Food Chemistry 240 (2018) 1154–1160

Contents lists available at ScienceDirect

Food Chemistry

journal homepage: www.elsevier.com/locate/foodchem

Influence of replacing wheat bran with barley bran on dough rheology, digestibility and retrogradation behavior of chapatti

Hardeep Singh Gujral*, Bharati Sharma, Manali Khatri

Department of Food Science and Technology, Guru Nanak Dev University, Amritsar 143005, India

ARTICLE INFO

Keywords:
β-Glucan
Starch digestibility
Starch retrogradation
Mixolab
Chapatti

ABSTRACT

Refined wheat flour and hulless barley bran (from 9 different cultivars) were blended to create nine composite flours and their functionality compared with a control wheat flour. Mixolab studies revealed that replacing wheat bran with barley bran increased dough water absorption up to 71.5% and consistency at peak during heating up to 2.11 Nm, and reduced starch retrogradation by 26.44%. The composite flours contained up to three-times more β-glucan and significantly more total phenolics including flavonoids. Chapattis prepared from the composite blends had significantly more slowly digestible and resistant starches. Incorporating barley bran lowered starch retrogradation, based on more soluble starch and soluble amylose, and the starch retrogradation index correlated positively with decreases in soluble starch and soluble amylose. Total β-glucan correlated negatively ($r = -0.846$, $p < 0.05$) with starch retrogradation index, indicating that β-glucan is associated with starch retrogradation.

1. Introduction

Chapatti is a flat bread commonly consumed in India and its neighboring countries, and a huge population is dependent on it for calories in their daily diet (Gujral & Pathak, 2002; Gujral, Singh, & Rosell, 2008). Wheat is the most preferred cereal for chapatti as it possess viscoelastic properties that enable the dough to form thin sheets. Wheat flour with a high extraction rate (80–100%) is preferred for chapatti (Gujral, 2010). Milling companies can make flours of varying extraction rates by blending different proportions of refined wheat flour with wheat bran, depending on consumer preference and marketing strategies.

The health benefits of whole-grain cereals are well recognized and promoted widely for reducing the risk of cardiovascular diseases and type 2 diabetes (Ye, Chacko, Chou, Kugizaki, & Liu, 2012). Whole-grain cereals, in addition to being primary sources of carbohydrates, also provide trace minerals, dietary fiber and bioactive compounds (Sharma & Gujral, 2010a, 2010b). Research on barley in human diet is increasing because of the health benefits associated with its dietary fiber, which reduces plasma cholesterol (Cavallero, Empilli, Brighenti, & Stanco, 2002; Hanhineva et al., 2010) and glycemic index (Brennan & Cleary, 2005). Barley also contains more phenolic compounds and antioxidant activity than the more widely consumed wheat and rice flours (Gujral, 2010; Sharma & Gujral, 2014b).

In the Indian subcontinent (India, Pakistan, Sri Lanka & Bangladesh), the majority of wheat is milled into high extraction rate flour and consumed in the form of chapatti. Therefore, chapatti made from composite blends of wheat and barley has become an efficient delivery vehicle for bioactive components of barley (Sharma & Gujral, 2014a). Hulless barley is similar to wheat grain in its morphological structure and roller milling behavior (Bhatty, 1997). However, it yields less refined flour because the bran is heavily coated with fragments of endosperm (Moza & Gujral, 2017). Bhatty (1999) reported that, during roller milling, the higher β-glucan level in barley endosperm cell wall causes the endosperm to stick to the bran fraction, which is a rich source of soluble fiber and antioxidants and hence a potential functional ingredient. Since the bran fraction of barley grain contains more bioactive constituents (Moza & Gujral, 2017), chapatti flour with a higher neutraceutical potential could be made available by blending the appropriate amount of refined wheat flour and barley bran. However, such flour will have altered dough mixing behavior, chapatti making characteristics, starch retrogradation and starch digestibility. Therefore, the purpose of this study was to understand changes in the chapatti making qualities of a wheat-based composite flour in which wheat bran has been replaced by barley bran.

* Corresponding author.
E-mail address: hsgujral7@yahoo.co.in (H.S. Gujral).

http://dx.doi.org/10.1016/j.foodchem.2017.08.042
Received 21 October 2016; Received in revised form 31 May 2017; Accepted 13 August 2017
Available online 16 August 2017

2. Materials and methods

2.1. Barley samples

Hulless barley cultivars were procured from different regions in India:Sindhu, Nurboo, SBL 8 and SBL 9 were procured from High Mountain Arid Agriculture Research Institute, Leh Ladakh (3500 m); Geetanjali from Chandra Shekhar Azad University of Agriculture & Technology, Kanpur (126 m); Dolma and HBL 276 from Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Hill Agricultural Research & Extension Centre, Bajaura (1219 m); BHS 352 was obtained from Indian Agriculture Research Institute, Shimla (2200 m); Upasana (NBD-943) from Narendra Dev University of Agriculture & Technology, Faizabad (97 m). The hulless barley grains (10 kg of each cultivar) were collected after threshing and cleaning at the farm and transported to the lab in jute bags and a corrugated fiber box. In the lab, the grains were thoroughly cleaned manually and stored at 4 °C in a refrigerator until analysis.

