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Bioactive components and nutritional evaluation of underutilized cereals

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Abstract

Whole-grain cereals have received considerable attention in the past years due to the presence of bioactive components like phytochemicals and antioxidants. However, still the bioactive and antioxidant properties of cereals have not received much attention as compared to fruits and vegetables. Studies show that increased consumption of whole-grains and its products has been associated with reduced risk of developing chronic diseases. The various bioactive components present in coarse cereals are recognized for their health benefits. In this study, the bioactive and nutritional composition of underutilized cereals, Foxtail and Kodo millets are evaluted. The total polyphenolic content by Folin-Ciocalteu, and antioxidant activity by DPPH % scavenging activity was analyzed. The crude proteins, crude fiber, total ash and fat contents of the two cereal grains were analyzed. Hence, it is suggested that both of the selected underutilized cereals can be considered to be functional crops due to their antioxidant effects and high nutrient contents.

Key words: Antioxidant, millets, cereals, phytochemicals, bioactive

1. Introduction

Cereals are an important part of daily diet across the world. However, the bioactive phytochemicals present in them have not received attention as that of fruits and vegetables, despite they contain a unique blends of bioactive phytochemicals. These cereals as a group were represented by major millets and minor millets. Sorghum (*Sorghum bicolor* (L.) Moench), Pearl millets (*Pennisetum americanum* (L.) Leeke), are major millets while minor millets include Finger millet (*Eleusine coracana* Gaertn), Foxtail millet (*Setaria italica* (L.) Beauv), Kodo millet (*Paspalum scrobiculatum* L.), Proso millet (*Panicum miliaceum* L.), Little millet (*Panicum sumatrense* Roth ex Roem. and Schultz) and Barnyard millet (*Echinocloa frumentacea* (Roxb.) Link) (Sertharama and Rao, 2004; Asharani *et al.*, 2010). Over the past three decades, the areas under cultivation by these crops and their production has been decreased significantly (Vijaykumar and Mohankumar, 2009; DoMD, 2009; Sharma, 2007). A large shift from consumption of coarse grains such as sorghum, barley, rye, maize and millet to more refined cereals, like polished rice and refined wheat has been observed especially among the urban population and higher income groups (Vijaykumar and Mohankumar, 2009; DoMD, 2009; Sharma, 2007). The total food grain production in India in the year 2008-2009 was 264.38 million tonnes, out of which coarse cereal contributed 42.68 million tonnes (mt) (Agricultural statistics Division, 2014).

Millets are designated as 'nutritious millets' and they deserve to be reclassified so, because of its nutritional properties. They also possess antioxidant properties as they contain phenolic compounds (Rao *et al*., 2011; Hodzic *et al.*, 2009; Sreeramulu *et al.*, 2009; Dykes and Rooney, 2007). Millets have been utilized in the development of some of the traditional recipes in India (Asha *et al*., 2005; Anju and Sarita, 2010). However, their commercial exploitation is very limited. The new lifestyle adopted by people today has changed the basic food habits of the latter. Consumption of the junk food has increased manifold, leading to a number of diseases, caused due to improper nutrition (Pushpangadan *et al*., 2014). Millets are considered underutilized cereal, *i.e.*, whose potential is not fully exploited.

Table 1: Top ten millet producing countries

Rank	Country	Production(1000 MT)
1	India	11,000.00
2	Nigeria	5,000.00
3	Niger	3,400.00
4	China	1,800.00
5	Mali	1,450.00
6	Burkina Faso	1,100.00
7	Uganda	820.00
8	Ethiopia	750.00
9	Senegal	650.00
10	Chad	650.00

Source: United States Department of Agriculture (2014). MT- million tons, Ahmed *et al.* (2013).

Millets contain minerals such as magnesium and phosphorous, vitamins, bioactive phytochemicals such as phytic acid (Shashi *et al*., 2007; Ahmed *et al*., 2013). Therefore, realizing the health

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benefits of millets, industries are now exploring millets for product development. Therefore, specific design of foods and new products which are acceptable to the population of the region and group specific can help in promoting the millet consumption and thereby, nutritional intake of the consumers significantly (Verma and Patel, 2013).

