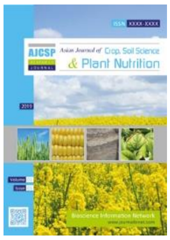
Published with Open Access at Journal BiNET
Vol. 06, Issue 02: 242-250

Asian Journal of Crop, Soil Science and Plant Nutrition

Journal Home: https://www.journalbinet.com/ajcsp-journal.html



Grain physical properties analysis of some improved rice varieties

Nazmul Hoque[1], Mohammad Zahidul Islam[2], Farzana Rahman[1], Nadim Mahmud[1], Mahfuzur Rahman[1] and Bishal Biswas[1]

[1]Department of Agriculture, Bangabandhu Sheikh Mujibur Rahman Science and Technology University, Gopalganj - 8100, Bangladesh.
[2]Bangladesh Rice Research Institute, Regional Station Gopalganj - 8100, Bangladesh.

✉ Article correspondence: shikshatoroo@gmail.com (Hoque, N)
Article received: 12.12.2021; Revised: 30.01.2022; First published online: 20 March, 2022.

ABSTRACT

Physical characteristics of rice grains from eight Boro rice varieties (BRRIdhan50, BRRIdhan63, BRRIdhan74, BRRIdhan84, BRRIdhan88, BRRIdhan89, BRRI dhan96 and BRRI dhan100) were investigated in September 2021, with completely randomized design including three replications in the Department of Agriculture's laboratory at Bangabandhu Sheikh Mujibur Rahman Science and Technology University Gopalganj. The grain's physical dimensions (length, width, thickness and equivalent diameter) were determined, as well as its grain surface area, sphericity, aspect ratio, volume, bulk density, solid density, porosity and 1000 grain weight. The physical characteristics of the rice varieties differed significantly, according to the findings. The rice grains were extra-long in length, with a length-to-width ratio of 3.18 to 6.20. BRRIdhan100 had the lowest mean value for grain length (8.05 mm), thickness (1.55 mm), equivalent diameter (2.97 mm), surface area (25.23 mm^2), volume (10.77 mm^3), solid density (0.62 g/cm^3), porosity (22.95%) and 1000 grain weight among the eight rice varieties (15.33 g). In contrast, BRRIdhan74 had the highest grain width (2.87 mm), thickness (1.95 mm), equivalent diameter (3.75 mm), surface area (58.01 mm2), aspect ratio (0.31), volume (37.39 mm^3) and 1000 grain weight (30.33 g). Pearson correlation revealed the highest positive significant correlation of grain width with thickness, equivalent diameter, grain surface area, sphericity, aspect ratio, volume, bulk density, solid density, porosity, and 1000 grain weight, ranging from r = 0.791 to r = 0.980 (at $p \leq 0.05$ and $p \leq 0.01$). Surface area, sphericity, aspect ratio and bulk density all had positive significant correlations (at $p \leq 0.01$) with grain thickness, with correlation values ranging from r = 0.909 to r = 0.962. Physical dimensions of rice grains had a positive significant relationship with other physical properties of grains. The findings of this study will be useful in rice breeding to improve grain quality, as well as in designing postharvest processing and storage facilities based on varietal differences in rice varieties.

Key Words: *Correlation, Grain, Physical Properties, Rice and Quality.*

Cite Article: Hoque, N., Islam, M. Z., Rahman, F., Mahmud, N., Rahman, M. and Biswas, B. (2022). Grain physical properties analysis of some improved rice varieties. Asian Journal of Crop, Soil Science and Plant Nutrition, 06(02), 242-250.
Crossref: https://doi.org/10.18801/ajcsp.060222.29

I. Introduction

Rice has a diverse range of consumer preferences around the world and the value placed on various grain characteristics varies by region and socio-cultural environment. Consumers in Bangladesh choose high-quality rice with a good taste, whiteness, slenderness, short grain and scent (Custodio et al. 2019; BBS, 2020). This is true even for low-income families. The top three most significant rice characters mentioned by urban households in Dhaka, as well as most other cities and socioeconomic classes, were good flavor, whiteness and slenderness (Custodio et al., 2016; USDA, 2021). Understanding the physical qualities of grain materials enables the design of appropriate machinery for grain processing activities such as sorting, drying, heating, cooling and milling, as well as the optimization associated with each unique variety (Mir et al., 2013). The presence of phenolic chemicals, flavonoids and antioxidants in rice make it a nutraceutical powerhouse. Meeting the increasing worldwide demand for high-quality rice, particularly nutraceutical-enriched premium quality rice, has the potential to boost rice-producing countries' export earnings. In this way, Bangladesh cannot be regarded as an outlier (Shozib et. al., 2020). Rice is high in energy, vitamins, minerals and several essential amino acids. Brown rice is made up of hulled bran layers (6–7% of total weight), embryo (2–3%) and endosperm (about 90%) that come directly from rough rice (Chen et al., 1998). Brown rice contains more nutrients than white rice, such as proteins, lipids, dietary fiber, vitamins and minerals. These nutrients are typically found in rice grains' germ and bran layers. They are almost entirely removed from brown rice during the milling process, resulting in white rice, which is far more popular than brown rice.

