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Physical, functional and cooking properties of PRSW 43 finger millet

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Abstract
The knowledge of some physical, functional and cooking properties of millets is an important tool for designing agricultural machines and equipment for planting, harvesting, processing, developing novel products, packaging, and storage. In the present study PRSW 43 finger millet can easily transported and stored because of its weight and volume i.e., 1.82g and 1.4ml per 1000grains respectively. Also the grain was too small which has a thickness of 1.30mm. The grain was white in color, the L, a* and b* values are 61.18, 3.20 and 25.47 respectively, it was suitable for bakery and confectionery products and the children can easily accept this millet as the normal finger millet was dark in color. The husk percentage was low compared to other millets i.e., 6.33% and the grain was strong as there was minimal breakage during milling. Bulk density is a function of the closeness of packaging, bulk density of PRSW 43 finger millet was observed as 0.76g/ml. The grain has high gelatinization temperature that is 90̊C, so the beverages prepared from this grain can withstand pasteurization without any change in structural composition.

Keywords: PRSW 43 finger millet, physical properties, functional properties, cooking properties, color, thickness, husk percentage, bulk density, gelatinization temperature.

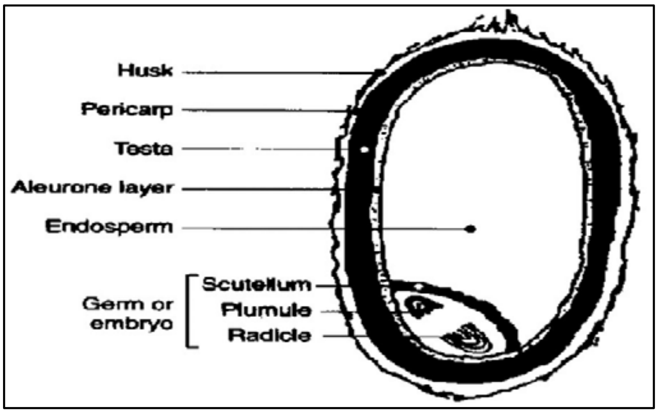
Introduction

Millets have great importance for food and nutrition security among increasing agricultural costs, climate change and growing mouths to feed world population. Millets are highly nutritious, they have various health benefits, require very less costs for cultivation and are able to tolerate biotic and abiotic stresses (Bandyopadhyay *et al*., 2017) [1].

'Millet' is a generic term for a heterogeneous group of Poaceae (Gramineae) forage grasses recognized for their small-sized coarse grains. (Weber and Fuller, 2008) [2]. It was derived from the French word 'mille' which means thousands, literally meaning that thousands of grains are available as a handful of millet (Taylor and Emmambux, 2008) [3].

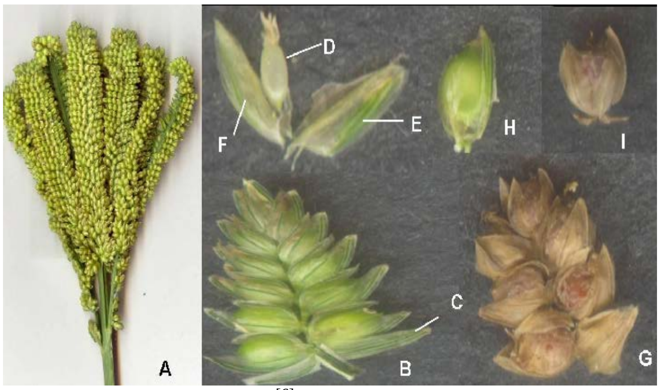
Finger millet is the common English name of the *Eleusine coracana* (L.) *Gaertn*. seed, a domesticated African cereal that spreads to Asia in prehistory, also sometimes referred to as coracan or ragi (in India a common local name) or dagusa (in Ethiopia). Its common English name derives from the growth shape of its seed heads (panicles) in the form of many fingers. In eastern and central Africa, India and Sri Lanka, this cereal is widely cultivated and spreads eastward through the Himalayas to southern China, the hills of south-east Asia and the hills of Taiwan, and parts of Indonesia and Guam.

