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Cookie making behavior of wheat–barley flour blends and effects on antioxidant properties

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ABSTRACT

Refined wheat flour was replaced with whole barley flour at varying levels and the blends were evaluated for their cookie making behavior. The spread factor of cookies decreased as the proportion of barley flour increased while snap force and water activity increased significantly upto 114.7 N and 0.397 in only barley flour cookies. Increasing levels of barley flour lead to a significant decrease in L^* and b^* values of cookie dough. Peak viscosity (PV) and final viscosity (FV) increased significantly as the levels of barley flour increased. A significant increase in antioxidant activity (AOA), total phenolic content (TPC), metal chelating activity (MCA), reducing power (RP) and total flavonoid content (TFC) was observed as the proportion of barley flour increased. Baking lead to a significant decrease in TPC and TFC whereas AOA, MCA and RP increased. Baking lead to a significant increase in the non-enzymatic browning index of cookies.

1. Introduction

Barley (*Hordeum vulgare* L.) is considered as a functional grain because it contains β-glucan, B-complex vitamins, tocotrienols, tocopherols and has significant antioxidant potential (Madhujith, Izydorczyk, & Shahidi, 2006; Sharma & Gujral, 2010a). It is mainly utilized in malting and brewing and as animal feed however these days it is gaining popularity as a human food in different baked and extruded foods such as cookies, chapattis, breads and extruded snacks etc. (Gill, Vasanthan, Ooarikul, & Rossnagel, 2002; Gujral & Gaur, 2002; Sharma & Gujral, 2013).

Barley has higher amount of phenolic compounds and antioxidant activity as compared to the more widely consumed cereals wheat and rice (Sharma, Gujral, & Singh, 2012). The phenolic compounds in barley include; benzoic and cinnamic acid derivatives, proanthocyanidins, quinines, flavonols, chalcones, flavones, flavanones, and amino phenolic compounds (Goupy, Hugues, Boivin, & Amiot, 1999). The risk imposed by the consumption of free radicals and oxidation products could be lowered by the intake of dietary phenolics (Gujral, Sharma, Bajaj, & Solah, 2012). The thermal processing of food may have either increasing or lowering effect on phenolic compounds and antioxidant activity (Randhir, Kwon, & Shetty, 2008).

The supply of barley bioactive compounds through baked products like cookies may be an effective way (Frost, Adhikari, & Lewis, 2011) to supply the bioactive compounds in barley. Cookies are a low specific volume product and generally require soft wheats having lower protein contents as compared to bread where gluten content is more important and has a major influence on bread volume. Replacing wheat flour with barley flour will definitely dilute the wheat gluten proteins but since high gluten content is not a requirement for cookies barley flour could be a potential raw material for cookie making having improved bioactive value. Limited studies have been reported on cookie making behavior of barley flour and effects of baking on antioxidant properties. The objectives of the present investigation were to study the physicochemical properties, color, pasting and cookie making behavior of the wheat–barley flour blends and the effects of baking on the antioxidant properties.

2. Materials and methods

2.1. Milling of hulled barley and wheat

From our previous study carried out on eight different hulled barley cultivars (Sharma, Gujral, & Rosell, 2011) we selected the barley cultivar PL-172 for cookie making because it contained higher amount of total β-glucan (5.3 ± 0.1 g/100 g flour) and is most commonly grown in North India. Barley was dehusked as described by Sharma and Gujral (2010b) and milled in a stone mill (Amar Industries, Amritsar, India) to obtain whole barley flour. Wheat

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cultivar PBW-343 was subjected to roller milling (Brabender Quadrument Junior, Germany) to obtain refined flour having an extraction rate of 72 g/100 g flour. The wheat flour was replaced with whole barley flour from PL-172 and the blends were reported as control (100 parts of wheat flour), WBF-25% (wheat–barley flour blend with 25 parts barley flour and 75 parts of wheat flour), WBF-50% (wheat–barley flour blend with 50 parts barley flour and 50 parts of wheat flour) and WBF-75% (wheat–barley flour blend with 75 parts barley flour and 25 parts of wheat flour), WBF-100% (100 parts of barley flour).

