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Physicochemical and pasting properties of barley/wheat flour blends and the physical, baking and sensory characteristics of cakes

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ABSTRACT

Background: Since barley possesses various components beneficial to health, replacement of wheat flour with barley flour in bakery products could be an attractive approach. Hence, the objective of this study was to replace wheat flour with barley flour for the preparation of cakes.

Materials and methods: Test blends were obtained by incorporating barley flour into wheat flour at 20%, 30%, 40% and 50% levels of substitution and the physiochemical and pasting properties of the blended flour were studied. The study also investigated the physical, baking and sensory characteristics of the cakes.

Results: There was a slight increase in protein content from 8.4% to 9.6% and a reduction in moisture content from 13.57% to 11.27% with increasing levels of barley flour. Pasting properties showed significant differences among the samples, with a slight increase in pasting temperature and significant variations in stirring number. The baking time, symmetry index and volume index of cakes decreased with increased barley flour content, but there was no change in organoleptic properties.

Conclusion: Wheat flour can be replaced with up to 50% barley flour with little decline in the quality parameters of cakes.

Keywords
Barley
Wheat
Cakes
Sensory analysis
Texture analysis

Introduction

Barley (*Hordeum vulgare*) is a widely consumed cereal important for human nutrition [1]. Approximately 80–90% of the barley harvest is used as animal feed and to produce malt. However, barley is now receiving renewed interest as an ingredient in functional foods due to its high concentrations of bioactive compounds such as β-glucans and polyphenols [2–6]. Additionally, consumption of barley is associated with lower total and serum cholesterol, improved postprandial glucose and insulin response [7, 8], and reduced incidence of heart disease [9] and cancer [10]. Inclusion of barley flour in plain wheat bread formulations may enhance their β-glucan content and other bioactive components which may have a beneficial effect on human health. The number of new products containing barley, including breads, has increased, mainly due to the health-related bioactive components found in barley [11, 12]. The use of barley flour and bran in various food products such as baked foods, instant foods, pasta and extruded snacks, has broadened its application [13–15]. Researchers have incorporated natural components like whey protein, buckwheat, green tea powder and other ingredients into wheat flour to improve the functional and nutraceutical properties of wheat-based foods [16–18]. However, studies on the cake-making behaviour of barley–wheat flour blends are limited. Thus, the objective of this study was to determine the optimal level of barley flour in cakes enriched with the fibre and the nutraceutical components present in barley.

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Materials and methods

Commercially milled fine wheat flour (Maida) was obtained from a local market in Srinagar, Kashmir, while barley flour was obtained from M/s Ladakh Food, Kargil. Test blends were obtained by incorporating 20%, 30%, 40% and 50% barley flour into the wheat flour. Blends were sieved three times in order to achieve uniform mixing.

Proximate analysis

Protein and moisture contents were determined according to standard AACC methods [19]. The Kjeldahl method was used to estimate protein content, while moisture content was estimated using an infrared moisture analyser (Sartorius, Gottingen, Germany).

Rheological analysis

The pasting properties of the flour samples were measured with a Rapid Visco Analyser (Newport Scientific, Warriewood, Australia).

Stirring number/amylase activity

The stirring number (SN) was measured with the Rapid Visco Analyser. The SN is an indication of amylase activity and is highly correlated with the falling number. Higher SN values indicate lower amylase activity.

Baking and baking properties

Flour blends containing 0%, 20%, 30%, 40% and 50% barley flour were used to make cakes. Sugar and butter were creamed together and egg was then added. Flour sieved with baking powder was incorporated into the mixture. The batter was poured into a greased cake mould and baked at 160°C until cooked. Cakes were cooled for 30 min and then cut into two halves so that volume index, symmetry index and uniformity index could be measured using AACC methods [19] (Figure 1).

Organoleptic analysis

Ten semi-trained panellists comprising staff and students evaluated the sensory properties of the cakes. Panel members were asked to rate organoleptic parameters by assigning scores according to AACC methods [19].

Statistical analysis

Analysis of variance (ANOVA) was conducted using the commercial software package SPSS 10.1, using Duncan's multiple range tests at the 5% significance level. Results were expressed as the mean±standard deviation. All analyses were performed in triplicate.

Results and discussions

Proximate composition of flours

The proximate characteristics of flour blends were determined before baking. A significant increase in protein content from 8.4% to 9.6% was observed as the level of substitution with barley flour increased, as shown in Table 1. Vasanthan *et al* [20] reported high levels of protein content in barley, but Dhingra and Jood [21] reported the same level of protein content in soy–wheat blends as in barley–wheat flour blends. Our findings may be due to the high protein content of the barley used in the present study. A slight reduction in moisture content from 13.57% to 11.27% was observed as the level of barley flour was increased (Table 1). Yalcin and Celik [22] also reported 11.2% moisture in hull-less barley flour.

