Food Chemistry 231 (2017) 156–164

Contents lists available at ScienceDirect

Food Chemistry

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

Effect of incorporating finger millet in wheat flour on mixolab behavior, chapatti quality and starch digestibility

Bharati Sharma [a], Hardeep Singh Gujral [a,*], Vicky Solah [b]

[a] Department of Food Science and Technology, Guru Nanak Dev University, Amritsar 143005, India
[b] School of Public Health, Curtin Health Innovation Research Institute, Curtin University, Perth, Western Australia, Australia

ARTICLE INFO

Article history:
Received 5 October 2016
Received in revised form 9 March 2017
Accepted 20 March 2017
Available online 23 March 2017

Keywords:
Resistant starch
Retrogradation
Damage starch
Mixolab
Phytic acid
Soluble starch

ABSTRACT

Wheat and finger millet flour (two cultivars) were blended in the ratio (3:1) to form a composite flour and its dough properties were studied on the mixolab. The chapatti making and digestibility behavior of the composite flour was also investigated. The wheat finger millet (WFM) flour blend displayed up to 30.7% higher total phenolic content (TPC), 38.2% higher total flavonoid content (TFC) and 75.4% higher antioxidant activity (AOA) than the wheat flour. Chapattis prepared from the composite blends exhibited lower retrogradation as evident by the mixolab retrogradation index, higher values of soluble starch and soluble amylose in stored chapatti. The slowly digestible starch (SDS) correlated positively ($R = 0.816$, $p < 0.05$) with TPC and water absorption correlated positively ($R = 0.995$, $p < 0.05$) with damage starch content. The chapattis made from the composite flour had higher SDS and resistant starch (RS) values demonstrating potential as a food with functional characteristics.

1. Introduction

Finger millet (*Eleusine coracana* L.) also known as Ragi, is a popular millet in India and is the principal food grain of the population living in the poorer rural areas. This minor cereal has tiny seeds that are light brown to brick red in color and has higher polyphenol content compared to cereals such as barley, rice, maize and wheat. India is the major producer and accounts for nearly 60% of the total global production of finger millet with a production of 1.92 million tons in 2011-12 (NAAS, 2013). This millet grain contains about 5–8% protein, 15–20% dietary fiber, 65–67% carbohydrates and 2.5–3.5% minerals (Chethan & Malleshi, 2007) with highest calcium content (344 mg/100 g) along with tannins (0.61%), polyphenols and trypsin inhibitory factors (Devi, Vijayabharathi, Satyabama, Malleshi, & Priyadarisini, 2014). The regular intake of millet foods is linked to health benefits such as the moderation of hypocholesterolemic, and hypoglycemic effects and antiulcerative characteristics (Shobana & Malleshi, 2007). The polyphenols of finger millet contribute to antioxidant properties and have been reported to have an antimicrobial, anti-inflammatory, antiviral, anticancer activity (Pradeep & Sreerama, 2015; Vishwanath, Urooj, & Malleshi, 2009). Finger millet is generally utilized in the form of roti or chapatti (unleavened flat bread) and other preparations such as mudde (dumpling) and ambali (thin porridge) for human consumption. Several studies have indicated the possibilities of incorporating millet in wheat flour at various proportions for producing bread, biscuit and other snacks (Gavurnikova et al., 2011; Mridula, Gupta, & Manikantan, 2007).

Carbohydrates present in finger millet are slowly digested and assimilated as result of which there is delayed absorption of glucose which ultimately controls the blood glucose levels (Chethan & Malleshi, 2007). Finger millet also contains high proportion of dietary fiber and resistant starch (RS) which is also known as a functional fiber. RS escapes enzymatic digestion and imparts various beneficial effects by preventing several intestinal disorders and also acts as a preventive mechanism for colon cancer by production of metabolites such as butyrate that stabilize colonic cell proliferation.

Due to the nutraceutical potential of this grain it is important to study how its incorporation in wheat flour will affect the rheology of the dough. Therefore in this study finger millet flour from two cultivars have been used to form composite flours with refined wheat flour and the chapatti making behavior, starch digestibility and retrogradation behavior have been reported.

2. Material and methods

2.1. Preparation of wheat finger millet (WFM) blends

Two different finger millet varieties – GPU 28 (red colored) and KMR 340 (white colored) were procured from AICSMIP, ICAR,

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

http://dx.doi.org/10.1016/j.foodchem.2017.03.118
0308-8146/

Bengaluru, India and were cleaned and stored at 4 °C in a refrigerator for further evaluation. The finger millet was subjected to mild abrasion in a rice polisher (McGill Rice Miller No. 2, Rapsco Brookshire TX, USA) to remove lightly attached hull. After dehulling, the finger millet grain was ground in Super Mill-1500 (Newport Scientific, Pty. Ltd.) till all of it passed through 250 μm sieve. Wheat cultivar HD 2967 was selected as it is the most widely grown cultivar in North West India. It was conditioned to 14% moisture content and subjected to roller milling (Brabender Quadrument Junior, Germany) to obtain refined wheat flour having an extraction rate of 67%. Refined wheat flour was blended with the ground wheat bran obtained from the Brabender mill in a proportion of 3:1 and this resulted in flour having an extraction rate of 90%. It is to be noted that wheat flour having an extraction rate of around 90% is favored for chapatti making (Gujral, 2010). Initial trials were carried out by blending refined wheat flour and finger millet flour in various proportions and chapattis were made and it was found that blends of 3:1 wheat to finger millet resulted in acceptable chapatti. The blends were prepared in triplicate and stored in airtight polypropylene bags at −20 °C for further analysis. The refined wheat flour and finger millet flour composite blend has been referred to as WFM blend throughout the manuscript.

