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NUTRITIONAL, SENSORY AND TEXTURAL ANALYSIS OF BISCUITS SUPPLEMENTED WITH MALTED BARLEY (*HORDEUM VULGARE*)

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ABSTRACT

With the advent of convenience foods available in the market, the nutritional value has taken a dip. Malting is a controlled germination process which activates the enzymes of the resting grain resulting in high bioavailability of nutrients. The effect of partial replacement of refined wheat flour with malted barley flour on nutritional and sensory attributes of biscuit preparation was studied. Barley was procured from local market and cleaned before malting. Barley was malted by optimizing the conditions like time and temperature and malted barley flour obtained which was further nutritionally analyzed (moisture, ash, protein, iron and calcium). Malted barley flour was incorporated in biscuits by replacing refined wheat at various incorporation levels. Levels of mixture used were 25, 30, 40, 50 and 55% with the aim of maximum incorporation possible. Biscuits prepared were evaluated for their sensory attributes and analyzed and the most accepted biscuits with malt flour incorporation were selected. The developed products were analyzed for their nutritional and textural properties. Sensory evaluation results revealed that 50% incorporation of malted barley flour was the most acceptable followed by 40% level. Ash and fiber contents gradually increased with higher incorporation levels. The protein, iron and calcium content of biscuits with 50% malted barley flour increased by 12.14, 189.3 and 12.53% respectively compared to control biscuits. Textural attributes as hardness and fracturability increased with the incorporation of malted barley flour.

Keywords: Barley, Malting, Biscuits, Texture, New product development

INTRODUCTION

About 32 per cent of the country's total food market, the food processing industry is one of the largest industries in India and is ranked fifth in terms of production, consumption, export and expected growth (http://indiainbusiness.nic.in/newdesign/index.php?param= industryservices_landing/337/1). Food industry has been striving to cater to the diverse needs of consumers which keep on changing with time. With the advent of convenience foods and people's dependency on Ready To Eat (RTE) products, nutritional value take a dip. Realizing the need, introduction of nutritional aspect in foods is on rise. It is mainly the advances in understanding the relationship between nutrition and health that resulted in the development of the concept of functional foods, which means a practical and new approach to achieve optimal health status by promoting the state of well-being and possibly reducing the risk of disease (Siro I, et, al, 2008).

Wheat *(Triticum aestivum*) is a cereal grain grown all over the world for its highly nutritious and useful gain. It is one of the top three most produced crops in the world, along with corn and rice. According to Okaka, only wheat contains substantial amount of gliadin and glutenin (special protein) which when kneaded with water give gluten, the elastic material important in yeast or aerated baked goods (Okaka, JC, 2005).

Barley (*Hordeum Vulgare*) was presumably first used as human food but evolved primarily into a feed, malting and brewing grain due in part to the rise in prominence of wheat and rice, and there is renewed interest throughout the world in barley food because of its nutritional value. β-glucans (from barley, oat, and other cereals) has also been regarded as important functional ingredients for the cereal foods industry (Brennan CS, Cleary LJ, 2005). Anti-nutritional factors however need to be addressed as grains have nutritional value which is of public importance.

Cereal grains are usually submitted to technological processes, such as fermentation and germination, in order to improve the nutritive value of the final products (Yang F, et al, 2001). Malting is a controlled germination process which activates the enzymes of the resting grain resulting in the conversion of starch to fermentable sugars, partial hydrolysis of proteins and other macromolecules (Potter NN, et al, 1995). Several studies have reported higher levels of nutrients and lower levels of anti-nutritional factors in sprouts compared to the non-germinated seeds (Honke J, et al, 1998). During germination there is a substantial increase in combined βamylase activity. Superoxide dismutase (SOD)-like activity increases significantly when compared to the raw seeds upon germination which is two-fold higher and almost three-fold higher than on the last day of germination (Zieliński H, et al, 2006). Drying process in malting, stops the germination process further and presents enzymes in active form along with high bio-accessibility of nutrients in the end product. Moreover, due to dehydration the total solids viz. sugars, proteins, minerals etc are concentrated, exerting osmotic pressure to inhibit the micro organisms (Pathirana RA, et al, 1983).