2.2. Reagents

Standard ferulic acid, 2,2-diphenyl-1-picrylhydrazyl (DPPH), ferrozine, protease (from *Streptomyces griseus*) and catechin were procured from Sigma–Aldrich (Steinheim, Germany). L-Ascorbic acid, potassium ferricyanide, ferric chloride, ferrous chloride, trichloroacetic acid, sodium carbonate and Folin–Ciocalteu's reagent were procured from Loba Chemie, Mumbai, India. All chemicals were of analytical grade. Each test was performed in triplicates on dry weight basis. The Milli Q water (Millipore, France) was used for all analytical tests.

2.3. Water absorption capacity, water solubility index and oil absorption capacity

Water absorption capacity and water solubility index of wheat–barley flour blends were measured as described by Sharma and Gujral (2010b). The oil absorption capacity was determined according to method of Lin, Humbert, and Sosulski. (1974).

2.4. Cookies preparation

The cookies were prepared by AACC method (10-50D) using the following ingredients – flour (225 g, 14% moisture basis) shortening (vegetable ghee, Dalda, India) (64 g), sugar (130 g), salt (2.1 g), sodium bicarbonate (2.5 g), distilled water (16 ml) and 33 ml of dextrose solution (5.93 g dextrose/100 ml water). The width, diameter and spread factor were calculated as described in AACC method (10-50D). The bake loss of cookies was calculated by weighing five cookies before and after baking. The difference in weight was noticed, averaged and reported as percent bake loss.

2.5. Preparation of dough and cookie sample for analysis

A portion of the cookie dough was freeze dried in a freeze dryer (Heto, Switzerland). The freeze dried dough was ground in a laboratory grinder (Sujata, India). Similarly, the cookies were also ground and resulting flour was stored at −20 °C until further analysis. The powder sample produced after grinding the cookie is hereafter reported to as cookie flour.

2.6. Water activity

Water activity of cookies was measured using a water activity meter (AquaLab, Model 3TE, Decagon Devices Inc., Pullman, WA).

2.7. Color characteristics

Color measurement of flours, flour blends, cookies surface and ground cookies was carried out using a Hunter Colorimeter fitted with optical sensor (Hunter Associates Laboratory Inc., Reston, VA, USA) on the basis of CIE L^*, a^*, b^* color system.

2.8. Pasting properties

Pasting properties of flours, flour blends and freeze dried cookie dough were studied using a Rapid Visco Analyzer (Newport Scientific Pty Ltd., Australia) using the Standard profile 1.

2.9. Texture analysis

The fracture force of cookies was determined on a Texture Analyzer (Model TA-HD_i Stable Microsystem, Surrey, UK). The cookies were placed on a bridge with a 44 mm gap between the ridges. A blunt edge knife probe having a thickness of 4 mm attached to a 50 kg load cell and traveling at a pre, post and test speed of 1.5, 10 and 1 mm s^{-1}, respectively was used. The peak force to snap the cookies was reported as fracture force in Newton.

2.10. Sensory evaluation of cookies

A semi-trained panel of 15 members comprising of staff and students from the department, evaluated the sensory properties of the cookies. A nine-point hedonic scale with 1, dislike extremely; 5, neither like nor dislike and 9, like extremely was used (Ajila, Leelavathi, & Prasada-Rao, 2008). Water was provided to rinse the mouth between evaluations.

2.11. Total phenolic content (TPC)

The total phenolic content (TPC) was determined according the Folin–Ciocalteu spectrophotometric method (Gao, Wang, Oomah, & Mazza, 2002). The results were expressed as μg of ferulic acid equivalents (FAE)/g of sample.

2.12. Antioxidant activity (DPPH radical scavenging activity)

Antioxidant activity (AOA) was measured using the method described by Brand-Williams, Cuvelier, and Berset (1995).

Antioxidant activity was calculated as percent discoloration.

$$\text{DPPH radical scavenging activity}\,(\%) = (1 - (A\,\text{of sample}\,t = 30 / A\,\text{of control}\,t = 0)) \times 100$$

where A is absorbance.

2.13. Reducing power

The reducing power was measured as described by Zhao et al. (2008). A standard curve was prepared using various concentration of ascorbic acid and results were reported as ascorbic acid equivalents (AAE)/g of sample.

2.14. Total flavonoid content (TFC)

The total flavonoid content (TFC) was determined as previously described by Jia, Tang, and Wu (1998). Catechin was used as standard and results were reported as microgram catechin equivalent (CE)/g of sample.

2.15. Metal chelating (Fe^{+2}) activity

The metal chelating activity of samples was measured as reported by Dinis, Madeira, and Almeidam (1994). The chelating activity of the extract for Fe^{+2} was calculated as follows: