



STUDIES ON GRAIN PHYSICOCHEMICAL CHARACTERISTICS OF BANGLADESH INDIGENOUS RICE CULTIVARS

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Abstract: Laboratory experiments were conducted to characterize 367 local cultivars from 6 ecotypes of Bangladesh rice based on physicochemical properties of the grains. The study was carried out at the Agronomy Laboratory of Agrotechnology Discipline, Khulna University, Khulna, Bangladesh. The cultivars were collected from 6 regions of the country *viz.* Rajshahi, Dhaka, Sylhet, Barisal, Khulna and Chittagong. The range of grain length and width varied between 2.71 mm, and 8.08 mm and 1.16 mm and 3.28 mm, respectively. Medium grains (5.51-6.60 mm length and length width ratio 2.10-3.00) showed the maximum frequency. Significant relationship was observed among the grain parameters studied. Alkali spreading scores of 1 to 7 were detected among the cultivars tested, scores 1 and 2 were frequent. Flaky rices or rices with medium gel consistency are found in maximum number of cultivars followed by cultivars with hard gel consistency. The results of various characters studied in the experiments suggest that some good characters do exist in our local cultivars.

Key words: Bangladesh rice; size; shape; alkali digestibility, gel consistency; grain quality

Introduction

Rice is the most important food crop of Bangladesh, where about 27 million metric tons produced from nearly 10 million hectare of land. Rice constitutes 95% of the cereals consumed in Bangladesh and supplies more than 70% of the calories (Khush, 1997) and more than 50% of the protein (Islam, 1996; Khush, 1997) in the daily diet of Bangladesh people. The Himalayan foothills including parts of Bangladesh are considered to be at least a center of diversity of the genus *Oryza* (Morishima, 1984). Perhaps for this reason Bangladesh is rich in genetic diversity of cultivated rice. Nearly 10,000 land races of rice are considered to exist in Bangladesh (Haque and Miah, 1990). With the expansive culture of modern varieties, the number of traditional rice cultivars reduced. The promotion of high yielding variety (HYV) rice mono-culture has led to loss of diversity including 7000 traditional rice varieties (Singh *et al.*, 2000). The rapid rate of disappearance or extinction of indigenous cultivars of rice points to the danger of narrowing genetic base. Very few systematic attempts have so far been made to make an inventory of this valuable gene pool. It is not known what useful genes could be tapped from this source in the breeding program. Along with the collection, a systematic analysis of these cultivars for various traits including that for the yield, physicochemical and cooking quality needs to be urgently undertaken.

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Most rice grown in Bangladesh is traded within the domestic market. High quality rice commands premium price. In the regional and international markets, consumers demand for quality rice is always high. However, no universal standard of rice grain quality can be set because of wide variety of consumer choices both between and within the country (Kaosa-ard and Juliano, 1991).

In Bangladesh, consumer demand for rice, as reflected by price, is mostly influenced by grain size and shape (Choudhury, 1991). Many of the traditional rice varieties are of better quality than the modern varieties in terms of size and shape of the grains, cooking quality and nutritional value, etc. (Kaul *et al.*, 1982; Islam, 1990, 1996; Jahan *et al.*, 2002a, 2002b, 2005). Cooking and eating characteristics are largely determined by the properties of starch that makes up 90% of milled rice. Gelatinization temperature, amylose content and gel consistency are the important starch properties that influence cooking and eating characteristics (Cruz and Khush, 2000).

Although there has been a long tradition of rice research in this region, work on the characterization of the varieties based on grain physicochemical properties seems inadequate. Islam (1990) studied grain characteristics of 490 varieties of deep water rice. With the attainment of self-sufficiency in food grains, national breeding programs are now attaching much importance on quality aspects. The characterization of grains of the endangered local cultivars may be of use in varietal improvement. A series of laboratory experiments were, therefore, undertaken to explore grain characteristics of 367 local rice varieties of Bangladesh.

Materials and Methods

Plant materials: Three hundred and sixty seven Bangladesh rice cultivars representing 6 ecotypes were used in the study. The sampling places of the cultivars and their corresponding ecotypes are shown in Table 1. The seed samples were collected from 6 regions during 1990-91 by a joint group of Bangladeshi-Japanese Researchers. All of the cultivars were grown at the Khulna University Farm during 2003-2004. After harvesting, analysis was done at different laboratories of Agrotechnology Discipline, Khulna University.