The consumption of cereal foods such as biscuit has become very popular globally. Biscuit is a small thin crispy cake made from unleavened dough. Biscuits have been suggested as a better use of composite flour than bread due to their ready to eat form, wide consumption, relatively long shelf life, and good eating quality (Okpala LC, Chinyelu VA, 2011) but at the same time being prepared with refined wheat flour limits its nutritional quality. Partial replacement with malted barley flour rich in bio-accessible nutrients (such as protein, iron, calcium etc.), dietary fiber; will increase nutrient content, diversify utilization of malted barley, and increase biscuit variety. The biscuits can be used as a vehicle for desirable and bio-available nutrients supplementation targeting not only obese/diabetic audience but also for geriatric, children and even malnourished children/individuals. Despite the inherent potential of malted barley flour, little research has been carried out to incorporate them in most food formulations apart from malt based drinks available in food industry. The aims and objectives of this research work were (1) to prepare barley malt flour and incorporate it into the biscuits up to maximum levels, (2) to analyze the sensory attributes of the biscuits prepared using malted barley flour, and (3) to study the nutritional components and texture of selected biscuits.

MATERIALS AND METHODS

MATERIALS

Refined wheat flour was obtained from Delhi Flour Mill, New Delhi and barley was obtained from Hauz Khas market, New Delhi. Barley was sieved, cleaned, washed and dried before malting. The other consumable products were obtained from Hauz Khas market, New Delhi and they were as follows-fat, sugar, coconut powder and baking powder.

PREPARATION OF MALTED BARLEY FLOUR

The process of preparation of malted barley flour was standardized according to the method described by Pathirana et al with slight modifications (Pathirana RA, et al, 1983). The cleaned barley grains were steeped in water for 18hrs at room temperature and allowed to germinate for 96 hours. They were mixed regularly and watered when appeared dry. Germinated grains were then dried in a dehydrator, rootlets removed, grinded to fine malt powder and stored in an air-tight container for further use.

STANDARDIZATION OF BISCUIT

Biscuit was prepared by partially replacing refined wheat flour (RWF) with 25, 30, 40, 50 and 55% of malted barley flour (MBF). The percent increase in replacement was done till they were acceptable without giving off flavors (Table 1). Recipe was tried and modified to mask the malt off-flavor with ajwain or carom (*Trachyspermumammi*), cocoa powder and coconut powder. The recipe with coconut powder was finally selected with due consideration from sensory panel. Recipe of the standardized biscuits was as follows- cereal mixture (100%), fat (50%), sugar (43%), coconut powder (40%), milk (20%) and baking powder (4%). Preparation was as follows- Firstly, cereal mixture and baking powder were sieved together aiding in better mixing of baking powder. Coconut powder was then added to the above mixture. Fat *(butter)* and sugar were creamed together separately and as creaming continued, flour mixture and milk was added to form dough. The biscuit dough obtained was sheeted on a metal platform to a thickness of 3 mm using wooden rolling pin. The dough was cut into circular shape using a metallic cutter and arranged on a baking sheet and baked in a pre-heated oven to 160°C until golden brown. After baking, biscuits cooled to room temperature, packed in polypropylene pouches and sealed for further analysis.

Table 1. Recipe for biscuit samples

	RWF (g)	Malted Barley flour (g)	Butter (g)	Sugar (g)	Coconut Powder (g)	Baking Powder (g)
I. (25%)	22.5	7.5	15	15	10	¼ t
II. (30%)	21	9	15	15	10	¼ t
III. (40%)	18	12	15	15	10	¼ t
IV. (50%)	15	15	15	15	10	¼ t
V. (55%)	13.5	16.5	15	15	10	¼ t

RWF- Refined Wheat Flour

NUTRITIONAL ANALYSIS

Percentages of moisture, ash and protein (Kjeldahl method) were determined according to the method described by AOAC (2002). Furthermore, percentages of iron and calcium were determined using the atomic absorption spectroscopic method (AOAC, 2002).

