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ANALYSIS OF PHYSICO CHEMICAL AND FUNCTIONAL CHARACTERISTICS OF FINGER MILLET (*ELEUSINE CORACANA L*) AND LITTLE MILLET (*P. SUMANTRANSE*)

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ABSTRACT

Millets are important foods in many underdeveloped countries because of their ability to grow under adverse weather conditions like limited rainfall. Millets are more nutritious and they are non-glutinous and non-acid forming and easy to digest. Millets are good sources of energy, protein, fatty acids, vitamins, minerals, dietary fibre and polyphenols. The aim of the study was to find the physico-chemical and functional properties of selected millets (viz., finger millet and little millet). Millets are good sources of energy, protein, fatty acids, vitamins, minerals, dietary fibre and polyphenols. Thousand grain weights of the selected millets were found to be high in finger millet. Bulk density of millets was recorded to be high bulk density was seen in finger millet (0.70g) when compared to little millet. Water absorption capacity of millet was ranged from 1.27 ml/100g and 1.04ml/100g for little millet and finger millet. Oil absorption capacities of two millets were 1.25g/g and 1.04g/g respectively of finger millet and little millet. Among the millets, the protein content was recorded to be highest in little millet 13.6g/100 than finger millet 8.8 g/100g. Among the millets the lowest fat content was observed to be 1.9g/100 in little millet followed by finger millet. The highest fibre content was recorded in finger millet (5 g/100g) and little millet (5g/100g). Among the two millets the higher levels of calcium iron and phosphorus was observed in all millets. It was inferred that that among the different millets, finger millet had the highest proportion of total minerals (332%). Crude protein content had the positive correlation against ash, titarable acidity and moisture content. The ash, titarable acidity, moisture and crude protein content were significant and negatively correlated with the fat content and energy content. Positive correlations were seen among amylose, sodium, potassium and iron content were positively correlated with total starch content of millets.

Keywords: Pearl millet, Finger millet, Physical, Chemical and Functional.

INTRODUCTION

Millet is a generic term describing a range of small-seeded grains in two tribes Paniceae and Chlorideae of the family Poaceae (true grass). It became a staple food for humans 10,000 years ago already before the rise of wheat and rice (Lu et *al.,* 2009).

Millets are important foods in many underdeveloped countries because of their ability to grow under adverse weather conditions like limited rainfall. In contrast, millet is the major source of energy and protein for millions of people in Africa. It has been reported that millet has many nutritious and medical functions (Obilana and Manyasa, 2002; Yang *et al.,* 2012). Millets are unique among the cereals because of their richness in calcium, dietary fibre, polyphenols and protein (Devi et al., 2011).

Finger millet (*Eleusine coracana L.*) is important millet grown extensively in various regions of India and Africa, constitutes as a staple food for a large segment of the population in these countries. It ranks sixth in production after wheat, rice, maize, sorghum and bajra in India. It is a naked caryopsis with brick red-coloured seed coat and is generally used in the form of the whole meal for preparation of traditional foods, such as roti (unleavened breads or pancake), mudde (dumpling) and ambali (thin porridge). Epidemiological studies have demonstrated that regular consumption of whole grain cereals and their products can protect against the risk of cardiovascular diseases, type II diabetes, gastrointestinal cancers and a range of other disorders (Mc.Keown 2002).

Little millet (*Panicum sumatrense*) the grains of little millets, being nutritionally superior to rice and wheat, provide cheap proteins, minerals and vitamins to poorest of the poor, where the need for such ingredients is the maximum. Practically devoid of grain storage pests, the little millets have indefinite storage life.

Minor millets, with their low carbohydrate content, low digestibility and water soluble gum content (b-glucan) have been attributed to improve glucose metabolism. These grains release sugar slowly in the blood and also diminish the glucose absorption (Anderson et.al., 1991). The dietary fibre and resistant starch of minor millets have been attributed to exhibit hypoglycemic and hypolipidemic effects (Pathak, 1998). Little millet has a significant role in providing nutraceutical components such as phenols, tannins and phytates along with macro and micro-nutrients (Itagi, 2003).

