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RESEARCH ARTICLE

DETERMINATION OF IMPORTANT PHYSICAL PROPERTIES AND WATER ABSORPTION CAPACITIES OF FOURTRADITIONAL PADDY VARIETIES IN SRI LANKA

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ABSTRACT

Four Sri Lankan traditional paddy varieties (*Unakola samba, Suduru samba, Rathna samba and Kahamaala*) were subjected to an experiment to determine physical properties and water absorption capacities. Physical Properties such as dimensions and grain masses were measured using laboratory test methods. Whereas other properties were calculated based on relationship equations. Major dimensions (Length, Width and Thickness), 1000 grain weight, geometrical mean diameter, surface area, volume, sphericity and aspect ratio were significantly different ($p<0.05$) among paddy varieties. While similar physical properties ($p>0.05$) were also observed. Water absorption capacities were investigated by steeping paddy samples in water, controlled at 70 ^{0}C. Respective samples, having different holding times, were drawn timely for the moisture analysis. As a result of steeping, moisture contents of paddy samples had been increased to various levels ($p<0.05$). Although rapid moisture increment was observed at the initial stage of steeping. Subsequently, rate of absorption was declined by reaching to the equilibrium where the hydration rate was insignificant ($P>0.05$). All paddy varieties reported their highest water absorption capacities after 5 hours of steeping and were ranged from 28.22% to 30.97% (wet basis). While *Unakola samba, Suduru samba and Kahamaala* recorded the highest water absorption, there was no significant difference ($P>0.05$) between these three varieties in water absorption. The varietal differences and steeping time were significantly influenced ($P<0.05$) on water absorption capacities in paddy.

KEY WORDS: Traditional paddy varieties, Water absorption capacities, Equilibrium state, Hydration rate, Steeping

INTRODUCTION

Since ancient eras, Sri Lankans has used to cultivate different indigenous traditional paddy varieties (*Oryza Sativa* L.), in order to fulfill their dietary requirement. Usually paddy is rich in macro nutrients such as carbohydrates, proteins, fats, and micronutrients, namely minerals and vitamins that vital for healthy living (Ejebe, 2013). Sri Lankan traditional paddy types are more eminent owing to its unique medicinal, organolaptic and cultivating features in addition to their nutritional value. Therefore, at present, most paddy farmers in Sri Lanka moving to cultivate traditional paddy varieties parallel to the demand built up within local and international market. Morphological properties of any type of paddy variety are an important tool for designing equipment for the purpose of harvesting and post harvesting activities like dehulling, drying, handling as well as storing (Bashar *et al.*, 2014). Improperly designed machineries and faulty operations could be effected on physical quality of paddy by creating cracks and breakage consequently reduce the marketing Value (Ghadge and Prasad 2012). Steeping of paddy is common practice and is a critical step in parboiling process because it is essential for completing gelatinization of starch and changing the composition and distribution of nutrients within grains simultaneously (Otegbayo *et al.*, 2001; Sareepuang *et al.*, 2008; Mir and Bosco, 2013, Kale *et al.*, 2015). Quantitative data on hydrating treatments are useful in finding the effect of process variables, optimizing processes and designing processing equipments accordingly. (Taiwo *et al.*, 1998; Abu-Ghannam and McKenna 1997a; Verma and Prasad, 1999; Bhattacharya, 1995). Aim of this study is to quantify water absorption capacities and physical properties such as thousand grains weight, axial dimensions, geometrical mean diameter (G.M.D.), surface area, volumes, sphericity and aspect ratio of four Sri Lankan traditional paddy varieties.

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MATERIALS AND METHODS

Samples Preparation

Twenty five kilo grams of, commercially available four traditional paddy varieties, known as *Kahamaala, Rathna samba, Suduru Samba* and *Unakolla Samba* were purchased from paddy suppliers and impurities of these paddy such as dirt, husk, immature or broken seeds, stones and other particles were removed and shade dried. Dried paddy was packed in polypropylene bags and stored in-house conditions (28-30^{0}C/R.H. 70-75%). A portion of paddy sample was drawn for the experiment from each paddy variety.

