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Physico-chemical and nutritional composition of proso millet varieties

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Abstract

Millets are a group of small-seeded, annual grasses used for domestic purpose. In the present investigation two proso millet varieties (DhPM-2769 released from UAS Dharwad and Local Proso millet variety) were analyzed for the physico-chemical and nutritional composition using standard procedures. Results from study revealed that, significant difference existed between the two varieties for 1000 grain volume, hydration capacity and swelling capacity. Functional characteristics such as water and oil absorption capacity varied from 70.07 to 70.13 and 65.65 to 65.71 per cent respectively in DhPM-2769 and Local proso millet variety. Moisture and Ash content differed significantly between the local and DhPM-2769 proso millet variety and higher values for moisture (8.34%) and ash (1.66 g) contents were observed in DHPM-2769 proso millet variety. Protein, fat, crude fiber and carbohydrates in local and DhPM- 2769 variety varied from 13.09 to 13.96, 2.92 to 3.35, 2.37 to 2.66 and 73.12 to 77.33 g/100 g respectively. DhPM-2769 variety recorded higher protein (13.96 g) and crude fiber (2.66 g) content than Local Proso millet variety (Protein 13.09 g, Crude fiber 2.3g). Minerals such as iron, manganese, zinc and copper were found in the range of 3.65- 3.78 mg, 5.53-8.82 mg, 12.96- 13.33 mg and 4.45- 5.90 mg in the two varieties studied.

Keywords: Proso millet, physico-chemical, nutrient composition, mineral composition

1. Introduction

Millets are one of the oldest food grains known to mankind and possibly the first cereal grain used for domestic purposes. India is the top most producers of millets followed by Nigeria. In India, eight millet species (Sorghum, Pearl millet, Finger millet, Foxtail millet, Kodo millet, Proso millet, Barnyard millet and Little millet) are commonly cultivated under rain fed conditions. Millets have great potential for being utilized in different food systems by virtue of their nutritional quality and economic importance. The millets contain 7 - 12% protein, 2-5% fat, 65-75% carbohydrates and 15-20% dietary fiber.

Proso millet (*Panicum miliaceum*) is common and important minor millet belonging to the family Gramineae. This short duration millet variety is widely grown in India. It is specially adapted to hot summer in tropics and high altitudes, where the growing season is short and the soil is marginal and poor in fertility. Among grain crops, the common millet has the lowest water requirement; it grows on any kind of soil except coarse sand.

Functional properties have been defined as “Those physical and chemical properties that influence the behavior of proteins in food systems during processing, storage, cooking and consumption” (Kinsella, 1976). Therefore, the functional properties of food are important in food processing and food product formulation. These are important in determining the quality (nutritional, sensory, physico-chemical and organoleptic properties) of the final product as well as facilitating processing.

It also becomes equally important to investigate the nutritional difference existing among the varieties so that efforts could be made on identified genotypes and popularize for wider consumption. Hence the present investigation was undertaken with an emphasis to evaluate the “physico-functional, nutritional composition of proso millet varieties.

2. Materials and Method

A. Procurement of grains

The physical characteristics of Proso millet varieties

Proso millet variety DhPM -2769 was procured from seed unit, UAS, Dharwad and Local Proso millet variety was procured from local market of Dharwad. Dehulling of grains was

Carried out in a commercial mill fabricated for the dehulling of millets at Haveri. The bran, husk, whole seeds were separated in a mechanical sifter. Grains were cleaned manually and stored at ambient conditions for further estimations.

The physico-chemical and functional characteristics of the Proso millet such as weight, volume, bulk density, hydration capacity, hydration index, pH, titrable acidity, water and oil absorption capacity were studied using standard procedures. All the estimations were done in triplicates. The means of each triplicate values are represented in Table 1, 2, 3 & 4.

B. Physical Characteristics of Proso millet

The physical characteristics of the Proso millet such as weight, volume, bulk density, hydration capacity, hydration index, were done in triplicates. The means of each triplicate values are represented in Table 1.

1000- Seed weight (g)

Thousand seeds of each of the proso millet varieties were counted randomly in duplicate and weighed in an electric balance (Singh and Singh, 1998) [9].

Seed volume (William *et al.*, 1983) [11]

Thousand seeds were transferred to a 15 ml measuring cylinder and 5 ml demineralized water was added using a pipette. Seed volume (ml/seed) was calculated as below.

$$\text{Seed volume} = \frac{\text{Total volume} - 5}{1000}$$

Hydration capacity (William *et al.*, 1983) [11]

Hydration capacity was measured by placing weighed 1000 seeds into a flask and soaking in water overnight. Further, water was drained off and seeds were air dried and weighed. Hydration capacity was calculated as:

Hydration capacity = Weight after soaking - Weight before soaking

Hydration index (William *et al.*, 1983) [11]

Hydration index was calculated as:

$$\text{Hydration index (\%)} = \frac{\text{Hydration capacity}}{\text{Seed weight}} \times 100$$

Swelling capacity (William *et al.*, 1983) [11]

Swelling capacity was measured by adding 1000 seeds of known volume into a flask and soaked in water overnight. Subsequently water was drained off and seeds were air dried and displaced volume was measured in graduated jar.

