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Extraction and Utilization of Barley β-glucan for the Preparation of Functional Beverage

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ABSTRACT

Barley contains β-glucan as a source of soluble dietary fiber. The barley flour was prepared from Pakistani barley variety (Haider-93) and analyzed for its chemical composition. The barley flour possessed 11.48% total dietary fibre and 4.87% β-glucan content. β-glucan extracted from barley flour contained 75.05% soluble dietary fiber 10.25%, insoluble dietary fiber and 85.30% total dietary fiber. The beverage was prepared by incorporating β-glucan at 0, 0.2, 0.4, 0.6, 0.8 and 1.0% levels. The L*-value of beverage increased, while b*-value decreased progressively by incorporation of barley β-glucan. The viscosity and acidity of the beverage also improved significantly with β-glucan level. Sensory evaluation revealed that the beverage containing 0.2 and 0.4% β-glucan showed similar response as that of control. Overall the incorporation of β-glucan upto 0.8% did not significantly affect sensory parameters of flavor, color and acceptability.

Key Words: Barley; β-glucan; Functional beverage; Sensory attributes

INTRODUCTION

The barley (*Hordeum vulgare* L.) accounts for 12% of the world's total cereal production and occupies fourth position with respect to grain production after wheat, rice and corn (Jadhav *et al.,* 1998). The barley grain was produced 137.47 million metric tones in the world during the crop years 2006-2007. In Pakistan barley grain yield was 98,000 tones during the years 2007-2008 (GOP, 2008). Barley is getting renewed interest as an ingredient in the production of functional foods due to its higher content of bioactive compounds. It possesses high amount of dietary fiber (DF) with high proportion of soluble viscous components, offering more suitability among cereal grains in the human diet (Bjorck *et al.,* 1990).

The barley contains substantially higher amounts of functional ingredient β-glucan. The use of β-glucan extracted from barley as human food due to its, positive role in human health has received a growing attention. The cell wall of barley and oat contains β-glucan, a non-starch polysaccharide composed of β-(1-4)-linked glucose units separated every two to three units by a single β-(1-3)–linked glucose and referred to as a mixed linkage β-glucan (Carpita, 1996). β-glucan delays glucose absorption and regulates the level of blood glucose (Wood *et al*., 1994). The viscous nature of β-glucan physically slows glucose absorption in the gut. This property of β-glucan may be useful in the formulation of food products targeting management of diabetes.

Functional foods including functional beverages are important for their role in health promotion and disease prevention. The barley grains can be used to enhance the flavor, texture, appearance and nutritional composition in a variety of functional foods, including hot cereals, cookies, crackers, breads, tortillas, granola bars, fruit-filled cereal bars, extruded snacks and pastas and development of different beverages (Arndt, 2006). Growing interest in new functional foods with special characteristics and health benefits has led to the development of new functional beverages. These beverages may enrich diet and improve human health, because of its ease of consumption along with a usual meal. Barley β-glucan assume to be well suited for such an functional application, being capable of imparting a smooth mouth feel to beverage products and providing an excellent source of soluble dietary fiber. A barley β-glucan gum with similar functional properties, could potentially serve as an alternative to traditional beverage thickeners such as alginates, pectin, xanthan and carboxymethylcellulose (Giese, 1992).

The present study was planned to extract the β-glucan from Pakistani barley variety (Haider-93) and utilize it for the development of functional beverage, keeping in view the potential of barley β-glucan against glycemic index and functional importance of beverage the research was conducted to evaluate the functional and sensoric properties of barley β-glucan from Pakistani Barley variety.

MATERIALS AND METHODS

Preparation and analysis of barley flour. Barley flour was

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prepared from Barley (cv. Haider-93) by grinding barley grains through UDY cyclone mill (mesh size 20 mm). The barley flour was analyzed for proximate composition i.e., moisture, crude fat, crude protein, ash, crude fiber and nitrogen free extract (NFE) by following methods of AACC (2000).

Extraction and purification of β-glucan. β-glucan gum was extracted from barley flour by following with the method of Wood *et al.* (1978) with some modifications. The barley flour (50 g) was suspended in 500 mL water, pH was adjusted to 10 with Na_2CO_3 (20%, v/w) and stirred vigorously for 30 min at a temperature of 45ºC. The mixture was centrifuged (Model 3K30, Sigma, Germany) at 15000 x g at 4ºC for 15 min. The supernatant was adjusted to pH 4.5 with 2M HCL and centrifuged again (20 min at 21000 x g at 4ºC) to separate precipitated protein, which was discarded. The β-glucan was precipitated by adding of an equal volume of ethanol (99.9%) to the supernatant with slow stirring. The precipitate was recovered by centrifugation at 3300 x g for 10 min allowed to settle overnight at 4ºC and dried in a vacuum drier (Model: DZF 6020 R-A-alpha M). The extracted β-glucan was stored as pellets in high density polyethylene bags at 50^{o}C for further studies.