Nutritional potential of millets in terms of protein, carbohydrate and energy values are comparable to the popular cereals like rice, wheat, barley or bajra. Finger millet contains about 5–8% protein, 1–2% ether extractives, 65–75% carbohydrates, 15–20% dietary fiber and 2.5–3.5% minerals (Chethan and Malleshi, 2007a). Hence, the present study aims to assess the physicochemical and functional characteristics of the selected millets. The objectives of this work were to study the effect of process conditions on the physicochemical and functional properties of selected millets.

MATERIALS AND METHODS

MATERIAL

Finger Millet (*Eleusine coracana*- Co 9 Variety) and Little millet (*p. Sumantranse*- Co 4 Variety) were purchased from local market Salem, Tamilnadu, India.

CLEANING AND MILLING OF THE MILLET

The raw finger millet and little millet grains were placed in a tray and the chaff and damaged grains as well as stones/pebbles together with all other extraneous matter were removed by hand and discarded. Milling of grains and extrudates to produce flour was carried out using 2 mm mesh.

DETERMINATION OF PHYSICAL PROPERTIES OF MILLETS

Millet samples were assessed for physical characteristics such as thousand grain weights; thousand grain volumes were analyzed using standard procedure.

THOUSAND GRAIN WEIGHT AND THOUSAND GRAIN VOLUME

Weight of randomly selected thousand grains was recorded in grams using electronic balance with a sensitivity of 0.01 mg. Thousand randomly selected grains were dropped in a measuring cylinder containing known volume of distilled water. The difference in volume was recorded in ml.

DETERMINATION OF FUNCTIONAL PROPERTIES OF MILLETS

WSI were determined by the method of Anderson (1982). Foaming Capacity (FC) and Foam Stability (FS) were determined by method of Narayana and Narasinga Rao (1982). Oil absorption capacity was determined with slight modification to the method of Wani et.al., (2013).

BULK DENSITY (BD)

The BD of the grain flour was determined by the method of Ige *et al*., (1984).
A specified quantity of the sample was put into an already weighed 5 ml measuring cylinder (W_1); it was gently taped to eliminate air spaces between the flour in the measuring cylinder and the volume was noted (W_2). The new mass of the sample and sample was determined. The BD was computed as

$$BD = \frac{W_2 - W_1}{\text{Volume of sample}}$$

HYDRATION CAPACITY AND INDEX

Hydration capacity was calculated as the difference in weight of grain after soaking for 24 hours. It was expressed as weight per gram (Dhingra *et al.*, 1992). Hydration index was calculated by using the formula given by Kantha *et al.* (1986).

$$\text{Hydration index} = \frac{\text{Hydration capacity per 1000 seeds}}{\text{Original dry weight of 1000 grain}} \times 100$$

SWELLING CAPACITY AND INDEX

Swelling capacity was calculated as the difference in volume of grain after soaking for 24 hours. It was expressed as weight per gram (Dhingra *et al.*, 1992). Swelling index of the grain was calculated as described by Kantha *et al.* (1986) using the formula.

$$\text{Swelling index} = \frac{\text{Swelling capacity per 1000 seeds}}{\text{Seed volume per 1000 seeds}} \times 100$$

WATER ABSORPTION

The water absorption capacity of the flour was determined by the method of Sathe *et al.*, (1982). 10ml of water was added to 1gm of each sample in a beaker, the suspension was stirred using magnetic stirred for 5 min at 1000 rpm on Gallankamp magnetic stirrer hot plate. The suspension was transferred into centrifuge tube and centrifuged at 3500rpm for 30mins; the volume of the supernatant obtained was measured. The density of the water was assumed to be 1gm/ml. The water absorbed by the powder and the volume of the supernatant obtained after centrifuging was noted.

$$\text{Water absorption (ml)} = \frac{\text{Weight of the Sediment}}{\text{Weight of the Sample}}$$

