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EVALUATION OF NUTRITIONAL AND FUNCTIONAL STATUS OF THREE VARIETIES OF FOXTAIL MILLET CULTIVARS IN BANGLADESH

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Abstract

The objective of this work was to assess the proximate composition and selected functional status of three Bangladeshi cultivars (BK1, BK2 and BK3) of Foxtail millet (FT) flour. The results showed that the BK3 millet flour contained significantly higher ($p < 0.05$) amount of protein, fiber and lower amount of carbohydrate than BK1 and BK2 FT millet flour. In case of ash, no significant differences ($p < 0.05$) were observed among the three varieties. However, the water absorption capacity of BK3 millet flour was significantly lower ($p < 0.05$) then BK1 and BK2 FT millet flour. Whereas oil absorption capacity, foaming capacity, emulsion stability and bulk density were not significantly varied ($p < 0.05$) among the three FT millet flours. FT millet flour could be potentially used for the preparation of the various nutrient rich recipes and may help to generate technology and to diversify the use of FT by the food processing enterprises.

Introduction

The nutritional status of a community has been recognized as an important indicator of national developments. Therefore, agricultural products must be introduced to people as nutritional foods which are underutilized and ignored by them. Foxtail millet (*Setaria italica* (L.) P. Beauvois), also locally known as Kaon, is one of the most important cereals. Cultivation of millets and promotion for its utilization will be one of the successful potential approaches for improving the nutritional status of the least developed population. Millets have been found to have high nutritive values and are comparable to other major cereals like wheat, rice, maize and sorghum (Nazni and Bhuvaneswari 2015). It is reported that major cereals consumption contributes 70 - 80% of total energy in the majority of Indian diets and millets contribute to only about 2% of total calorie (Radhika *et al.* 2011). In Bangladesh, no research datum has been found regarding the production rate, present and future status of millet, but now it is being realized that the millets have importance as health foods largely due to their nutritional and medical functions. Millets are being recognized as potential future crops because of relatively high dietary fiber, antioxidants, micronutrients, sulphur containing amino acids and essential fatty acids (Yang *et al.* 2012). So it may be designated as store-houses of nutrition and it is more advanced than rice and wheat and it is eco-friendly. Foxtail millet (*Setaria italica* (L.) P. Beauvois, Fam.: Poaceae) is one of the most important cereals of the semi-arid tropics, originated from China, and is now planted all over the world. It is more nutritious, non-glutinous, non-acid forming, easy to digest type of food and is a good source of energy (Nazni and Bhuvaneswari 2015).

In Bangladesh, usually the people from low income level use this cereal as an alternate source of rice which mainly contributes in fulfilling their carbohydrate demand. But the diversified use of FT in different recipes like bread, cake, noodles, paish, hotchpotch and so forth are hardly observed. Although different varieties of FT millets are used in many traditional recipes in

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Bangladesh but no comprehensive study has been reported on the nutritional and functional status of FT millet and its market value. Thus the objective of this research was to assess the comparison of proximate, minerals and functional properties of three varieties of foxtail millet cultivars in Bangladesh.

Materials and Methods

Three different varieties of Foxtail millet namely, BARI kaon 1 (BK1), BARI kaon 2 (BK2) and BARI kaon 3 (BK3) were selected as experimental material. The millets were collected from Plant Breeding Division, Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur. The FT millet flour was prepared by the following schematic flow diagram as shown in Fig. 1. Then the flours were packaged in air-tight plastic containers for further analysis.

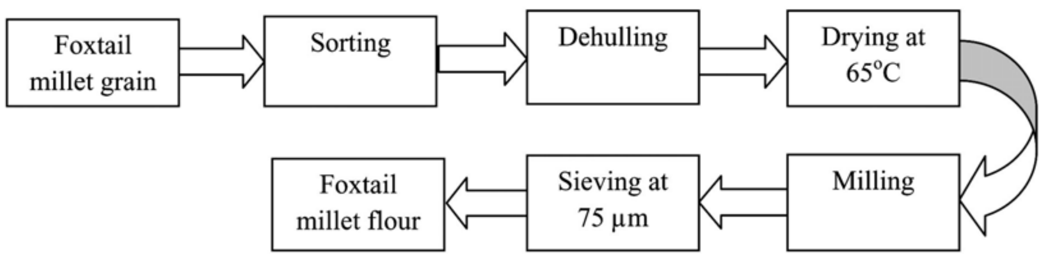

Fig. 1. Flow diagram for the production of foxtail millet flour.

