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Flour functionality and nutritional characteristics of different roller milled streams of foxtail millet (*Setaria italica*)

Koppalu V. Preetham Kumar [a], Usha Dharmaraj [a, *], Suresh D. Sakhare [b], Aashitosh A. Inamdar [b]

[a] Department of Grain Science and Technology, CSIR-Central Food Technological Research Institute, Mysore, 570020, India
[b] Department of Flour Milling, Baking and Confectionery Technology, CSIR-Central Food Technological Research Institute, Mysore, 570020, India

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ABSTRACT

Foxtail millet contains husk as a separate entity which needs to be dehusked before consumption. In the present study, the feasibility of preparing different fractions from foxtail millet (without dehusking) using roller mill was explored. Three endospermic fractions C1, C2, C3 and a bran rich fraction, BDR, were prepared. A straight run flour (SRF) was prepared by mixing endospermic and bran fractions. The nutritional potential and flour functionality of the fractions were evaluated. It was observed that, the fat content of endospermic fractions decreased by 42% compared to control sample but protein contents did not change significantly. BDR fraction contained 25.36 g protein, 13.12 g dietary fiber and 17.4 mg iron per 100 g but showed comparatively lower protein and carbohydrate digestibility. Significant decrease in phytic acid and polyphenols of endospermic fractions was observed which resulted in lower ferrous reducing and total antioxidant activities. However, there was no significant difference in antioxidant activity by DPPH method. The total carotenoid contents of endospermic fractions did not change significantly. C1 fraction showed highest swelling power and peak viscosity on cooking. The study indicated the feasibility of preparation of flour fractions and nutrient rich bran fraction from foxtail millet without dehusking step.

1. Introduction

Foxtail millet (*Setaria italica*) is one of the important food crops in parts of the Indian subcontinent and China and also in African countries (Singh, Latha, & Malleshi, 2004). In India, it is cultivated in Andhra Pradesh, Karnataka, Tamil Nadu and some parts of Maharashtra. Foxtail millet gains prominence because of its nutritional significance. It contains complex carbohydrates and forms a good source of dietary fiber, iron and other minerals (Hadimani & Malleshi, 1993; Usha, Sripriya, & Chandra, 1996). The millet is also a good source of polyphenols and carotenoids. Millet phenolics may serve as potential sources of natural antioxidants for inhibition of lipid peroxidation in LDL cholesterol (Bangoura, Nsor-Atindana, & Ming, 2013; Chandrasekara & Shahidi, 2012). It was reported that, the peptides from fermented foxtail millet exhibit significant antioxidant and antimicrobial activities (Amadou, Le, Amza, Sun, & Shi, 2013). The millet helps in improving insulin sensitivity and cholesterol metabolism (Choi et al., 2005) and contains sitostanol which has a unique property of lowering the level of serum cholesterol by suppressing cholesterol absorption (Narumi & Takatsuto, 1999). Foxtail millet is one of those unique grains, which develops gama amino butyric acid (GABA) during germination (Bai, Fan, Gu, Cao, & Gu, 2008) and hence can be made use in preparation of different functional foods.

In spite of all these nutritional benefits, the usage of this millet in food industry is low and is confined to traditional users only. Non availability of suitable milling machineries is one of the major constraints for the preparation of dehusked millet. Similar to paddy rice, foxtail millet contains husk as a distinct entity which is a nonedible portion of the grain and needs to be dehusked before consumption. The millet is generally dehusked in centrifugal sheller or such other rice milling machineries with suitable adjustments (Singh et al., 2004). However, the millet cannot be completely dehusked in a single run and usually in the first step, one generally ends up with a mixture of husked and dehusked grains. This necessitates the separation of husked grains from the

* Corresponding author.
E-mail address: ushasdharmaraj@gmail.com (U. Dharmaraj).

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dehusked kernels followed by recycling the husked grains to the mill again. In general practice, separation of husked and dehusked grains is not very convenient. In Indian situation, the millet after dehusking is passed through a series of cone polishers (>10 cones), wherein the remaining husked grains also gets pearled to result in a highly polished millet which is locally termed as "bhagar" (Ushakumari & Malleshi, 2007). Similar to rice, the endosperm of the foxtail millet is also covered by a bran layer which is a store house of protein, dietary fiber and other minerals. Removing bran layer completely will deprive the kernel of its nutrients. Similar to any other cereals, the distribution of the nutrients in the millet varies. This uneven distribution of nutrients in the grain provides space for preparation of different nutrient rich fractions from the millet. Generally, wheat is milled using roller mill to separate different fractions rich in endosperm, germ and bran. This technology has been successfully extended to fractionate fenugreek seeds (Sakhare et al., 2014). Hence, the possibilities of fractionating foxtail millet using roller mill without dehusking step was explored. This method contains two advantages; 1) preparation of flour from the millet, bypassing the dehusking step, and 2) preparation of different fractions rich in specific nutrients which can be potentially used in different designer foods. Generally, grains which do not possess husk, can conveniently be fractionated in roller mill. However, fractionating grains which contain husk as a nonedible component, poses a challenge to millers because, husk, being fragile in nature, can get easily admixtured with other fractions, thereby affecting the nutritional quality. The details on optimization of roller milling process to prepare different fractions from foxtail millet with minimum or no husk contamination are being published elsewhere by the same group of authors. In this study, foxtail millet milled at the optimum milling conditions was evaluated for its quality characteristics. Hence, the main objectives of this study were to prepare different bio-component rich fractions from foxtail millet and to evaluate the flour functionality of the different streams.

