analysis to determine the level of significance and Completely Randomized Design (CRD) was applied and Duncans New Multiple Range test was used to compare the difference among different means by following the methods described by Steel *et al.* (1997).

RESULTS AND DISCUSSIONS

β-glucan extraction and composition of wheat flour

A hot water extraction procedure was used for extraction of β-glucan. The yield of gum pellet containing β-glucan was 5.253 %. This gum did not represent the whole quantity of β-glucan. In addition to β-glucan this gum also contained some fat, protein, starch and minerals (ash). Therefore, to determine the efficiency of extraction method, β-glucan recovery was determined. This recovery corresponds to the % ratio of weight of β-glucan in gum product (that was obtained from 100 g flour) to the weight of β-glucan actually present in 100 g flour and it also showed the efficiency of purification process. In this process a recovery of 83.48 % was experienced.

Regarding the composition, the wheat flour had an ash content of 0.44% , crude fat 1.31%, Crude fiber 0.21 % and the protein content was 12.1% on dry weight basis. These parameters indicated medium strong characteristics of flour and satisfied the necessary requirements for bread preparation.

External characteristics of bread

Loaf volumes of bread improve with the increase in concentration of β-glucan. Control bread samples got the least score of 4.806 while maximum score of 7.333 was achieved when β-glucan was incorporated at 5% level (Table 2). A statistically significant ($p<0.05$) effect of β-glucan incorporation and storage was observed on bread volume. As concerned with effect of storage, bread volume remained stable up to 48 hours then started declining slightly (Table 3). The increase in volume may be attributed by better gas retention and inline with earlier findings of Bell (1990) while working with hydrocolloids like HPMC and methylcellulose. The results obtained for bread volume during storage are also in agreement to the findings of Butt *et al.*, (2001) who found that volume of the bread decreased during storage.

The color of crust is important parameter and has a great bearing on acceptability of product. Treatments with high level of β-glucan fetch more uniform color of the crust. Color of crust varied from dull brown to creamy white in control and treated samples respectively. There was a significant ($p<0.05$) effect of treatments on crust color while storage did not effect crust color significantly. All samples carry higher score as compared to control, the uniform crust color may be due to interaction of β-glucan with gluten proteins which eventually take part in color forming reaction during bread baking. Pyler (1988) also reported that addition of food additives in bread resulted in improvement of crust color of breads.

Symmetry of forms is important in deciding protruding crust, uneven top, low ends and shrunken sides of the bread. There is not much variation in scores of symmetry of form among various treatments but it varied significantly ($p<0.05$) from control (Table2). Bread samples with 5% β-glucan concentration achieved highest value of 2.667 while control samples received lowest values of 2.306. As expected, symmetry of form was not significantly affected by storage intervals.

Character of crust refers to crust characteristics like thick crust, tough crust, hard crust, or brittle crust. An acceptable crust should be thick and tough. Results about effect of treatment on character of crust are presented in Table 2. Higher values for this parameter were observed in treatments with higher concentration

Table 2. Effect of various levels of β-glucan on external characteristics of bread

β-glucan Concentration (%)	Volume	Color of crust	Symmetry of form	Evenness of bake	Character of crust	Break and shred
0	4.806 d	3.972 d	2.306 b	2.500 a	2.306 b	2.556 a
1	5.111 cd	4.306 d	2.500 ab	2.500 a	2.333 b	2.556 a
2	5.361 c	4.861 c	2.500 ab	2.667 a	2.556 ab	2.639 a
3	5.889 b	5.667 b	2.639 a	2.667 a	2.639 a	2.667 a
4	6.111 b	5.994 b	2.667 a	2.639 a	2.667 a	2.833 a
5	7.333 a	6.500 a	2.667 a	2.833 a	2.667 a	2.833 a

Means carrying similar letters in a column do not differ significantly ($p<0.05$)

Table 3. Effect of storage on external characteristics of β-glucan containing bread

Storage time (Hours)	Volume	Color of crust	Symmetry of form	Evenness of bake	Character of crust	Break and shred
0	6.306 a	5.250 a	2.556 a	2.639 a	2.556 a	2.528 a
24	6.306 a	5.139 a	2.556 a	2.639 a	2.556 a	2.556 a
48	6.000 a	5.278 a	2.528 a	2.611 a	2.500 a	2.528 a
72	5.611 b	5.222 a	2.528 a	2.639 a	2.500 a	2.528 a
96	5.222 c	5.222 a	2.556 a	2.639 a	2.528 a	2.556 a
120	5.167 c	5.139 a	2.556 a	2.639 a	2.528 a	2.556 a

Means carrying similar letters in a column do not differ significantly ($p<0.05$)

of β-glucan, while control samples had lowest values. A non significant difference ($p<0.05$) was observed upon 3%, 4% and 5 % addition of β-glucan in bread formulation. Storage intervals also affected non-significantly ($p<0.05$).

The evenness of bake reflects that all sides including top and bottom are uniformly baked and it also reflects the intensity of baking whether the sides having lighter or darker shade. A non significant ($p<0.05$) affect of both treatment and storage interval was observed on evenness of bake. The results are comparable with the findings of Rehman and Mudassar (2003) who studied the effect of CMC (1%) on the shelf life of bread. Regarding the data about break and shred of the bread a statistically non significant affect of β-glucan concentration and storage interval was observed in all bread samples.

