Journal of Cereal Science 72 (2016) 153–161

Contents lists available at ScienceDirect

Journal of Cereal Science

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

Nutritional, sensory and in-vitro antioxidant characteristics of gluten free cookies prepared from flour blends of minor millets

Seema Sharma, Dharmesh C. Saxena, Charanjit S. Riar*

Department of Food Engineering and Technology, Sant Longowal Institute of Engineering and Technology, Longowal, 148106, Sangrur, Punjab, India

ARTICLE INFO

Article history:
Received 23 August 2016
Accepted 31 October 2016

Keywords:
Minor millets
Germination
Textural characteristics
In-vitro antioxidant activity

ABSTRACT

In order to enhance sensory appeal, seed germination technique was used in the preparation of gluten free cookies from flour blends of minor millets comprising foxtail, barnyard and kodo millets. Analyses (physicochemical, total phenolic content, *in-vitro* antioxidant, pasting, textural and nutritional, colour, and sensory characteristics) were carried out for flour blends as well as cookies to evaluate the processing effects. Analyses revealed that germinated flour blends contained highest proteins, total phenolics and possessed high *in-vitro* antioxidant activity, less fat and carbohydrate contents than raw flour blend. Germination had a negative effect on pasting characteristics whereas functional properties were significantly improved of the flour blends. Cookies prepared from raw minor millets flour blends showed highest spread ratio, followed by cookies from germinated flour blends and wheat flour. Snap test values were lowest for cookies made from germinated flour blends whereas phenolic content (45.43 mg/100 g), DPPH activity (42.34%), dietary fibre (12.36 g/100 g) and nutritional value were highest followed by cookies prepared from raw minor millets and control. The sensory evaluation revealed that cookies (A_2) prepared from incorporation of germinated foxtail, barnyard and kodo millets in the proportions of 70:20:10 respectively, were most acceptable, highly nutritious and were having desirable functional properties.

1. Introduction

Millets, known as *ragi* and *mandia* in the Bastar region of Chhattisgarh (India) have high nutritional value as compared to major cereals such as wheat and rice and offers livelihood security for human beings and also feed security for diverse livestock populations in dry land regions of rural India (Pradhan et al., 2010). Millets are significantly rich in resistant starch, soluble, insoluble dietary fibers, minerals, antioxidants (phenolic acids, glycated flavonoids) and nutraceuticals. It contains about 92.5% dry matter, 2.1% ash, 2.8% crude fiber, 7.8% crude fat, 13.6% crude protein, and 63.2% starch (Ali et al., 2003).

Barnyard (*Echinochloa frumentacea*), Kodo (*Paspalum scrobiculatum*) and foxtail (*Setaria italicl*) are the important minor millets having fair amounts of protein (12%) that is highly digestible (81.13%) coupled with low carbohydrate content (58.56%) of slow digestibility (25.88%) and the fat with higher polyunsaturated fatty acids (Veena, 2003). Geervani and Eggum (1989) have reported that the dietary fibre about 13% is an important phytochemical component of minor millets containing about 35.66%, soluble and 64.34%, insoluble fractions. These are considered essential in the management of disorders like diabetes mellitus, obesity, hyperlipidemia etc. Similarly, kodo millet grain possesses a high in-vitro antioxidant capacity.

Germination or malting of cereal grains may result in some biochemical modifications and produces malt with improved nutritional and sensory quality that can be used in various traditional recipes. Apart from changing the level of nutrients, the biochemical activities, which occur during germination, can also generate bioactive components, such as ascorbic acid, tocopherols, tocotrienols and phenolics. Some of these compounds possess antioxidants properties, thus resulting in an increase in seeds antioxidant activities (Fernandez et al., 2008). Eyzaguirre et al. (2006) have reported that the *in-vitro* extractability and bio-accessibility

Abbreviations: IAOA, In-vitro antioxidant activity; GAE, Gallic acid equivalents; GT, Germination temperature; Gt, Germination time; RSM, Response Surface Methodology; RU, Rutin; ST, Soaking time; TFC, Total flavonoid content; TPC, Total phenolic content; WAI, Water absorption index; WSI, Water solubility index; BD, Bulk density; TDF, Total dietary fibre.

* Corresponding author.
E-mail address: charanjitriar@yahoo.com (C.S. Riar).

http://dx.doi.org/10.1016/j.jcs.2016.10.012
0733-5210/

of minerals such as calcium, iron and zinc increases in finger and pearl millets due to germination. Malting helps to improve the availability of nutrients, sensory attributes and extends the shelf life. Millet malts also find use as a cereal base for low dietary bulk and calorie-dense weaning food, supplementary foods, health foods and in amylase-rich foods.

Cookies represent the largest category of snack foods and are commonly consumed in most parts of the world. Dotsey (2009) has reported that urbanization has increased the consumption of processed food and bakery products leading to high cost of production as well as increase in the demand for importation of wheat. The main ingredients in the formulation of cookies include flour, sugar and fat along with desired flavouring substances. The commercially available cookies prepared from white wheat flour are considered nutritionally poor as compared to cookies prepared from whole wheat flour (Pareyt and Delcour, 2008). Incorporating soy protein, fibers etc can improve the nutritive value of bakery products. Gupta et al. (2011), have reported that by incorporating navy bean, chickpea, barley can improve the nutritive values of cookies.

