EFFECT OF PROCESSING ON FUNCTIONAL PROPERTIES OF SELECTED MILLET FLOURS

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Abstract : Millets are abundantly cultivated in various underdeveloped countries and are a staple crop which used to feed huge sections of population. Millets are gaining importance because of their nutritional composition over other cereals and increasing utilization in many processed foods. Utilization of these millets in many food products need to be explored because of their behavior under different processing methods. The effect of traditional processing methods such as germination, roasting and milling on functional properties of four millets flours and one composite flour were investigated.Sorghum (Sorghum bicolor), Foxtail millet (Setariaitalica), Pearl millet (Pennisetumglaucum) and Finger millet (Eleusinecoracana) were soaked and germinated for 24 hour. Thereafter, roasted and milled to fine flour and also used for formulation of composite flour and stored for further analysis. The Oil Absorption Capacity (OAC), Water absorption Capacity (WAC), Least Gelation Concentration (LGC) and Bulk Density (BD) of the raw and processed millet flours were analysed using standard techniques. The results for the raw and processed millets were then compared for their functional properties.WAC for processed millets showed significant difference when compared to raw millet flours in all millets except pearl millet, whereas OAC was significantly increased for all processed flours including composite flour. WAC was highest for processed sorghum (335.00$\pm$ 2.9ml/100g) whereas OAC was highest for processed pearl millet (308.33+4.4ml/100g). When raw and processed values were compared for BD, except for pearl millet, other millets showed significant differences at ($p<0.05$). For LGC, there was no significant difference in processed and raw flour values. This concludes that, traditional processing methods affected the functional properties of the four millet flours and composite flour.

***Key words* - finger millet, sorghum, pearl millet, foxtail millet, processing of millets, functional properties**.

I. INTRODUCTION

Millets is a generic term referring to a number of small-seeded annual grasses Paniceae and Chlorideae of the family Poaceae (true grass) [Zhang *et al.*, 2009]. Millets are grown primarily on marginal lands in dry zones of mild, subtropical and tropical regions under agrarian conditions, in which major cereals fail to give substantial yield [Adekunle,2012]. Millets are food grains locally restricted to smaller regions or individual countries [*FAO*,1996]. Millets are unique among the cereals due to their richness in micronutrients. Finger millet, also known as Ragi, is of great importance, as it is considered as '*staple food*' in some parts of India and Africa. It is a good source of micronutrients, calcium, magnesium, iron, phosphorus and B vitamins [Devi *et a*l, 2014, Saleh *et al*; 2013]. It is also used in many processed food products such as weaning foods, bakery and beverages [Verma and Patel, 2013; Gull and Prasad, 2015]. In Afriica, production of pearl millet is high as compared to others. As a steam cooked product, pearl millet forms a major component of meals. Chikwendu *et al.*,2014 stated that, compared to other millets, pearl millets has better nutritive value in terms of iron, zinc, lipids and high quality proteins. Sorghum, because of its adaption to extreme weather conditions is termed as a '*resistant crop*'. Being a good source of protein, vitamins, minerals and carbohydrate, it is widely cultivated all over the world as food and feed. As one of the oldest cultivated crop, foxtail millet is important in many regions. It is also called as '*Italian Millet*'. It is widely produced in northern China, where it originated as well, and is used for different traditional preparations for pregnant woman [Pawar and Machewad, 2006].

Traditional processing has been applied to millets for the preparation of food and to improve sensory, nutritional and edible properties [Saleh *et al*, 2013]. Germination is widely used as a traditional processing method which modifies different components and grain structure of the millet by enhancing enzyme activity [Traoré *et al*, 2004]. Physicochemical and functional properties can get affected by these processing methods. Significance of studying functional properties of grains can be re-iterated by evaluation of possible changes occurring in behavior of nutrients, molecular structure and physicochemical properties of millets [Mattil, 1971; Kinsella and Melachouris ,1976].There is an increased utilization of millets in different processed, value added foods due to their nutritive and therapeutic qualities and contribution towards meeting objective of sustainable diet, food security and eradication of hunger [FAO, 2017]. Also, there is very less information available on functional properties of processed millets and their composite flours. Hence, the present study was undertaken with an objective of studying the effect of processing of millets on their functional properties namely, Water Absorption Capacity (WAC), Oil Absorption Capacity (OAC), *Least Gelation Concentration* (LGC) and Bulk Density (BD).Presently, a hype is being observed in processed millet based baked food products as well. Increasing use of millets in bakery sector demands for more researches on millets in the field of millets processing. Analysis of the functional properties of millets would also help to determine different baking properties of the end food product [*Shrestha and Srivastava, 2017*].

