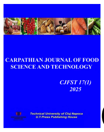

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Research Article

RELATIONSHIP AMONG GLYCEMIC INDEX WITH PHYSICO-CHEMICAL TRAITS OF BRRI HYBRID RICE VARIETIES

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ABSTRACT

Various rice grain qualities could be the determinants of safe consumption, especially for diabetic or non-diabetic individuals. The present investigation was conducted to assess the interrelationship between the glycemic index with the biochemical and cooking properties of six BRRI hybrid rice cultivars, along with their categorization and subsequent relationship. Biochemical traits, like protein, moisture, fat, ash, fiber and amylose content, and cooking properties, including length-breadth ratio, grain elongation, cooking time, water uptake ratio, gel consistency and an alkali spreading test were measured. The result revealed that most of the BRRI hybrid rice cultivars possessed intermediate- class amylose varying from 20.87% to 24.30% along with medium Glycemic Index of 56.31 to 63.83, except BRRI hybrid dhan 4 which had a low amylose content of 17.23% with a high Glycemic Index of 70.89. Heera2 had a minimum L/B ratio of 2.35 mm, a high cooking time of 20 minutes. BRRI hybrid dhan 6 had a maximum L/B ratio of 3.76 mm, a low cooking time of 16 minutes, and a high alkali spreading value of 6.42. On the other hand, BRRI Hybrid Dhan2 had a low alkali spreading value of 3.92. According to gel consistency, both the soft gel and medium gel consistency rice were found in this experiment. The Glycemic index of BRRI hybrid rice varieties correlated positively with milled rice length, a length-breadth ratio, gel consistency and also, correlated negatively with water uptake ratio, amylose content, milled rice breadth, cooking time, an alkali spreading value and grain elongation.

1. Introduction

The majority of the people in the world, particularly in Asia, keeps rice in their daily diets as an important supplier of carbohydrates and nutrients. Regular intake of rice increases the risk factor of developing a diabetic condition due to increased blood glucose levels (Barclay et al., 2008). Now a days, people are cautious about healthy foods and they are searching for the right variety of rice for diabetic and non-diabetic individuals.

The nutritional and economic worth of rice mainly count upon its grain quality and cooking properties, which can be evaluated by determining cooking time, a water uptake ratio, amylose content, gelatinization temperature, a grain elongation ratio, gel consistency etc. Moreover, the gelatinized structure of starch is resistant to digestion, which lowers the glycemic index (GI) and it can be formed from cooked and cooled rice. In the large intestine, resistant carbohydrates are broken down and serves as a medium for the growth of gut bacteria, which boosts immunity in the body.

Jenkins et al.initially presented the Glycemic Index (GI) in 1981. The GI system classifies foods heavy in carbs on a scale of 0 to 100 using the postcibal blood sugar response (Brand-Miller et al., 2012). Different rice varieties have different glycemic index (GI) values based on the combination of starch type and grain shape. Rice's amylose-amylopectin ratio is the variable that causes changes in insulin and glucose sensibility. Long-grain rice with less stickiness and a higher amylose content has been proven to have a lower glycemic index.

For a diabetic person, the judicial selection followed by adaptation of the desired rice variety in the regular meal could be a cost-effective promoter of lowering blood glucose levels as well as other related health hazards. Physical grain properties would be simple traits even for the layperson to predict the level of GI of the rice variety. In association with these physical traits, amylose and amylopectin content, gelatinization temperature and gel consistency determination could be easy tools to identify and select desired rice varieties for rice breeders.

Studies on different biochemical, morphological, and cooking properties may reveal a correlation with GI, which could make it easier to evaluate the grain quality in favor of controlling diabetes. The experiment was accomplished for the assessment of the grain attributes and cooking quality features of various selected BRRI hybrid rice varieties to establish relationships between glycemic index and the cooking properties of BRRI hybrid rice varieties with a view to recommending suitable rice varieties for consumers.

2. Methods

2.1. Location of experiment and time

The experiment was done in the Nutrition and Grain Quality Laboratory of Bangladesh Rice Research Institute (BRRI), and in the Professor Muhammad Hossain Post Graduate Laboratory of Bangladesh Agricultural University, from November 2022 to July 2023.

2.2. Grain size, shape, collection of samples and sampling procedure

Five BRRI hybrid rice varieties, BRRI hybrid dhan 6, BRRI hybrid dhan 5, BRRI hybrid dhan 4, BRRI hybrid dhan 3, BRRI hybrid dhan 2, Heera2 (hybrid) and low GI rice (ACI) were brought from a local market and the Bangladesh Rice Research Institute (BRRI), respectively. Applying Graham's, (2002) technique, the milled rice's length (L) and width (B) were measured using a digital slide caliper. Firstly, the digital slide caliper was turned on and set to auto zero. Then, a total of 10 rice grains were taken without any deformities or breakage from each genotype for measurement and to measure the individual length of the grain. Lastly, 10 data points were averaged into three entries. The length-breadth ratio is determined by dividing length by breadth.

2.3. Cooking time

The time when starch granules fully disappear from the boiling water with increased time is called cooking time (Rao & Juliano, 1970). Cooking time is considered as the quality of cooking. For the determination of cooking time, 50 ml boiled water and five gm of milled rice were taken in a 100 ml beaker. At least ten grains were massed per minute between two Petri dishes after being cooked in extremely hot water for 10 minutes. The grains were thought to have been cooked after at least 90% of the massed grains had not shown a blurred center (Figure 1).

