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Determination of Important Physical Properties and Water Absorption Capacity of Medium Type Improved Paddy Varieties of Sri Lanka

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Abstract: Four popular paddy varieties in Sri Lanka, BG 300, BG352, BG366 and AT307, were experimented in order to determine the important physical properties and water absorption capacities. Axial dimensions (length, width, thickness),1000 grain mass ,geometrical mean diameter, surface area ,volume, sphericity and aspect ratio were determined as the physical properties of paddy varieties. According to the research outcome, most of the physical properties were significantly different ($p<0.05$) among the varieties while some similarities ($p>0.05$) were also observed. To investigate the water absorption capacity of different paddy varieties in terms of moisture gain, the paddy varieties were immersed in hot water at 70 ^{0}C for 5 hours. Samples were drawn from respective paddy variety for every 30minutes in order to measure the moisture absorption. According to the results, during the initial stage of soaking, all paddy varieties illustrated rapid moisture increment. Afterward the rate of moisture increment was gradually declined and attained to the saturation point, where the moisture variations were insignificant ($P>0.05$) for paddy varieties. Until reaching to the saturation point, moisture absorption pattern of paddy varieties were significantly different ($p<0.05$).Results indicated that highest and lowest moisture increment was recorded by BG300 and BG366 respectively. The soaking time and varietal differences were also significantly influenced ($P<0.05$) on water absorption capacities.

Key words: Improved paddy varieties, Moisture absorption capacity, Moisture content, Soaking time, Saturation point

1. Introduction

Paddy (*Oryza sativa L.*) is the major cereal crop in Sri Lanka and is cultivated in many countries of the world. More than half of the global population consumes this cereal as a staple food, because it is an important source of energy and other nutrients [1]. Paddy essentially goes through different hydrothermal treatments while further processing [2]. Soaking of paddy/rice is a common practice, that employs for various processes such as parboiling, puffing and flaking rice [3],[4].For the cooking purposes, rice is soaked in water for softening the grain, which facilitates water uptake by starch during cooking [5]. As well as soaking is an essential step in wet milling because it reduces the mechanical stress and enhancing the extraction of significant constituents such as starch and essential micronutrients [5],[3],[6],[7].

The temperature of the soaking medium is greatly affected on the rate of water absorption [8]. If higher the temperature of the soaking medium, the higher the rate of moisture absorption [4]. In order to minimize grain's splitting and solid leaching which occurs during soaking, the temperature of the soaking medium should be controlled below the starch gelatinization temperature of paddy [9].The water absorption rate of the grains is also impacted on the type of paddy variety, consisting differences in physical and chemical characteristics [10]. The purpose of this experiment was to measure the important physical properties and investigating the moisture absorption pattern of four most commonly cultivated improved paddy varieties in Sri Lanka with a view to get an idea about the water absorption capacity at 70 ^{0}C.

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2. Materials and Methods

2.1 Samples Preparation

Ten kilo grams of commercially available, four prominent improved paddy varieties (BG300,BG352,BG366 and AT307) 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.

(**BG**- Bathalegoda ; **AT**- Ambalantota - The letters depicted two paddy research centers in Sri Lanka)

2.2 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 [1], 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 [11].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 [12]: The Surface area (S)- (3) as stated in [8] : Grain volume (V)- (4) according to [13] and The Aspect ratio (R_a)-(5) as given in[14].

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

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

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

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

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

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

2.3 Determination of Moisture Absorption Capacity

Experiment was designed based on previous studies of [5],[15],[16] 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^{0}C) in the thermostatic water bath (Gallenkamp-BKS350). Triplicate measurements were taken from each paddy variety. Paddy grains were periodically removed, during hot soaking, 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 [17] using triplicates from each variety.

3. Results and Discussion

3.1 Physical properties

Locally, BG 300, BG352, BG366 and AT307 were popular as medium grain white *Nadu* rice. The major axial dimensions and the masses of thousand grains of these paddy varieties are given in Table 1.

Table 1: Dimensions and thousand grain mass of BG300, BG352, BG366 and AT307

Rice Variety	Thousand grain mass,(g)	Length, (mm)	Width, (mm)	Thickness, (mm)
BG300	27.36 ± 0.89^a	8.17 ± 0.23^a	3.00 ± 0.16^a	2.14 ±0.12^{ab}
AT307	21.95 ± 0.86^c	7.39 ± 0.28^d	2.81 ± 0.18^b	2.12 ± 0.06^b
BG352	27.28 ± 1.67^a	7.87 ± 0.34^b	2.97 ± 0.18^a	2.17 ± 0.07^a
BG366	23.99 ± 1.25^b	7.67 ± 0.28^c	2.84 ± 0.19^b	2.06 ± 0.07^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).

According to the Table 1, highest 1000 grain masses were reported by BG300 and BG352, which were not significantly different (P>0.05) and lowest 1000 grain mass was reported by AT307. Highest grain length was given by BG300 and the lowest grain length was given by AT307. Both BG300 and BG352 were reported the highest grain widths, where the values were not significantly difference (P>0.05). Lowest grain widths were shown similarly (P>0.05) by AT307 and BG366.While BG352 recorded the highest grain thickness, lowest value exhibited by BG366.

Physical parameters pertaining to the Geometrical Mean Diameter (G.M.D.), Surface area, Sphericity, Volume and Aspect ratios for BG300, BG352, BG366 and AT307 have been presented in Table 2.

Table 2: Physical parameters of Geometrical Mean Diameter (GMD) ,Surface area, Sphericity, Volume, Aspect ratios for BG300,BG352,BG366 and AT307

Rice Variety	G.M.D. (mm)	Surface area(mm^2)	Sphericity	Volume (mm^3)	Aspect ratio
BG300	3.74 ± 0.15^a	44.00 ± 3.43^a	0.46 ± 0.01^d	28.33 ± 3.28^a	0.37 ± 0.02^a
AT307	3.53 ± 0.14^b	39.20 ± 2.93^b	0.48 ± 0.01^a	23.61 ± 2.65^b	0.38 ± 0.02^b
BG352	3.70 ± 0.17^a	43.05 ± 3.88^a	0.47 ± 0.00^b	27.33 ± 3.76^a	0.38 ± 0.01^b
BG366	3.55 ± 0.16^b	39.75 ± 3.51^b	0.46 ± 0.00^c	24.27 ± 3.42^b	0.37 ± 0.01^a

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

According to the Table 2, BG300 and BG352 reported the highest as well as similar values (p>0.05) for the physical properties of geometric mean diameter (G.M.D.) , surface area and volume. The lowest values for previously mentioned each parameter were similarly (p>0.05) given by AT307 and BG366.Highest value for sphericity was given by AT 307 and lowest sphericity was given by BG300. AT 307 and BG352 were found with highest aspect ratios which were not significantly different (p>0.05). The lowest aspect ratios were given by BG300 and BG366, which were not significantly different (P>0.05).

When increasing the moisture content, dimensions of paddy grains are also increasing gradually and this is significantly influenced on physical parameters [18]. Information on the physical properties of paddy including dimensions (width, thickness , length), seed mass , surface area, volume, sphericity and aspect ratio etc. are important tools for analyzing the behavior of the product in handling and designing equipment for the purpose of drying, dehulling, grading and storing etc.[18],[19].

3.2 Moisture absorption pattern of different paddy varieties

Although initial moisture contents of BG300, BG352, BG366 and AT307 were remained at 12.67±0.50%,11.38 ±0.19%,13.37±0.16% and 13.89±0.05% (wet basis) respectively, moisture contents of all paddy varieties had been increased to different moisture levels (p<0.05) during 300 minutes of soaking period, while having similar moisture contents (p>0.05) in some instances. The moisture absorption pattern of BG300, BG352, BG366 and AT307 are graphically presented in Figure 1.

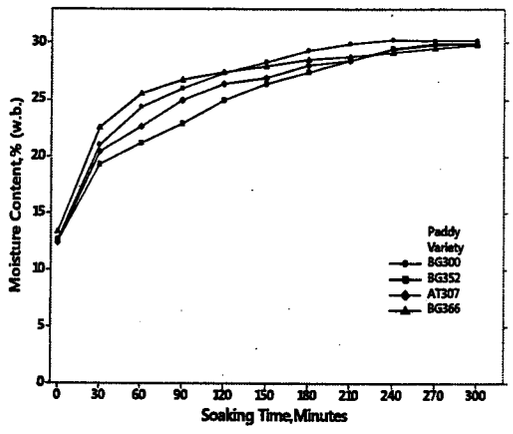

Figure 1: Moisture absorption pattern of BG300, BG352, AT307 and BG366 at 70 ^{0}C

According to the Fig.1, during the first 30min of soaking, the intensity of water absorption was rapid comparative to the latter periods of soaking. Under this circumstance, paddy varieties tend to absorb water at different rates and BG366 displayed the highest rate of absorption. Usually rapid water absorption attributed to the natural capillaries available in the outermost layers of the seed coat and pericarp [20].Thereafter, moisture contents of paddy varieties were

increased between 30min to 270min gradually, however at a declining rate. The rate of water absorption into the grain depends on the driving force which is created by the moisture gradient between inner and outer periphery of the grain. When hydration proceeds, the water content gradually increases and subsequently the absorption rate decreases due to the weakening of the driving force [16].

At the end of soaking period, there were no noticeable increments in moisture content in all paddy varieties because, all of them should be reached to an equilibrium at almost similar moisture contents which could be observed in between 270min to 300min. Statistical evaluation of data revealed that the moisture contents of BG300, BG352 and AT307 were not significantly different ($p>0.05$) during this soaking periods. The soaking time which indicates the insignificant variations in moisture content could be considered attainment of saturating point or equilibrium moisture levels of relevant paddy varieties. According to the studies of [20], capillary inhibitions in seed coats during further soaking are cause to attain equilibrium with the hydration medium.

Final moisture contents (w.b.) after soaking 300min. were 30.24±0.10%, 29.97±0.03%, 29.87±0.20% and 29.87±0.02% for the paddy varieties of BG300, BG352, AT307 and BG366 respectively. Therefore BG300 was the variety displayed the highest moisture content which was significantly different ($P<0.05$) from other varieties. BG366 reported lowest moisture content after 300 minutes of soaking time. Further evaluation revealed that the varietal difference and duration of soaking significantly influence ($p<0.05$) the final moisture content of the paddy varieties subjected to this experiment.

4. Conclusions

- The highest paddy masses were reported by BG300 and BG352 while lowest paddy mass was given by AT307. The highest paddy length was found in BG300 and lowest length was found in AT307. BG300 and BG352 reported the highest paddy width, while the lowest paddy widths were shown by AT307 and BG366. The highest paddy thickness was given by BG352 and lowest was shown by BG366.

- Geometric Mean Diameter (G.M.D.), Surface area and Volume of paddy grains were highest in both BG300 and BG352, whereas AT307 and BG366 were the lowest. The highest value for sphericity was given by AT 307 and lowest was given by BG300. The aspect ratios of AT307 and BG352 were the highest and the lowest aspect ratios were given by BG300 and BG366.

- All paddy varieties, at the beginning of soaking, illustrated rapid water absorption which was followed by a slower rate of absorption until grains become to the saturation point or equilibrium moisture content. Moisture absorption capacities vary among different paddy varieties and it is also depending on the duration of soaking.

- The water absorption capacity was highest in BG300 compared to other varieties and the lowest was BG366.

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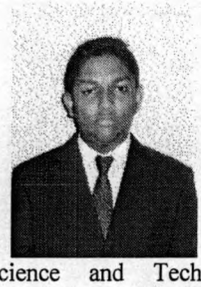

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