LWT - Food Science and Technology 59 (2014) 889–895

Contents lists available at ScienceDirect

LWT - Food Science and Technology

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

Nutrients and antinutrients in foxtail and proso millet milled fractions: Evaluation of their flour functionality

Rajesh Devisetti, Sreerama N. Yadahally, Sila Bhattacharya*

Grain Science & Technology Department, CSIR-Central Food Technological Research Institute, K.R.S. Road, Mysore 570020, India

ARTICLE INFO

Article history:
Received 28 January 2014
Received in revised form
29 June 2014
Accepted 3 July 2014
Available online 22 July 2014

Keywords:
Proso millet
Foxtail millet
Functional properties
Antinutrient
Milling

ABSTRACT

Two varieties of foxtail and one variety of proso millet were milled to obtain brown and polished grains. The flours from these milled fractions along with whole grain flour were evaluated for nutrient composition, antinutritional factors and flour functionality. A considerable variation in the content of nutrients and antinutrients was found among the milling fractions. The protein content (9.9–14.8 g/100 g) varied significantly ($p \leq 0.05$) among the milled fractions of millets and was higher in brown grains for all the millet varieties ($p \leq 0.05$). Whole grains of both the millets showed significantly higher ash contents ($p \leq 0.05$). The total dietary fibre was significantly higher ($p \leq 0.05$) in whole grain flours than in brown and polished grain flours. Soluble dietary fibre was significantly higher ($p \leq 0.05$) in brown grain flours (1.2–1.5 g/100 g) and lower in polished grain flours (0.7–1.1 g/100 g). Phenolic compounds and phytic acid were present in significantly higher ($p \leq 0.05$) amounts in whole grains and brown grains. The nitrogen solubility of millet flours was in the range of 2.9–16.4 mg/g and 4.7–16.9 mg/g in water and 0.5 M NaCl, respectively. The brown grain flours also had the highest water and oil absorption capacity, emulsion activity and stability, and foaming capacity. Depending on technological or nutritional demands, appropriate milled fractions may be chosen based on these results to achieve the desired product.

1. Introduction

Millets are a type of cereal commonly grown in most Asian and African countries and parts of Europe and consumed as a staple food among the majority of people of arid and semiarid tropics of the world. Foxtail (*Setaria italica*) and proso millets (*Panicum miliaceum*) are the oldest cultivated millet crops and are often cultivated in harsh conditions as an alternative to maize because of their better adaptability to arid and barren lands than most other crops (Panaud, 2006). They are superior to rice and wheat, and therefore provide protein, mineral, and vitamins to the poor where the need for such nutrients is in high demand (Taylor & Emmanbux, 2008). In addition to the nutritional benefits, millets including foxtail and proso millets possess certain phytochemicals with antinutrient effects (Saleh, Zhang, Chen, & Shen, 2013) which may hinder efficient utilization, absorption, or digestion of nutrients, and thus reduce their nutrient bioavailability and nutritional quality (Lestienne, Buisson, Lullien-Pellerin, Picq, & Trèche, 2007). Antinutrients are unevenly distributed in the grain. Depending on their localization, the proportions of these antinutrients in the diet can be reduced by dehulling and further processing (Akingbala, Oguntimein, & Abass, 1991; Sharma & Kapoor, 1996). Although millets are nutritionally superior; the nonavailability of refined and processed millets in ready-to-use form has limited their wider use and acceptability.

Millet grains contain greater proportions of husk and bran, requiring dehusking and debranning prior to consumption. Dehusking of pearl and little millets in centrifugal sheller followed by debranning in huller yields the grain of satisfactory quality (Hadimani & Malleshi, 1993). Good quality of proso millet flour was obtained by dehulling in barley pearler and dehulled grain in Quadrumat Jr. mill (Lorenz, Dilsaver, & Bates, 1980). Abdelrahman, Hoseney, and Varriano-Marston (1983) produced low fat pearl millet grits by using roller mill. Optimum degree of polishing, best milling yield and less brokens were obtained by dehulling barnyard millet in a Satake grain polisher (Lohani, Pandey, & Shahi, 2012).

The use of grain flours in food formulations is dependent on flour functionality. The water absorption capacity plays an important role in the development of food products because it influences to a large extent their interaction with water. The protein/nitrogen solubility provides useful information on effective utilization

* Corresponding author. Tel.: +91 0821 2510843; fax: +91 0821 2517233.
E-mail address: silabhat@gmail.com (S. Bhattacharya).

http://dx.doi.org/10.1016/j.lwt.2014.07.003
0023-6438/

of millet flours in various food products. The ability of the starch to readily form a gel when heated is a desirable quality in the food industries, particularly in food products like jams. Processing may increase the bioavailability of nutrients and bioactive compounds in millet grains; however processing may also decrease their levels.

Therefore, the purpose of this study was to evaluate the nutritional and functional properties of flours from milled fractions of millets to explore the possibility of using them as ingredients for food processing. This is expected to give insight on the influence of milling on physicochemical and functional properties of millet flours and their quality.