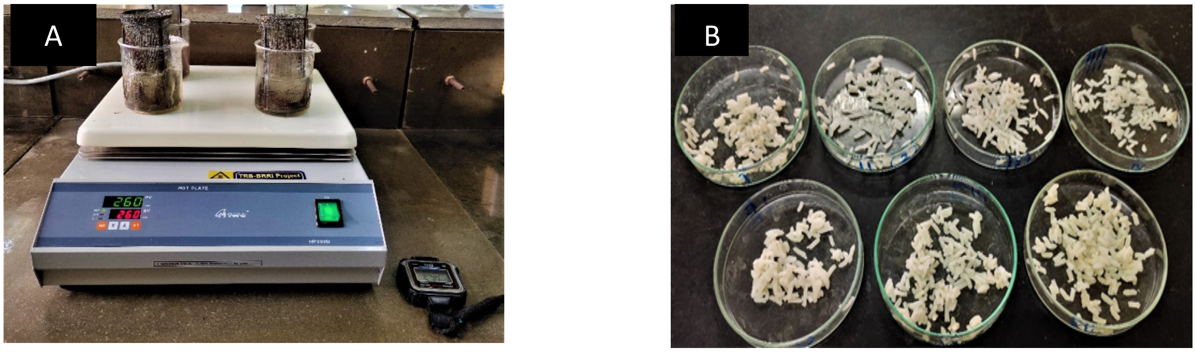


Figure 1. Determination of cooking time.

2.4. Water uptake ratio

The approach of A. O. et al. (2012) was followed to determine the water uptake ratio. First, 20 milliliters of distilled water were applied to boil 20 grams of rice kernels from each treatment in a bath of heated water. The cooked rice's surface water was eliminated, and the sample's accurate weight was then measured. Finally, the water uptake ratio was calculated applying the formula below.

$$\text{Water uptake ratio} = \frac{\text{Weight of cooked rice}}{\text{Weight of raw rice}} \quad (1)$$

2.5. Grain elongation (GER)

The approach of Juliano & Perez, (1984) was used to estimate the grain elongation ratio. Before cooking, the starting grain length (L_o) was measured and after cooking, the final grain length (L_1) was quantified. Grain elongation (L_2) was counted by subtracting the starting grain length (L_o) from the final grain length(L_1). The grain elongation ratio was then calculated using the formula below.

Grain elongation ratio = L_1 / L_2.

2.6. Gelatinization temperature and alkali spreading value

In order to ascertain the gelatinization temperature (GT), the alkali spreading test was employed (Little et al., 1958). First, 15 ml of 1.7% KOH was mixed with ten intact-milled grains on a petri dish at room temperature. After that, the mixture was held for 23 hours; the degree of spread was then marked using a 7-point scale by visual confirmation (Table 1), followed by Jennings et al. (1979).

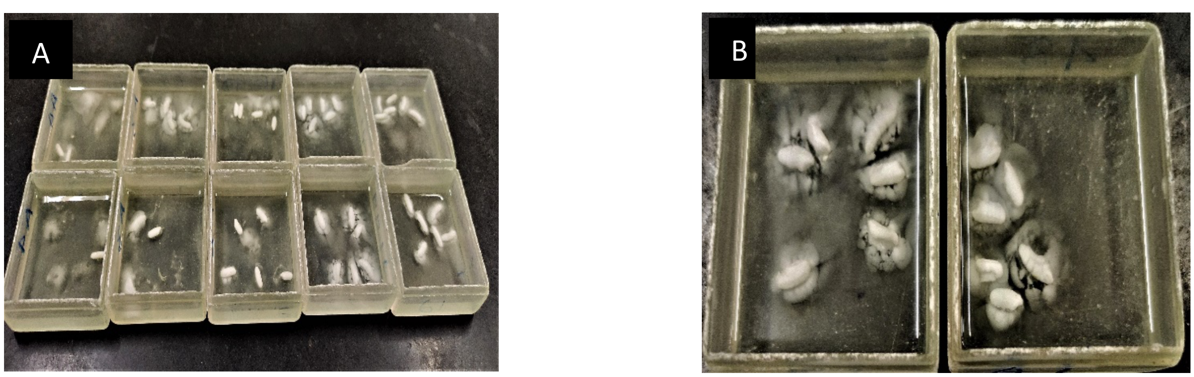


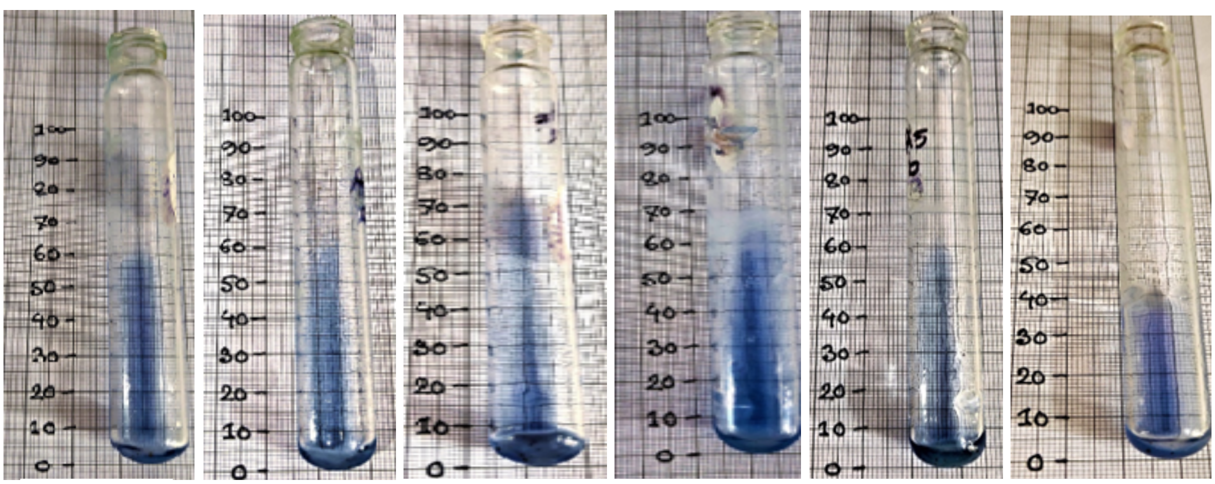
Figure 2. Determination of gelatinization temperature. Here A indicates the result after incubation, B indicates the magnified grain structure for ascertaining alkali spreading value.