Pasting properties

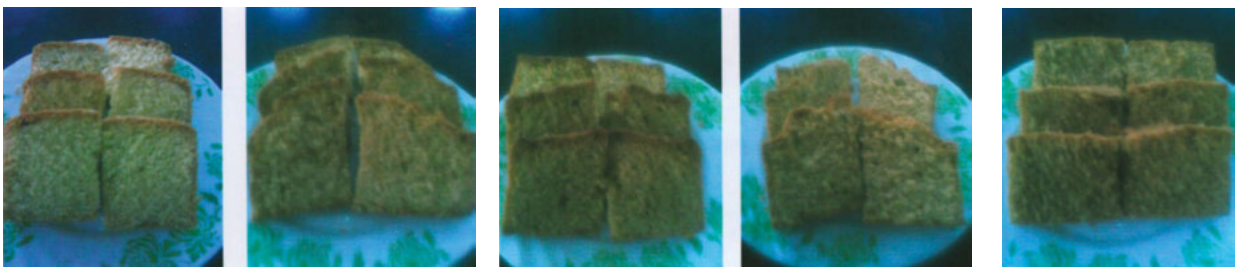
The pasting properties of the flour samples are shown in Table 2. Significant differences were observed in the pasting behaviour of wheat flour and barley–wheat flour blends during heating and cooling. The wheat flour sample had

Barley flour (%)	Protein (%)	Moisture (%)
0	8.4±0.07^{a}	14±0.01^{a}
20	8.5±0.05^{a}	13.57±0.14^{a}
30	8.7±0.03^{b}	13.24±0.04^{b}
40	9.2±0.003^{c}	12.25±0.01^{c}
50	9.6±0.02^{d}	11.27±0.02^{d}

Values with different superscript lower-case letters in the same column differ significantly ($p \leq 0.05$)

Values are the mean±SD of three independent determinations

Table 1 - Proximate composition of flour blends



(0) (20) (30) (40) (50)

Barley Flour (%)

Figure 1 - Cakes prepared from barley and wheat flour blends

Barley flour (%)	Pasting temperature	Peak viscosity	Hold past viscosity	Final viscosity	Breakdown	Setback	Stirring number
0	62.1±0.07^{a}	2760±0.06^{a}	1920±0.07^{a}	3165±0.55^{a}	840±0.05^{a}	1245±0.08^{a}	2800±0.07^{a}
20	63.4±0.05^{b}	2238±0.03^{b}	1740±0.04^{b}	2903±0.3^{b}	798±0.04^{b}	1163±0.6^{a}	2500±0.04^{b}
30	63.7±0.04^{b}	2238±0.03^{b}	1745±0.04^{b}	2758±0.2^{c}	770±0.03^{c}	1013±0.4^{b}	2400±0.03^{c}
40	63.9±0.04^{b}	2178±0.003^{d}	1440±0.004^{c}	2563±0.1^{d}	738±0.02^{d}	1143±0.3^{c}	2300±0.02^{d}
50	64.2±0.03^{c}	2110±0.002^{e}	1298±0.002^{d}	2275±0.02^{e}	812±0.04^{e}	977±0.1^{d}	2200±0.01^{e}
Values with different superscript lower-case letters in the same column differ significantly ($p\leq0.05$)							
Values are the mean±SD of three independent determinations							

Table 2 - Effect of barley flour incorporation into wheat flour on the pasting characteristics of the flour blend

Barley flour (%)	Baking time (min)	Symmetry index (cm)	Volume index (cm)
0	60±0.06^{a}	0.9±0.4	14.5±0.23^{a}
20	59±0.05^{a}	0.7±0.21^{b}	14.2±0.17^{c}
30	55±0.04^{b}	0.6±0.24^{b}	14.1±0.18^{b}
40	53±0.03^{c}	0.5±0.39^{c}	13.9±0.15^{c}
50	50±0.02^{d}	0.4±0.42^{d}	13.7±0.15^{c}
Values with different superscript lower-case letters in the same column differ significantly ($p\leq0.05$)			
Values are the mean±SD of three independent determinations			