2. Materials and methods

2.1. Material

Foxtail millet (PS4) procured from Krishi Vigyan Kendra, Hanumanamatti, Karnataka, was cleaned to remove impurities like, chaff, stones etc. The cleaned millet was stored in the plastic containers and used for the studies. The initial moisture content of the sample was 12 ± 1 g/100 g. Preliminary studies have indicated that, tempering the millet to raise its moisture content up to 16% prior to milling is highly desirable. Hence, 5 kg of the millet was tempered with additional water to raise its moisture content to 16 g/100 g in an air tight container and rested for 24 h before milling. The tempered foxtail millet was milled in a laboratory roller mill MLU 202 (Buhler, Switzerland). The Buhler laboratory-scale mill used for the experiment consisted of three corrugated break rolls (B1 − B3) and three smooth reduction rolls (C1 − C3). The break rolls were adjusted to separate the husk from endosperm with little damage to husk. The separated endosperm was milled on the reduction rolls to produce flour. The scalping of the last reduction roll (C3) was treated in the laboratory bran duster for dusting to remove any adhered flour particles. The 'throughs' of the bran duster were mechanically sieved by Buhler lab sifter using 150 μ sieve to recover the flour as a bran duster flour (BDR, admixture of more bran and less endosperm). Break rolls produced small quantity of dull colored flour which was mixed with the BDR fraction. The flour streams from the C1, C2 and C3 (endosperm rich fractions; EDR) were collected from the reduction passages. Among the fractions obtained from reduction passage, C1 comes from the center part of the endosperm and C3 is from outer part of the endosperm. Husk was obtained in two forms; coarse fraction from break rolls and fine (pollard) fraction from bran duster overtails. Finally, C1, C2, C3 and BDR flour streams were collected along with straight run flour (SRF, obtained by mixing of C1, C2, C3 and BDR streams) and used for the study. The dehusked foxtail millet grains pulverized to 250μ size was served as control sample.

2.2. Nutrient composition

Moisture, fat, protein and ash contents of foxtail millet fractions were determined according to AACC (2000) methods and the soluble, insoluble and total dietary fiber contents were estimated by the method of Asp, Johansson, Hallmer, and Siljestrom (1983). The ash contents were dissolved in dilute HCl and the solutions were used for estimation of iron and zinc by atomic absorption spectroscopy. The total and soluble amylose contents of the samples were determined according to Sowbhagya and Bhattacharya (1971). The polyphenol contents were determined as per the procedure of Singleton, Orthofer, and Rosa (1995). The phytic acid content was determined using Megazyme kit (K-PHYT 05/07, Megazyme, Ireland).

2.3. Carbohydrate digestibility

The carbohydrate digestibility of defatted fractions was estimated according to Mouliswar, Kurien, Daniel, Malleshi, and Rao (1993). One hundred milligrams of the defatted sample was cooked in boiling water bath for 15 min with 15 ml of water and 0.1 ml Termamyl. To the solution, 15 ml of 0.2 M Glycine - HCl buffer of pH 2 with 15 mg pepsin was added and incubated at 37 °C for 2 h. The pH of the solution was adjusted to 6.8 with 0.2 M NaOH. To that, 15 ml of 0.05 M phosphate buffer containing 15 mg of pancreatin was added and incubated at 37 °C for 2 h. The pH of the solution was adjusted to 4.8 using 0.1 M HCl followed by the addition of 15 ml acetate buffer (0.05 M) containing 15 mg amyloglucosidase and incubated at 55 °C for 2 h. The final volume of the solution was made up to 100 ml with water. The reducing sugars were estimated by dinitro salicylic acid method.

2.4. Protein digestibility

The protein digestibility of defatted samples was estimated according to Mouliswar et al. (1993). About 100 mg protein equivalent defatted sample was incubated with 50 ml of 0.1 M HCl containing12.5 mg of pepsin for 3 h. The pH of the solution was adjusted to 8 by 0.5 N NaOH, followed by the addition of 0.05 M phosphate buffer containing 6 mg pancreatin and incubated at 37 °C for 24 h. Final volume of the solution was made up to 100 ml with water and centrifuged at 4760×*g* for 15 min. The protein content of the digested sample was estimated by Lowry's method (Schacterle & Pollack, 1973).

2.5. Total starch

The total starch contents of the samples were estimated following the enzymatic digestion method (Holm, Bjorck, Drews, & Asp, 1986). Defatted millet samples (100 mg) were cooked in boiling water bath for 15 min with 10 ml of water and termamyl solution. To the contents, 15 ml of 0.05 M phosphate buffer containing amyloglucosidase was added and incubated at 60 °C for 16 h. The volume of the solution was made up to 100 ml, filtered and the total starch content was estimated by dinitro salicylic acid method. Glucose was used as a standard for calculating the starch content.