The present investigation includes the formulations of gluten free cookies from the flour blends of raw and germinated foxtail, barnyard and kodo millets. This provides an insight of ingredient delivery system and methods of producing gluten-free cookies that could be sensory comparable to cookies prepared from wheat used as a control. At present, the literature regarding composite flour of raw and germinated minor millets (foxtail, barnyard and kodo millets) flour for cookies production is not available and therefore present study was conducted to explore the possibility of using germinated flour blends for the preparation of nutritional and sensory acceptable cookies. Accordingly, the developed gluten-free cookies were examined for nutritional composition, physico-chemical and sensory properties that are considered important parameters in the formulation of related food products.

2. Materials & methods

2.1. Materials

The foxtail (*Setaria italica*), barnyard (*Echinochloa frumentaceae*), and kodo (Paspalum scrobiculatum) millets were purchased from authorized seed centre located in Sangrur (Punjab), Uttarakhand University of Horticulture and Forestry, Uttarakhand (India) and Hyderabad (India) respectively. Wheat flour, shortening, sugar, skim milk powder and salt were purchased from local market (Sangrur, India) available in standard brands. All the chemicals and reagents used were of AR (analytical reagents) grade.

2.2. Germination of minor millet grains

The minor millets of foxtail, barnyard and kodo millets were washed and soaked in tap water at room temperature at variable time's intervals (12 h). Soaked seeds were germinated in a pilot scale seed germinator (Seed germinator Macro scientific works Pvt. Ltd. India) at different germination temperatures (GT) (30 °C, 33 °C, 39 °C) having germination time (Gt) of,36.45 h, 33.45 h, 35.82 h), respectively. The optimum time and temperature used for the seeds germination was the result of previous studies carried out by the authors. A relative humidity of 80–90% within the chamber was maintained by using trays containing water. The resulting bio-processed minor millets seeds were dried at 45 °C for 8 h in a cabinet drier to final moisture content of 7–8%. The seeds were immediately cooled to 25 °C, packed in air tight containers and kept at 4 °C for further analysis.

2.3. Preparation of minor millets flour (raw & germinated grains)

Dried minor millets of all the selected varieties were milled in a lab scale disc mill (Agrosa Pvt Ltd. India) to obtain minor millet flours. To get flours of uniform particle size they were passed through a 60 mesh sieve. The resulting flours were packed in air tight containers and kept at 4 °C for further analysis as well as product formulations.

2.4. Preparation of flour blends

Flour blends (100 g, each) were prepared by mixing foxtail, barnyard and kodo millets flour in the proportions of 80:15:5, 70:20:10, 60:25:15, 50:30:20, 40:35:25, 35:35:30, which were referred as A_1, A_2, A_3, A_4, A_5, and A_6 flour blended samples respectively.

2.5. Chemical analysis of flour blends

The moisture, protein (micro Kjeldhal, N × 6.25), fat (solvent extraction), ash were determined by the AOAC (1995) methods. Carbohydrate contents were determined by the difference. Total dietary fibres of samples were determined by using the method, IS-e-11062 of ISO (1984). All the analyses were performed in triplicates.

2.6. Determination of functional properties of flour blends

2.6.1. Water absorption index (WAI) and water solubility index (WSI)

WAI and WSI were determined according to the method developed for cereals of (Stojceska et al., 2008; Yagci and Gogus, 2008). The ground flour blends as above after thorough mixing, were suspended in water at room temperature for 30 min, gently stirred during this period, and then centrifuged at 3000 g for 15 min. The supernatants were decanted off into an evaporating dish of known weight. The WAI was determined as the weight of gel obtained after removal of the supernatant per unit weight of original dry solids. The WSI was measured as the weight of dry solids in the supernatant expressed as a percentage of the original weight of sample.

2.6.2. Bulk density (BD) of flour blends

Bulk densities of flour blends were determined as per the method of Wang and Kinsella (1976). Ten grams of the tested flour blends were placed in a 25 ml graduated cylinders, packed by gentle tapping of the cylinders on a bench top for ten times, from a height of 58 cm. The final volume of the test flour blends were measured and expressed in (g/ml).

2.7. Pasting properties of flour blends

Pasting properties of both raw as well as germinated millet flour blends were studied in a Rapid Visco Analyzer (RVA Tecmaster, Perten, Australia) using the standard profile-1 method.

2.8. Cookies formulation and preparation

The cookies were prepared with slight modification in the standard method (10-50D) of AACC (2000) using following ingredients:- Flour blends (100 g), sodium bicarbonate (1.0 g), salt (1.0 g), skim milk powder (20 g), shortening (50 g), sugar (40 g) and distilled water (20 ml). Shortenings and sugar were creamed using an electric mixer at medium speed for 5 min. Eggs and milk were added while mixing and the resultant mix was mixed for a period of