When evaluating drying and storage, as well as anticipating rice quality deterioration until it is ready to be sold, the moisture content, volume, specific gravity and porosity of rice seed or grain are the most significant elements to consider. Specific gravity is defined as the mass-to-volume ratio of an object. This ratio can be used to determine the true specific gravity of an individual grain and it specifies the bulk density when applied to the bulk grain. Porosity is defined as the ratio of inter-granular void space volume to bulk grain volume (Mohsenin, 1986). The porosity of bulk grain can be determined using the direct method, which entails measuring the amount of liquid used to fill the blank area. Bulk density, true density and porosity are all physical parameters of grain that can be used to construct grain hoppers and storage facilities. During aeration and drying processes, grain porosity affects the rate of heat and mass transfer of moisture. Low porosity grain beds are more resistant to water vapor escape during the drying process, necessitating the use of more electricity to run the aeration fans. Furthermore, rice grain densities have piqued the interest of breakage susceptibility and hardness research. Several authors have underlined the importance of studying different physical features of rice grains over the years. The thousand grain weight of rough rice grain is used to calculate the head rice yield after milling. In most cases, head rice is defined as three-quarters or more of the total milled rice kernels separated from the total milled rice (USDA, 1990). Head rice yield is influenced by the length of rough rice grains. Fan et al. (2000) also looked at how head rice yields were affected in long and medium grain rice cultivars under different harvesting and drying conditions. To assess the kernel size and distribution, as well as the fraction of broken rice kernels, information on the grain length, width, aspect ratio and perimeter is necessary (Van Dalen, 2004). Rice physical parameters can be used to compute kernel volume and surface area, which are crucial in grain drying, heating, cooling and aeration modeling. The rate of heat and mass transmission during aeration and drying is determined by grain density (Malik and Saini, 2016). As a result, grain hoppers and storage facilities are chosen based on density values.

Rice milling is a critical step in the rice production process. The market value of the grain is determined by the milling machine's accuracy and efficiency, as well as the behavior of the grains during milling. Rice's market value as an agricultural product is defined by its physical characteristics after harvesting. For the rice processing industry, the proportion of whole grain is the most important factor (Marchezan, 1991). Broken grain rice has half the market value of broken grain rice. The primary purpose of milling is to obtain an edible and contaminant-free white rice kernel (Singh et al., 2015). Rice grain quality is defined by a variety of characteristics depending on which target group in the post-harvest system is being involved. For example, the miller requires high total and head milled rice production, whereas physicochemical parameters, particularly visible amylase concentration, dictate cooking and eating quality (Noomhorm et al., 1997; Perdon et al., 1997). The basic axial dimensions of a rice grain can be used to calculate milling power and sieve selection for separation (Singh et al., 2015). Rice grain properties must be studied in order to build equipment that can be used

EISSN 2706-5510

for handling, transportation, separation, dehulling, drying, storage and other things. There is a scarcity of research and information on the grain physical characteristics of high yielding rice cultivars grown in Bangladesh. So, the goal of this study was to look at the physical properties of grain (rough rice) from eight different rice varieties to help with the design of processing and packaging machinery for better rice production and marketing, as well.

II. Materials and Methods

All the physical analysis of the rice grain was carried out in the laboratory of Department of Agriculture, Bangabandhu Sheikh Mujibur Rahman Science and Technology University Gopalganj in September, 2021. The rice variety viz. BRRIdhan50, BRRIdhan63, BRRIdhan74, BRRIdhan84, BRRIdhan88, BRRIdhan89, BRRIdhan96 and BRRIdhan100 used in this study collected from Bangladesh Rice Research Institute (BRRI), Gopalganj.

Preparation of sample

Standard grain samples that were free of disease were weighed and utilized in the experiment. The grains (rough rice) were hand cleansed to eliminate foreign materials (as stones, straw and dirt). Using a conventional mesh, the broken grains and dust were separated from the rice and husk. To minimize moisture loss or gain, the rough rice samples were sealed in airtight polythene bags. On a wet basis, the initial moisture content of each rough rice sample was measured. For 6 hours, samples were dried at 40± 2 °C. On a dry weight basis, the percent moisture content was computed.