Table 2: Presence of different kinds of phenolic acids in coarse cereal grains

Coarse cereals	Phenolic acids	Amount (µg/g dry weight)
Bajra	Protocatechuic, Genistic, *p*-hydroxybenzoic acid, Vanillic, Syringic, Ferulic, Caffeic, *p*-Coumaric, Cinnamic	1478
Barley	Protocatechuic, p-hydroxybenzoic acid, Salicylic, Vanillic, Syringic. Ferulic, Caffeic, p-coumaric, o-coumaric, m-coumaric, Sinapic	450–1346
Maize	Protocatechuic, p-hydroxybenzoic acid, Vanillic, Syringic, Ferulic, Caffeic, p-coumaric	601
Oats	Protocatechuic, p-hydroxybenzoic acid, Vanillic, Syringic, Ferulic, Caffeic, p -coumaric, Sinapic	472
Ragi	Protocatechuic, Genistic, p-hydroxybenzoic acid, Vanillic, Syringic, Ferulic, Caffeic, p-coumaric, Cinnamic	612
Sorghum	Gallic, Protocatechuic, p-hydroxybenzoic acid, Gentisic, Salicycilc, Syringic. Ferulic,Caffeic,p-coumaric, Cinnamic, Sinapic	385–746

Source: Andreason *et al.* (2000); Subbarao and Murlikrishna (2002); Zhou *et al.* (2004); Matilla *et al.* (2005); Tian *et al.* (2005); Dykes and Rooney (2006); Kim *et al.* (2006).

2. Materials and Methods

Study on antioxidant properties has been carried out at Centre of Food Technology, University of Allahabad. The nutritional properties of two selected millets, *viz.*, Kodo millet (*Paspalum scrobiculatum* L.) and Foxtail millet (*Setaria italica* L.) were analyzed in triplicate and the data were compared with the wheat flour which is the raw ingredient used by the bakery industries for product development. The selected cereals were purchased from the local market of Allahabad district, Uttar Pradesh, India and were analyzed in the present study.

2.1 Determination of total phenol content (TPC)

Total polyphenols were estimated as per procedure described by Singleton and Rossi (1999), using Folin-Ciocalteu method, where 250 mg sample was taken in 10 mLof mehanol and water (80:20 v/v) solution in a graduated test tube and heated on water bath at 70°C for 10 min. The sample was brought to room temperature, centrifuged at 3000 rpm for 10 min. The supernatant (0.2 mL) was made up to 10 mLwith distilled water. This solution was diluted 10 fold and sample solution (5 mL) was mixed with saturated sodium carbonate (0.5 mL) and Folin-Ciocalteaue reagent (0.2 mL) and made up to 10 mL with distilled water. The absorbance was read at 765 nm after 60 min by UV visible double beam spectrophotometer (Model Evolution 600, Thermo Electron, US).

2.2 Determination of FRAP

The antioxidant capacity of each sample was estimated according to adapted procedure of Benzie and Strain (1996) with some modifications. FRAP reagent was prepared as using 300 mM acetate buffer, pH 3.6 (3.1 g sodium acetate trihydrate, plus 16-mL glacial acetic acid made up to 1L with distilled water); 10 mM TPTZ (2,4,6-tri(2-pyridyl)-striazine),in 40 mM HCl; and 20 mM $FeCl_3$ $6H_2O$ in the ratio of 10:1:1 to give the working reagent. FRAP reagent, 3,900 µL, prepared freshly and warmed at 37°C, was mixed with 100 µL test sample in 80 % methanol, standards, or extraction solvent as reagent blank. After 30 min, the absorbance was measured at 595 nm wavelength. The result was expressed as milligrams of equivalents per 100 g of fresh sample (mg TE/g of FW).

2.3 Radical scavenging activity

The antioxidant activities of native and processed raw materials were also measured by using the stable 2,2-diphenyl-1-picrylhydrazyl radical (DPPH), (De Ancos *et al.*, 2002). An aliquot (0.10 mL) of sample extract in 80 % methanol was mixed with 2 mL of methanolic 0.1 mM DPPH solution and the volume was made up to 5 mL with distilled water. The mixture was thoroughly vortex-mixed and kept in dark for 30 min. The absorbance was measured at 515 nm. The result was expressed as percentage of inhibition of the DPPH radical. The percentage of inhibition of the DPPH radical was calculated according to the following equation:

Per cent (%) antiradical activity

$$= \frac{\text{Control absorbance} - \text{Sample absorbance}}{\text{Control absorbance}} \times 100$$

2.4 Protein, crude fiber, total ash, moisture and crude fat

The protein content, crude fiber, crude fat and total ash of each sample was determined as per the method given by AOAC (2005).

2.5 Statistical analysis

All the experiments were conducted in triplicates, and the data were expressed as Mean ± Standard deviation ($\bar{x} \pm s$). One-way-analysis of variance (ANOVA) and Duncan's multiple range test were carried out to determine significant difference ($p<0.05$) between the means by Statistical Packages for Social Sciences (SPSS version 12.0).

3. Results and Discussion

The quantitative analysis of Kodo millet, Foxtail millet and Wheat flour has shown that Kodo millet has maximum TPC (240 mg GAE/100g), followed by foxtail (210 mgGAE/100g) and Wheat flour (115.42 mgGAE/100g). DPPH % radical scavenging activity ranged (31.46-47.1%) in descending order of Kodo millet, Foxtail millet and Wheat flour (47.1%, 43.78% and 31.46%, respectively) (Figure:1). Davies (1999) has reported that the oxidative damage is very important effect of cellular-free radicals which can lead to damage of cellular constituents. Their repair depends on presence of antioxidants. The antioxidant can donate either an electron or hydrogen to cellular molecules oxidized by free radicals. They can, thus, prevent damage of cellular constituents, including DNA, proteins and lipids membranes from free radicals (Davidson *et al*., 1972).