Table 1. Description of alkali spreading value scores for rice.

Description	Score	Alkali digestion
Grain unaffected	1	Low
Grain Swollen	2	Low
Grain Swollen, collar imperfect or small	3	Low/Intermediate
Grain Swollen, collar perfect and wide	4	Intermediate
Grain segmented, collar complete and wide	5	Intermediate
Grain dispersed, merging with collar	6	High
Grain completely dispersed and intermingled	7	High

2.7. Gel consistency (GC)

The approach of Cagampang et al. (1973) was used to measure the gel consistency of rice. Firstly, 100mg of powdered milled rice was dipped in 0.2 ml of 95% ethanol, which contains 0.025% bromothymol blue. Then the sample was put in a tube. Afterwards, 2 ml of 0.2N KOH was added. After that, the tube spent eight minutes in a hot water bath. The tube was then allowed to cool for 20 minutes in an ice bath. After the tubes cooled, they were placed horizontally on line-marked graph paper, and an hour later, the gel length was measured (Figure 3). Cagampang et al. (1973) categorized the rice into three classes such as hard gel consistency rice (< 40 mm), medium gel consistency rice (40-60 mm), and soft gel consistency rice (> 60 mm).



Heera2 BRRI Hybrid BRRI Hybrid BRRI Hybrid BRRI Hybrid BRRI Hybrid

Figure 3. Gel consistency values of six BRRI hybrid rice cultivars.

2.8. Protein content (%)

Protein content (%) was determined by using an Infratec" 1241 Grain Analyzer machine. In the grain analyzer machine, 200 mg of rice grain was analyzed for the determination of protein content (%). The entire procedure was carried out three times, and then the mean value was taken for the total protein content. Moisture and fat content (%) of rice samples were also measured with the grain analyzer machine (Model: Infratec"1241).

2.9. Fiber content %

AOAC Official Method, (2020) was used to estimate the rice's fiber content. Initially, 100 ml of TCA digesting agent were introduced to a 500 ml flask containing 5 grams of rice flour. The mixture was boiled and then kept for about

40 minutes, and then it was filtered using 15.0 cm Whatman paper. After rinsing with hot water, the remainder was placed in a porcelain plate. Later, the sample was dried at 105ºC in an oven for the whole night. The sample was placed in a desiccator and weighted as W_1 after drying for the whole night. After that, the sample was burned for 6 hours in a sound proofed furnace at 500°C and allowed to rest, then weighed again as W_2.

$$\text{Fiber \%} = \left(\frac{W_1 - W_2}{W_o}\right) \times 100 \qquad (2)$$

Where, W_1 is the weight of the crucible, fiber and ash, W_2 is the weight of the crucible and ash, and W_o is the dry weight of the sample food.

2.10. Total ash content %

The overall ash content was calculated using the technique of Alexandre, (2020). First, 5 g of a fresh sample was taken for analysis, and then it was heated using a muffle furnace set to 550–600°C for three hours. A desiccator was used to chill the sample before it was weighted. The weight of the empty crucible was measured first, then later the crucible containing ash, and the crucible with a sample for the test were measured. Finally, the total ash was calculated on a dry basis in percent. The ash content percentage was calculated as follows:

$$\text{Ash(\%)} = \left(\frac{\text{Initial weight ofcrucible} - \text{Final weight ofcrucible}}{\text{Weight of sample}}\right) \times 100 \qquad (3)$$

2.11. Amylose content %

Amylose content was measured by the Click or tap here to enter text. approach. Initially, 1 ml of 95% ethanol was mixed with 100 mg of powdered rice and then, 9 ml of 1 normal sodium hydroxide was combined to that mixture. After a 10-minute immersion in hot water, the sample was allowed to cool. The sample's volume was then increased to 100 ml. In a 100 ml volumetric flask, five milliliters of the sample solution were inserted. Next, two milliliters of a 0.2% iodine solution and one milliliter of regular acetic acid were then included to the volumetric flask. The volume of the mixture was increased to 100 ml. The mixture was vortexed and left for 20 minutes at 30°C. Absorbance was counted by a UV/visible spectrophotometer at 620nm. The total amylose content was computed from the standard curve (Figure 4).