Swelling capacity was calculated as

Swelling capacity = Volume after soaking - Volume before soaking

Swelling index (William *et al.*, 1983) [11]

Swelling index was calculated as

$$\text{Swelling index (\%)} = \frac{\text{Swelling capacity}}{\text{Swelling volume}} \times 100$$

Bulk density (g/ml)

The volume of 100 g of each sample (ml) was obtained by

gently pouring the grain into a 250 ml graduated cylinder. The values were expressed as g/ml (Bhattacharya and Pushpa, 2000) [2].

C. Chemical Characteristics of Proso millet

The chemical characteristics of the Proso millet such as pH and titrable acidity were done in triplicates. The means of each triplicate values are represented in Table 2.

Total titratable acidity (T.T.A)

Ten ml aliquots (triplicates) will be pipetted from the filtrate used for pH estimation and titrated against 0.1 M NaOH to phenolphthalein end point and the acidity will be calculated as per cent lactic acid (Anon, 2000).

D. Functional Characteristics of Proso millet

The functional characteristics of the Proso millet such as water and oil absorption capacity were studied using standard procedures. All the estimations were done in triplicates. The means of each triplicate values are represented in Table 2.

Water absorption capacity

To determine the water absorption capacity five gram of flour was weighed and added to pre-weighed centrifuge tube (W1). To this 30 ml of water was added and stirred with a glass rod for 5 min. The contents were allowed to stand for 30 min and then centrifuged at 11,000rpm for 25 min. The free liquid was passed off and the inner sides of the tube were wiped with tissue paper. The centrifuge tube was weighed again (W2). The water absorption capacity was calculated using following formula.

$$\text{WAC (\%)} = \frac{W_2 - W_1}{5} \times 100$$

Oil absorption capacity

To determine the oil absorption capacity one gram of flour was mixed with 10 ml oil (ground nut oil) in weighed centrifuge tube (W1). The tubes were stirred for 1 min for complete dispersion. Sample was centrifuged at 3000 rpm for 25 min. The separated oil was then removed and tubes were inverted on oil absorbent paper to drain the oil prior to reviewing (W2). The oil absorption capacity was calculated using formula.

$$\text{OAC (\%)} = \frac{W_2 - W_1}{1} \times 100$$

E. Estimation of proximate

Proximates such as moisture, protein, fat and crude fiber were analyzed using AOAC, 1980 procedures. All the estimations were done in triplicates. The means of each triplicate values are represented in Table 3.

F. Micronutrients (mg/100g): The trace elements (iron, zinc, copper and manganese) were estimated by wet digestion using triacid mixture. A known aliquot of test sample is diluted and micronutrients in the test sample (Fe, Zn, Cu and Mn) were determined using Atomic Absorption Spectrophotometer All the estimations were done in triplicates. The means of each triplicate values are represented in Table 4.

3. Results and Discussion

Physical characteristics of Proso millet varieties

Proso millet variety DhPM-2769, released from UAS,

Dharwad and Local Proso millet variety procured from local market of Dharwad were used for analysis. Between the two varieties Local Proso millet variety recorded relatively higher seed weight (4.67g) followed by DhPM-2765 (4.51g). However, the difference was not significant. 1000 seed volume was significantly higher in Local Proso millet variety (3.52 ml) when compared to DhPM -2769 (3.36 ml). The results are in accordance with the study conducted by Reddy *et al.*, (2019) who reported that mean weight of proso millet was 4.97 g, volume 4.63 and density 1.07 g/ml.

In a study reported by Shilpa *et al.*, 2019 slightly lower value for 1000 grain weight (2.20- 2.81g) and 1000 grain volume (1.00 to 2.50 ml) was noticed in foxtail millet cultivars. The mean bulk density ranged from 1.34 to 1.39 g/ml. Local Proso millet variety (5.53 ml) recorded significantly higher Hydration Capacity than DhPM-2769 (5.28 ml). Similarly the Hydration Index was found higher in Local Proso millet variety (118.41%) and lower being in the variety DhPM-2769 (117.07%). However, significant difference was not found between the varieties with respect to Hydration Index. Local Proso millet variety recorded significantly higher Swelling capacity (4.05 ml) compared to DhPM-2769 variety (3.83 ml). The mean swelling index was found to be 113.98 per cent in DhPM-2769 and 114.20 per cent in Local Proso millet variety in both the varieties. The high swelling index indicates that rice-wheat flour blend could be more suitable in food systems where swelling is required. The variation in physical properties may be due to varietal difference, growing condition of the crop, soil type, soil mineral content and

environmental conditions.