Investigation of physical properties of rice grains

Length, width and thickness

The rice grains' length L (mm), width W (mm), and thickness T (mm) were measured using a Digital slide caliper with a 0.01 mm accuracy. On each variety, rice grains were chosen at random and each dimension was measured and recorded 10 times. For grain classification, the following scale was used: extra-long, >7.50 mm; long, 6.61 to 7.50 mm; medium, 5.51 to 6.60 mm; and short, 5.50 mm. Slender grain has a length-to-width ratio of >3.0; medium grain has a length-to-width ratio of 2.1 to 3.0; bold grain has a length-to-width ratio of 1.1 to 2.0 and round grain has a length-to-width ratio of 1.0 (IRRI, 2017).

Equivalent diameter

Equivalent diameter, D_e(mm) was calculated using the following equation (Mohsenin, 1986):

$$D_e = \left(L\frac{(W+T)^2}{4}\right)^{\frac{1}{3}}$$

Surface area

The surface area S (mm²) was calculated using the variables length, width, and thickness. The formula used for surface area suggested by (Mohsenin, 1986) and Jain and Bal (1997):

$$S = \frac{\pi \times B \times L^2}{2 \times L - B}$$

Where, $B = (W \times T)^{1/2}$ (mm) is a function of width and thickness.

Sphericity

The sphericity $\varphi(-)$, was calculated by the formula suggested by Mohsenin (1986):

$$\varphi = \frac{(L \times W \times T)^{1/3}}{L}$$

Aspect ratio

The aspect ratio $R_a(-)$ was calculated using the formula (Varnamkhasti et al., 2008) as:

$$R_a = \frac{W}{L}$$

Volume

The volume of grain V (mm³) was calculated by the formula suggested by Jain and Bal (1997) as:

$$V = \frac{1}{4} \times [(\pi/6) \times L(W \times T)^2]$$

Bulk density

The bulk density ρ(kg/m³) was calculated according to formula suggested by Fraser et al. (1978). The 200 ml beaker was filled with rice up to 100 ml mark and then the mass of rice grain was weighed and repeated three times. The weight of the rice was divided with the volume of the beaker (100 ml).

$$\rho_b = \frac{M_g}{V_b}$$

Where, M (g) is mass of the grain and V(mm³) is volume of the beaker.

Solid density

The solid density ρ (kg/m³) was calculated by filling the 100- ml beaker with 50 ml of distilled water and then placing 3 g sample of rice in it. The displaced water (volume of the grains) was recorded and the measurement was repeated three times (Shittu et al., 2012)

$$\rho_s = \frac{M_{gs}}{V_{dw}}$$

Where, M_{gs}(g) is mass of the grain and V_{dw}(mm³) is volume of displaced water.

Porosity

The Porosity ε (%) was calculated using results of analysis mentioned above - solid density and bulk density. The formula was suggested by Jain and Bal (1997):

$$\varepsilon = 100 \times \left(1 - \frac{\rho_b}{\rho_s}\right)$$

Thousand grain weight

The 1000 grain weight was taken from randomly selected grains of each variety and weighed carefully on digital scale with accuracy of 0.001g and the final weight presented in grams. The procedure was repeated three times, and average values were taken according to the method suggested by Varnamkhasti et al. (2008).

III. Results and Discussion

Physical properties

Physical properties of rice grain on the basis of shape and size of BRRIdhan50, BRRIdhan63, BRRIdhan74, BRRIdhan84, BRRIdhan88, BRRIdhan89, BRRI dhan96, BRRI dhan100 are presented in the Table 01. All the studied varieties are extra-long in shape and slender in size. Grain length varied from 8.05 mm to 11.35 mm. On the other hand length to width ratio varied from 3.18 to 6.20.

Table 01. Variation in grain length, length-to-width ratio of 8 rice varieties.

Rice variety	Length (mm)	Shape	Length-to- width ratio	Size
BRRIdhan50	11.35 (±0.031)	Extra long	6.20 (±0.026)	Slender
BRRIdhan63	10.41 (±0.032)	Extra long	5.09 (±0.006)	Slender
BRRIdhan74	9.14 (±0.023)	Extra long	3.18 (±0.021)	Slender
BRRIdhan84	9.45 (±0.015)	Extra long	4.00 (±0.012)	Slender
BRRIdhan88	9.00 (±0.008)	Extra long	4.04 (±0.010)	Slender
BRRIdhan89	9.06 (±0.0318)	Extra long	3.68 (±0.025)	Slender
BRRIdhan96	8.27 (±0.006)	Extra long	3.63 (±0.010)	Slender
BRRIdhan100	8.05 (±0.019)	Extra long	3.90 (±0.038)	Slender