Grain morphology: Measurements were done for length and width of dehulled grains, using ten grains of each cultivar. The distance between the tip and the bottom of the grain was taken as the length and widest part from the abdomen to the back was as the width of the rice grain. Measurements were done at the largest position of the respective characters. Moreover, of the dehulled grains, calculations were done on the ratio of 'length to width' using average value of the respective characters. The cultivars were grouped based on the mean values. Standard deviations of each cultivar were also determined for all the parameters studied. Correlation coefficients between grain length and grain width as well as between grain length and L/W ratios of dehulled grains were estimated to make relationship among the grain characters. All the seed samples (n = 367) were employed to calculate the correlation coefficient values. The correlation coefficients were subjected to t-test to determine the level of significance at 365 (i.e. n-2) df.

Table 1. Distribution of rice cultivars according to ecotypes and geographical regions in Bangladesh.

Region	Ecotype						Total
	Aus	T. Aman	B. Aman	DWR	Boro	All Season	
Rajshahi	2	55	6	0	0	0	63
Dhaka	1	37	6	0	0	0	44
Sylhet	5	13	6	1	14	1	40
Barisal	0	60	0	0	0	0	60
Khulna	0	81	0	3	1	0	85
Chittagong	0	74	0	0	2	0	75
Total	8	319	18	4	17	1	367

Detection of alkali spreading score: The alkali spreading score for each grain was determined following the method of Little *et al.* (1958). A single hulled grain was halved vertically and was put into a well of 24-well plate (Ashi Techno Glass Co., Tokyo, Japan). The disintegration of starch granules were detected by standing the grains in 1 ml/well 1.7% (w/v) KOH solution for 24 hours at room temperature.

Determination of gel consistency: Ten whole milled rice grains were ground with the help of a mortar and pestle to give fine flour (100 mesh). One hundred mg (± 1 mg) of powder was weighed in triplicate into the culture tube (13mm x 100 mm). 0.2 ml of 95% ethyl alcohol containing 0.025% thymol blue was added. Two milliliters of 0.2 N KOH was added. Contents were mixed well. The test tubes are then covered with glass marbles (to prevent steam loss, and to reflux the sample). The samples were cooked in vigorously boiling water bath for 8 minutes, making sure that the tube contents reach 2/3rd the height of the tube. The test tubes were removed from the water bath and let them stand at room temperature for 5 minutes. The tubes were cooled in an ice-water bath for 20 minutes and laid horizontally on a laboratory table lined with millimeter graphing paper. The total length of the gel was measured in millimeter from the bottom of the tube to the gel front.

Results

Grain type: Based on length, the grains were grouped into 4 different grain size classes according to the classification by Cruz and Khush (2000) as very long (> 7.50 mm), long (6.61-7.50 mm), medium (5.51-6.60 mm) and short (≤ 5.50 mm) (Fig. 1). Length of grains was found between 2.71 mm and 8.08 mm with an average value of 5.84 mm. Lahiri *et al.* (1993) observed that the length of 4 induced rice mutants from BINA ranged from 4.75 mm -7.10 mm. Satoh *et al.* (1990a, 1990b) reported that grain length of husked rices from Tanzania varied from 3.76 to 8.11 mm and from Madagascar between 4.61 to 7.76 mm. Cultivar grouping based on length of the grain, as depicted in Fig. 1, shows that majority of the cultivars are medium grain rices. Accordingly, 235 (64%) cultivars were grouped into medium, 91 (25%) cultivars were ranked as short and 38 (10%) cultivars were termed as long. Only 3 (0.08%) cultivars were extra-long.

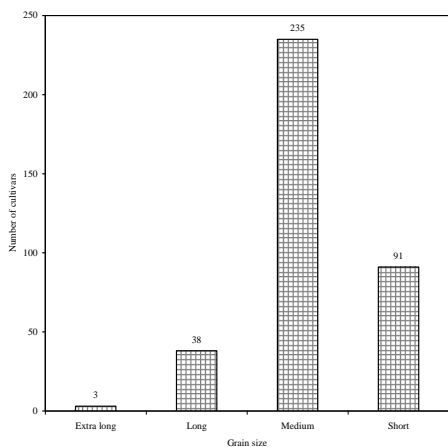


Fig. 1. Frequency distribution of rice cultivars based on size of the grains.

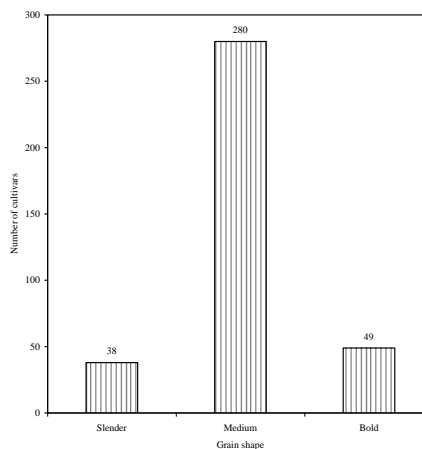


Fig. 2. Frequency distribution of rice cultivars based on the shape of the grains.