Determination of Physical Properties

The major dimensions of paddy were determined by measuring three major axial dimensions, length (L), width (W) and thickness (T) of randomly selected 100 grains of each type using dial type thickness Indicator having the resolution of 0.01 mm. According to the methods stated in (Sadeghi *et al.*, 2010), thousand-grain mass of paddy varieties were determined by selecting 100 grains randomly and weighing by using digital electronic balance (OHAUS-PA214) with the accuracy of 0.0001 g. These measurements were repeated ten times for each variety and final readings were multiply by 10 to give the mass of 1000 grains (Nalladulai *et al.*, 2002). The important physical properties were calculated using measured dimensions according to the given equations; Geometric Mean Diameter (D_e)- (1) and the Sphericity (S_p) -(2) as describe in Mohsenin (1986) ; The Surface area (S)- (3) as stated in McCabe *et al.* (2005); Grain volume (V)- (4) according to Jain and Bal (1997) and The Aspect ratio (R_a)-(5) as given in Varnamkhasti *et al.* (2008).

$$D_e = (LWT)^{\frac{1}{3}} \quad \text{.......................} (1)$$

$$S_p = (LWT)^{\frac{1}{3}}/L \quad \text{.......................} (2)$$

$$S = \pi D_e^2 \quad \text{...............} (3)$$

$$V = 0.25[(\pi/6)L(W+T)^2] \quad \text{........} (4)$$

$$R_a = W/L \quad \text{..............................} (5)$$

Where, L is the length (mm), W as the width (mm) of the paddy and T represents the paddy thickness (mm).

Determination of Moisture Absorption Capacity

Experiment was designed based on previous studies of Kashaninejad *et al.* (2007); Mir and Bosco (2013); Resio *et al.* (2005); Palipane and Valance (1977), with few modifications. About 10g of paddy from each variety were placed separately in dry clean boiling tubes containing equal volumes of distilled water (volume ratio, 3:1/Water : Paddy) which were already preset to the desired temperature ($70^0C \pm 0.5$) in the thermostatic water bath (Gallenkamp-BKS350). Triplicate measurements were taken from each paddy variety. Paddy grains were periodically removed, during hot steeping, initially starting from 30min and thereafter 1hr time intervals up to five hours. Then wet grains were allowed to drain out excess water and sample was quickly blotted three-four times with filter paper until the superficial water was removed. Then the grains were transferred to a clean dry metal container with a lid and reweighing was done using the same balance (0.0001 g). At the same time, moisture contents of paddy varieties were determined based on (AOAC, 2000) using triplicates from each variety.

RESULTS AND DISCUSSION

Physical properties

Kahammala, Rathna Samba (Ma Vee), *Unakola samba* and *Suduru Samba* are popular as white rice strains with superior flavor profiles. The major axial dimensions and thousand grains weight of these paddy varieties are given in Table 1. According to the data given in table 01, highest values for length, width and thickness were reported by *Kahamaala* and lowest dimensions given by *Suduru samba*. Generally, major three dimensions were significantly different ($p<0.05$) among these four paddy varieties except the thicknesses of *Rathna samba* and *Unakola samba*. Highest value for thousand grain mass was given by *Kahamaala* and lowest grain mass was reported by *Suduru samba*. The thousand grain weights of all paddy varieties were also significantly different ($p<0.05$) to each other. Major axial dimensions of paddy grains are useful in selecting meshes for sieve separators and in calculating power requirement during the rice milling process. Thousand grain mass is used for calculating the head rice yield and in designing of paddy/rice cleaners, using aerodynamic forces (Ghadge and Prasad, 2012; Zareiforoush*et al.*, 2009). Calculated Physical properties such as geometrical mean diameter (G.M.D.), Surface area, Volumes, Sphericity and Aspect ratio are tabulated in Table 2. According to the table 2, although most parameters were significantly different ($p>0.05$) among the varieties, volumes, surface areas and aspect ratios were not significant ($p>0.05$) between *Rathna samba* and *Unakola samba*. Highest values for geometric mean diameter (G.M.D.), surface area and volumes were reported by *Kahamaala*. Lowest values for above three parameters were provided by *Suduru samba*. The highest sphericity was reported from *Unakola samba*, while lowest had with *Kahamaala*. While both *Rathna samba* and*Unakola samba*gave the highest aspect ratios ($p<0.05$). The lowest was recorded by *Suduru samba*.