BRRI – Bangladesh Rice Research Institute, V – Variety, Values are expressed as mean (standard error)

Physical properties of rice grain differed significantly (Table 02). Physical dimensions among the varieties, the length of grain varied from 8.05 mm (BRRIdhan100) to 11.35 mm (BRRIdhan50). The variation in width ranged from 1.83 mm (BRRIdhan50) to 2.87 mm (BRRIdhan74). Grain thickness showed a variation from 1.55 mm (BRRIdhan100) and 1.95 mm (BRRIdhan74). Correa et al. (2007); Shittu et al. (2012) and Mir et al. (2013) reported the wide range of variation in grain dimension for different rice varieties. According to Varnamkhasti et al. (2008), sieve separator selection and power calculation during rice milling operation depends on rice grain principal axil dimension. The first step in characterizing the rice shape is to measure the grain dimensions, which are then used in several dimensional calculations. Grain dimension is one of the main characteristic that needs to be considered during measuring the physical properties of rice (Bhattacharya, 2011). While discussing the physical properties of rice, the majority of the authors establish basic values of grain length, width and thickness (Díaz et al., 2015; Oli et al., 2016).

Table 02. Mean performance of 8 rice varieties based on physical characteristics of grain

Property	BRRIdhan50	BRRIdhan63	BRRIdhan74	BRRIdhan84	BRRIdhan88	BRRIdhan89	BRRIdhan96	BRRIdhan100
Length (mm)	11.35[a]	10.41[b]	9.14[d]	9.45[c]	9.00[f]	9.06[e]	8.27[g]	8.05[h]
Width(mm)	1.83[h]	2.04[g]	2.87[a]	2.36[c]	2.23[e]	2.46[b]	2.28[d]	2.07[f]
Thickness (mm)	1.69[cd]	1.66[d]	1.95[a]	1.72[c]	1.67[d]	1.76[b]	1.71[c]	1.55[e]
Equivalent diameter (mm)	3.27[d]	3.29[d]	3.75[a]	3.40[c]	3.24[e]	3.43[b]	3.20[f]	2.97[g]
Surface area (mm^2)	31.47[g]	33.09[e]	58.01[a]	38.29[c]	33.31[d]	40.32[b]	32.75[f]	25.23[h]
Sphericity	1.03[h]	1.13[f]	1.86[a]	1.35[c]	1.24[e]	1.45[b]	1.30[d]	1.07[g]
Aspect ratio	0.16[f]	0.20[e]	0.31[a]	0.25[d]	0.25[d]	0.27[b]	0.28[b]	0.26[c]
Volume (mm^3)	14.27[e]	15.63[d]	37.39[a]	20.38[c]	16.21[d]	22.31[d]	16.39[d]	10.77[f]
Bulk density (g/cm^3)	0.37[c]	0.46[b]	0.51[ab]	0.47[b]	0.49[ab]	0.51[ab]	0.53[a]	0.47[b]
Solid density (g/cm^3)	0.95[d]	0.66[e]	0.95[d]	1.08[c]	1.18[b]	1.08[c]	1.44[a]	0.62[f]
Porosity (%)	60.64[ab]	29.70[e]	46.42[d]	56.52[bc]	58.33[abc]	53.07[c]	62.98[a]	22.95[f]
Thousand grain weight (g)	18.00[de]	21.00[bcd]	30.33[a]	24.00[bcd]	22.00[bcd]	25.00[b]	20.00[cd]	15.33[e]

Values are expressed as mean. Mean with different letters within the same row differ significantly at $p \leq 0.05$.

The equivalent diameters of grain varied from 2.97 (BRRIdhan100) mm to 3.75 mm (BRRIdhan74). Measurement of equivalent diameters is an important variable to express rice grain characteristics. Varnamkhasti et al. (2008), Mir et al. (2013) also reported a range of 3.60 mm to 3.79 mm for equivalent diameters in different rice varieties, which are comparable to the result of the present study.

Grain Surface area values ranged from 25.23 mm^2 (BRRIdhan100) to 58.01 mm^2 (BRRIdhan74). Surface areas recorded in the rice varieties are higher than the earlier reported by Varnamkhasti et al. (2008). Surface area is an important factor because diffusion of water in rice grain during cooking and cooking time varies for this property (Mohapatra and Bal 2006; Juliano's, 1993). Surface area also affects grain drying time and energy requirements (Zareiforous et al., 2011).

Sphericity of rice grains varied with a range from 1.03 (BRRIdhan50) to 1.86 (BRRIdhan74). Sphericity values depend on rice shape and size. Rice varieties in the present study were extra-long. Mohsenin (1986) reported that the sphericity value of rough rice varies from 0.32 to1. Variation in sphericity also fluctuated with the grain pointed tips and length axis (Thakur and Gupta, 2007).