II. MATERIALS AND METHODOLOGY

Four millets namely finger millet, pearl millet, sorghum and foxtail millet were purchased from the local market in Visakhapatnam, Andhra Pradesh. Millets were dry and wet cleaned using water, sorted and processed in the next step.They were soaked in water for 8 hours and then drained. Soaked millets were then germinated for 24 hours in dark. Thereafter, Germinated millets were dried in an oven at 60-65°C. Dried millets were then roasted, till grains turned brown and sweet aroma was released. Millets were milled after cooling. One composite millet flour sample was formulated with equal amount of all four millets. Each millet samples and composite flour were stored in an air tight container for analysis of the functional properties.

2.1 Water Absorption Capacity (WAC)

The WAC of the flour was determined by the method given by Sathe *et al.*, [1982]. 10ml of water was added to 1*g* of each sample in a beaker. The suspension was stirred using magnetic stirrer for 5 min at 1000 RPM on Gallankamp magnetic stirrer hot plate. The suspension was then transferred into centrifuge tube and was centrifuged at 3500 RPM for 30 mins and the volume of the supernatant obtained was measured. The density of the water was assumed to be 1*g*/ml. The water absorbed by the powder and the volume of the supernatant obtained after centrifuging was noted and is given by Equation 1, as follows:-

$$\text{Water Absorption Capacity (ml per 100 g)} = \frac{\text{Weight of the Sediment}}{\text{Weight of the Sample}} * 100 \qquad (1)$$

2.2 Oil Absorption Capacity (OAC)

The oil absorption was determined using the method stated by Lin *et al.*, (1974). The sample (500 mg) was added to about 10 ml of oil, mixed thoroughly and agitated for 1 hour. Then the sample was centrifuged at 2000 RPM for 30 mins. The supernatant was discarded and the sediment was weighed. The Oil Absorption Capacity was calculated by:-

$$\text{Oil Absorption Capacity (ml per 100 g)} = \frac{\text{Weight of the Sediment}}{\text{Weight of the Sample}} *100 \qquad (2)$$

2.3 Least Gelation Concentration (LGC)

The method given by Coffman and Garcia (2007) was modified and used for evaluating the LGC. In distilled water, 5 ml Flour dispersion from 2 to 30 % (w/v) were prepared in test tubes and heated to 90°C for 1 hour in water bath. Then tubes were cooled under tap water and thereafter kept for 2 hours in ice cold water. The flour concentration, at which sample did not slip after inverting the tube, was considered as Least Gelation Concentration for the respective flour.

2.4 Bulk Density (BD)

Bulk density was calculated by the method given by Ige *et al.*,[1984]. A specified quantity of the sample was put into an already weighed 5 ml measuring cylinder (W1). Tapping of measuring cylinder was undertaken in order to eliminate air spaces between the flour particles and then the volume was measured (W2). It was calculated as g/ml.

$$\text{Bulk Density (g/ml)} = \frac{W2-W1}{\text{Volume of the sample}} \qquad (3)$$

III. STATISTICAL ANALYSIS

The statistical analysis was carried out by SPSS version 16.0. Mean and standard error was calculated for functional properties of the flours and compared by t test to find significant difference between samples and properties.

IV. RESULTS AND DISCUSSION

4.1 Water Absorption Capacity (WAC)

Hydrophilic groups which bind water in foods, define the WAC of the food [Singh *et al.*, 2005]. He also stated that, different factors such as degree of milling, particle size of the flours and presence of large proportion of husk in whole flours, affect the WAC. Flours with good WAC are useful in baking .Table 1 showed that Water Absorption Capacity has showed significant difference for all millets except pearl millet. The raw WAC value for pearl millet was found as 225.4±0.85ml/100g and processed value was 235.00±2.9ml/100g, which are similar to the results observed by Sade, 2009, who proposed that germination increases WAC of pearl millet, which leads to change in both the quality and quantity of protein. Finger millet showed raw and processed flour values as 147.50±1.1ml/100g and 258±1.67ml/100g, where, low values in raw are may be due to the compactness of structure and high values in processed flour may be attributed to lose structure of starch polymers, as described by Adebowale *et al.*, 2012. The WAC for sorghum showed significant difference in raw and processed flour values, 148.46±0.68ml/100g and 335.00±2.9ml/100g respectively, whereas foxtail millet showed WAC values as 125.80± 0.85ml/100g and 246.67± 3.3ml/100g respectively. Composite flour also showed significant difference in raw and processed flour at $p<0.05$.