Removal of millet husk leads to loss of hydrophilic polysaccharides which decreases the water absorption capacity (Ghavidel and Prakash, 2006). Dehulling and debranning decreases the oil absorption capacity and this may be due to the fact that binding ability of the lipid depends on the surface availability of the hydrophobic amino acids (Kamara *et al.*, 2009). Swelling capacity and swelling index of little millet were 2.92 ml/1000 grains and 8.71 respectively. Swelling index of little millet was higher compared to proso millet and swelling capacity was lower compared to proso millet (3.36 ml /1000 grains) as stated by Roopa (2011). When starch was heated with excess water it relaxes the crystalline structure and the groups of amylase and amylopectin associate with water molecules through hydrogen bonding. This could be the reason for higher values of swelling power and solubility of the granules (Hoover, 2001). From the Proso millet colour value L* (Lightness), a* (redness) and b* (yellowness) values, it is clear that proso millet DhPM-2769 is lighter than the Local Proso millet, with less red and more yellowish in colour. The yellow colour of the proso millet may be due to presence of carotenoid pigments (Matangi *et al.*, 2013).

DhPM-2769 variety (7.13) recorded slightly higher pH than Local Proso millet (7.10). The mean oil absorption capacity ranged from 1.25 to 1.50 ml/g. higher being 1.50 ml/g in Local Proso millet variety and lower value was recorded in the DhPM-2769 Proso millet variety.

Table 1: Physical Characteristics of Proso millet varieties

Variety	1000 Grain Weight (g)	1000 Grain Volume (ml)	Bulk Density (g/ml)	Hydration Capacity (g/1000 grains)	Hydration Index (%)	Swelling Capacity (ml/1000 grains)	Swelling Index (%)	Colour		
								L*	a*	b*
DHPM-2769	4.51±0.11	3.36±0.04	1.34±0.02	5.28±0.04	117.07±2.0	3.83±0.04	113.98±0.01	76.14±0.75	6.56±0.05	31.57±0.19
Local Proso millet	4.67±0.13	3.52±0.04	1.39±0.04	5.53±0.02	118.41±3.0	4.05±0.04	114.20±0.02	76.09±0.83	5.18±0.00	28.73±0.00
t-test	1.62 (NS)	4.89*	1.93(NS)	9.68**	0.64(NS)	6.73**	1.84(NS)	0.10 (NS)	53.26*	2.75 (NS)

*significant at 5% level, ** significant at 1% level, NS- Non significant

Table 2: Chemical and Functional characteristics of Proso millet varieties

Variety	Chemical characteristics		Functional characteristics	
	pH	Total titratable acidity	Water absorption capacity (%)	Oil absorption capacity (%)
DHPM-2769	7.13 ±0.06	2.15±0.38	70.07 ±0.02	65.65±0.49
Local Proso millet	7.10±0.01	3.60±0.15	70.13±0.25	65.71±0.21
t-Test	1(NS)	6.18*	0.31(NS)	0.76(NS)

*significant at 5% level, ** significant at 1% level, NS- Non significant

The observations on chemical (pH, Total titratable acidity) and functional (water and oil absorption capacity) characteristics of proso millet varieties are presented in Table 2. Under the functional properties, water absorption capacity and oil absorption capacity were measured and the observed values are reported in Table 2.

The chemical characteristics such as pH and total titratable acidity of the proso millet varieties were found to be 7.10-7.13 and 2.15 to 3.60, respectively. However, higher pH (7.13) was observed in DhPM-2769 whereas, total titratable acidity was observed higher in Local Proso millet variety (3.60). Statistically significant difference was observed for total titratable acidity at five per cent level.

Study of functional characteristics indicates the suitability of grains for processing and product development. Water absorption capacity varied from 70.07 to 70.13 per cent and

was highest in the Local Proso millet variety (70.13%) as compared to other variety. The mean oil absorption capacity ranged from 65.65 to 65.71 per cent. Higher capacity being 65.71 per cent in Local Proso millet variety and lower value was recorded in the DhPM-2769 (65.65%). The results of water absorption capacity were similar to the findings of Ramashia *et al.*, (2018) of Finger millet flours ranging from 0.93 ± 0.06 to 1.23 ± 0.06 mL/g. However, in a study reported by Siroha *et al.* (2016) water absorption capacity (WAC) of the pearl millet flours ranged from 153 to 177.