OIL ABSORPTION

The oil absorption was determined using the method of Lin *et al.,* (1974). The sample (500mg) was added to about 10 ml of oil, mixed thoroughly and agitated for 1 hour. Then the sample was centrifuged at 2000rpm for 30 minutes. The supernatant was discarded and the sediment was weighed.

$$\text{Oil absorption (ml)} = \frac{\text{Weight of the Sediment}}{\text{Weight of the Sample}}$$

DETERMINATION OF CHEMICAL COMPOSITIONS IN MILLETS

By using the standard methods, all the samples moisture, Ash, crude fat, crude fibre, and crude protein and carbohydrate contents of each food sample were analyzed and all of which were carried out in triplicate. Moisture content was determined by heating 2.0 g of each fresh sample to a constant weight in a crucible placed in an oven maintained at 105°C.The ash content was determined by the incineration of 1.5 g samples placed in a muffle furnace maintained at 550 0C for 5 -8 hrs. The crude fibre was obtained by digesting 2 g of the samples with H2SO4 and NaOH and incinerating the residue in a muffle furnace maintained at 550 °C for 5 -8 hrs. The crude protein (% total nitrogen X 6.25) was determined by Kjeldahl method, using 2 g of the samples. The crude lipid content was obtained by exhaustively extracting 10 g of each sample in a Soxhlet apparatus using N-Hexane as the extractant. Each analysis was carried out in triplicates. The carbohydrate content was determined by the difference i.e. deducing the sum of the percentage (moisture, ash, fibre, fat, and protein) from 100 using standard techniques of AOAC. (1990).

Calcium, magnesium was determined by the method described, Jackson (1973), iron, zinc and copper were determined by the method described by Lindsay and Norvell (1978) and phosphorus was determined by the method described by Piper (1966). Amylose content was estimated by the iodine colorimetric method of Mohana *et al.*, (2007).

STATISTICAL ANALYSIS

The data reported in all of the tables are the averages of triplicate observations. Statistical analysis of the results was done with Microsoft Excel 2007 (Microsoft Inc., USA) and Duncan's test was applied to determine the differences between means.

RESULT AND DISCUSSION

PHYSICAL PARAMETERS OF MILLETS

The physical parameters like thousand grain weight, seed volume and bulk density etc were assessed and the results are presented in Table 1.

Table 1- Physical characteristics of millets

S.no	Parameters	Finger Millet	Little Millet
1.	Thousand grain weight (g)	2.46±0.005	2.59±0.005
2.	Thousand grain Volume (ml)	2.03±0.05	3.06±0.1

The maximum thousand grain weight was observed in little millet 2.59 g/100g followed by finger millet (2.46g/100g) and little millet (2.59g/100g). Thousand grain volumes were more in little millet (3.06ml/100g) and finger millet (2.03ml/100g).

FUNCTIONAL PROPERTIES OF RAW MILLETS

Bulk density, hydration capacity, hydration index, swelling capacity, Water Absorption Capacity (WAC) and Oil Absorption Capacity (OAC) of selected millet and pulse flours were presented in Table 2.

Table -2 – Functional properties of millets

S.no	Properties	Finger Millet	Little Millet
1.	Bulk Density (g/ml)	0.70±0.01	0.44±0.005
2.	Hydration Capacity (g/1000 seeds)	2.39±0.01	1.61±0.02
3.	Hydration Index (%)	99.7±0.51	61.5±0.05
4.	Swelling Capacity (ml/1000 seeds)	0.11±0.01	0.21±0.01
5.	Swelling Index (%)	5.05±0.05	6.71±0.02
6.	Solubility Per gram (%)	5.5±0.65	30.8±1.05
7.	Water Absorption Capacity (g/g)	1.15±0.05	0.94±0.02
8.	Oil Absorption Capacity (g/g)	1.04±0.01	1.09±0.02

The bulk density of the two millets was 0.70g/ml and 0.440g/ml respectively of finger millet and little millet. Hydration capacity was more in finger millet (2.39g/100g) than little millet and swelling capacity was more in little millet (0.21ml/1000seeds) than finger millet (0.11ml/1000seeds). Hydration Index and Swelling Index was more in little millet (6.71%) than finger millet (99.7% and 5.05%). Solubility Per gram was more in little millet (30.8%) than pearl and finger millet. The water absorption capacity of millet was ranged from 1.27 ml/100g and 1.04ml/100g for finger millet. Oil absorption capacities of two millets were 1.04g/g and 1.09g/g respectively finger millet and little millet.