Finger millet showed difference in the WAC as 75.14% where as pearl millet it showed as 4.19%. There was a increase in the WAC of the sorghum by 125.65%, for foxtail millet by 98.08%, where as for mix flour it was 81.62% as showed in graph 1A.As studied by, Njoki *et al.,* 2014 dry heat processing leads to partial gelatinization of starch which attributes to higher WAC in roasted (58.67%) and popped (80.00%) little millets composite flour. The increase in the processed flour values depends upon solvent, pH, physical environment, presence of lipids and carbohydrates as stated by Kinesella, 1982. Composite flours which exhibit high WAC can be used for bakery items, sausage, dough processed cheese. Loss of starch crystalline structure, amylose leaching and solubility are always associated with increase in WAC of the flours. Polysaccharides also contribute to increase in this activity. The difference found in the composite flour and single millet flour is may be due to protein concentration difference, conformational characteristics and their degree of interactions as stated by Butt and Batool, 2010.

4.2 Oil absorption capacity (OAC)

Table 2 shows that Oil Absorption Capacity values for all flours have significant difference between processed and raw values. For OAC, all processed samples of millets flours showed significant increase at ($p<0.05$). Processed flours of Finger millet, pearl millet, sorghum, foxtail millet and mix millet (composite flour) showed values as 249.3±0.67ml/100g, 308.3±4.41ml/100g, 248.3±1.67 ml/100g, 100..06±0.2ml/100g, 258.6±1.33ml/100g and raw values as 143.497+ 0.36 ml/100g, 151.863+0.34 ml/100g, 163.713+0.17 ml/100g, 112.83+0.65 ml/100g, 157.967+0.34 ml/100grespectively. All millets showed rise in oil absorption capacity. Finger millet showed increased OAC by 73.27 % from raw to processed samples, where as pearl millet showed 103.03% of difference between raw and processed millet flours. Sorghum has showed less difference when compared to other millets, as 51.69%, foxtail millet showed highest percentage of difference as 105.33% between raw and processed flours for OAC. Mix flour showed 63% or rise in OAC from raw to processed samples, as represented in graph 1B.The higher oil absorption lead to retention of better flavors than refined wheat flour, as stated by Shreshtha and Srivastava, 2017. The highest increase in OAC value is observed for pearl millet. Increase in lipophilic content due to grain germination, may be attributed to change in protein quality and lead to increased OAC of processed flours. From the interior protein molecules, the unmasking of non-polar residues lead to increased availability of amino acids which in turn increases OAC of the flour. Flours with high OAC are found good in formulation of various foods [Elkhalifa *et al.,* 2005]. Bakery products, demand good fat absorption in flours, and this purpose is served by composite flours. They are useful in retaining flavors, improving the palatability and extending the shelf life of bakery goods because of their high OAC [Aremu *et al.*,2007].