The key botanical components of the millet kernel are the seed coat, the embryo (germ), and the endosperm. Yellow, white, tan, red, brown, or violet colored varieties are available; however, only red-colored varieties are widely grown worldwide. Compared to other millets, such as sorghum, pearl millet, proso millet, and foxtail millet, the seed coat or testa is multi-layered (five layered), which is unusual and may be one of the possible explanations for the higher dietary fiber content in finger millet (FAO 1995) [4].



Source: (Ramashia 2018) [5]

Fig 1: Structure of finger millet grain.



Source: (Gupta *et al*., 2012) [6]

Fig 2: Inflorescence and spikelet of finger millet. (A) Inflorescence; (B) Spikelet of finger millet; (C) Outer glume; (D) Ovary; (E) Lemma; (F) Palea; (G) Matured spikelet; (H) Grain with in lemma and palea; (I) Matured grain with in lemma and palea.

An attempt was made to study some of the physical, functional and cooking parameters for finger millet (PRSW 43)-white ragi, developed by RARS-Palem, PJTSAU, Mahabubnagar district of Telangana state.

Fig 3: PRSW 43 Finger millet

Material and methods

I. Physical and functional properties

Physical properties are necessary for the design of equipment to handle, transport, process and store the crop. Functional properties are the essential physicochemical properties of foods that reflect the complex interactions between the structures, molecular conformation, compositions, and physicochemical properties of food components with the nature of the environment and conditions in which these are measured and associated.

The physical and functional parameters include: color (Hunter Lab, 2013) [7], 1000 grain weight (Sahay and Singh, 2005) [8], 1000 grain volume (Kamatar *et al*., 2013) [9], Hydration capacity of thousand grains (Williams *et al*., 1983) [10], Swelling capacity of thousand grains (Williams *et al*., 1983) [10], Thickness (AACC, 2000) [11], Bulk density (Stojceska *et al*., 2008) [12], Tapped density (Narayana and Narasinga) [13], Solid content of uncooked PRSW 43 finger millet (Hossain *et al*., 2019) [14], Milling yield (Lohani *et al*., 2012) [15].

II. Cooking properties

The cooking quality of PRSW 43 finger millets was analysed using Elongation ratio (Sidhu *et al*., 1975) [16], Volume expansion ratio (Sidhu *et al*., 1975) [16], Cooking time (Wani *et al*., 2013) [17], Water uptake ratio (Subedi *et al*., 2016) [18], Gruel solid loss (Hamid *et al*., 2016) [19], Equivalent weight of cooked PRSW 43 finger millets (Hossain *et al*., 2019) [14], Solid content of cooked PRSW 43 finger millet (Hossain *et al*., 2019) [14], Alkali degradation (Bhattacharya and Sowbhagya, 2007) [20], Gelatinization temperature (Juliano *et al*., 2009) [21].

Results and discussion

Colour- L*, a* and b* were directly read. It was considered that the CIELAB uniform space in which two colour coordinates, a* and b* as well as a psychometric index of lightness, L* were measured. L* indicated luminosity and extended from 0.0 (black) to 100.0 (white). The other two coordinates a* and b* represented redness (+a* value) to greenness (-a* value) and yellowness (+b* value) to blueness (-b* value) respectively. The L value of PRSW 43 finger millet was 61.18, positive values obtained for coordinates a* and b*; a* value was 3.20 and b* value was 25.47. The positive values for a* and b* coordinates indicate that all samples had varying concentration of red and yellow pigmentation in their grains. similar findings were observed by Ramashia *et al*. (2018) [5] in milky white finger millet where L* value was 52.97, a* value was 3.77 and b* value was 19.38.