The proximate composition of the three varieties of Foxtail millet flour was determined according to Ceirwyn (1995). The moisture content, ash, fat, carbohydrates and minerals were determined by using the standard method as described by AOAC (2005). The crude protein was determined by the Micro-Kjeldahl method (Thachuk 1969). The total energy value was calculated according to Mahgoub (1999). Sodium and potassium were determined by flame photometry (Flame Photometer Model: PFP7, Germany). Calcium was determined by the method described by Jackson (1973) and iron, Phosphorous were determined using Atomic Absorption Spectrophotometer according to the method of AACC (2000). The water and oil absorption capacity of the flours were determined by the method of Sosulski *et al.* (1976). The emulsion activity and stability were followed by Yasumatsu *et al.* (1972), foam capacity (FC) and foam stability (FS) were determined according to the methods described by Narayana and Narasinga (1982) with slight modification. Bulk density of flour was determined according to the method of Appiah *et al.* (2011). Water absorption index (WAI) and water solubility index were determined by the methods used by Anderson *et al.* (1970). For each experiment, in three replications were maintained. The data were subjected to statistical one-way ANOVA test and Fisher’s Least Significant Difference (LSD) to compare among treatments at the 5% significant level by using SPSS version 22.

Results and Discussion

The moisture content in the wet basis of selected millets flour ranged from 9 to 12% (Table 1). The present results were in accordance with the findings of Nazni and Bhuvaneswari (2015). Kamara *et al.* (2009) had found that total moisture content of three varieties of foxtail millet flour ranged from 10.45 to 12.09%. The ash content of FT millet flours ranged from 1.2 - 1.5%. The lowest ash content (1.06%) was found in BK2, and the highest ash (1.45%) was observed in BK3. Singh and Sarita (2016) had reported that the ash content of foxtail millet flour was about 3.3%.

Among the three varieties of foxtail millet, the lowest fat content (3.86%) was observed in the variety of BK1 and the highest content (5.0%) was observed in BK2 variety which was significantly higher than the other two varieties ($p < 0.05$). Kumar and Parameshwaran (2006) had reported that the fat content of foxtail millet flour ranged from 2.3 to 5.9%. The fibre content of BK1, BK2 and BK3 varieties were significantly different ($P < 0.05$) with each other and the corresponding values were recorded as 2.62%, 3.63% and 4.53%, respectively. The highest fiber content was recorded in BK3, 4.53%, indicating significantly higher ($p < 0.05$) than the other two varieties BK1, 2.62% and BK2, 3.63%. The protein content showed that BK1 and BK2 contained more or less close values which were significantly different ($p < 0.05$) with that in BK3. Previously it had been reported that the protein content of FT millet flour varied from 10.4 - 12.3% (FCTB 2013, Singh and Sarita 2016).

Table 1. Comparison of macronutrients of three varieties of FT millet flour.

Macronutrients	Sample name		
	BK1	BK2	BK3
Moisture (%)	11.23 ± 0.66^{a}	9.58 ± 0.53^{b}	11.85 ± 0.43^{a}
Ash (%)	1.30 ± 0.11^{a}	1.06 ± 0.13^{a}	1.45 ± 0.95^{a}
Protein (%)	8.60 ± 0.23^{b}	9.06 ± 0.21^{b}	10.6 ± 0.41^{a}
Fat (%)	3.86 ± 0.30^{b}	5.0 ± 0.21^{a}	4.70 ± 0.45^{b}
Fiber (%)	2.62 ± 0.24^{c}	3.63 ± 0.51^{b}	4.53 ± 0.11^{a}
Carbohydrate (%)	74.4 ± 0.43^{b}	76.2 ± 0.27^{a}	73.0 ± 0.52^{b}
Energy (Kcal)	375 ± 1.70^{b}	382 ± 3.53^{a}	365 ± 1.77^{c}

Data present as mean value ± standard deviation. Means in a row with same superscript letters are not significantly different at ($p < 0.05$).

The carbohydrate contents of three varieties of FT millet flour ranged from 73 -76.2% whereas BK2 variety of FT millet flour showed significantly higher ($p \leq 0.05$) amount of carbohydrate as compared to the other two varieties (Table 1). Butt and Batool (2010) had reported that carbohydrates are good sources of energy and its high concentration is desirable in the formulation of breakfast meals. The BK2 FT millet flour contained significantly higher amount of energy values (382 Kcal/100g) than BK1 (375 Kcal/100 g) and BK3, (365 Kcal/100 g), respectively. Present study showed the more or less similar results with (FCTB 2013) and it was about 355 Kcal/100 g.

Table 2 shows that the minerals varied significantly ($p < 0.05$) amongst the three varieties of Foxtail millet flour. Ca content of BK1 FT millet flour was 1.32 mg/100g which is significantly lower ($p < 0.05$) than BK2 and BK3 variety of FT millet flour (3.62 mg/100g and 3.64 mg/100g respectively). BK1 four had the higher amount of potassium, 352.62 mg 100/g and phosphorous 787.62 mg/100 g, which were significantly different ($p < 0.05$) with BK2 and BK3, respectively. Kamara *et al.* (2009) had reported that the presence of other minerals such as iron is highly important because of its requirement for blood formation. The higher quantity of iron was found in BK2 variety, 7.01 mg/100g which was significantly different ($p < 0.05$) with the sample BK3, 5.51 mg/100 g and BK1, 6.22 mg/100 g. In case of sodium, the BK1 variety contained the highest amount of sodium than the other two varieties of FT millet flour.