4.3 Bulk Density (BD)

`Heaviness of the flour can be measured by Bulk Density (BD). Low BD grain flour is used for formulation of weaning food products. Except for pearl millet, other millet flours showed significant difference in Bulk Density for the raw and processed values. Finger millet showed significant increase in Bulk Density for processed flour (1.14667±0.0033 g/ml). Study done by Nazni and Bhuvaneshwari, 2015 stated that, there is a positive correlation between starch content and Bulk Density at 0.01% level. Chandra *et al.*,2014, found that moisture and particle size affect the Bulk Density of the flours. Flours with low Bulk Density can be used in complementary foods whereas, high Bulk Density foods proved good as thickeners [Akubor, 1999]. Ramashia *et al.*, 2017 studied three different varieties of finger millet in Sub-Saharan Africa and reported that BD varies from 0.89± 0.01 to 0.93±002 depending on the variety. Foxtail mill*et al*so showed increase in Bulk Density from raw to processed flours as 0.5467±0.0067g/ml to 1.3067±0.0067g/ml. similar kind of result for processed flour sample of foxtail millet was also found by Nazni and Shobhana 2016. They reported the value of raw foxtail millet BD to be 0.52±0.005g/ml, germinated foxtail millet to be 0.43g/ml and roasted foxtail millet to be 0.53g/ml. Kamara *et al.*, 2009 studied and reported that 2 varieties of defatted foxtail millet namely yellow and white showed similar BD values, 0.27 g/ml and 0.23 g/ml. The mix or composite flour showed increase in BD value from 0.7133±0.015g/ml to 1.20333±0.0033g/ml. For composite flour of tigernut 3%, plantain flour 20%, wheat flour 77%, Bamigbola *et al.*, 2016, found the Bulk Density to be 0.90 g/ml whereas for 100% wheat flour it was 0.70 g/ml. Foxtail millet showed highest difference in bulk density as 139.02% where as finger millet showed lowest percentage difference among raw and processed flours as 55.65%. Pearl millet, sorghum and mix millet showed rise in bulk density by 97.8%, 45.15% and 68.7% respectively (Graph 1C).

4.3 Least Gelation Concentration (LGC)

Gelation Concentration Index can be measured as lowest concentration of protein at which sample did not slip when the tube was inverted. Table 4 describes the Least Gelation Concentration (LGC) of various millet flours. Kaushal *et al.*, 2012, described that protein gelation and starch gelatinization influence the physical absorption of water. Better ability of protein can be described by lower gelation capacity of the food as explained by Akintayo *et al.*, 1999 and Aremu *et al.*, 2007, described that interactions between carbohydrates, protein and fats also affects the functional properties.In terms of the Least gelation, the average % for Foxtail is comparatively higher than that of the rest of the studied millets. The average least gelation of finger and Sorghum was 4%. Chandra, *et al.*,[2015]has evaluated the Least Gelation Concentration (LGC) by employing a method of Coffman and Garcia (1977). The least gelation concentration is described as the least protein absorption which means gelatin is remained in the inverted tube.

Except for pearl millet which showed reduced least gelation capacity of the processed flour, other flours such finger millet, sorghum, foxtail millet and mix millet showed increased LGC in processed flours. Pearl millet showed that LGC was decreased by 66.67% in the processed flour as shown in graph 1D.

V. CONCLUSION

Physical, chemical and sensory properties of the food are defined by the various functional properties of the raw material. Therefore, present study stands relevant and important for the analysis of functional properties of different millets after processing. Significant variation is observed among different millets with respect to functional properties when traditional processing methods were applied. Considering increasing utilization of millets in different food products, above findings will help in defining nature of individual millets and composite flour and their role in development of food product.

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Tables :

Table 1 Water Absorption Capacity

Millet flours	Raw(ml/100g)	Processed(ml/100g)	P-Value
Finger	147.50 ± 1.1	258.33± 1.7*	0.000*
Pearl	225.54± 0.85	235.00± 2.9	0.088 NS
Sorghum	148.46± 0.68	335.00± 2.9*	0.000*
Foxtail	125.80± 0.85	246.67± 3.3*	0.001*
Mix	136.73± 1.4	248.33± 1.7*	0.000*

Values are shown as mean ± standard error, compared at significance ($p<0.05$), *- show values which are significantly different, NS-non significant

Table 2 Oil Absorption Capacity (OAC)

Millet flours	Raw(ml/100g)	Processed(ml/100g)	P-Value
Finger	143.497+ 0.36	249.33+0.67*	0.000*

Pearl	151.863+0.34	308.33+4.4*	0.001*
Sorghum	163.713+0.17	248.33+1.7*	0.000*
Foxtail	112.83+0.65	231.67+1.7*	0.000*
Mix	157.967+0.34	258.67+1.3*	0.000*

Values are shown as mean± standard error, compared at significance (p<0.05), *- show values which are significantly different, NS-non significant