SENSORY EVALUATION

Selected biscuit samples coded with different numbers were presented to 30 trained panelists from Institute of Home Economics, University of Delhi, New Delhi. A five point Hedonic rating scale (1- Unsatisfactory to 5- Excellent), was used. Panelists were asked to rate each sensory attribute; appearance, color, texture, taste, aftertaste and overall acceptability.

TEXTURE ANALYSIS OF THE BISCUITS

Texture analysis of the standardized biscuits was done by using the Texture Analyzer TAXT2 with exponent software. The hardness and fracturability of the biscuits were analyzed. Biscuits in triplicate were put in the analyzer where once the trigger force was attained; the force was seen to increase until such time till the biscuit fractures and breaks into pieces. This is observed as the maximum force and can be referred to as 'hardness' of the sample. The distance at the point of break is the resistance of the sample to bend and so relates to the 'fracturability' of the sample. The results were obtained in the form of a graph, force vs time or distance (Fig 1). Once the tests were performed, the results were analyzed through MACRO (software for analysis of curve) (Bourne; MC, 1982).

STATISTICAL ANALYSIS OF DATA

The statistical analysis was conducted using the SPSS package. The sensory analysis was statistically analyzed. Analysis of variance and Tukey's HSD was used to assess significant differences between means at 5% level of probability. Each experiment (in triplicate) repeated at least twice and the values presented in terms of means ± standard deviation.

RESULTS AND DISCUSSIONS

NUTRITIONAL ANALYSIS OF RAW MATERIALS

Mean values for analysis of raw materials are tabulated in Table 2. The moisture content of refined wheat flour and malted barley flour was 10.3 and 8.2% respectively. Ash content of MBF was 2% higher than RWF of 0.48% due to least amount of fiber present in latter and hence low in mineral content as well. It can also be observed from Table 2, ash and moisture percents decreased post malting process of barley which can be attributed to the germination and dehydration of grains respectively. Protein content of RWF, barley flour and MBF was 7.71, 9.01 and 10.8% respectively. It was observed that protein content increased during malting of barley grains. As malting process activates enzymes and nutrients made more bio-available might have contributed for the same. The results are supported with studies showing that malting increases protein and decreases ash content (Traoré T, et al, 2004).

Table 2. Nutritional analysis of raw materials

Moisture (%)	10.3 ± 0.03	11.23± 0.02	8.2 ± 0.03
Ash (%)	0.48± 0.1	2.78± 0.12	2± 0.11
Protein (g/100g)	7.71± 0.03	9.01± 0.03	10.8± 0.05
Iron (mg/100g)	0.83± 0.02	3.1± 0.04	3.91± 0.04
Calcium (mg/100g)	14.1± 0.02	28.8± 0.03	33.6± 0.03

Values are means ± standard deviations (n=3)

SENSORY EVALUATION OF PRODUCED BISCUITS

Biscuits were standardized by replacing RWF with MBF at different levels and by trying with different flavors like cocoa, coconut powder and also ajwain were tried for masking off-flavor. Sugar content was varied and adjusted at each level of replacement to assess the acceptability of the biscuits with maximum incorporation possible. While standardizing, coconut powder was finally selected as a masking agent and mid evaluations suggested that incorporations could go as high as 50% replacement with MBF. Therefore, two variations i.e. 40 and 50% incorporations levels were selected for final evaluations along with control (Table 3). Biscuits having 50% replacement of RWF with MBF were found to be most acceptable in appearance, color, taste, after taste and overall acceptability by the members of panel with no significant difference when compared to control. The obtained results are in agreement with those of Sudha et al (2007) and Leelavathi and Rao (1993) that biscuits made with higher level of fiber from sources of wheat, oats and barley are more acceptable than lower levels.