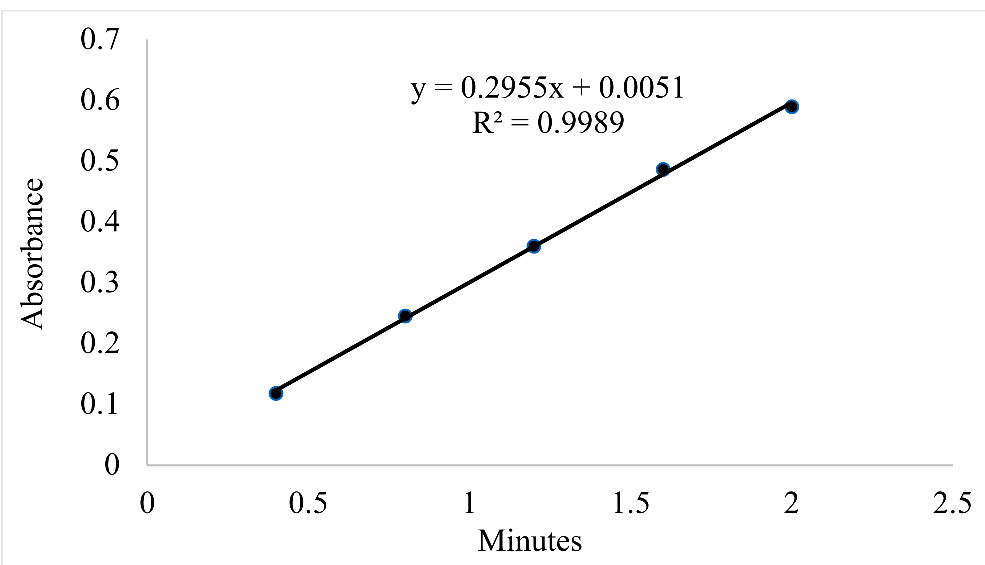


Figure 4. Standard curve of amylose content (%).

2.12. Determination of GI values

The standard glycemic index determination protocol was done with 10 non-diabetic subjects who were allowed to study in the morning after an overnight fast. The study was conducted for a maximum of 3 days per week. Three fasting blood samples were obtained from the finger prick at the start of the trial in order to assess blood glucose using a Contour TS glucometer. Then blood glucose levels were recorded. 50g of available carbohydrate (test food) was fed to the subjects and after that, blood samples were collected and measured at 15, 30, 45, 60, 90 and 120 minutes after initiating the ingestion of the test food. The trial of each variety was conducted on each subject with standard food (glucose). The blood glucose level after each meal was recorded; Each variety's GI was determined following the trapezoid rule's incremental area under the curve in the Excel 2008 application. The area under the base line value of the standard (glucose) food was ignored to get the IAUC value of the standard food.

2.13. Statistical analysis:

The statistical tool for agricultural research, or STAR, was used to do the statistical analysis. The experiment plan was developed according to the object of the completely randomized design (CRD) with three separate trials. Multiple range tests were accomplished to analyze the least significant difference (LSD). Frequency distributions were checked. Mean, percentage, standard deviation (STD) and standard error with a 1% level of significance were obtained using the Statistical Tool for Agricultural Research (STAR). Pearson's comparison test was performed to correlate different varieties of grain quality traits.

3. Results and Discussions

3.1 Biochemical traits of milled rice

The chemical compositions (AC, MC, PC, fat, fiber, ash) of BRRI hybrid rice varieties are represented in Table 2. Amylose content had considerable variation among the rice varieties, ranging from 17.23% to 30.56%. The results showed that BRRI hybrid dhan 4 had the lowest amylose content (17.2%), and ACI rice had the highest amylose content (30.56%). The rest of the BRRI hybrid dhan showed intermediate class amylose content ranging from 20.87% to 24.30%. The varieties with a low amylose content of less than 20% are a potential group that needs attention for breeding new high quality rice varieties.

The fat, fiber and ash content were quite similar for all the BRRI hybrid varieties, but they were higher compared to ACI rice. BRRI hybrid dhan 5 showed a higher content of protein and fiber compared to other BRRI hybrid dhan varieties and ACI rice. All rice cultivars had varying percentages of moisture, fat, fiber, protein, and ash, which were (11.78 to 12.83) %, (0.98 to 2.64) %, (1.21 to 4.31) %, (7.3 to 8.53) %, and (1.09 to 1.6) %, respectively. According to the presence of carbohydrates, the serving size of the test food was calculated. This allowed each participant to intake 50g of the test food containing carbohydrates in order to show a blood glucose response.

3.2. The selection of study subjects for the assessment of the Glycemic Index

Table 3 shows the characteristics of the participants. Participants consist of ten healthy subjects (male 5, female 5; with an average value ± SD for age 25.7 ± 0.48 years, height 1.59 ± 0.08, body weight 56.20 ± 7.71). The mean BMI of the study subjects was 22.2 ± 2.57. Fasting blood glucose level was measured in fasting conditions in the morning.

Table 2. Proximate composition of chemical properties of test foods.

Rice variety	Amylose content %	Moisture %	Fat %	Fiber %	Protein %	Ash %	Available Carbohydrate %	Rice (g) cooked per serving
BRRI Hybrid dhan2	20.87	12.33	2.64	3.61	7.93	1.17	72.32	69.14
BRRI Hybrid dhan3	22.55	11.78	2.15	3.75	7.33	1.2	73.79	67.75
BRRI Hybrid dhan4	17.23	12.13	1.87	2.33	7.47	1.09	75.11	66.57
BRRI Hybrid dhan 5	23.75	12.83	1.94	4.31	8.23	1.6	71.09	70.33
BRRI Hybrid dhan 6	23.25	12.23	2.34	4.05	7.63	1.5	72.25	69.20
ACI low GI rice	30.56	12.5	0.98	1.21	7.3	1.18	76.78	65.12
Heera 2	24.30	11.77	1.85	4.52	8.53	1.71	71.64	69.79