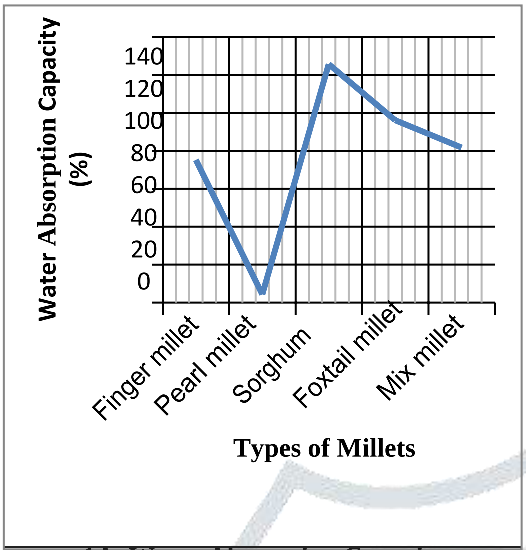
Table 3 Bulk Density (BD)

Millet flours	Raw(g/ml)	Processed(g/ml)	P-Value
Finger	0.7367±0.0067	1.14667±0.0033*	0.000*
Pearl	0.60667+0.00882	1.2000+0.00000	NA
Sorghum	0.8267±0.0088	1.2000±0.0058*	0.000*
Foxtail	0.5467±0.0067	1.3067±0.0067*	0.000*
Mix	0.7133±0.015	1.20333±0.0033*	0.001*

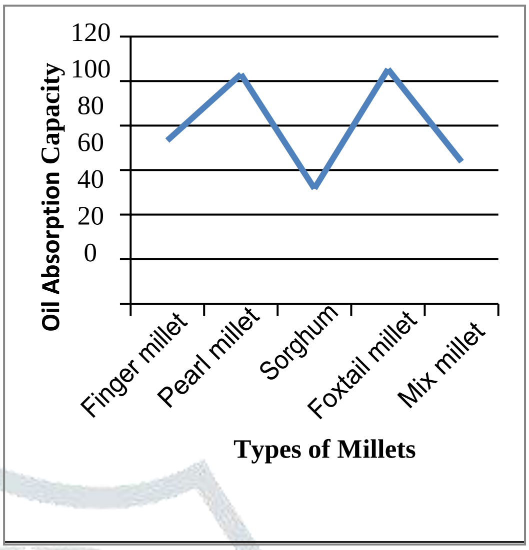
Values are shown as mean± standard error, compared at significance (p<0.05), *- show values which are significantly different, NS-non significant

Table 4 Least Gelation Concentration (LGC)

Millet flours	Raw	Processed
Finger	2.0	4.0
Pearl	6.0	2.0
Sorghum	4.0	4.0
Foxtail	6.0	6.0
Mix	4.0	6.0



1A. Water Absorption Capacity



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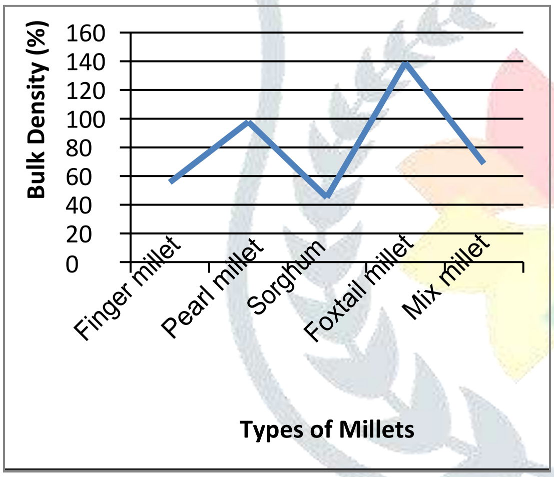
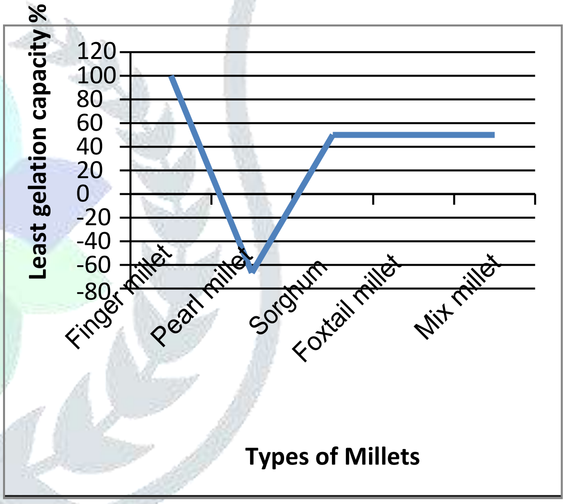


1C : Bulk Density



1D: Least Gelation Capacity

Figure 1: Percent increase and decrease in functional properties of different millet flour