2. Materials and methods

2.1. Materials

Two certified varieties of foxtail millet (PS-4, SIA-3126 variety) and one variety of proso millet (TNAU-145) were procured from Agricultural Research Station Mysore, India. These grains were dehusked in a centrifugal sheller, debranned in a cone polisher to obtain the different milled fractions i.e. dehusked or brown grains and polished grains. The yield of the brown and the polished grains (8% polish) were determined; the whole grains, brown grains and the polished grains for each of the millet varieties were then ground to a fine flour to pass through 250 μm B.S.S sieve employing a laboratory model pulverizer. The grinding operation was conducted below 40 °C. The flours obtained were used for analysis.

2.2. Nutrient composition

The millet flours were analyzed for protein, fat, ash and moisture content following the methods of AOAC (2002). The total dietary fibre (TDF) was determined by rapid enzymatic assay (Asp, Claves, Johnson, Hallmer, & Siljestrom, 1983). The analytical values were evaluated from the mean of three determinations for each sample.

2.3. Antinutritional factors

2.3.1. Phenolic compounds

The total phenols from defatted millet flour were extracted with methanol containing 1% HCl (1:20w/v) followed by centrifugation. The phenolic compounds and proanthocyanidin content (PC) were measured by the method of the Chandrasekara and Shahidi (2010) and expressed as mg gallic acid equivalents/g and mg catechin equivalents/g of defatted flour, respectively. The total flavonoid content (TFC) was determined by aluminium chloride calorimetric assay (Kim, Jeong, & Lee, 2003) and expressed in catechin equivalents/g of defatted meal.

2.3.2. Phytic acid

Megazyme phytic acid assay kit (Cat. No. K-PHYT, Megazyme International, Ireland) was used to determine the phytic acid content of the milled fractions after extracting the flours with hydrochloric acid and calculated from a calibration curve using standard phosphorus.

2.4. Functional properties

2.4.1. Bulk density (BD)

The flour bulk density was estimated by using the method of Okezie and Bello (1988) and calculated as the weight of sample per unit volume of sample (g/l).

2.4.2. Nitrogen solubility

The soluble nitrogen content of millet flours was determined in distilled water (pH 7) and in 0.5 N NaCl (pH 7). The amount of protein in the supernatant was determined by using Pierce bicinchoninic acid (BCA) protein assay kit (Thermo Scientific, Rockford, Illinois, USA). The soluble protein was expressed in mg/g of flour sample.

2.4.3. Water absorption capacity (WAC), oil absorption capacity (OAC) and water solubility index (WSI)

WAC and OAC of the millet flour were determined following the procedures of Elhardallou and Walker (1993) and Sosulski, Humbert, Bui, and Jones (1976), respectively, and reported as the g of water/oil absorbed/100 g of the dry flour. The water solubility index (WSI) was measured according to the method of Anderson, Conway, Pfeifer, and Griffin, (1969) and calculated from the weight ratio of dissolved solids in the supernatant and dry sample.

2.4.4. Foaming and emulsifying properties

Foam capacity (FC) and foam stability (FS) were determined according to the method of Coffmann and Garcia (1977). The volume of the foam was recorded as foam capacity and monitored at regular intervals for 60 min to evaluate stability. Emulsion activity (EA) and emulsion stability (ES) were evaluated by using the method of Yasumatsu et al. (1972).

2.4.5. Gelation

The gelation was evaluated by the method of Sathe and Salunkhe (1981) with slight modifications by using 1–15% (W/V) millet flour suspensions at 1% intervals. The least gelation concentration was found to be the concentration of a sample that does not slip when the tubes are inverted.

2.5. Statistical analysis

One-way and two-way ANOVA (factorial) with replications were used to analyze the significant difference between the results of different samples. Multiple comparisons were made for all experiments employing Duncan's multiple range test (DMRT) at the 5% level of significance. All statistical analyses were performed using statistical software Statistica'99 (StatSoft, Tulsa, OK, USA).

3. Results and discussion

3.1. Nutrient composition

The yield and nutrient composition of the milled fractions of the millets are presented in Table 1. Although higher yields of brown and polished grains are recovered in proso millet, both the foxtail millet varieties show a similar yield. No statistical differences are observed in the moisture content of the different milled fractions ($p > 0.05$, Table 2). Protein content ranges between 9.9 and 14.8 g/100 g and varies significantly ($p \leq 0.05$, Table 2) between the milled fractions of millets. The protein content is more in brown grains due to the presence of bran layers. The high protein content of 14.8 g/100 g is observed in brown proso millet flour, which are in agreement with the earlier reports of Kamara, Zhou, Zhu, Amadou, and Tarawalie (2009) and Bagdi et al. (2011). The total carbohydrate accounts for more than 70 g/100 g of the grain composition for all the millets. Foxtail millets contain higher carbohydrate content than proso millet ($p \leq 0.05$, Table 2). The fat content of the millet flours ranged between 1.2 and 4.9 g/100 g. Dehulling does not have a significant effect on the fat content of the millets but similar to wheat (Singh & Singh, 2010), debranning of millets results in a significant decrease ($p \leq 0.05$, Table 2) in the fat content of polished grains due to the removal of the lipid-rich bran layers. The proso