Grain width ranged between 1.16 mm and 3.28 mm with an average value 2.41 mm. The shape of the grain was indicated by length width (L/W) ratio. Ratios of grain length to grain width were

observed between 1.57 and 3.77 with an average value of 2.45. Hoshikawa (1993) reported that the length width ratio values of *Indica* type rice belonging to the long grain group are generally greater than 2.0. Islam (1990) observed that length width ratio of husked grains of deep water rice varied from 1.65 to 3.67. Based on length/width (L/W) ratios, Bangladesh rice cultivars were classified into shape groups as bold (L/W ratio 1.10-2.00), medium (L/W ratio 2.00-3.00) and slender (L/W ratio > 3.00) according to the classification of Cruz and Khush (2000). In the present study the frequency distribution of the cultivars were in the order of medium > bold > slender (Fig. 2). Medium shaped grains were found in a maximum number of cultivars followed by the bold group. Seventy six percent of total cultivars belonged to the medium type while 13% were bold grained (Fig. 2). Only 10% of the cultivars possessed slender grains.

Disintegration of rice kernels: Based on disintegration behavior of rice kernels, Bangladesh cultivars tested were classified from low to high alkali digestibility (Fig. 3). As expected, kernels with high alkali digestibility were disintegrated almost completely in 1.7% KOH solution, kernels having intermediate digestibility showed partial disintegration and kernels with low alkali digestibility were unaffected. Within individual group, significant differences were observed in the degree of spreading (disintegration) for rice kernels among the rice cultivars studied. Therefore, cultivars from each of the alkali digestibility group were divided further for better characterization. Low alkali digestibility consisted of the alkali spreading scores 1 and 2 as determined by the degree of spreading of rice kernels in 1.7% KOH solution after 24 hours of immersion at room temperature. Intermediate alkali digestibility composed of alkali spreading scores 3, 4 and 5, and high alkali digestibility consisted of alkali spreading scores 6 and 7. Kaul *et al.* (1978) found the alkali spreading scores between 2 to 7 in 60 rice cultivars from Bangladesh. Lahiri *et al.* (1993) reported that the alkali spreading score of 10 artificial mutants developed from two Bangladesh rice cultivars was between 2 and 6.

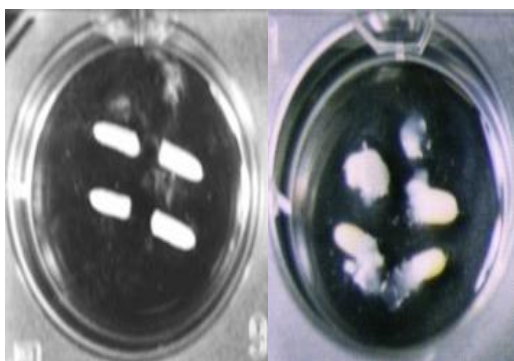


Fig. 3. Alakali digestibility in rice cultivars tested; left: low, right: high.

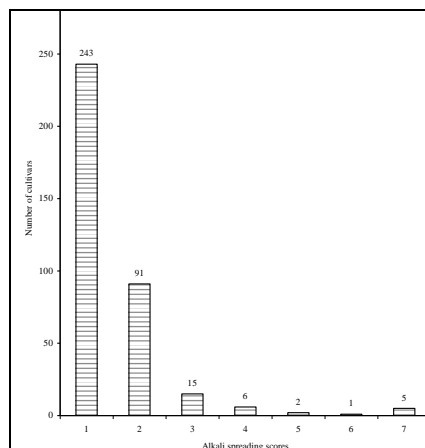


Fig. 4. Frequency distribution of rice cultivars based on their disintegration in dilute alkali.