Aspect ratio was recorded to be lowest in BRRIdhan50 (0.16), where highest in BRRIdhan74 (0.31). Grain classification and determination of the extent of quality rice grain depends on aspect ratio of rice grains. According to Mir et al. (2013) aspect ratio ranges from 0.19 to 0.43 in different cultivars. In a different study Varnamkhasti et al. (2008) found mean aspect ratio ranging from 0.24 to 0.28. In comparison with those values for aspect ratio in the present study is between the ranges of previous repot.

The differences in the grain volume ranged from 10.77 mm^3 (BRRIdhan100) to 37.39 mm^3 (BRRIdhan74) which revealed the connection with grain dimension. The volume measurement of rice grain is critical for modeling grain aeration facilities and, by extension, all drying, heating, and cooling systems. (Varnamkhasti et al., 2008). Diaz et al. (2015) reported earlier that values of grain volume ranged from 21.1 mm^3 to 36.4 mm^3 which is in accordance with the findings of this study for higher value but lower in term of grain lower value due to lower grain dimension.

The bulk densities of rice grains ranged from 0.37 g/cm^3 (BRRIdhan50) to 0.53 g/cm^3 (BRRIdhan96). Bulk density represents the grain behavior in the dry mass. Bulk density value in this study comparable with the value (0.58 g/cm^3) reported by Wratten et al. (1969) for long type grain. Weight of grain product in the hopper is usually determined by the information of bulk density of grain and which also helps to design silos and hoppers for ease handling of grain and its storage.

The solid density of grains measured by water test mainly focused on particular volume of that grains take in space. Solid density in the rice varieties ranged from 0.62 g/cm^3 (BRRIdhan100) to 1.44 g/cm^3 (BRRIdhan96). Nadvornikova et al. (2018) also reported highest value of solid density 1.41 g/cm^3 in medium to long grain rice genotypes.

The porosity recorded in the range of 22.95% (BRRIdhan100) to 62.98% (BRRIdhan96). Porosity value relatively varied largely. Varnamkhasti et al. (2008); Mir et al. (2013) and Varnamkhasti et al. (2008) also reported porosity range from 28.2% to 63.33% in rice. Low percentage of porosity found in a variety in the present study can make the active drying of rice difficult. Varnamkhasti et al. (2008) previously showed that low porosity indicates poor resistance to air combustion in forced draft convective drying, resulting in slower drying than high porosity rice cultivars.

The rice varieties had a mass weight equivalent to 1000 grains ranging from 15.33 g (BRRIdhan100) to 30.33 g. (BRRIdhan74). According to Mir et al., (2013) and Diaz et al., (2013), the 1000-grain weight of high yielding commercial and premium quality rice varieties ranges from 15.33 g to 28.63 g. (2015). Thousand grain weights, according to Luh (1980) and Ravi et al. (2014), is a useful index for measuring milling outturn and relative amount of dockage in rice, shriveled grain, and estimation of the weight proportion of the paddy that is made up of the husk.

Table 03. Pearson correlations among physical properties of grain in 8 rice Varieties

Property	W	T	D_e	S	φ	R_a	V	ρ_b	ρ_s	ε	1000GW
Length (mm)	-0.420^{ns}	0.084^{ns}	0.220^{ns}	0.009^{ns}	-0.265^{ns}	-0.797*	-0.052^{ns}	-0.697^{ns}	-0.251^{ns}	0.160^{ns}	-0.013^{ns}
Width (mm)		0.824*	0.791*	0.894**	0.980**	0.880**	0.914**	0.585^{ns}	0.280^{ns}	0.127^{ns}	0.831**
Thickness (mm)			0.280^{ns}	0.962**	0.962**	0.917**	0.512	0.959**	0.234^{ns}	0.353^{ns}	0.832^{ns}
Equivalent diameter (mm)				0.967**	0.879**	0.411^{ns}	0.949**	0.160^{ns}	0.172^{ns}	0.281^{ns}	0.880**
Surface area (mm^2)					0.958**	0.591^{ns}	0.996**	0.292^{ns}	0.159^{ns}	0.187^{ns}	0.884**
Sphericity						0.791*	0.972**	0.481^{ns}	0.270^{ns}	0.181^{ns}	0.861**
Aspect ratio							0.637^{ns}	0.748*	0.313^{ns}	-0.002^{ns}	0.546^{ns}
Volume (mm^3)								0.314^{ns}	0.153^{ns}	0.162^{ns}	0.876**
Bulk density (g/cm^3)									0.393^{ns}	-0.056^{ns}	0.302^{ns}
Solid density (g/cm^3)										0.869**	0.230^{ns}
Porosity (%)											0.249^{ns}

Length = L , width = W, thickness = T, equivalent diameter= D_e, surface area = S, sphericity = φ, aspect ratio = R_a, volume of grain = V, bulk density = ρ_b, solid density = ρ_s, porosity= ε, 1000 grain weight = 1000GW; *' ** Indicate significant at $p \leq 0.05$, $p \leq 0.01$ level respectively. ns: Not significant at (n-2) df.