Table 3. Demographic characteristics of the non-diabetic individuals (N=10)

Characteristics	Mean ±SD
Age (Years)	25.7 ± 0.48
Height (m)	1.59 ± 0.08
Body weight (kg)	56.2 ± 7.71
BMI (kg/m²)	22.2 ± 2.57
Fasting glucose level (mmol/L)	5.63 ± 0.19

Note: **N**= number of volunteers in research work

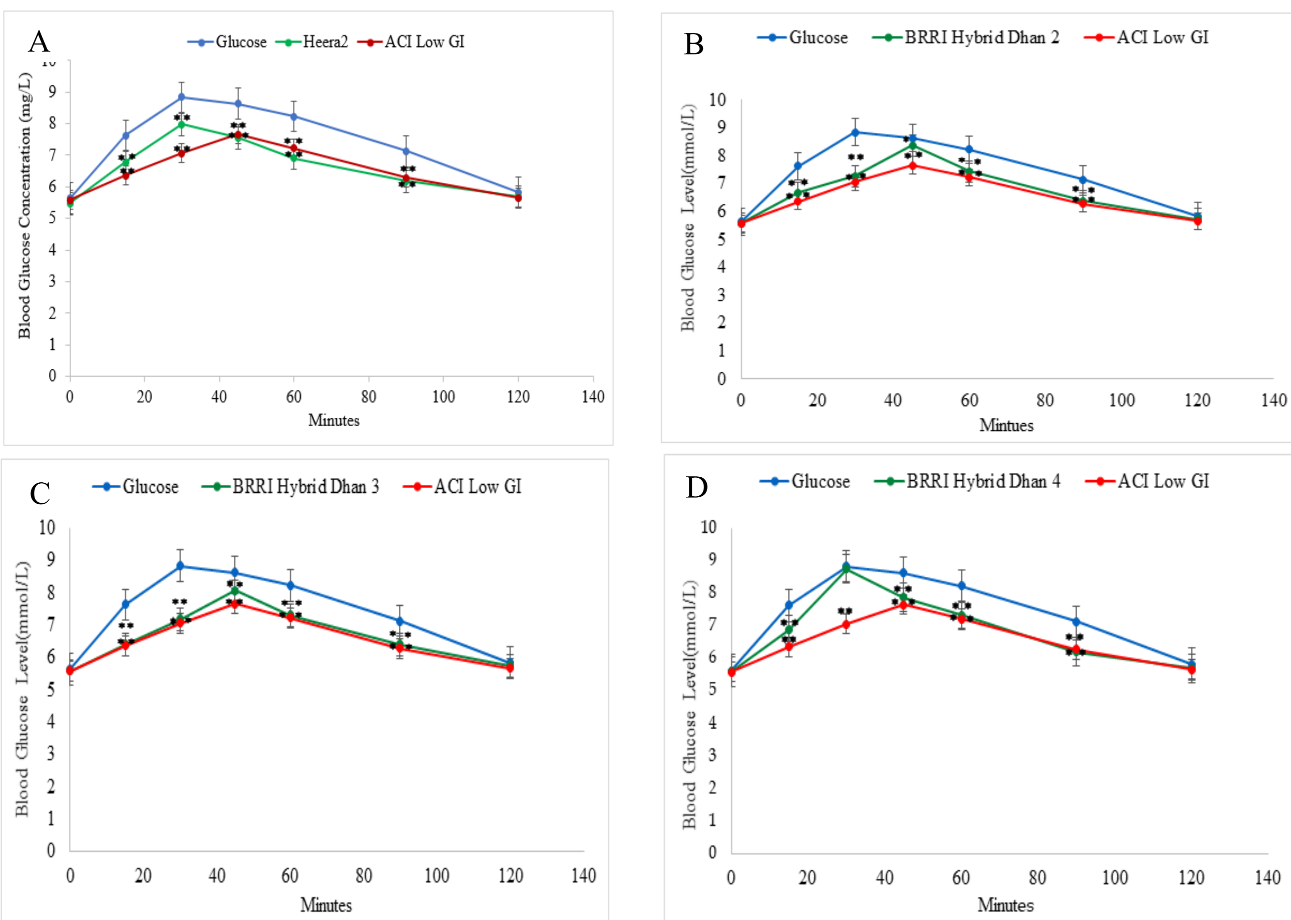
3.3.Assessment of GI from IAUC of selected test rice and glucose

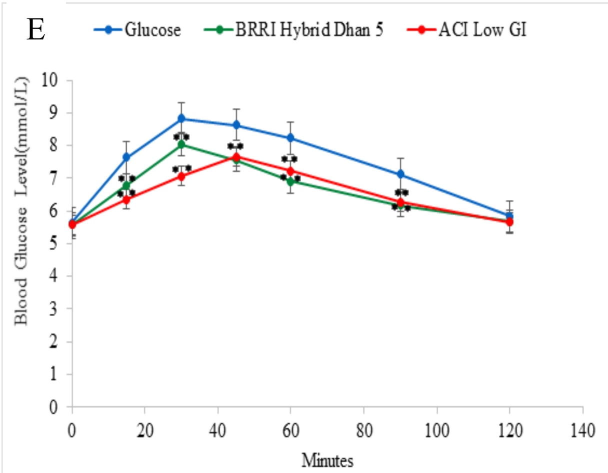
The inconsistent change in blood glucose level for 2 hours after the intake of test food and also standard food (glucose) is presented in Figure 5 (A–F). After the ingestion of test foods and standard foods, the blood glucose response did not show any significant variation between 0 and 120 minutes, as expected. Above the baseline value, a varied level of significance was found between the standard food and the test food (at $p<0.01$ and $p<0.05$). The computed sum of IAUC (mmol/l.min) as mean ± SEM for individual test foods is shown in (Table 4). The IAUC of BRRI hybrid rice varieties ranged from 133.9 ± 17.29 to 139.57 ± 17.72 mmol/l.min. Standard glucose and control ACI rice showed IAUC of 150.89± 20.51 and 132.4 ±19.07 mmol/l.min, respectively. GI values were calculated from the mentioned IAUC. Three classes of GI rice were found. ACI rice showed a low GI of 52.45 and the most of the BRRI hybrid dhan had a medium GI ranging from 56.31 to 63.83, except BRRI hybrid dhan 4 with a high GI of 70.89