Gel consistency behavior: The gel consistency test is based on the consistency of the rice paste and differentiates among varieties with high amylose content. Varietal differences in gel consistency exist among varieties of similar amylose content (Cruz and Khush, 2000). The test separates high-amylose rices into three categories:

1. Very flaky rices with hard gel consistency (length of gel, ≤ 40 mm);
2. Flaky rices with medium gel consistency (length of gel, 41 to 60 mm); and

3. Soft rices with soft gel consistency (length of gel, ≥ 61 mm).

All of the categories were observed in the rice cultivars tested (Fig. 5). Flaky rices or rices with medium gel consistency are found in maximum number of cultivars followed by cultivars with hard gel consistency (Fig. 6). However, Very flaky rices (hard gel consistency) and soft rices (soft gel consistency) were found in almost equal number of cultivars. These results suggest that Bangladeshi people prefer flaky rices. The results of the present study are in consistent with the findings of Cagampang *et al.* (1973) who reported that many traditional Asian varieties of rice would be classified as flaky and showed gel consistency values of over 50 mm.

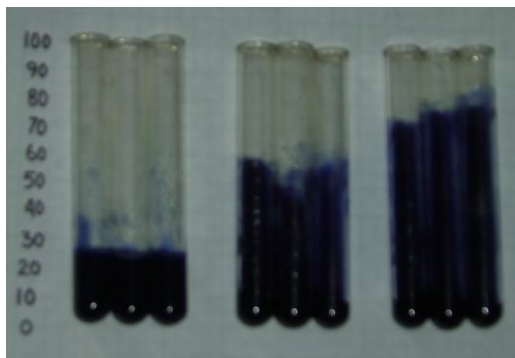


Fig. 5. Typical gel consistency values of milled rice. From left to right: hard, medium and soft gels.

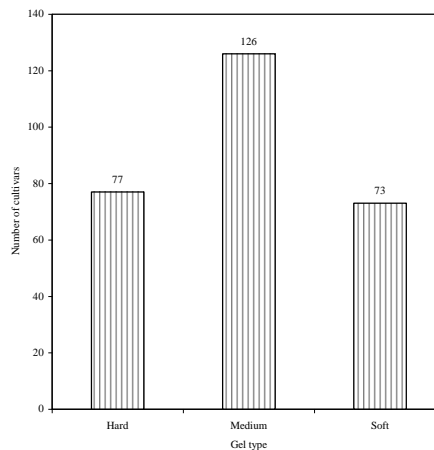


Fig. 6. Frequency distribution of rice cultivars based on gel length.

Discussion and Conclusion

Approximately one third of the world population relies on rice plants as major food supplier. It is well known that rice grains exhibit distinct physicochemical properties depending on their cultivars and the quality of starch largely influences cooking properties of rice. These properties have been utilized and selected by people living in each country of the world (Nakamura *et al.*, 2002). The 367 local rice cultivars were taken in the study. History of the cultivars as to when these were domesticated or for how long these cultivars are being grown is not known. However, most of the local cultivars are localized and being grown for several decades and thus represents the old varieties of cultivated rice.

Medium sized grains (5.51-6.60 mm) were found in maximum number of cultivars followed by short ones. However, based on length/width ratio (grain shape), medium grains (L/W 2.10-3.00) showed the maximum frequency, which was followed by the bold ones. This result suggests the preference for medium grains. However, it was reported that the people of Bangladesh like long, slender and shiny grains (Choudhury *et al.*, 1989; Unnevehr *et al.*, 1992).

Correlation coefficients of grain length and grain width of dehulled grains were calculated as 0.34, suggesting that a positive correlation exists between them. Satoh *et al.* (1990a, 1990b) also found positive correlation among length and width of husked grains in cultivars collected from some African countries. A linear and positive relationship was observed in length and length width ratio

of rice grains. Afroze (1996) and Saha (1998) also reported similar results in Bangladesh local rice cultivars.

More than 90% of the cultivars studied possessed alkali spreading scores of 1 and 2 (Fig. 4), revealed that most of the Bangladesh rice cultivars are resistant to alkali. These results are supported by the findings of Choudhury (1979) and Unnevehr *et al.* (1992). Gel consistency is a good index of cooked rice texture. In the present study, most of the rice cultivars tested had medium gel consistency (Fig. 6). However, literature indicates that peoples of Bangladesh prefer cultivars of soft gel consistency (Juliano, 1979). The discrepancy may be explained from the fact that in this study a large number of cultivars of diverse characters were used while Juliano (1979) used only 20 cultivars.

Researches carried out on rice so far focused mainly on the varietal improvement and cultural and management aspects. The grain characteristics relating quality, particularly grain morphology, are remaining of secondary importance and thus overlooked. Currently available data on rice do not provide a good basis for judgment of grain quality (Kaosa-ard and Juliano, 1991). The present work is an attempt to characterize the cultivars based on some selected traits of grain quality. The variations of grain quality characters obtained in Bangladesh rice cultivars can be regarded as useful materials which can be exploited through breeding.

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