Comparative evaluation of functional properties of finger millet flour and foxtail millet flour with refined wheat flour

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ABSTRACT : The present study was conducted to evaluate the functional properties of finger millet flour and foxtail millet flour and their comparison with refined wheat flour. Flours from finger millet and foxtail millet were taken andevaluated for functional properties viz. water absorption, fat absorption, emulsion activity and emulsion stability, sedimentation value, dough raising capacity and particle size distribution. Gluten content of all the millet flour was also analysed. The results showed thatfoxtail millet flour exhibited higher functional characteristics than finger millet flour and refined wheat flour.

Key words: Finger millet, foxtail millet, functional properties, emulsion activity, sedimentation value, gluten, particle size.

Finger millet (*Eleusine coracana*), also known as African millet or ragi is an annual plant widely grown as a cereal in the arid areas of Africa and Asia. Finger millet is originally native to the Ethiopian Highlands and was introduced into India approximately 4000 years ago. It is very adaptable to higher elevations and is grown in the Himalaya up to 2,300 meters in elevation. The millet can be grown in all possible land types which have been abandoned due to one or other reason (Singh *et al*., 2000).Foxtail millet (*setaria italica*) is one of the most important food crops of the semiarid tropics, originated from China, and is now planted all over the world (En *et al.,* 2008 ; Amadou *et al*., 2011). It plays a very important role in the agriculture and food of many developing countries because of its ability to grow under adverse heat and limited rainfall conditions. It was reported that foxtail millet has many nutritious and medical functions. Foxtail millet is non-glutinous, like buckwheat and quinoa, and it is not an acid forming food, so it is soothing and easy to digest. In fact it is considered to be one of the least allergenic and most digestible grains available and it is a warming grain (Prashant *et al.,* 2005; Xue *et al.,* 2008). The millet bran is used as animal feed in China extensively (En *et al.,* 2008). Traditionally foxtail millet grains are cooked like rice. With its increasing significance as a multipurpose crop in agriculture and human nutrition, finger millet and foxtail millet deserves more attention towards its improvement. The present study was designed to compare the functional properties of local variety of finger millet and foxtail millet flour with the refined wheat flour.

MATERIALS AND METHODS

Finger millet and foxtail millet, obtained from the local market, was cleaned to free it from extraneous matter. Flour was obtained by using the steps of debranning, grinding in the atta flour mill, followed by sieving and used for the study.

Functional properties

Water absorption

Water absorption was measured by a method used by Lin *et al.,* (1974). Water (10 ml) was added to 1 g of sample in a 35 ml centrifuge tube. The mixture was sonicated for 1 min to disperse the sample. The suspension was shaken for 30 min at 24^0 C, and centrifuged at 3700 rpm for 25 min. The volume of free water was measured and the retained water was computed as water absorbed, i.e., ml water absorbed per gram of sample.

$$\text{Water absorption (ml/g)} = \frac{\text{Volume of water absorbed (ml)}}{\text{Weight of sample (g)}} \times 100$$

Fat absorption

Fat absorption was measured by a modification of the method used by Lin *et al*., (1974). Peanut oil (3ml) was added to 500 mg of sample in a 12 ml centrifuge tube. The contents were stirred and sonicated for 1 min to disperse the sample. After holding at 24^0 C for 30 min, the sample was centrifuged at 3700 rpm for 25 min. The volume of free oil was measured and the oil retained in the sample was expressed as fat absorbed in ml of oil per g of sample.

$$\text{Fat absorption (ml/g)} = \frac{\text{Volume of oil absorbed (ml)}}{\text{Weight of sample (g)}} \times 100$$

Emulsion activity and emulsion stability

Emulsion activity (EA) and emulsion stability (ES) were determined by the method of Yasumatsu *et al.,* (1972). A 0.7 g sample was added to 10 ml of water and dispersed at low speed (12,000 rpm) in a blender. Peanut oil (10 ml) was added and the blending was resumed at high speed (20,000 rpm) for 1 min. The emulsion thus formed was divided equally into two 12 ml centrifuge tubes and centrifuged at 3200 rpm for 5 min. emulsion activity was expressed as the

$$\text{Emulsion activity} = \frac{\text{Height of emulsified layer}}{\text{Heights of total contents in the tube}} \times 100$$