Correlation among characters

Correlation coefficients were estimated for grain length, width, thickness, equivalent diameter, surface area, sphericity, aspect ratio, volume, bulk density, solid density, porosity and 1000 grain weight (Table 03). Grain length showed positive correlation with grain thickness, equivalent diameter and porosity, whereas negative correlation with grain width, sphericity, volume, bulk density and 1000 grain weight but significant negative correlation with aspect ratio (r = -0.797, $p \leq 0.05$). Singh et al. (2005) also reported the negative correlation of grain length with bulk density. In another study, Yadav et al. (2009) also found negative correlation of gain length with 1000 grain weight. Grain width had positive significant correlation with grain thickness, equivalent diameter, surface area, sphericity, aspect ratio, volume, and 1000 grain weight though correlation with bulk density, solid density, porosity were positive but not significant. Highest positive significant correlation was found between grain width and grain sphericity (r = 0.980, $p \leq 0.01$).

Grain thickness showed positive correlation with sphericity, aspect ratio, volume, bulk density, solid density, porosity and 1000 grain weight, but positive significant correlation were found with surface area, sphericity, aspect ratio and bulk density. Shitu et al. (2012) also reported positive correlation of grain thickness with some physical properties of rice grain. Correlation value of grain thickness with surface area and sphericity were highest ($r = 0.962$, $p \leq 0.01$). Equivalent diameter showed positive significant correlation with sphericity, volume and 1000 grain weight and positive correlation with surface area, aspect ratio, bulk density, solid density and porosity. Among these highest positive significant correlation was found between equivalent diameter and volume ($r = 0.949$, $p \leq 0.01$). Surface area had positive significant correlation with sphericity, volume, 1000 grain weight, meanwhile positive non-significant correlation with aspect ratio, bulk density, solid density and porosity. Surface area showed highest positive correlation with volume ($r = 0.996$, $p \leq 0.01$). Shitu et al. (2012) stated that positive correlation of surface area with volume is the result of positive correlation of grain width with these two characters. Grain sphericity showed positive correlation with aspect ratio, volume, bulk density, solid density, porosity and 1000 grain weight, where grain sphericity had highest positive significant correlation with grain volume ($r = 0.972$, $p \leq 0.01$) and 1000 grain weight ($r = 0.884$, $p \leq 0.01$). Aspect ratio had positive correlation with grain volume, bulk density, solid density and 1000 grain weight, but the correlation with porosity was negative. Among these, aspect ratio showed highest positive correlation with bulk density ($r = 0.748$, $p \leq 0.05$). Grain volume showed positive correlation with bulk density, solid density and 1000 grain weight, where highest positive significant was found with 1000 grain weight ($r = 0.876$, $p \leq 0.01$). Bulk density showed positive non-significant correlation with solid density and 1000 grain weight, but negative correlation with porosity. Solid density had positive significant correlation with porosity ($r = 0.869$, $p \leq 0.01$), while a non-significant correlation recorded with 1000 grain weight. Correlation between porosity and 1000 rain weight was positive but non-significant. Physical dimension of rice grain is the most significantly correlated one with grain volume, surface area and bulk density, which are important character to be considered during modeling of grain drying, aeration, heating and cooling (Yadav and Jindal, 2007; Shitu et al., 2012).

IV. Conclusion

This research contains a wealth of information on the physical features of rice cultivars. According to the findings, physical dimensions and size-related features differ significantly. The grain width and thickness of all the kinds were substantially connected with equivalent diameter, surface area, sphericity, aspect ratio, volume bulk density, solid density, porosity, and 1000 grain weight. This study's findings on rice grain characteristics are essential for farmers and consumers, and these will also provide useful guidance for breeding, improvement, postharvest processing, storage and marketing of these rice varieties.

References

[1]. BBS (Bangladesh Bureau of Statistics) (2020). Yearbook of Agricultural Statistics-2019. Bangladesh Bureau of Statistics (BBS), Statistics and Informatics Division, Ministry of Planning, Government of the People’s Republic of Bangladesh, Dhaka, Bangladesh.