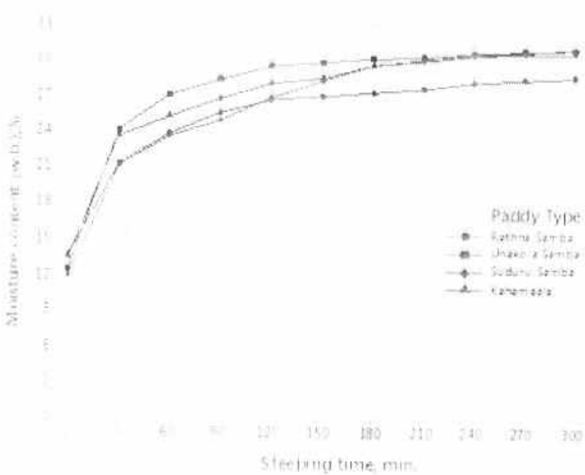

Figure 1. Moisture absorption capacities of *Rathna samba*, *Unakola samba*, *Suduru samba* and *Kahamaala* at 70 ^{0}C

The surface area is a tool for determining the shape of the seeds and it is an indication of the behaviour of kernels on oscillating surfaces during processing (Ghadge and Prasad, 2012; Alonge and Adigun, 1999). The G.M.D. is useful in estimating projected area of a grain. Projected area is supportive to recognize the grains behaving pattern in a flowing fluid (air) as well as the conveniences of separating extraneous materials from the grains during cleaning by pneumatic means (Omobuwajo *et al.*, 1999). Aspect ratio and sphericity indicates a tendency to either roll or slide in which

Table 1. Dimensions and thousand grain mass of four Sri Lankan traditional paddy varieties (*Kahamaala, Rathna samba, Unakola samba and Suduru samba*)

Traditional Paddy Variety	Length(mm)	Width(mm)	Thickness(mm)	1000 grain mass(g)
Kahamaala	7.89±0.11^{a}	2.90±0.17^{a}	2.07± 0.12^{a}	22.80±0.55^{a}
Rathna samba	6.22±0.11^{b}	2.61±0.19^{b}	1.78± 0.12^{b}	14.74±0.45^{b}
Unakola samba	6.03±0.35^{c}	2.54±0.15^{d}	1.79±0.09^{b}	14.08±0.28^{d}
Suduru samba	5.78±0.32^{d}	2.02±0.15^{e}	1.65±0.15^{c}	9.72±0.11^{c}

Table values are the mean ± SD of replicates. Values in the same column, shear same superscript letters, are not significantly different (P >0.05).

Table 2. Physical parameters of Geometrical Mean Diameter (GMD), Surface area, Sphericity, Volume, Aspect ratios for *Kahomaala, Rathna samba, Unakola samba and Suduru samba*

Paddy Variety	G.M.D (mm)	Surface area(mm^{2})	Sphericity	Volume(mm^{3})	Aspect ratio
Kahamaala	3.61 ± 0.21^{a}	41.12±4.63^{a}	0.46±0.00^{d}	25.64 ±4.26^{a}	0.37±0.01^{b}
Unakola Samba	3.25 ± 0.18^{b}	28.65±3.00^{c}	0.50±0.01^{a}	14.93 ±2.31^{b}	0.42±0.01^{a}
Rathna Samba	3.07 ± 0.20^{c}	29.06±2.80^{b}	0.49±0.00^{b}	15.86 ±2.94^{b}	0.42±0.01^{a}
Suduru Samba	2.68 ± 0.16^{d}	22.59±2.82^{c}	0.46±0.01^{c}	10.28 ±2.00^{c}	0.35±0.02^{c}

Table values are the mean ± SD of replicates. Values in the same column, shear same superscript letters, are not significantly different (P >0.05).

necessary for designing hoppers for the milling process. Lower the values of aspect ratio and sphericity generally indicate a likely difficulty in getting the kernels to roll than that of spheroid grains. (Ghadge and Prasad, 2012). However, all physical properties, measured of a grain, can be altered with the variations in moisture content (Bashar *et al.*, 2014).