Emulsion stability was determined similarly to that of emulsion activity except that emulsion in the centrifuge tube was initially heated in water bath (80^0 C) for 30 min and subsequently cooled to 15^0 C before centrifugation. Emulsion stability was measured as the

$$\text{Emulsion stability} = \frac{\text{Height of emulsified layer after heating}}{\text{Heights of total contents in the tube}} \times 100$$

Sedimentation value

Sedimentation value was determined by following AACC (1969) procedure. Flour sample (3.2 g) was taken in a graduated stoppered cylinder. Fifty ml of water containing 4 ppm bromophenol blue was added and the contents were mixed to get a uniform suspension. The measuring cylinder was then placed on a mechanical shaker for 5 min. Twenty five ml of lactic acid reagent was added to flour suspension and mixed again for 5 min. The cylinder was allowed to stand in upright position for 5 min. At the end of 5 min, volume of sediment in the cylinder was noted in ml.

Dough raising capacity

Dough raising capacity was determined by the method of Ahmad and Al-Eid (2005). Yeast (2.5g) is dissolved in water (45ml) having 40°C temperature. Wheat flour (35g) is taken in a beaker, 1g sugar is added to it and then mixed with the yeast suspension. This mass is made into smooth batter and transferred to a 250 ml graduated cylinder and base volume of the batter is noted down. The rise in the level of dough is noted at 15 minutes interval for one hour.

Calculation

$$\text{Dough raising capacity (\%)} = \frac{\text{(B-A)}}{\text{A}} \times 100$$

Where, A = volume of the dough before fermentation.
B = volume of dough after one hour fermentation.

Particle size distribution

The particle size distribution of flour sample was determined according to the method of Bedolla and Rooney (1984) by sieving 100 g flour in a series of 16, 36, 60, 85 and 100 mesh standard sieves. The sieves were shaken for 15 minutes in a Rotary type sieve shaker. Weight of the sample over 16, 36, 60, 85 and 100 mesh sieve was recorded. Percentage of the sample particles on each sieve was calculated.

Analysis of gluten content

Gluten content was determined following AACC (1962) procedure. Twenty five gram flour was weighed and a dough ball was made in a bowl with a spatula adding sufficient tap water and taking care that no material adhered to the utensil and to the hands. The dough ball was placed in water at room temperature for one hour. The dough was then kneaded and worked with fingers gently in a thin stream of tap water until all the starch and soluble matter were removed. The gluten thus obtained by washing was pressed as dry as possible between hands, made into a ball and weighed in a tared flat bottom dish. The gluten was then dried in the dish at 100 ºC for 24 hours to a constant weight. Per cent wet and dry gluten were calculated.

RESULTS AND DISCUSSION

Results revealed that the water absorption of finger millet flour, foxtail millet flour and refined wheat flour were 107.50, 189.70 and 120.66 ml/g, respectively (Table 1). Significant difference was observed between both the millet flour with each other and also with the refined wheat flour. Singh *et al* (2005) reported a value of 110 and 200 ml/g for finger millet and foxtail millet flour respectively, which is higher than the value of present study. Difference in water absorption of various millet flours has been attributed to differences in particle size of flour, degree of milling, presence of large proportion of husk in whole flours, percentage of damaged starch in milled flours and protein content of different millet flours (Singh *et al.,* 2005). Gernah and Ariahu (2011) reported that the water absorption of finger millet flour ranged from 88.4- 114.5 ml/g. The fat absorption of finger millet flour was 145 ml/g while for foxtail millet flour and refined wheat flour it, was 150 and 110 ml/g. Significant difference was observed between the flour. Singh *et al* (2005) reported a range of 110- 160 ml/g for different millet flour samples. Emulsion activity of finger millet flour, foxtail millet flour and refined wheat flour was 16.0 and 27.31 per cent and 35.01 per cent, respectively. Significant difference was observed between both the millet flour and refined wheat flour. Emulsion activity is a measure of dough strength. It is also used as a measure of crumb softness. It confers strength to wheat dough due to the complex formation with gluten proteins (Miyamoto *et al.,*2005; Goméz *et al.,* 2004). The emulsifier present in the flour bind to the protein hydrophobic surface promoting aggregation of gluten proteins in dough. A strong protein network results in better texture and increased volume of the product (Miyamoto *et al.,*2005; Ribotta *et al.,* 2008). Emulsion stability of finger millet flour, foxtail millet flour and refined wheat flour was 11.0, 22.0 and 34.02 per cent, respectively. Singh *et al* (2005) reported a value of 15.01 and 20-32.50 per cent for finger millet and foxtail millet flour respectively.