The swelling power and solubility of starch granules showed a great evidence of interaction on the starch chains between the amorphous and crystalline regions. When starch was subjected to heating in excess water, there is a relaxation of the crystalline structure and the groups of amylose and amylopectin associate with water molecules through hydrogen bonding. This causes an increase in the swelling power and the solubility of the granules (Hoover, 2001).

CHEMICAL COMPOSITIONS IN MILLETS

The chemical compositions of selected millets are given in Table 3.

Table 3- Chemical compositions of millets

S.no	Parameters	Finger millet	Little Millet
1.	pH	6.8 ±0.20	6.9 ±0.31
2.	Ash (g)	2.4 ±0.07	6.9 ±0.31
3.	Total titrable Acidity	0.28 ±0.001	24.6 ±0.71
4.	Moisture (%)	9.5 ±0.28	9.8 ±0.28
5.	Crude Protein (g)	8.8 ±0.26	13.6±0.39
6.	Crude Fibre (g)	5.0 ±0.14	5.0±0.14
7.	Carbohydrates (g)	75 ±2.21	65 ±1.89
8.	Fat (g)	3.9 ±0.11	1.9±0.05
9.	Energy (k.Cal)	370.3 ±10.90	331.5±9.66
10.	Total Starch (g)	16.32 ±0.48	18.5 ±0.53
11.	Amylose content (g)	10 ±0.29	28.4 ±0.82
12.	Sodium (mg)	9 ±0.26	16±0.46
13.	Potassium (mg)	258 ±7.59	347 ±10.12
14.	Iron (mg)	9.1±0.26	9.2±0.26
15.	Calcium (mg)	332 ±9.77	43±1.25
16.	Phosphorus (mg)	285± 8.39	265±7.72

The chemical compositions of selected millets are given in Table 3. The maximum moisture content of selected millets ranged from 9.5 to 8.88 g/100g. Kulkarni and Naik (2009) reported that proso millet recorded a high moisture content ranging from 10.60 to 15.00 per cent, followed by little, foxtail and kodo millet with values of 10.7, 11.5 and 10.2 per cent, respectively. Among the millets, the protein content was recorded to be same in finger millet 8.8 g/100g followed by little millet (8.2 g/100g). The average protein content in proso, little, kodo and foxtail millet were reported to be about 8.5, 9.5, 8.8 and 11.07 per cent respectively, with varietal differences within species as reported by several investigators (Veena *et.al.*, 2005). Among the millets the lowest fat content was observed to be 2.4 g/100g in peral millet followed by finger millets. Kumar and Parameshwaran (2006) found that foxtail millet recorded a fat content ranging from 2.3 to 5.9 per cent, followed by proso (2.1 to 5.2%), little (3.10 to 4.1 %) and kodo millet (1.1 to 3.3%).

Among the selected millets, the highest fibre content was recorded in finger millet and little millet (5 g/100g). Crude fibre content reported in kodo millet was 6.3 per cent, little millet was 5.73 per cent and proso millet was 5.51 per cent (Kulkarni *et.al.*, 2002). The highest total starch content of millet was recorded in little millet (18.5g/100g) than finger millet (16.32 g/100g). Kim et al. (2012) evaluated the amylose content of proso millet to be between 1.2 and 21.5 per cent. Starch content ranged from 84.4 to 85.67 per cent respectively. Higher levels of calcium iron and phosphorus was observed in all millets. It was inferred that that among the different millets, finger millet had the highest proportion of total minerals (332%). The ionisable iron content was 9.1mg in finger millet respectively. Similar range of values for iron and calcium in barnyard millet viz., 1.27 to 1.50 mg, and 20.31 to 32.78 mg/100 g respectively was reported by Veena *et al.* (2005).