Proximate Composition of Proso millet

Macro and micro nutrients such as moisture, fat, ash and minerals were analyzed and the results are depicted in Table 3. Moisture contents were ranged from 8.04 to 8.34 per cent significantly higher moisture content was recorded in DhPM-

2769 (8.34%) while, lowest moisture content was recorded in Local Proso millet variety (8.04%). Analysis of proso millet varieties for moisture content showed significant difference at 5 per cent level. Zhang *et al.*, 2014 ^[12] recorded a high moisture content ranging from 7.96 to 9.63 per cent in proso millet cultivars.

The fat content of prosomillet varieties ranged between 2.92 and 3.35 g/100g. Higher fat content was recorded in Local Proso millet variety (3.35 g), while lowest fat content was recorded (2.92 g) in DhPM-2769 variety. In a study conducted by Zhang *et al.*, 2014 ^[12] fat content were reported to be 3.64 to 4.40g which was found slightly higher than the present study.

Protein content in proso millet variety DHPM-2769 found to be 13.96 g similarly in Local Proso millet variety it as found to be 13.09 g per 100 g of the sample. However statistically it was found non-significant. Slightly lower values (*i.e.*10.54 to 11.62g) for protein were observed in Proso millet cultivars a study conducted by Zhang *et al.*, 2014 ^[12].

Crude fibre was found higher in DHPM-2769 variety with 2.66g and in Local Proso millet variety it was found to be 2.37 g per 100g similarly carbohydrate contents in proso millet varieties did not vary significantly, in DHPM-2769 it is reported to be 73.12 and in Local Proso millet variety it was found to be 77.33 Kcal.

Between the two prosomillet varieties, ash content was ranged from 1.53 to 1.66 g/100g. DhPM-2769 (1.66 g) recorded

significantly higher ash content and Local Proso millet variety recorded lower (1.53 g) ash content. Statistical analysis carried out showed a significant difference between the two varieties at five per cent level.

Similar results were obtained in the study of Thilagavathi *et al.*, (2015) ^[10] who reported that moisture, fat, fiber, ash and total carbohydrate content were 11.75g, 3.78g, 4.87g and 64.84g respectively.

The micronutrients/ minerals such as iron, manganese, zinc and copper were found in the range of 3.65-3.78 mg, 5.53-8.82 mg, 12.96-13.33 mg and 4.45-5.90 mg respectively. Significantly higher values for manganese (8.82 mg), and copper (5.90 mg) were recorded in Local Proso millet variety: while DhPM-2769 variety recorded higher values for iron (3.78 mg) and Zinc (13.33 mg). Proso millet is rich source of zinc. Consumption of 50 g of proso millet will meet half day requirement of the zinc for adult (6.66 mg/ day). Kalinova (2007) reported that proso millet is rich in iron, potassium, phosphorus and it is poor in calcium. According to Kalinova (2007) and Dendy (1995) proso millet contains 156 – 230 mg per cent of phosphorus, 78 – 140 mg per cent of magnesium, 8.20 mg per cent of calcium, 0.80 – 5.20 mg per cent of iron, 1.40 – 2.60 mg per cent of zinc. However the present results are on par with the above investigation. The variation in mineral content may be due to the varietal difference, growing condition of the crop.

Table 3: Proximate Composition of Proso millet varieties

Variety	Moisture (%)	Protein (g)	Fat (g)	Crude fiber (g)	Carbohydrate (Kcal)	Ash (g)
DHPM-2769	8.34±0.03	13.96±1.84	2.92±0.60	2.66±0.45	73.12±2.48	1.66±0.02
Local Proso millet	8.04±0.13	13.09±3.51	3.35±0.14	2.37±0.28	77.33±3.45	1.53±0.02
t-Test	3.99*	0.37(NS)	1.23(NS)	0.95 (NS)	1.71(NS)	7.96*

*significant at 5% level, ** significant at 1% level, NS- Non significant

Table 4: Mineral composition of Proso millet varieties

Variety	Fe (mg)	Mn (mg)	Zn (mg)	Cu (mg)
DHPM-2769	3.78±0.17	5.53±0.35	13.33±2.40	4.45±0.49
Local Proso millet	3.65±0.33	8.82±0.19	12.96±0.28	5.90±0.48
t-Test	0.58 (NS)	14.22**	0.26(NS)	3.64*

*significant at 5% level, ** significant at 1% level, NS- Non significant

4. Conclusion

From the results of the study it is clear that both the proso millet varieties are good source of protein and zinc. Proso millet variety DHPM-2769 had slightly higher values for zinc (13.33). Whereas other minerals were found on par with that of Local Proso millet variety. Hence variety DHPM-2769 with good amount of zinc can be exploited and popularized among the consumers in order to get health benefits.

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