[2]. Bhattacharya, K. R. (2011). Rice quality: A guide to rice properties and analysis, 1st ed. Sawston: Woodhead Publishing. https://doi.org/10.1533/9780857092793

[3]. Chen, H., Siebenmorgen, T. J. and Griffin, K. (1998). Quality characteristics of long grain rice milled in two commercial systems. Cereal Chemistry, 75(4), 560-565.

[4]. Corrêa, P. C., da Silva, F. S., Jaren, C., Afonso, P. C. and Arana, I. (2007). Physical and mechanical properties in rice processing. Journal of Food Engineering, 79, 137–142. http://dx.doi.org/10.1016/j.jfoodeng.2006.01.037

[5]. Custodio, M. C., Cuevas, R. P., Ynion, J., Laborte, A. G., Velasco, M. L. and Demont, M. (2019). Rice quality: how is it defined by consumers, industry, food scientists, and geneticists? Trends in Food Science and Technology, 92, 122–137. https://doi.org/10.1016/j.tifs.2019.07.039

[6]. Custodio, M. C., Demont, M., Laborte, A., Diaz, C., Ynion, J. and Islam, R. (2016). Rapid value chain assessment and rice preferences of consumers, farmers, and other rice value chain actors in Bangladesh. Report for TRB Project Market Research Team, Social Sciences Division International Rice Research Institute. pp. 1-137.

[7]. Díaz, E. O., Kawamura, S., and Koseki, S. (2015). Physical properties of rough and brown rice of Japonica, Indica and NERICA types. Agricultural Engineering International: CIGR Journal, 2015, 274–285.

[8]. Fan, J., Siebenmorgen, T. J. and Yang, W. (2000). The head rice yield reduction of long and medium grain rice varieties in relation to various harvested and drying conditions. Transaction of the ASAE 436, 1709–1714.

[9]. Fraser, B. M., Verma, S. S. and Muir, W. E. (1978). Some physical properties of faba beans. Journal of Agricultural Engineering Research, 23(1), 53–57. https://doi.org/10.1016/0021-8634(78)90079-3

[10]. IRRI (International Rice Research Institute). (2017). Measuring white rice quality, Rice knowledge bank. Available at: http://www.knowledgebank.irri.org

[11]. Jain, R. K. and Bal, S. (1997). Properties of pearl millet. Journal of Agricultural Engineering Research, 66(2), 85–91. https://doi.org/10.1006/jaer.1996.0119.

[12]. Julianos, B. O. (1993). Rice in human nutrition. Rome: Food and Agriculture Organization of the United Nations.

[13]. Luh, B. S. (1980). Rice: Production and Utilization. Inc., West port, CT. AVI publishing company.

[14]. Malik, M. A. and Saini, C. S. (2016). Engineering properties of sunflower seed: Effect of dehulling and moisture content. Cogent Food & Agriculture, 2, 1145783. https://doi.org/10.1080/23311932.2016.1145783

[15]. Marchezan, E. (1991). Grãosinteirosemarroz (Whole rice kernels in rice). LavouraArrozeira 44: 3-8 Porto Alegre, Brazil.

[16]. Mir, S. A., Bosco, S. J. D. and Sunooj, K. V. (2013). Evaluation of physical properties of rice cultivars grown in the temperate region of India. International Food Research Journal, 20(4), 1521–1527.

[17]. Mohapatra, D. and Bal, S. (2006). Cooking quality and instrumental textural attributes of cooked rice for different milling fractions. Journal of Food Engineering, 73(3), 253–259. https://doi.org/10.1016/j. jfoodeng.2005.01.028

[18]. Mohsenin, N. N. (1986). Physical Properties of Plant and Animal Materials, second ed. Gordon and Breach Science Publishers, New York.

[19]. Noomhorm, A., Kongseree, N. and Apintanapong, N. (1997). Effect of aging on the quality of glutinous rice crackers. Cereal Chemistry, 74, 12–15.

[20]. Oli, P., Ward, R., Adhikari, B. and Torley, P. (2016). Colour change in rice during hydration: Effect of hull and bran layers. Journal of Food Engineering, 173, 49–58. https://doi.org/10.1016/j.jfoodeng.2015.10.036

[21]. Perdon, A. A., Marks, B. P., Siebenmorgen, T. J. and Reid, N. B. (1997). Effects of rough rice storage conditions on the amylograph and cooking properties of mediumgrain rice cv. Bengal. Cereal Chemistry, 74, 864–867.