The results on the functional properties of foxtail millet flours are presented in Table 3. The water absorption capacity (WAC) of BK3 FT millet flour was 7.56% which was significantly lower ($p < 0.05$) than the other two varieties of FT millet flour. Water absorption capacity represents the ability of the products to associate with water under conditions when water is limiting such as dough's and pastes (Akubor and Badifu 2001). In case of WAI, no significant differences ($p < 0.05$) were observed among the samples BK1, BK2 and BK3 (Table 3). For WSI, BK1 and BK2 were not significantly varied ($P < 0.05$) but BK3 showed the significantly ($P < 0.05$) lower amount than the BK1 as shown in Table 3. The oil absorption capacity (OAC) of flour is equally important as it improves the mouth feel and retains the flavor and no significant differences ($p < 0.05$) were observed among the varieties of BK1, BK2 and BK3 FT millet flour. The relatively high oil absorption capacity of millet flour suggests that it could be useful in food formulation where oil holding capacity is needed such as sausage and bakery products (Ahmed *et al.* 2014).

Table 2. Comparison of minerals of the three varieties of FT millet flour.

Sample name	Sodium (mg/100g)	Potassium (mg/100g)	Iron mg/100g)	Calcium (mg/100g)	Phosphorous (mg/100g)
BK1	0.50 ± 0.04^{a}	352.62 ± 3.91^{a}	6.22 ± 0.66^{b}	1.32 ± 0.03^{c}	787.62 ± 21.13^{a}
BK2	0.41 ± 0.03^{b}	311.81 ± 9.91^{b}	7.01 ± 0.15^{a}	3.62 ± 0.03^{b}	595.12 ± 9.54^{c}
BK3	0.22 ± 0.06^{c}	215.82 ± 14.86^{c}	5.51 ± 0.37^{c}	3.64 ± 0.04^{a}	740.71 ± 15.10^{b}

Data present as mean value ± standard deviation. Means in a column with same superscript letters are not significantly different at ($p < 0.05$).

Table 3. Comparison of functional properties of three varieties of FT millet flour.

Properties name	Sample name		
	BK1	BK2	BK3
WAC (%)	11.83 ± 1.04^{a}	8.50 ± 0.50^{b}	7.56 ± 0.15^{c}
OAC (%)	7.97 ± 0.95^{a}	7.22 ± 1.11^{a}	8.93 ± 0.31^{a}
WAI (%)	7.63 ± 0.31^{a}	7.26 ± 0.83^{a}	8.80 ± 0.71^{a}
WSI (%)	4.51 ± 0.50^{a}	3.83 ± 0.21^{ab}	3.61 ± 0.20^{b}
FC (%)	0.78 ± 0.06^{a}	0.70 ± 0.05^{a}	0.88 ± 0.04^{a}
FS (%)	0.29 ± 0.04^{c}	0.89 ± 0.10^{a}	0.63 ± 0.02^{b}
EA (%)	42.33 ± 1.53^{a}	40.00 ± 1.00^{a}	41.33 ± 1.53^{a}
ES (%)	41.79 ± 0.74^{a}	41.33 ± 0.46^{a}	41.90 ± 1.13^{a}
BD (g/ml)	$0.95 \pm 0.02^{c\ a}$	0.95 ± 0.03^{a}	0.94 ± 0.02^{a}

Here WAC- Water absorption capacity, OAC- Oil absorption capacity, WAI-Water absorption Index, WSI: Water solubility Index, FC-Foaming capacity, FS- Foaming stability, EA-Emulsion activity, ES-Emulsion stability and BD-Bulk density. Data present as mean value ± standard deviation. Means in a row with same superscript letters are not significantly different at ($p < 0.05$).

The foaming capacity of BK3 FT millet flour was higher (0.88%) than the other two varieties and the values were 0.78% and 0.70%, respectively. Foaming capacity is assumed to be dependent on the configuration of protein molecules. Akubor *et al.* (2013) noted that the foaming capacity and foaming stability depend on protein concentration, protein solubility, swelling power and other factors.

Yasumatsu *et al.* (1972) had reported that emulsion is a fluid system in which liquid droplets are dispersed in a liquid and emulsion stability refers to the ability of an emulsion to resist change in its properties over time. The result showed that emulsion activity and stability did not differ significantly among the three varieties of FT millet and the corresponding values were 42.33%, 40%, 41.33% and 41.79%, 41.33%, 41.90%, respectively. The bulk density of BK1, BK2 and BK3 FT millet flours were 0.95, 0.95 and 0.94 g/ml, which were not significantly varied among the varieties. According to Appiah *et al.* (2011) bulk density is a function of particle size and particle size being inversely proportional to bulk density. Shittu (2012) had reported that the bulk density of millet flour would be an advantage in the use of the flour for preparation of complementary foods.

Each variety of foxtail millet flour is superior concerning to almost most of the nutritional components. The nutritional data showed that the BK2 FT millet flour was good for general people and children because it contained more energy, fat, carbohydrate and iron. However, BK3 variety of FT millet is good for diabetes, cancer and hypertension suffering patients because it has more fiber, protein and calcium content. So, FT millet contributes towards a healthy food that can enhance nutritional security more easily through regular consumption along with keeping the environment safe as they are low input crops and mostly adapted to marginal land.

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