Analysis and utilization of β-glucan. The purified β-glucan pellets were analyzed for proximate composition, total dietary fiber (TDF), soluble and insoluble dietary fiber (SDF & IDF) as described by AACC (2000). The purified β-glucan was utilized in different formulations for the preparation of functional beverages, as given in Table I.

Preparation and evaluation of β-glucan beverage. The β-glucan beverage was prepared following the formulation of Temelli *et al.* (2004) with some modifications (Table I). The functional beverage samples were then organoleptically evaluated for sensory parameters such as color, flavor, sweetness, sourness and overall acceptability by a panel of five judges. The nine point hedonic scale was employed for the evaluation of samples.

Physicochemical evaluation of β-glucan beverage. The color values of β-glucan beverage samples were measured according to method of Yu *et al.* (2003) by using the L* a* b* color space (CIELAB Space) with Color Tech-PCM (USA). The acidity of beverage samples was determined by following the method given in AOAC (2000). The viscosity of functional beverages was measured by following the procedure of AACC (2000) through Rion viscometer (Rion Tech., USA).

Statistical analysis. The data were subjected to analysis of variance (ANOVA) using CoStat-2003 software following the method as described by Steel *et al.* (1997). The Duncun Multiple Range (DMR) was used to determine the level of significance between samples.

RESULTS AND DISCUSSION

Chemical composition of barley flour. The barley flour contained 11.65%, 2.31%, 6.75%, 2.22% and 77.07% crude protein, crude fat, crude fiber, ash and nitrogen free extract (NFE), respectively (Table II), which corroborated the earlier findings for Canadian varieties by (Li *et al*., 2004). The dietary fiber of barley flour in the present study was found 4.11% soluble, 7.37% insoluble and 11.48% total dietary fiber. The β-glucan is a soluble dietary fiber component and is present in the highest amounts in the endosperm of barley.

Analysis of β-glucan. The β-glucan is found to be the most abundant component of the soluble dietary fiber in oats and barley (Bjorck *et al.,* 1990). The results of the present study indicated that β-glucan possessed 9.96%, 1.17%, 7.22%, 1.72% and 76.38% of crude protein, crude fat, crude fiber, ash and nitrogen free extract (NFE), respectively (Table III), which are in close agreement with the findings of Bhatty (1991). The fat content in the β-glucan was found higher as compared to reported by Faraj *et al.* (2006), who found 0.05% lipids in high purity β-glucan concentrate, which might be due to less impurity of β-glucan extracted in the present study. The contents of starch, SDF, IDF and TDF in the present study are also in consistent with the findings of Faraj *et al.* (2006), who found variation from 0.4- 1.43% in starch content of β-glucan in soluble dietary fiber (SDF) range from 71.81–75.75% and the in insoluble dietary fiber (IDF) content of β-glucan gum pellets in the range of (8.77-17.3%).

Physicochemical evaluation of β-glucan beverages. The color values of beverage samples presented in Table IV indicated that the L*-value (color index) of functional beverages increased significantly as the level of β-glucan increased in the formulation of different beverages. The beverage containing 1.0% β-glucan showed the highest L*-value (21.28) and followed by control beverage (without β-glucan), which got L*-value 19.69. However the beverage containing 0.8% β-glucan gave the highest a*-value (1.65) and the lowest a*-value (2.27) was given by control beverage (without β-glucan). Similarly, b*-value was significantly affected by treatments. The control beverage containing 0.2% pectin possessed the highest b*-value (10.80) followed by the beverage containing 1% β-glucan and significantly the lowest b*-value was recorded in the beverage with 0.2% β-glucan.

The present study indicated that incorporation of β-glucan resulted in improvement of beverages color as compared to the control beverage, which was prepared by the addition of 0.2% pectin without addition of β-glucan. A small amount of precipitate was visible at the bottom of the β-glucan beverage, which is due to insoluble protein and fiber components present in the β-glucan at low levels. Thus the precipitation of this material in case of β-glucan supplemented beverage might be a cause of higher L*-value for these treatments of beverage. In the present study a*-value decreased significantly by increasing the level of β-glucan in the beverages, which indicated that increased β-glucan concentration resulted in a less reddish product as compared to the control beverage.