[22]. Ravi, U., Menon, L., Madhavan, R., Priyadharshini, S. and Dhivya, M. E. (2014). Determination of quality characteristics of indigenous organic Asian Indian rice variety-Neelam samba. Agricultural Science Digest, 34(3), 177–182. https://doi.org/10.5958/0976-0547. 2014.00997.5

[23]. Shittu, T. A., Olaniyi, M. B., Oyekanmi, A. A. and Okeleye, K. A. (2012). Physical and water absorption characteristics of some improved rice varieties. Food and Bioprocess Technology, 5(1), 298–309. https://doi.org/10.1007/s11947-009-0288-6

[24]. Shozib, H. B., Siddiquee, M. A., Rahman, N. M. F., Mamun, M. A. A., Sarkar, M. A. R., Rabbi, H. M. S. A., Salam, M. U. and Kabir, M. S. (2020). Grain Quality Research of Rice for Ensuring Nutritional Food Security. Bangladesh Rice Journal, 24(2), 103-117.http://doi.org/10.3329/brj.v24i2.53451

[25]. Singh, M., Kaur, P. and Singh, J. (2015). Physical properties and milling characteristics of different paddy varieties. International Journal for Science and Advance Research in Technology, 1, 59–63.

[26]. Singh, N., Kaur, L., Singh, S. S. and Sekhon, K. S. (2005). Physiochemical, cooking and textural properties of milled rice from different Indian rice cultivars. Food Chemistry, 89(2), 253-259.

[27]. Thakur, A. K. and Gupta, A.K. (2007). Water absorption characteristics of paddy, brown rice and husk during soaking. Journal of Food Engineering, 75, 252–257.

[28]. United States Department of Agriculture (2021). Bangladesh Grain and Feed Annual. Global Agricultural Information. Network Report number BG2021- 0014. https://apps.fas.usda.gov/newgainapi/api/Report/

[29]. USDA. (1990). Inspection handbook for the sampling, inspection, grading, and certification of rice. HB918-11, Washington, DC, Agriculture Marketing Service.

[30]. Van Dalen, G. (2004). Determination of the size distribution and percentage of broken kernel of rice using flatbed scanning and image analysis. Food Research International, 37, 51–58.

[31]. Varnamkhasti, M. G., Mobli, H., Jafari, A., Keyhani, A. R., Soltanabadi, M. H., Rafiee, S. and Kheiralipour, K. (2008). Some physical properties of rough rice (*Oryza sativa* L.) grain. Journal of Cereal Science, 47(3), 496–501. https://doi.org/10.1016/j.jcs.2007.05.014
[32]. Wratten, F. T., Poole, W. D., Chesness, J. L., Bal, S. and Romaroa, V. (1969). Physical and thermal properties of rough rice. Transactions of the ASAE 126: 801–803.
[33]. Yadav, B. K. and Jindal, V. K. (2007). Water uptake and solid loss during cooking of milled rice (*Oryza sativa* L.) in relation to its physicochemical properties. Journal of Food Engineering, 80(1), 46–54. https://doi.org/10.1016/j.jfoodeng.2006.05.011
[34]. Yadav, G. S., Kumar, D., Shivay, Y. S. and Singh, H. (2009). Zinc-enriched urea improves grain yield and quality of aromatic rice. Better Crops, 3, 4–5.
[35]. Zareiforoush, H., Hosseinzadeh, B., Adabi, M. E. and Motavali, A. (2011). Moisture dependent physical properties of paddy grains. Journal of American Science, (7), 175-182.

HOW TO CITE THIS ARTICLE?

MLA
Hoque, N. et al. "Grain physical properties analysis of some improved rice varieties". Asian Journal of Crop, Soil Science and Plant Nutrition, 06(02), (2022): 242-250.

APA
Hoque, N., Islam, M. Z., Rahman, F., Mahmud, N., Rahman, M. and Biswas, B. (2022). Grain physical properties analysis of some improved rice varieties. *Asian Journal of Crop, Soil Science and Plant Nutrition*, 06(02), 242-250.

Chicago
Hoque, N., Islam, M. Z., Rahman, F., Mahmud, N., Rahman, M. and Biswas, B. "Grain physical properties analysis of some improved rice varieties". Asian Journal of Crop, Soil Science and Plant Nutrition, 06(02), (2022): 242-250.

Harvard
Hoque, N., Islam, M. Z., Rahman, F., Mahmud, N., Rahman, M. and Biswas, B. 2022. Grain physical properties analysis of some improved rice varieties. Asian Journal of Crop, Soil Science and Plant Nutrition, 06(02), pp. 242-250.

Vancouver
Hoque, N, Islam, M. Z, Rahman, F, Mahmud, N, Rahman, M and Biswas, B. Grain physical properties analysis of some improved rice varieties. Asian Journal of Crop, Soil Science and Plant Nutrition, March 2022 06(02), 242-250.