The nutritional evaluation of selected cereals has been given in Figures 2 and 3. All the selected millet grains tested, found to contain crude fiber content ranging from 0.3% to 4.54%, ash 1.06% to 4.31%, fat content from 0.42 % to 3.41%, protein content from 9.14% to 12.2% while moisture from 8.43% to 11.72%. The Kodo millet showed maximum crude fiber content (4.54%) which is in agreement with the reports of Geetha *et al.* (2012), Kiran *et al.* (2012) and the results for nutritional content in Foxtail millet was in agreement with those of Ahmed *et al.* (2013). Therefore, it is clear from the study that the crude fiber, polyphenol and antioxidant content of selected millets (Kodo millet and Foxtail millet) are better than Wheat flour at 0.05 probability level (Figures 2 and 3). This information supports that the selected cereals are healthy sources of carbohydrates for persons with insulin sensitivity or diabetes (Davies *et al*., 1999). The high-crude fiber in the millets may enhance their digestibility and also aid the peristaltic movement of the intestinal tract (Davies *et al*., 1999). Whole grain containing high amount of polyphenols and other antioxidant compounds, have been associated with a decreased risk of number of chronic disease such as coronary heart disease and diabetes (Ryan *et al.*, 2011). Hence, commercialization of millets for alternative and health food uses by industries needs to be viewed and it was an emerging challenge and opportunities for food processing industry.

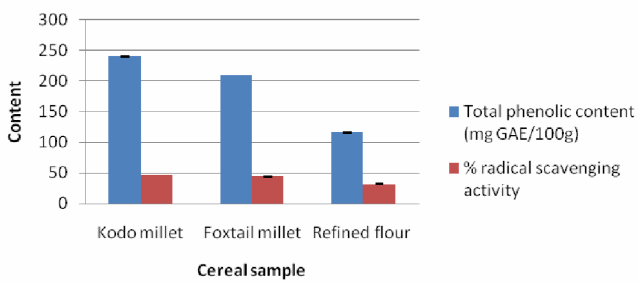

Figure 1: Total phenolic content (TPC) and radical scavenging activity (DPPH %) of selected cereals(n=3)

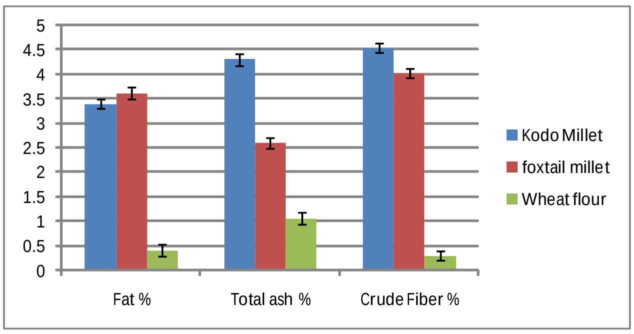

Figure 2: Fat, total ash and crude fiber content of selected cereals (n=3)

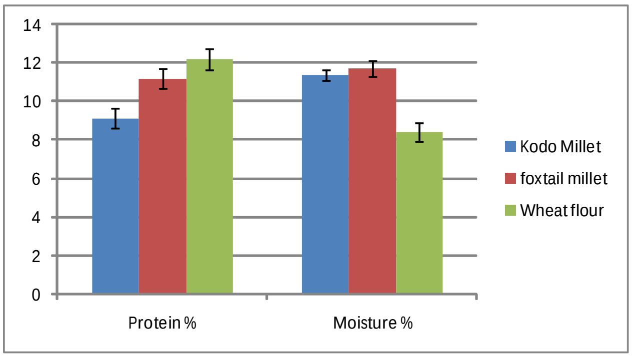

Figure 3: Protein and moisture content of selected cereals (n=3)

4. Conclusion

Millets are nutritionally superior to cereals and provide balanced nutrients. The presence of phenols and phytochemicals had further enhanced antioxidant activity which helps to neutralize and counteract the effects of free radicals. Thus minor millets are significantly nutritious and have fairly high total antioxidant activity. To some extend the millets namely finger millet and pearl millet are exploited for industrial use however there is need to explore other millets such as barnyard millet, kodo millet, foxtail millet and little millet also especially those grown in eastern Uttar Pradesh region. The emphasis, therefore, should be on exploiting the potentially useful qualities of these grains to produce unique and alternative value-added products, and bakery products like bread, biscuit and other staple food.

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Conflict of interest

We declare that we have no conflict of interest.

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