Table 3. Effect of malted barley powder on sensory characteristics of biscuits

Sensory	Biscuits			Significant
	Control	With 40% BM	With 50% BM	
Appearance	3.77±0.76	3.67±0.87	3.67±0.79	0.1477
Colour	3.61±1.02	3.51±0.88	3.54±0.96	0.0818
Texture	3.77±0.88	3.32±0.70	3.51±0.85	2.3896
Taste	3.93±0.72^{a}	3.38±072^{b}	3.62±0.87^{ab}	3.8743*
After taste	3.83±0.82^{a}	3.20±0.87^{b}	3.56±1.11^{ab}	3.5058*
Overall acceptability	3.91±0.83^{a}	3.38±0.80^{b}	3.61±0.98^{ab}	3.4553*

BM= Barley malt biscuits , Values are means ± standard deviations, Means with different superscripts are significantly different as tested by Tukey'sHSD, *Significant at $p < 0.05$

Table 4. Nutritional analysis of raw materials and supplemented biscuits

Samples	Moisture (%)	Ash (%)	Protein (g/100g)	Iron (mg/100g)	Calcium (mg/100g)
Control Biscuits (RWF)	2.0 ± 0.03	1.64 ± 0.12	10.71± 0.05	0.375 ± 0.03	38.85 ± 0.02
BM Biscuits (40%)	2.5± 0.02	1.71± 0.11	12± 0.05	1.031± 0.04	42.17± 0.04
BM Biscuits (50%)	2.6± 0.03	2.08± 0.14	12.01± 0.03	1.085± 0.03	43.72± 0.03

Values are means ± standard deviations, BM- Barley Malt biscuits, RWF- Refined Wheat Flour

NUTRITIONAL ANALYSIS OF FINAL PRODUCT

As shown in Table 4, nutrient analysis of biscuits made with MBF at 50% replacement level found an increase in ash, protein (12.14%), iron (189.3%) and calcium (12.53%) when compared to control. Results of similar studies showed that noodles supplemented with malted ragi flour was rich in protein, crude fibres and minerals especially calcium, phosphorus and iron as compared to control due to addition of malted ragi flour (Sahoo AK, 2012, Desai AD, et al, 2010). Moreover, such nutrients in malted products are present in predigested and bio-accessible form and so are readily absorbed into blood stream. As also supported with studies by King et al (2007) where it was observed that supplementation of oatmeal with malted barley improves nutritional status of malnourished children, as evidenced by weight gain. Gahlawat et al (1993) also established that the effect of malting on total extractable minerals – calcium, iron, phosphorus, zinc and copper were higher and improved due to reduced content of phytic acid in barley, wheat and oat and though present in small amounts is readily absorbed in the body. Sathya et al (2002) supported the above by showing that upon germination anti-nutritional factors decrease, protein content increase and maximum content of riboflavin, ascorbic acid and thiamine were observed with greater bio-availability.

TEXTURE ANALYSIS OF THE BISCUITS

The fracture point for barley malt biscuits was higher than the control (could be due to surface characteristics) but the distance travelled was found to be longer for control than barley malt biscuits having 40 and 50% incorporation with 7.338 mm, 5.736mm and 5.526mm respectively (Table 5 and Figure 1). With the reduced amount of RWF and replacement with malt supplemented biscuits became softer and crumblier both because of texture accounting to increasing fiber content and reduced gluten content. With similar observation and supported with a study by Gallagher et al (2008) that baked products having too low gluten results in dry, sandy mouth feel. A number of studies have also shown that with the incorporation of millet, plantain and chickpea flour or other composite flours in biscuit making increases hardness as well as fracturability (Chakraborty SK , et al, 2011, Yadav RB , et al, 2012).