Table 4. Assessment of GI from IAUC of selected rice and Glucose

Standard & test food	IAUC mmol/L.min (mean ± SEM)	GI	GI Class (Brand-Miller *et al.*,2012)
Glucose	150.89 ± 20.51	100	
BRRI hybrid dhan2	136.83 ± 18.92	63.83	Medium (56-69)
BRRI hybrid dhan3	134.8 ± 19.28	58.62	Medium (56-69)
BRRI hybrid dhan4	139.57 ± 17.72	70.89	High (≥70)
BRRI hybrid dhan 5	133.9 ± 17.29	56.31	Medium (56-69)
BRRI hybrid dhan 6	134.3 ± 18.08	57.33	Medium (56-69)
ACI	132.4 ± 19.07	52.45	Low (≤55)
Heera2	129.75 ± 17.38	55.59	Medium (56-69)

Note: **IAUC** = Incremental Area Under Curve, **GI** = Glycemic Index





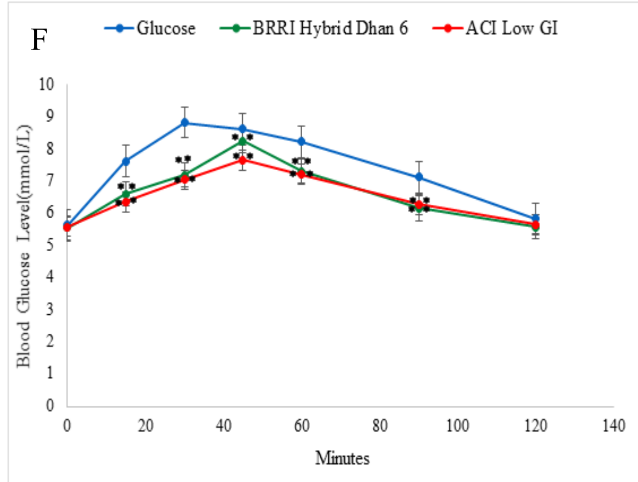


Figure 5. (A–F): Variations of Blood glucose level (mmol/l) at various times within 2 hours of glucose (standard food), control low GI rice (ACI) and rice (test food) ingestion: Figures A, B, C, D, E and F indicates glucose responses of Heera 2, BRRI hybrid Dhan 2, BRRI hybrid dhan 3, BRRI hybrid dhan 4, BRRI hybrid dhan 5 and BRRI hybrid Dhan 6 with significance level $p<0.05$ as (*) and $p<0.01$ as (**), consecutively.

3.4. Morphological and cooking properties of BRRI hybrid rice

The morphological and cooking properties correspond to the nutriment, texture, and cooking quality of the grain of six BRRI hybrid rice germplasms, as mentioned in Table 5. The milled rice changed in length and width from 1.88 mm (for BRRI hybrid dhan 4) to 2.41 mm (for BRRI hybrid dhan 3), and from 5.41 mm (for Heera2) to 7.28 mm (for BRRI hybrid dhan 6). The L/B ratio ranged from 2.35 mm for Heera 2 to 3.76 mm for BRRI hybrid dhan 6.

Vanangamudi et al. (1988) classified grains based on their length into 3 classes: long (L) if >6.0 mm, medium (M) if (5.0 to 6.0) mm, and short (S) <5.0 mm. Rice kernel shapes are categorized in accordance with the ratio of length to breadth; the round shape of the grain indicates a low L/B ratio; the medium shape indicates an intermediate L/B ratio and the slender shape of the grain indicates a high L/B ratio (Verma & Srivastav, 2020). Generally, an L/B ratio (>3) is accounted as slender (IRRI, 2002).

Table 5. Performance of 6 rice genotypes based on eight morphological and cooking quality traits properties

Variety	MRL (L) (mm)	MRB (B) (mm)	L/B Ratio (mm)	Shape	CT (min ±1)	WUTR	GE (mm)	GER (mm)	ASV	GC (mm)	GC Class
Heera2	5.41	2.3	2.35	Medium	20.30	3.04	2.99	1.55	4.42	60	Medium (40-60)
BRRI Hybrid dhan2	5.78	2.35	2.46	Medium	18.30	3.29	1.91	1.33	3.92	60	Medium (40-60)
BRRI Hybrid dhan3	5.82	2.41	2.42	Medium	19.00	3.04	3.11	1.54	5.58	73	Soft >60

BRRI Hybrid dhan4	6.87	1.88	3.66	Slender	17.00	2.95	1.89	1.28	5.5	70	Soft >60
BRRI Hybrid dhan5	6.86	2.25	3.05	Slender	18.00	3.29	3.49	1.51	5.08	64	Soft >60
BRRI Hybrid dhan6	7.28	1.94	3.76	Slender	16.00	3	2.02	1.28	6.42	42	Medium (40-60)

Note: **MRL** = Milled Rice Length, **MRB** = Milled Rice Breadth, **L/B** = Milled Rice Length and Breadth Ratio, **CT** = Cooking Time, **WUTR**= Water uptake ratio, **GE** = Grain Elongation, **GER =** Grain Elongation ratio**, ASV** = Alkali Spreading Value, **GC** = Gel Consistency.