Table 3 - Effect of barley flour incorporation into wheat flour on the baking time and physical characteristics of cakes

higher peak viscosity (2760 cP), hold viscosity (1920 cP) and final viscosity (3165 cP) than the blends containing barley flour, possibly because of differences in composition between barley and wheat flour. Differences in the protein composition of these cereals could also affect pasting properties [23, 24]. The higher breakdown viscosity of the control sample than the barley blends indicates that the heat-withstanding capacity of wheat flour is negatively affected by the addition of barley flour. Sanaa *et al* [25] also reported that barley flour has less heat stability than soft wheat flour. During cooling, re-association between starch molecules, especially amylose, results in the formation of a gel structure and therefore viscosity increases. This phase is commonly known as setback and is related to retrogradation and reordering of starch molecules. Low setback values indicate a low rate of starch retrogradation and syneresis. The lower setback values in barley flour-substituted blends than in control samples might be due to the addition of barley as it delays starch retrogradation because of its high fibre and β-glucan content that hinders association of amylose and amylopectin subunits. In general, the pasting properties of wheat flour can be manipulated by replacing wheat flour with barley flour up to a certain level as determined by the desired pasting properties and end uses.

Stirring number/amylase activity

The stirring numbers of the wheat flour and the barley–wheat blends were determined as an indirect measure of amylase activity. Significant variations in stirring number were observed (Table 2), with wheat flour having a higher stirring number (lowest amylase activity) than the barley-substituted blends. The level of amylase activity in grains influences starch viscosity and consequently pasting properties. Several factors (pH, temperature, presence of minerals) can be used to control amylase activity and the pasting properties of cereal flours.

Baking time and physical properties of cakes

The physical and organoleptic characteristics of cakes made from barley–wheat flour blends were evaluated. A change in baking time was observed with incorporation of barley flour (Table 3). The 60 min required to bake cakes containing control flour decreased significantly to 59, 55, 53 and 50 min with 20%, 30%, 40% and 50% barley substitution levels, respectively. This decrease in baking time may be attributed to the lower water-holding capacity of barley flour as dough with a higher moisture content may require more baking time. The symmetry index of the cakes decreased slightly from 0.9 to 0.4 cm as the level of substitution with barley flour increased. The volume index also showed a continuous decrease from 14.5 to 13.7 cm as the level of substitution with barley flour increased (Table 3). However, the uniformity index was not affected by the addition of barley flour, as also observed by Gupta *et al* [26].

Organoleptic characteristics of cakes

Organoleptic characteristics were evaluated to determine the acceptability of cakes prepared from blended flours. Differences were seen between cakes containing various levels of barley flour and the control sample (Table 4). Decreases in cell and grain scores were observed as the level of barley flour increased. The control sample had an average cell score of 30, which decreased to 29.3, 29, 28.2 and 28.1 with 20%, 30%, 40% and 50% substitution with barley, respectively. Similarly, the grain score decreased from

Barley flour (%)	Cells (30%)	Grain (16%)	Texture (34%)	Crumb colour (10%)	Flavour (10%)	Total (100%)
0	30	16	32	9.4	8.0	95.4
20	29.3	14.4	32.2	9.5	8.2	93.6
30	29	14.2	32.6	9.7	8.5	94
40	28.2	14	32.8	9.7	8.7	93.4
50	28.1	13.9	33	10	10	95

Table 4 - Effect of barley flour incorporation into wheat flour on the organoleptic properties of cakes

16 to 14.4, 14.2, 14 and 13.9 with 20%, 30%, 40% and 50% substitution, respectively. However, texture evaluation of cakes revealed that hardness increased with substitution level, possibly due to the grittiness imparted by barley flour. Cake crumb colour changed to a light brown colour with increasing levels of substitution and the average scores for crumb colour increased significantly. The control sample had a mean score of 9.4, which increased to 9.5, 9.7, 9.8 and 9.10 with 20%, 30%, 40% and 50% substitution, respectively. The flavour scores with 0%, 20%, 30%, 40% and 50% substitution were 8, 8.2, 8.5, 8.7 and 10, respectively. However, the total scores of cakes were not particularly affected by the addition of barley. The control sample scored 95.4, which decreased to 93.6, 94, 93.4 and 95 with 20%, 30%, 40% and 50% substitution. Nevertheless, as that decrease in one organoleptic characteristic was compensated for by increases in other properties, it is likely there would be no effect on the consumer acceptability of the cakes.

Conclusion

Barley flour in combination with wheat flour can be used to prepare cakes. This study suggested that up to 50% barley flour can be used without notable decline in cake quality. Cakes fortified with barley flour may have better functional properties than wheat flour cakes, with no changes in organoleptic properties or product cost.

Conflicts of interest

The authors declare that they have no conflicts of interest.

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