Internal characteristics of bread

While scoring the grain of bread, panelist considers the open, coarse, non-uniform, thick cell walls and holes in crumb of the bread. Increasing concentration of β-glucan affected statistically significantly ($p<0.05$) the grain of the bread. Highest value was observed (Table 4) in samples treated with 5 % β-glucan. While lowest value was found in control samples. Better grain features at higher concentration of β-glucan may be due to more water absorption and uniform gas distribution through out the dough matrix that imparts uniformity to grain of the crumb. Grain of bread was not affected significantly with storage (Table 5). The results obtained for grain in this study are in line with the results reported by Crowley *et al.,* (2000) who concluded that inclusion of additives or extension of mixing time had a significant effect on crumb and grain of wheat bread.

The values for crumb color ranges between 5.917 and 7.306 (Table 4) for various treatments. Increasing concentration of β-glucan imparts better color to crumb. A significant ($p<0.05$) effect of increasing concentration of β-glucan was observed in all samples, while storage interval (Table5) did not affect the crumb color significantly ($p<0.05$). Better color perception in higher concentration of β-glucan suggested that β-glucan did not impart its color to the crumb rather its native color was uniformly distributed in whole bread.

The value for aroma ranges between 5.278 and 6.306 (Table 3) for various treatments. Rising scores for aroma was observed as the concentration of β-glucan increased. Statistically a significant ($p<0.05$) affect was experienced in all treated samples. These results obtained are in conformity with Latif (1996) and Wilfred (1960) who observed the improvements in aroma of breads by the use of barley malt. Storage time also affected significantly ($p<0.05$) the values for aroma. A gradual decline in aroma values was observed with

Table 4. Effect of various levels of β-glucan on internal characteristics of bread

β-glucan Concentration (%)	Grain	Crumb color	Aroma	Taste	Mastication	Texture
0	5.167 e	5.917 d	5.278 c	8.417 c	6.361 b	8.556 b
1	5.500 e	6.083 d	5.694 b	9.444 b	6.583 b	9.972 a
2	6.028 d	6.361 cd	5.694 b	10.08 a	6.528 b	10.17 a
3	6.639 c	6.750 bc	5.917 b	9.944 a	6.917 a	10.28 a
4	7.167 b	7.194 ab	5.944 b	9.889 ab	7.167 a	9.778 a
5	8.000 a	7.306 a	6.306 a	10.33 a	7.222 a	10.36 a

Means carrying similar letters in a column do not differ significantly ($p<0.05$)

Table 5. Effect of storage on internal characteristics of β-glucan containing bread

Storage time (Hours)	Grain	Crumb color	Aroma	Taste	Mastication	Texture
0	6.417 a	6.611 a	6.667 a	11.25 a	7.389 a	10.81 a
24	6.389 a	6.528 a	6.333 ab	10.72 b	7.111 ab	10.47 ab
48	6.444 a	6.556 a	6.000 b	10.00 c	6.861 b	10.00 bc
72	6.417 a	6.750 a	5.639 c	9.361 d	6.806 bc	9.722 cd
96	6.417 a	6.639 a	5.278 d	8.750 e	6.500 c	9.250 de
120	6.417 a	6.528 a	4.917 e	8.028 f	6.111 d	8.861 e

Means carrying similar letters in a column do not differ significantly ($p<0.05$)

increasing storage time. The breads samples evaluated at 120 hours storage were ranked at the bottom with respect to scores assigned to aroma. This decline was ascribed by the loss of volatile aroma compounds during storage of bread.

The results in Table 4 indicated that the scores assigned to taste of bread increases significantly ($p<0.05$) with increase in β-glucan concentration. At the same time a linear decreasing relationship was found storage time and taste scores (Table 5). The score for taste decline from 11.25 in fresh samples to 8.028 at 120 hours storage. These results for taste are in conformation with results of Tarar (1999) who concluded that taste of breads was affected significantly by storage time. While scoring the Mastication or chewability of bread, panelist considered the properties like doughy, dry and toughness samples of bread. Increasing concentration of β-glucan affected statistically significantly ($p<0.05$) the mastication property of the bread. But a non significant difference was observed among 3%, 4%, and 5% level of β-glucan. Better mastication at higher concentration of β-glucan may be due to more water absorption that prevented dryness and toughness of the bread cells. Mastication was also affected significantly with storage (Table 5). The results are in conformation with earlier study of Sudha *et al.*, (2007) who found that incorporation of fiber resulted in improved chewability of product.

Texture of breads improved on increasing the levels of barley β-glucan, scores for texture increased from a value of 8.556 to a value of 10.36 in control and at 5 % level of β-glucan concentration respectively (Table 4) .A statistically significant ($p<0.05$) difference was observed for increasing concentration of β-glucan and texture scores.While a decreasing and statistically significant trend for texture was observed during storage of bread samples ($p<0.05$). Texture scores decline from a value of 10.81 in fresh condition to a value of 8.861 after 120 hours storage. Decline in texture score during storage may be due to firming of the cells of the bread along with moisture drop. Tavakolipour and Kalbasi (2006) make similar observation that texture becomes stiffer during storage of bread.

CONCLUSION

The results showed that barley β-glucan worked well in this kind of food product regarding its sensory properties. Bread sensory quality for both internal and external characteristics was positively affected with the addition of β-glucan. Concentration of β-glucan also showed its response, higher concentration of β-glucan appeared to have more pronounced affect as compared to addition of β-glucan at lower levels. Storage of bread negatively affected the volume aroma, mastication, texture and taste of bread. Results of this study indicate that β-glucan has a great potential to be used in bread industry as an alternative to commercial available gums and hydrocolloids.

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