The 1000 kernel weight is a measure of seed size. It is the weight in grams of 1,000 seeds. Seed size and weight can vary from one crop to another, between varieties of the same crop and even from year to year or from field to field of the same variety. Because of this variation in seed size, the number of seeds and, consequently, the number of plants in a pound or a bushel of seed is also highly variable. By using the 1000 kernel weight, a producer can account for seed size variations when calculating seeding rates, calibrating seed drills and estimating shattering and combine losses. Generally, higher thousand kernel weight values are positively related to potential flour extraction or yield, because this property is closely related to grain size and proportion of endosperm to germ and pericarp tissues (Serna-Saldivar 2010) [22]. The 1000 kernel weight of PRSW-43 finger millet was very low i.e., 1.82±0.30g. The 1000 seed weight of raw finger millet genotypes reported by Kumari and Srivastava (2000) [23] ranged from 2.42 to 3.23g. Similarly the 1000 seed volume of raw finger millet varieties ranged from 2.2 to 12.9 ml as reported by Hadimani and Malleshi (1995) [24] but the 1000 seed volume of PRSW-43 finger millet was 1.4±0.10ml which are in tune with the findings of Soubhagyalaxmi *et al*. (2019) [25].

Bulk density is defined as weight of seeds per unit volume, often expressed as g/ml, and is a good index of structural changes of seed (Sreerama *et al*., 2009) [26]. The 1000 grains weight indicated the density of grains and was directly related to bulk density (Rao *et al*., 2019) [27]. The bulking properties of a seeds are dependent upon the preparation, treatment and storage of the sample. The particles can be packed to have a range of bulk densities and, moreover, the slightest disturbance of the seeds may result in a changed bulk density.

The tapped density is an increased bulk density attained after mechanically tapping a container containing the sample. The tapped density was obtained by mechanically tapping a graduated measuring cylinder or vessel containing the sample. After observing the initial seed volume or mass, the measuring cylinder or vessel is mechanically tapped, and volume or mass readings are taken until little further volume or mass change is observed. The mechanical tapping is achieved by raising the cylinder or vessel and allowing it to drop, under its own mass, at a specified distance. Tapped density along with bulk density can be used to measure anatomy and packing of grains for transportation and storage. (Singh and Goswami, 1996) [28]. The bulk and tapped densities of PRSW 43 finger millet was 0.76±0.03 and 0.84 respectively.

Hydration capacity is determined as the maximum amount of water that 1g of material will imbibe and retain under low speed centrifugation. A study conducted by Vidhyavati (2001) [29] reported that hydration capacity of different finger millet varieties in raw samples ranged from 0.82 to 1.45. The hydration capacity of PRSW-43 finger millet was 1.03 and swelling capacity was 0.8 which is par with the findings of Mushtari *et al*, (2017) [30] i.e., 0.7 to 1.19. Decortication was generally done to the extent of removing 12-30% of the outer grain surface. Decortication of grains significantly reduce phytic acid, tannins, amylase inhibitors and polyphenols with resultant increase in protein, starch digestibility and mineral availability (Malleshi and Klopfenstein, 1998) [31]. It also lowers the hardness value, cooking time and augmented the edibility and sensory properties of various food grains (Rani *et al*., 2018) [32]. Cooking the grains with outer bran layer increases the vapour pressure inside the grain and made them burst consequently enhancing the gruel solid loss (Patil and Khan, 2012) [33].