Table 4 - Correlation co-efficient for the nutritional parameters in finger millet and little millet

Correlations								
	pH	**Ash (g)**	**Total titrable Acidity**	**Moisture (%)**	**Crude Protein (g)**	**Crude Fibre (g)**	**Fat (g)**	**Energy (k.Cal)**
pH	1	.776	.800	.933**	.786	.297	-.762	-.757
Ash (g)		1	.996**	.951**	1.000**	.543	-1.000**	-1.000**
Total titrable Acidity			1	.961**	.998**	.471	-.995**	-.995**
Moisture (%)				1	.956**	.456	-.944**	-.942**
Crude Protein (g)					1	.524	-.999**	-.999**
Crude Fibre (g)						1	-.543	-.548
Fat (g)							1	1.000**
Energy (k.Cal)								1

**. Correlation is significant at the 0.01 level (2-tailed).

The results of correlation of nutritional composition of millets were presented in Table 4. The moisture content was positively significant aginst pH, Ash and total tirable acidity. Crude protein content had the positive correlation against ash, titarable acidity and moisture content. The ash, titarable acidity, moisture and crude protein content were significant and negatively correlated with the fat content and energy content (Table 4). The correlation coefficients values varied from -1.000 to -0.999. There was a positive significant correlation between the fat content and energy content present in millet (1.000). Samathuran (1995) who obtained positive correlation between the number of productive tillers and grain yield in pearl millet from a study of yield in relation to population. In the present study, a negative correlation was observed between the number of productive tillers and panicle width, whereas positive correlation was recorded between the number of productive tillers and 1000-seed weight and grain yield.

Table 5- Correlation co-efficient for the in finger millet and little millet

Correlations										
	Bulk density - FM	**Bulk density - LM**	**Swelling Index (%) -FM**	**Swelling Index (%) -LM**	**Water Absorption Capacity (g/g) -FM**	**Water Absorption Capacity (g/g) -LM**	**Total starch -FM**	**Total starch -LM**	**Amylose content (g) -FM**	**Amylose content (g) -LM**
Bulk density - FM	1									
Bulk density - LM	-0.189	1								
Swelling Index (%) -FM	0.866	0.327	1							
Swelling Index (%) -LM	-0.866	0.655	-0.500	1						
Water Absorption Capacity (g/g) - FM	0.945	0.143	0.982	-0.655	1					
Water Absorption Capacity (g/g) - LM	0.000	0.982	0.500	0.500	0.327	1				
Total starch - FM	1.000**	-0.189	0.866	-0.866	0.945	0.000	1			
Total starch - LM	0.756	0.500	0.982	-0.327	0.929	0.655	0.756	1		
Amylose content (g) -FM	0.189	0.929	0.655	0.327	0.500	0.982	0.189	0.786	1	
Amylose content (g) - LM	0.945	0.143	0.982	-0.655	1.000**	0.327	0.945	0.929	0.500	1

**. Correlation is significant at the 0.01 level (2-tailed).

Regarding the correlation of physical characters and nutritional characteristics of finger millet and little millet were represented in table 5. Total starch content in finger millet showed a positive correlation against bulk density of finger millet at 0.01% level. Amylase content in little millet showed a positive correlation between water absorption capacities of finger millet at 0.01% level.

CONCLUSION

This investigation concluded that the selected two types of millets contained good sources of protein, fibre and minerals and had low fat content. Hence various innovative products may be developed to suit the consumer needs and also to achieve nutrition security. Both millets showed a great potential as well as a positive correlation between nutritional qualities, so these millets can be used in food industry either for the purpose of formulating new products or for the replacement in food products made from various conventional flour sources. There is also tremendous opportunity to develop functional food from such millets.

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