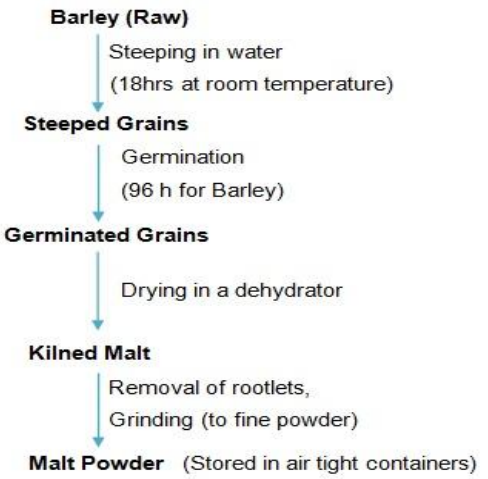

Figure 1. Preparation of barley malt powder

Table 5. Texture Analysis of biscuits

Sample	Force (g) (Hardness)	Distance (mm) (Fracturability)
Control (RWF)	3729.898 ± 4.45	7.338 ± 0.2
BM (40%)	3864.594 ± 6.95	5.736 ± 0.17
BM (50%)	3868.376 ± 2.45	5.526 ± 0.15

Values average of three determinations
BM- Barley malt biscuits
RWF- Refined Wheat Flour

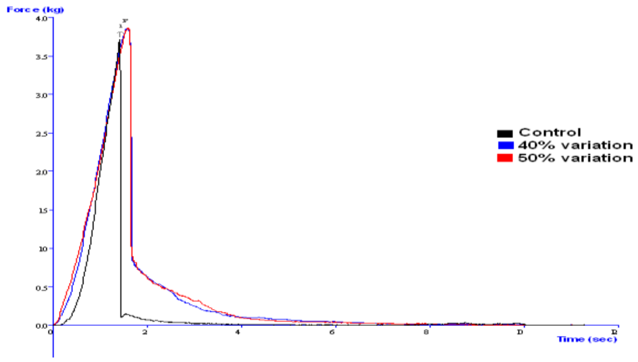

Figure 2. Comparison of peaks among the biscuit samples (an average of three determinations)

CONCLUSION

Biscuit is a common everyday snack in most households is an opportunist medium to be played upon to cater daily requirements of fiber, calcium and many more nutrients beyond the scope of this paper. Malting of barley as a process will not only allow the benefits of barley as a whole but in its easily digestible and highly bio-available form with reduced anti-nutritional factors. A standardization experiment thus carried out for preparation of malted barley biscuits with maximum incorporation as well as sensory acceptability was conducted. Biscuits preparation was standardized with 50 per cent replacement of refined wheat flour using barley malt which according to the sensory results of panel members on board was the most accepted variation. Biscuits, made with 50 per cent incorporation of barley malt also demonstrated an increase in protein, iron and calcium content when compared to control along with increased bio-accessibility and availability.

Although, the market is bombarded with the high fiber for obese/diabetic/cholesterol as targets, malted products despite fiber content limit themselves to only milk powders; a gap yet to be explored. Renewed interest in barley for food uses largely centres around the effects of β-glucans on lowering blood cholesterol levels and glycemic index. Wholegrain barley foods also appear to be associated with increased satiety and weight loss (Baik BK, Ullrich SE, 2008). This standardized recipe therefore is a step towards the further scope of experimentation and trials for a nutritious snacking option with apart from above target audience to also children, elderly, women, convalescent patients and even adults. A limitation however is drawn at the use of coconut powder which is a source of saturated fatty acids, a future study on the alternative option for increasing the acceptability of the product can help direct towards the development of a more balanced and healthy snacking option.

There is great potential to utilize barley in a large number of cereal-based food products as a substitute partially or wholly for currently used cereal grains such as wheat, oat, rice, and maize. Hence malting which is a century old technique to improve the availability of nutrient contents of food should be reconsidered for its use by food industry for providing healthy and variety of convenience foods than only currently available in market.

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