Table 5 indicates that BRRI hybrid dhan 4, BRRI hybrid dhan 5, and BRRI hybrid dhan 6 are slender-shaped rice, and the rest of the rice varieties are medium shaped rice.

The temperature at which proteins, amylose, and starch gelatinize influence the time rice takes to cook ((Bhattacharjee et al., 2002; Thomas et al., 2013) (Figure 1). The cooking time for Heera2 was high (20 minutes) and BRRI hybrid dhan 6 was low (16 minutes); the other rice varieties were ranged in between. The absorption of water after cooking indicates the ratio of water uptake. It ranged from 3.29 to 2.95. Water uptake ratios were high (3.29) for BRRI Hybrid dhan5 and BRRI Hybrid dhan2, and low (2.95) for BRRI Hybrid dhan4.

Grain elongation is an important inherent trait that reflects the grain starch composition. The BRRI Hybrid dhan 5 showed the highest grain elongation (3.49 mm), whereas the BRRI Hybrid dhan 4 showed the lowest (1.89 mm). Grain elongation ratio was high in Heera2 and low in BRRI Hybrid dhan 6 and BRRI Hybrid dhan 4.

According to the conversion of alkali spreading values through a reference value chart by Jennings et al. (1979), the greatest alkali spreading value was exhibited in BRRI Hybrid dhan 6 (6.42), while the smallest value was exhibited in BRRI Hybrid Dhan 2 (3.92), and the rest of the rice varieties exhibited intermediate alkali spreading values (Table 5 and Figure 2). An inverse relationship between the alkali spreading value and gelatinization temperature was found.

Corresponding to gel consistency (Figure 3), varieties BRRI hybrid dhan 5, BRRI hybrid dhan 4, and BRRI hybrid 3 had soft gel consistency, and varieties Heera2, BRRI hybrid dhan 2, and BRRI hybrid dhan 6 had medium gel consistency. These values were compared with the reference gel consistency values for their categorization (Table 5).

3.5. Correlation analysis

Correlation analysis was done among the glycemic index, biochemical, morphological, and cooking attributes of rice (Table 6). It was observed that the glycemic index of rice correlated positively with milled rice length (r = 0.181), gel consistency (r =0.374), and L/B (r = 0.357). Also, the glycemic index of rice correlated negatively with milled rice breadth (r = -0.474), cooking time (r = -0.364), eater uptake ratio (r = -0.226), gel elongation (r = -0.910), alkali spreading value (r = -0.654), and amylose content (r = -0.990). Milled rice breadth and length were negatively correlated (r = -0.795); L/B was positively correlated with milled rice length (r = 0.943) but negatively correlated with milled rice breadth (r = - 0.950).

Milled rice length (r = -0.164) and L/B (r = -0.408) exhibited a negative correlation with the water uptake ratio, while milled rice breadth (r = 0.567), cooking time (r = 0.185), gel elongation (r = 0.281), gel consistency (r = 0.0325), and amylose content (r = 0.319) had a positive correlation. A negative correlation was found among the gel elongation ratio and the length of milled rice (r = -0.262) and L/B (r = -0.466).

Cooking time (r = 0.579) and milled rice breadth (r = 0.5890) showed positive correlations with gel elongation. Alkali spreading value negatively correlated among milled rice breadth (r = -0.6210), cooking time (r =-0.673), water uptake ratio (r =-0.613), gel elongation (r = -0.083), gel consistency (r = -0.290), and amylose content (r = -0.061), and positively correlated among milled rice length (r =0.734) and L/B (r = 0.728). Both gel consistency and amylose content correlated negatively with milled rice length (r = -0.393, -0.247) and L/B (r = -0.399, -0.424), but expressed a positive correlation with cooking time (r = 0.464, 0.399).

Table 6. Correlation matrix among 10 traits of BRRI hybrid rice cultivars.

	MRL	MRB	L/B	CT	WUTR	GE	ASV	GC	AC
MRB	-0.795								
L/B	0.943	-0.950							
CT	-0.917	0.795	-0.910						
WUTR	-0.164	0.567	-0.408	0.185					
GE	-0.262	0.589	-0.466	0.579	0.281				
ASV	0.734	-0.621	0.728	-0.673	-0.613	-0.083			
GC	-0.393	0.369	-0.399	0.464	0.0325	0.357	-0.290		
AC	-0.247	0.533	-0.424	0.399	0.319	0.644	-0.061	-0.401	
GI	0.181	-0.474	0.357	-0.364	-0.226	-0.690	-0.054	0.374	-0.990