Table 1: Physical, functional and cooking properties of PRSW 43 finger millet

Characteristics	Results
1000 grain weight (g)	1.82±0.30
1000 grain volume (ml)	1.4±0.10
Hydration capacity (g)	1.03±0.03
Swelling capacity (ml)	0.8±0.00
Bulk density (g/ml)	0.76±0.03
Tapped density (g/ml)	0.84±0.00
Milled grain percentage	93.67±0.24
Husk percentage	6.33±0.15
Thickness of milled grain (mm)	1.30±0.08
Elongation ratio	1.28±0.01
Volume expansion ratio	0.78±0.03
Water uptake ratio	2.54±0.02
Gruel solid loss	1.21±0.04
Solid content of uncooked millet (g)	89.29±0.16
Solid content of cooked millet (g)	159.94±0.82
Equivalent weight (g)	255.59±0.71
Alkali degradation score	0 i.e., nil
Gelatinization temperature	90̊C
Cooking time	30 minutes

Note: Values are expressed as mean ± standard deviation of three determinants

However, excessive decortication lead to greater loss of fiber, fat, protein, vitamin and mineral contents that were predominantly found in bran portions of grain. Research and development efforts are still needed to develop improved dehulling technologies that enhances milling efficiency of minor millets, which are minute in size with outer firm bran portions (Rai *et al*., 2008) [34]. Milling yield and husk percentage of PRSW 43 finger millet was 93.67±0.24 and 6.33±0.15 respectively. Cooking quality refered to time required to cook and rapid cooking was considered beneficial, as the grains will not be exposed to high temperature for long duration of time resulting in protein degradation (Gai, 2003) [35]. The cooking time was also vital in determining the tenderness of cooked grains and stickiness to a great extent. The time taken for cooking of PRSW 43 finger millet was 30 minutes, the gruel solid loss after cooking was observed as 1.21±0.04.

Elongation ratio was the difference in length of the grain before and cooking, Mushtari *et al*. (2017) [30] reported that the kernel elongation ratio of decorticated finger millet was 1.66 and the elongation ratio of PRSW-43 finger millet was 1.28. Water uptake ratio of Finger millet-rice was 2.7 and water uptake ratio of PRSW-43 finger millet was 2.54 which is tune in the findings of Mushtari *et al*. (2017) [30]. Ramashia *et al*. (2018) [5] reported that the thickness of finger millets were ranged from 1.35 ± 0.06 mm to 1.22 ± 0.01 mm. Thickness of the PRSW-43 finger millet variety was 1.30±0.08.

Volume expansion ratio PRSW-43 finger millet was 0.78±0.03. The higher the volume expansion ratio of grain, lower was the energy content per unit volume or weight of cooked grain as they will have more water and less solid materials (Binodh *et al*., 2006 [36]; Sarmah *et al*., 2017) [37]. Solid content of uncooked PRSW 43 finger millet grain was 89.29±0.16 and solid content of cooked grain was increased to 159.94±0.82 due to absorption of water during cooking. Equivalent weight was noticed as 255.59±0.71.

The gelatinization temperature of amylose was commonly estimated using alkali degradation to get an idea. The higher the alkali degradation, the lower was gelatinization temperature (Zhao *et al*., 1988) [38]. The alkali degradation score for PRSW-43 finger millet was 0 i.e., kernel was unattacked or one- or two-minute cracks in one edge, which means the millet was strong enough to withstand pressure during milling. Gelatinisation is the melting of the crystalline region of starch granules. The gelatinization temperature represented the structural stability of starch molecules (Sharma *et al*., 2018) [39], in the cooking or baking process, it is the stage where starch granules swell and absorb water, becoming functional. The gelatinisation temperature was observed as 90̊ C for PRSW 43 finger millet, so the beverages prepared can be subjected to pasteurization temperature without making the beverage thick.

Conclusion

PRSW 43 finger millet can be used by food processors for the development of the new food products that can also be consumed in urban areas especially by people who suffer from chronic diseases. The information from this study can be used by agricultural engineers, food engineers, food processors and food scientists. The information is potentially useful in the designing of equipment which is suitable for planting, harvesting, storage, processing and packaging of grains and flour. Moreover, the size and shape properties of the grains need to be known by manufacturers as they contribute in designing better equipment suitable for grain and other food processing operations. Therefore, data obtained on the physical, functional and cooking properties of grains may measure the quality of grains used to produce novel food products.

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