Moisture absorption pattern of different paddy varieties

As explained by Lee and Rogers (1983); Luh and Mickus (1980) & Palipaneand Vellanki (1977), steeping was carried out below the temperature range of gelatinization ; because this temperature would facilitate to minimize irreversible swelling , solid leaching due to grains splitting and enhancing the rapidity of water uptake (Danbaba *et al.*, 2014 ; Ahromrit*et al.*, 2005). The amount of water absorbed by the grains during steeping is influenced by several factors. For instance, initial moisture content, varietal differences (physical and chemical composition), steeping time, pH and temperature of the water (Ejebe, 2013). Initial moisture contents of *Rathna samba, Unakola samba, Suduru samba* and *Kahamaala*were found as 13.55±0.11%, 12.44±0.07%, 11.92±0.27% and 13.58±0.13% (wet basis)respectively. Afterwards, the moisture contents of above paddy varieties had been increased to different levels (p<0.05) at different steeping time periods. As well as, despite of initial moisture contents, most paddy varieties were obtained almost similar moisture contents at the end of steeping process. For further clarifications, graphs were plotted for moisture absorption pattern (%) versus steeping times for four of traditional paddy varieties as illustrated in Figure 01. According to the Figure 01, a common pattern could be observed for moisture absorbing in all four paddy varieties. The graphs (Fig.01) clearly indicate, at first 30 minutes in steeping treatment, all paddy varieties displayed rapid moisture increment. In other words,the highest rate of hydrationwere reported at the first half an hour of the steeping. In this point,*Unakola samba* and *Kahamaala* indicated highest hydration rates than other two varieties. Thereafter, from 30min to 240min of steeping, the rapidness of moisture gaining was declined progressively. Even if the moisture levels were increased significantly (p<0.05). Studies of Palipane and Vellanki (1977) have revealed, that the rate of water diffusion into the grain is driven by the vapour pressure gradient between outer and inner periphery of the grain. Water enters the grain matrix via natural capillaries in the outermost layers of the grain (Becker, 1960). Slight swelling of grains by reason of hot soaking, are also created some paths for penetrating water into the grain (Palipane and Vellanki, 1977). As hydration proceed water content increases steadily and with the weakening of driving force, absorption rate decreases (Resio *et al.*, 2005). However, at the final stages (240min. to 300min.), moisture contents of most paddy verities were remained constant (p>0.05) by attaining equilibrium state with the water medium. Achieving of an equilibrium state was resulted the neutralization of net water movement through the grain structure. Saturation of starch granules with water in a given temperature, and/or inhibitions of capillaries on seed coat are some few reasons for this equilibrium (Becker, 1960 ;Palipane and Vellanki, 1977).Varieties like *Suduru samba* and *Rathna samba* showed this saturation earlier than the other varieties. The peak moisture contents of tested four paddy varieties had exhibited at the 300min. of steeping. Under the peak moisture levels, *Unakola samba, Suduru samba* and *Kahamaala* were found with 30.97±0.09%, 30.64±0.17% and 30.88±0.06% (w.b.) of moisture absorption capacities respectively. However, there was no significant difference (P>0.05) among the three varieties (*Unakola samba, Suduru samba* and *Kahamaala*) in water absorption capacity. The variety called *Rathna samba* showed comparatively low reading for the same steeping time by acquiring 28.22±0.20% (w.b.) of moisture content. Further evaluation of all of these data revealed, time of steeping and varietal difference significantly influence (p<0.05) for the moisture absorption capacities and the rates of hydration in test paddy varieties.

Conclusion

All paddy varieties have common hydrating pattern during entire steeping process at 70^{0}C. At the beginning of steeping, it makes rapid water absorption, followed by the slow rate of absorption until grains reached to the equilibrium state. After 5 hour of steeping time, traditional paddy varieties displayed about 28- 30% of peak moisture increment. Time of steeping and varietal difference is influenced on the moisture absorption capacity. The varieties such as *Unakola samba, Suduru samba and Kahamaala* were similarly reported the highest water holding capacities than *Rathna samba*. *Kahamaula* was the traditional paddy type having highest length, width, thickness, thousand grains, geometric mean diameter (G.M.D.), surface area and volume. While *Suduru samba* was the variety with lowest length, width, thickness, thousand grain mass, geometrical mean diameter (G.M.D.), surface area, volume aspect ratio. *Unakola samba* and *Kahamaula*had the highest as well as the lowest sphericities respectively. Highest aspect ratios provided by *Rathna samba* and *Unakola samba*. Volumes, surface areas and aspect ratios are similar among *Rathna samba* and *Unakola samba*.

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