4. Conclusions

Increased rice length is preferable compared to its breadth when overall quality is concerned. The highest values of length, and a length to breadth ratio of milled rice were 7.28 mm and

were in the standard range (11.77 – 12.83%) and (7.3–8.53%), respectively. Similarly, for good rice quality, amylose content should be intermediate, which was also resembled in all hybrid cultivars except for BRRI Hybrid dhan 4. The gel consistency chart showed that BRRI Hybrid dhan 5, BRRI Hybrid dhan 4, and BRRI Hybrid dhan 3 were classified as soft gel rice, while the remaining rice types were classified as medium gel. Thus, based on gel consistency, the genotypes could be categorized into two groups, such as a medium and a soft gel category. The range of gelatinization temperatures might classify the genotypes in low, intermediate and high groups. Thus, a low gelatinization temperature was found in the case of BRRI Hybrid dhan 6 and a high gelatinization temperature was in BRRI Hybrid dhan 2. However, other cultivars had an intermediate type gelatinization temperature. All the genotypes showed a medium class of glycemic index value, with an exception in BRRI Hybrid

3.76 mm in BRRI hybrid dhan 6. Proper moisture content (9-13%) is required for storage durability. In a good rice genotype, protein content should be above 7%. Moisture content and protein content in all the studied genotypes

dhan 4 (low). Comparing a mean performance of various biochemical, morphological and cooking quality traits BRRI Hybrid dhan6 performed the best and BRRI Hybrid dhan3 was ranked the worst.

5. References

A. O., O., B. E, U., & N., D. (2012). Rice Cooking Quality and Physico-Chemical Characteristics: a Comparative Analysis of Selected Local and Newly Introduced Rice Varieties in Ebonyi State, Nigeria. *Food and Public Health*, *2*(1), 43–49. https://doi.org/10.5923/j.fph.20120201.09

Alexandre, N. (2020). Effect of Parboiling Technique on the Nutritional Quality of Rice. *Global Journal of Nutrition & Food Science*, *2*(5), 1–13. https://doi.org/10.33552/gjnfs.2020.02.000548

AOAC Official Method. (2020). 920.39 Fat (Crude) or Ether Extract in Animal Feed. *AOAC International*, 4.5.01.

Barclay, A. W., Petocz, P., Mcmillan-Price, J., Flood, V. M., Prvan, T., Mitchell, P., & Brand-Miller, J. C. (2008). *Glycemic index, glycemic load, and chronic disease risk-a meta-analysis of observational studies*. https://academic.oup.com/ajcn/article-abstract/87/3/627/4633329

Bhattacharjee, P., Singhal, R. S., & Kulkarni, P. R. (2002). Basmati rice: A review. *International Journal of Food Science and Technology*, *37*(1), 1–12. https://doi.org/10.1046/j.1365-2621.2002.00541.x

Brand-Miller, J. C., Atkinson, F. S., Gahler, R. J., Kacinik, V., Lyon, M. R., & Wood, S. (2012). Effects of added PGX®, a novel functional fiber, on the glycemic index of starchy foods. *British Journal of Nutrition*, *108*(2), 245–248. https://doi.org/10.1017/S0007114511005447

Cagampang, G. B., Perez, C. M., & Juliano, B. O. (1973). A gel consistency test for eating quality of rice. *Journal of the Science of Food and Agriculture*, *24*(12), 1589–1594. https://doi.org/10.1002/jsfa.2740241214

Graham, R. (2002). *A Proposal for IRRI to Establish a Grain Quality and Nutrition Research Center*.

IRRI. (2002). A Proposal for IRRI to Establish a Grain Quality and Nutrition Research Center. *IRRI Discussion Paper Series No. 44*, *44*, 7.

Jenkins, D. J. A., Wolever, T. M. S., Taylor, R. H., Barker, H., Fielden, H., Baldwin, J. M., Bowling, A. C., Newman, H. C., Jenkins, A. L., Goff, D. V, & Biol, M. (1981). *Glycemic index of foods: a physiological basis for carbohydrate exchange 3*. https://academic.oup.com/ajcn/article-abstract/34/3/362/4692881

Jennings, P. R., Coffman, W. R., & Kauffman, H. E. (1979). *Rice improvement.* International Rice Research Institute.

Juliano, B. O., & Bechtel, D. B. (1985). The grain and its gross composition. *Rice Chemistry and Technology*, *March*, 17–57.

Juliano, B. O., & Perez, C. M. (1984). Results of a collaborative test on the measurement of grain elongation of milled rice during cooking. *Journal of Cereal Science*, *2*(4), 281–292. https://doi.org/https://doi.org/10.1016/S0733-5210(84)80016-8

Little, R. R., Hilder, G. B., & Dawson, E. H. (1958). Differential effect of dilute alkali on 25 varieties of milled white rice. *Cereal Chemistry*, *35*(2), 111–126. https://eurekamag.com/research/014/011/014011962.php

Rao, S. N., & Juliano, B. O. (1970). Effect of parboiling on some physicochemical properties of rice. *Journal of Agricultural and Food Chemistry*, *18*(2), 289–294. https://doi.org/10.1021/jf60168a017

Thomas, R., Wan-Nadiah, W. A., & Bhat, R. (2013). Physiochemical properties, proximate composition, and cooking qualities of locally grown and imported rice varieties marketed in Penang, Malaysia. *International Food Research Journal*, *20*(3), 1345–1351.

Vanangamudi, K., Palanisamy, V., & Natesan, P. (1988). Variety determination in rice phenol and potassium hydroxide tests. *Seed Science and Technology*, *16*(2), 465–470. https://eurekamag.com/research/006/896/006896245.php

Verma, D. K., & Srivastav, P. P. (2020). Exploring the physicochemical and cooking properties of some Indian aromatic and non-aromatic rice (Oryza sativa L.) cultivars. *Oryza-An International Journal on Rice*, *57*(2), 146–161. https://doi.org/10.35709/ory.2020.57.2.9

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