2.2. Reagents

Catechin, Ferrozine, Ferulic acid, MOPS, Pancreatin, Pepsin, Amyloglucosidase and Porcine salivary amylase buffer were procured from Sigma Aldrich (Taufkirchen, Germany). Aluminium chloride, Ferrous chloride, Folin Ciocalteu's reagent, Sodium nitrite, and DPPH was procured from Loba Chemie (Mumbai, India). Sodium carbonate and sodium acetate were procured from HiMedia Laboratories Pvt. Ltd. (Mumbai, India). Starch Damage Kit was obtained from Megazyme, Ireland. All reagents were of analytical grade and Milli-Q water was used for all the experiments.

2.3. Mixolab behavior

The dough mixing behavior of the flour samples was studied on the Mixolab 2 (Chopin Technologies, France). The protocol Chopin+ was followed, dough weight was kept constant at 75 g and optimum water for reaching a torque of 1.11 Nm was used. After an initial mixing for 8 min at 30 °C, the dough was heated for 15 min at the rate of 4 °C/min till the temperature of dough reached 90 °C. Dough was held at 90 °C for 7 min and then cooled to 50 °C at the rate of 4 °C/min and then mixed at 50 °C for 5 min. Various parameters like water absorption, dough stability, starch gelatinization speed, retrogradation index and viscosity index were recorded.

2.4. Chapatti making

The water absorption from the mixolab was used to form a dough by mixing in a laboratory 3 pin mixer (National Manufacturing Company, Lincoln, NE). However this water absorption resulted in dough which was too stiff for easy sheeting of the chapatti. Therefore 9.36% (for wheat flour), 2.70% (for GPU 28 wheat blend) and 3.74% (for KMR 340 wheat blend) additional water from their respective mixolab water absorption needed to be added so that the dough would sheet well with a rolling pin without the cracking of the edges. Three batches of dough were prepared from each blend. The dough was rested for half an hour and then 45 g dough ball was rounded and placed on rolling board with 1.5 mm guide rails and was sheeted to 1.5 mm thickness. The dough sheet was cut with a circular die having a diameter of 140 mm. The raw chapatti was placed on the roti maker (Surya, Arihant Industries, Delhi, India) which consisted of double hot plate with heating elements on both the bottom and upper plate. Baking was done at 300 °C and the chapatti was turned for a total of three times till puffing. The chapatti was allowed to cool for 10 min at 25 °C. The chapatti weight before and after baking was recorded to determine the amount of water lost upon baking, this was reported as bake loss. The change in the chapatti diameter before and after baking was also recorded and reduction in diameter was reported as the shrinkage (%).

2.5. Storage of chapattis

The fresh chapatti (0 h) after cooling for 10 min was sealed in a polypropylene pouch further sealed in a plastic jar and then stored in a deep freezer at −18 °C till further analysis. Another batch of chapatti was stored for 24 h at 25 °C and then stored at −18 °C till further analysis.

2.6. Sensory evaluation of chapatti

A semi-trained panel of fifteen members evaluated the sensory properties of the fresh chapatti. The samples were coded with specific numbers to eliminate bias. Panelists were instructed to evaluate appearance, taste, aroma, mouth feel, texture, color and overall acceptability. A nine-point hedonic scale with 1, dislike extremely; 5, neither like nor dislike and 9, like extremely was used (Sharma & Gujral, 2014). The panelists were asked to give high score when the chapattis had golden brown color with smooth surface (appearance), greater folding ability (pliability), soft texture, pleasant mouth- feel (with little chewiness) and little sweetish taste with typical wheatish aroma.

2.7. Analysis

The stored frozen chapattis (0 and 24 h) were freeze dried and ground in a Newport Super Mill until all the sample passed through 250 μm sieve. Moisture content was determined by heating the sample at 130 °C for 1 h. All the further chemical analysis was then carried out in triplicate on dry weight basis.

2.8. Total phenolic content (TPC)

The total phenolic content was determined according the Folin-Ciocalteu spectrophotometric method (Sharma & Gujral, 2010). Samples were extracted with acidified methanol (HCl/methanol/water, 1:80:10, v/v/v) at 25 °C for 2 h and the extract was used for determination of total phenolic content. The absorbance was read at 725 nm (Shimadzu, UV-1800, Japan). The results were expressed as μg of ferulic acid equivalents per gram of sample.

2.9. Total flavanoid content (TFC)

The total flavonoid content was determined as described by Jia, Tang, and Wu (1998). Methanol (80%) was used for extraction at room temperature, centrifuged and to the supernatant sodium nitrite, aluminium chloride and NaOH were added and the absorbance was measured at 510 nm. Catechin was used as standard and the results were expressed as μg catechin equivalent per gram of flour.

2.10. Antioxidant activity (DPPH radical scavenging activity)

Antioxidant activity (AOA) was measured using the method described by Brand-Williams, Cuvelier, and Berset (1995). Flour sample was extracted with 100% methanol and the extract was used for the determination of AOA. The absorbance was read at