The sedimentation value for the finger millet flour, foxtail millet flour and refined wheat flour was 10.0, 12.0 and 34 ml respectively (Table 1). The dough raising capacity of finger millet flour, foxtail millet flour and refined wheat flour was

Table 1: Functional property of finger millet flour and foxtail millet flour

Flour	Water absorption (ml/g)	Fat absorption (ml/g)	Emulsion activity (%)	Emulsion stability (%)	Sedimentation value (ml)	Dough raising capacity (%)	Gluten content	
							WG (%)	DG (%)
Finger millet flour	107.5±0.03	145±0.52	16.0±0.28	11.0±0.22	10.0±0.05	16.50±0.01	2.10±0.89	0.45±0.74
Foxtail millet flour	189.76±0.25	150±0.16	27.31±0.50	22.0±0.23	12.0±0.03	25.60±0.02	3.40±0.05	0.98±0.06
Refined wheat flour	120.66±0.16	110±0.21	35.01±0.05	34.02±0.21	34±0.01	94.5±0.20	27.69±0.12	8.92±0.02
t- value	253.80	104.10	34.33	26.94	13.45	32.22	3.91	1.50
S/NS	S	S	S	S	NS	S	NS	NS

-All results are mean±SD for 3 individual determinations
-S- Significant, NS- Non significant-WG- Wet gluten, DG- Dry gluten

Table 2: Particle size distribution of finger millet flour, foxtail millet flour refined wheat flour

Flour	Sieve No./ Mesh size (µm)					
	16 mesh sieve (%)	36 mesh sieve (%)	60mesh sieve (%)	85 mesh sieve (%)	100 mesh sieve (%)	At base (%)
Finger millet flour (%)	4.20±0.21	61.23±0.52	24.54±0.23	6.36±0.16	2.21±0.32	1.45±0.43
Foxtail millet flour(%)	4.45±0.95	65.32±0.06	23.25±0.35	5.43±0.68	1.10±0.23	0.45±0.12
Refined wheat Flour	0±0.00	12.20±0.16	58.43±0.35	20.76±0.65	3.93±1.30	4.68±1.20
S.Em.±	0.32	3.50	2.37	1.15	0.95	0.45
CD at 5 %	1.25	12.25	9.50	3.50	2.25	1.96

All results are mean±SD for 3 individual determinations
SEM- Standard error of mean, CD- Critical difference

16.50, 25.60 and 94.5 per cent respectively. Significant difference was found between flour. The principal functional protein of wheat flour is gluten. The quality of flour depends upon the quality and quantity of gluten present in it. Gluten has the important property that when it is moistened and worked by mechanical action, it forms elastic dough. It does this by forming linkages between protein molecules. These linkages form a three dimensional structure which provides strength to the dough (Potter and Hotchkiss, 1996). Sufficient gluten produces a light product with good volume. The gluten content of refined wheat flour and millet flour blends has been presented in Table 1

The gluten content of refined wheat flour on wet and dry basis was 27.69 and 8.92 per cent, respectively. Kaur and Bains (1979) reported 19.2 to 36.3 per cent wet gluten in white flour obtained from Indian *aestivum* wheat. Kamaraddi and Shanthakumar (2003) reported 9 per cent gluten on dry basis in wheat flour. Arya (2008) reported 28.64 and 8.72 per cent for refined wheat flour on wet and dry basis respectively. The gluten content of finger millet flour on wet and dry basis was 2.14 and 0.45 per cent, respectively while for foxtail millet flour; it was 3.40 and 0.98 per cent, respectively for wet and dry basis. Non significant difference was found between both the millet flour. Table 2 shows the specific particle distribution or percentage of finger millet flour foxtail millet flour and refined wheat flour on each sieve size. The maximum retention of finger millet flour and foxtail millet flour was found in 36 mesh sieve while for refined wheat flour maximum retention was found in 60 mesh sieve.

CONCLUSION

Functional properties of any flour play an important role for the formulation of final product. It affects the overall acceptability of the product by changing its texture, appearance and consistency characteristics. Thus from the present study we can conclude that both the millet flour (finger millet flour and foxtail millet flour) can be successfully used for formulating the value added products. The addition of gluten increases the possibility for their use in bakery products.

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Received: March 28, 2014
Accepted: July 3, 2017