Table I. Treatment plan for the preparation of beverages

Treatments	β-glucan (%)
0% β-glucan	0 control (0.2% pectin)
0.2% β-glucan	0.2
0.4% β-glucan	0.4
0.6% β-glucan	0.6
0.8% β-glucan	0.8
1% β-glucan	1.0

Table II. Chemical composition of barley flour

Component	(%) on dry weight basis
Crude protein	11.65±1.10
Crude fat	2.31±0.21
Crude fiber	6.75±0.59
Ash	2.22±0.19
NFE	77.07±5.50
β-glucan	4.87±0.39

Table III. Chemical Analysis of β-glucan

Component	(%)
Moisture	3.55±0.29
Crude protein	9.96±0.89
Crude fat	1.17±0.08
Crude fiber	7.22±0.55
Ash	1.72±0.14
NFE	76.38±6.99
Soluble dietary fiber	75.05±5.88
Insoluble dietary fiber	10.25±1.02
Total dietary fiber	85.30±6.79
Pentosans	2.63±0.19
Starch	1.90±0.17
β-glucan	4.87±0.39

The viscosity of beverages improved significantly due to the incorporation of β-glucan in beverages. The highest viscosity (21.75 mPa-s) was found in beverages containing 1% β-glucan followed by that containing 0.8% β-glucan (Table IV). The addition of β-glucan to water also results in the formation of a viscous hydrocolloid solution (Dawkins & Nnanna, 1995), which might be one of the reasons towards increase in the viscosity of beverages. The polysaccharide's hydroxyl groups are available to form hydrogen bonds with water, which makes the polymer water-soluble. Total acidity varied significantly as a function of treatment. The variation in acidity in the present study was due to the degradation of sucrose, high fructose corn syrup and β-glucan by the action of microorganisms, which causes production of acids in beverages (Renuka *et al.,* 2009).

Sensory evaluation of β-glucan beverages. The scores assigned to the sensoric attributes of 0.2% of β-glucan containing beverages revealed that these beverage got significantly the higher color scores (6.84) followed by the control beverage (0.2% pectin). Similar trend was observed in case of sweetness and sourness, however the scores assigned to beverage prepared by the incorporation of 0.4% β-glucan got the highest score for flavor (Table V). Contrarily the control treatment (0.2% pectin) got the top position regarding overall acceptability of beverage, followed by beverage samples prepared by incorporation of 0.2% β-glucan; with no significant differences in both treatments.

Table IV. Effect of β-glucan incorporation on organoleptic evaluation of beverage

Treatments	Acidity	Viscosity	Color Values L*	a*	b*
0% β-glucan	1.50±0.04	4.43±0.09	19.69±0.48	2.27±0.07	10.80±0.32
0.2% β-glucan	1.49±0.03	7.01±0.17	20.12±0.51	1.40±0.05	9.62±0.25
0.4% β-glucan	1.53±0.04	12.17±0.24	20.26±0.33	1.47±0.05	9.84±0.21
0.6% β-glucan	1.53±0.06	16.37±0.49	20.43±0.37	1.28±0.04	10.08±0.17
0.8% β-glucan	1.52±0.05	19.52±0.55	21.26±0.41	1.65±0.03	10.03±0.29
1% β-glucan	1.53±0.04	21.75±0.76	21.28±0.43	1.35±0.03	10.55±0.22

Means carrying same letters within a column or row do not differ significantly ($P < 0.01$)

Table V. Effect of β-glucan incorporation on organoleptic evaluation of beverage

Treatments	Color	Flavor	Sweetness	Sourness	Overall acceptability
0% β-glucan	6.63±1.08	7.29±1.13	6.74±1.18	6.43±1.09	7.26±0.81
0.2% β-glucan	6.83±1.23	7.37±0.58	6.69±0.63	6.40±1.11	7.31±0.93
0.4% β-glucan	6.57±0.93	7.54±0.53	6.17±1.17	6.37±0.66	7.00±0.86
0.6% β-glucan	6.03±0.90	6.60±1.09	5.89±0.91	6.14±0.92	6.43±0.78
0.8% β-glucan	5.00±0.92	6.00±0.91	5.11±0.44	5.51±0.88	5.37±1.21
1% β-glucan	4.94±0.73	5.86±0.66	5.03±0.71	5.11±0.72	5.37±0.73

Means carrying same letters within a column or row do not differ significantly ($P < 0.01$)

β-glucan's ability to increase viscosity upon addition to water makes it an excellent thickener for beverage applications. These characteristics are more appealing to the panelists for making decision about the overall acceptability of beverages. The results further indicated that in the beverages fortified with polysaccharides like β-glucan the quality characteristics of the beverages varies non-significantly but it was also revealed that the incorporation should be not more than 0.4% of β-glucan. The further increase in β-glucan level thickens the beverage and higher consistency not appeals the consumer regarding sensory prospective of beverage.

CONCLUSION

Incorporation of β-glucan has an effect on physicochemical characteristics and sensoric of beverage. The beverage improved regarding most of the physicochemical and sensory characteristics of the beverage. The acidity and viscosity of beverage improved linearly as the incorporation level of β-glucan increased in beverage formulation. Similarly the consumers like more viscous beverage, which was prepared by incorporation of β-glucan. However the beverages containing lesser than 0.8% β-glucan were the least acceptable by the panelists. Further research is needed to know the thermal stability of β-glucan and its behavior with other food ingredients in beverages application to make stable foods.

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