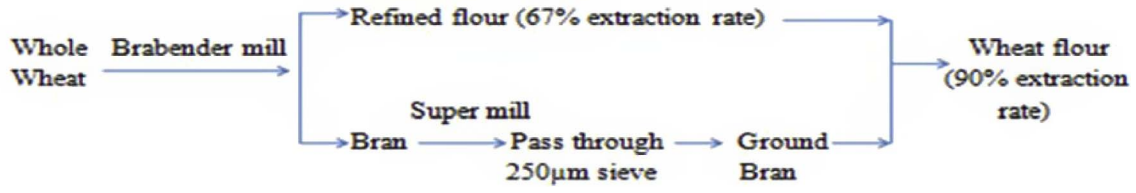
2.2. Reagents

Folin Ciocalteu's reagent, aluminium chloride, ferrous chloride and sodium nitrite were procured from LobaChemie (Mumbai, India). All the enzymes and chemicals, like ferulic acid, catechin, ferrozine and MOPS buffer, were procured from Sigma-Aldrich (Taufkirchen, Germany). A "Mixed Linkage β-Glucan kit (K-BGLU)" was obtained from Megazyme (Megazyme International Ireland Ltd., Wicklow, Ireland). Sodium acetate and sodium carbonate were procured from HiMedia Laboratories Pvt. Ltd. (Mumbai, India). All chemicals were analytical grade.

2.3. Preparation of composite flour

Wheat cultivar HD 2967 was subjected to roller milling (Brabender Quadrumat Junior, Germany) to obtain refined flour and bran. The extraction rate of the refined flour was 67%. The wheat bran was ground in a Super mill (Newport Super Mill, Australia) until all of it passed through 250 μm sieve. Refined wheat flour (670 g) was mixed with 230 g of ground wheat bran to obtain 900 g of wheat flour (90% extraction rate). Wheat flour with a 90% extraction rate is preferred for chapatti making (Gujral, 2010).

Hulless barley was subjected to milling (Moza & Gujral, 2017) in a Brabender laboratory mill (Brabender Quadrumat Junior, Germany) to obtain refined barley flour and barley bran. The barley bran obtained was further ground in a Super mill (Newport Super Mill, Australia), so that all of it passed through 250 μm sieve. Refined wheat flour (670 g) was mixed with 230 g of ground barley bran to yield a wheat-barley composite flour with a 90% extraction rate (WBC). The blends were stored in airtight polypropylene bags and kept at −20 °C for analysis.



2.4. Mixolab behavior

Mixolab 2 (Chopin Technologies, France) was used to analyze the mixing properties of the dough using the Chopin+ protocol, which examines the mixing behavior for 45 min. After an initial 8 min mixing, the dough was heated for 15 min at a rate of 4 °C/min until the temperature reached 90 °C where it was held for 7 min. The dough was then cooled to 50 °C at a rate of 4 °C/ min before being mixed at 50 °C for 5 min. The torque was measured throughout the 45-min mixing cycle. The first stage of the process gave information about the water absorption and the mixing stability of the dough; the second stage indicated protein destabilization; the third stage indicated torque at peak during heating; the fourth stage gave information about the gelling ability/amylase activity; and the fifth stage indicated starch retrogradation. The Mixolab water absorption is reported on 14% moisture basis throughout.

2.5. Chapatti making

Chapattis were prepared following the procedure of Gujral and Pathak (2002). The dough was formed by mixing flour and water (optimum water absorption from the mixolab, torque at C1 - 1.11 Nm) in a laboratory 3-pin mixer (National Manufacturing Company, USA). The dough was rested for half an hour. Dough balls (45 g) were rounded and placed on a rolling board with 1.5 mm guide rails, and spread out to 1.5 mm thickness. The dough sheet was cut with a circular die with a diameter of 140 mm, and placed on the roti maker (Surya, Arihant Industries, Delhi, India) with heating elements on both the lower and upper plates. Baking was at 300 °C for 90 s and the chapatti were turned three times until puffing occurred. The chapattis were cooled for 10 min at ambient temperature. The chapatti were weighed before and after baking to determine the amount of water lost during baking (bake loss). The change in the chapatti diameter before and after baking was also recorded and reported as shrinkage (%).

2.6. Storage of chapattis

The fresh chapatti (0 h storage) after cooling was immediately packaged in polypropylene bag and kept in a deep freezer at −18 °C until analysis. Another batch of chapatti were packaged and stored at 25 °C for 48 h.

2.7. Sensory evaluation of chapatti

A fifteen member semi-trained panel evaluated the sensory characteristics of chapatti using a 9-point Hedonic scale. The chapatti samples were coded to prevent bias. The panel scored the samples for color, appearance, aroma, pliability, texture, taste, mouth feel and overall acceptability. Higher scores were given to chapatti with golden brown color, smooth surface, greater folding ability, soft texture, pleasant mouth feel, sweetish taste and wheatish aroma.

2.8. Chapatti sample preparation for analysis

The frozen chapattis after storage (0 and 48 h) were freeze dried and ground in a Newport Super Mill (Newport, Australia) until the flour passed through 250 μm sieve. Moisture content was determined by heating the sample at 130 °C for 1 h. Chemical analysis was then carried out in triplicate on dry weight basis.

2.9. Quantification of total β-glucan content

The total β-glucan was quantified as per the method reported by