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SCREENING OF SOME BANGLADESH CULTIVARS OF RICE FOR THEIR CONSUMERS' PREFERENCE AND NUTRITIONAL CHARACTERISTICS

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Abstract

Large variation for the physicochemical and histochemical properties were found in the grains of sixty varieties of rice of Bangladesh. Red paricarped varieties, which are popular for their taste, had high amylose %. Nonwaxy rice varieties had 17.6 to 32.8% amylose, whereas the only waxy variety Binni retained 5 5% amylose. The protein content ranged from 6.1 to 12.8%, the mean being 8 5%. The local Boro varieties had higher protein content than the high yielding and other local varieties. The Dye-binding capacity values for Boro varieties also indicate better protein quality in them. The popular rice varieties like Biroi, Nizersail, Chikon, Ragusail etc. showed low nutritional value because of low protein content in them. Protein content in rice was found to be negatively correlated with the amylose content. The DBC technique was found to be more rapid, less expensive and more reproductive than Kjeldahl determination. The high protein varieties like Boiragi, Badshabhog, Hbj. B VI and Tepiboro had high microscope section score as well as high lysine and tryptophan content which indicates that these varieties can be used as good donors in a breeding program.

INTRODUCTION

Rice is the synonym for food in Bangladesh and has been the traditional source of carbohydrates and protein since prehistoric time. Grown on 9 8 m ha (24. 22 m acres) rice represents 99% of the food crops. Bangladesh being one of the most densely cultivated rice area has been considered to be within the centre of diversity of rice, by Vavilov (1926). It still retains a good deal of natural variability. The growing conditions are conducive throughout the year for one or the other type of rice. Distinct varieties exist for three growing seasons, namely Aus, Aman and Boro, for adaptability to water stress or flooding conditions or for broadcast or transplanting purposes.

With the spred of the 'Green revolution' in the last decade, the high yielding varieties introduced and bred locally are becoming more popular. With strong promotion by the government and good receptivity by the farmers these new varieties

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are replacing the old leading to serious erosion of the local varieties. These relatively primitive varieties have good appearance and cooking quality and numerous other advantages but unfortunately were poor yielders. Due to the acute scarcity of animal proteins and high price of traditional lagumes, nearly 95% of protein in the rural diet comes from rice. Projections suggest that this trend will continue, with undernutrition and malnutrition putting more and more emphasis on rice. Any genetic improvement in its composition particularly with reference to protein would be welcome. Rice grains have the highest digestibility, biological value and protein efficiency ratio among the cereals (Eggum, 1973) but the low percentage protein content makes it necessary that protein quantity be considered in any attempt aimed at improving the quality. The genetic enhancement of protein is the most acceptable method, provided the additional protein is of a high nutritive value (Kaul, 1970). This refers to the balanced amino acid make up of rice protein, where lysine, methionine and threonine are most limiting (Kaul, 1973).

Screening tests for protein characteristics, have to be rapid, reproducible, applicable to small quantities of seed and simple to use in the less sophisticated laboratories. One of the characters emphasized in this study is the histological characterisation of protein in the grain. This microscopic screening technique (Kaul et al, 1969) is useful to rice breeders when screening for the depth of protein bodies in the grain. No systematic attempt has been made to make an inventory of the gene pool. Only a very limited segment of the diverse germplasm has been conserved and evaluated.

The present work conducted on sixty varieties of rice was undertaken to estimate the consumers' preference characteristics and nutritional characteristics of rice judged by laboratory tests. The knowledge gained can be utilized in breeding programmes.

MATERIALS AND METHODS

The rice varieties screened were collected from various agricultural research institutes in Bangladesh and from the districts of Dacca, Mymensingh, Bogra, Patuakhali, Barisal, Rajshahi, and Sylhet. The material comprised six Boro, twelve Aus, four Broadcast Aman and thirty eight Transplant Aman. Out of 60 rice varieties studied, 6 were high yielding varieties.

Preparation of Samples

The grain samples were stored at room temperature in sealed glass bottles. Rough rice samples were cleaned and dehulled by a Satake grain mill before grinding to 60 mesh powder in a Wiley mill. Moisture content was determined, employing the air-oven method (AOAC, 1955) and all values are reported at 10% constant moisture basis.

Analytical methods

1. Colour and translucency :

Rice grains were visually classified for their seed coat colour into four classes namely white, cream, amber and red. Grains were visually scored for the presence or absence of white core, white belly, translucency and opaquenses.

2. Length/breadth ratio ; size and shape:

Grains were classified for their shape and size using the scale suggested by Adair *et al.* (1966).

3. Thousand Kernel Weight (TKW) and hulling recovery:

500 grain from each sample were weighed in triplicate and the mean weight was doubled to represent TKW.

Hulling recovery was determined by weighing 200 grains of rough rice and the same number of brown rice to get the following index.

$$\text{Hulling recovery\%} = \frac{\text{200 grains of brown rice}}{\text{200 grains of rough rice}} \times 100$$

4. Amylose content:

Amylose content was determined by the rapid colorimetric method employing the procedure outlined by Williams *et al.* (1970). Potato amylose (E. Merck) was used to plot the standard curve.

5. Alkali digestion test:

Alkali digestion test was performed following the procedure of Little *et al.* (1958). The concentration of KOH used was however 2.1% instead of 1 7% used by Little *et. al.* (1958). Sakalpuri and Binni were used as standard since they had the lowest and highest readings on the 7 point alkali spreading scale respectively.

6. Protein content :

Protein content was determined by the macrokjeldahl procedure (AOAC, 1955) with minor alterations in the amount of chemical used. The N% was multiplied by factor 5.95 to compute the crude protein content in the rice samples.

7. Dye-binding capacity (DBC) technique:

The procedure of macro dye-binding capacity outlined by Kaul *et. al.* (1970) was used to estimate the protein quality. The procedure is as follows :

200 mg of ground (60 mesh) rice samples were taken in duplicate in 25 ml. capacity airtight bottles. Two glass beads and 20 ml. of Acilane Organge dye were added to each bottle. The bottles in lots of 48 were shaken simultaneously for 1 hour. About 10 ml of the reacted dye was centrifuged in lots of 48 at 3500 rpm for 10 minutes. 0.5 ml of the supernatant unabsorbed dye was diluted to 100 ml and its absorption was read at 470 nm in a Beckman spectrophotometer. DBC value was obtained by substracting the absorption figures from the standard value (i.e. the absorption value of 0.5 ml of the unreacted dye diluted to 100 ml. 0. 368 at 470 nm in a Beckman spectrophotometer). For convenience of calculation figures were multiplied by 100.

8. Udy protein determination :

Protein content was also determined using the Udy protein analyzer (Udy. 1956).

800 mg sample along with 40 ml Acilane orange dye were shaken for 3 minutes and transmittance was read in a colorimeter (model 101 (R)). Calibration was made with a standard dye solution. Protein content was read from the 'rice' conversion table provided by udy Analyzer Co.

9. Protein index value :

Protein index value was calculated by the formula suggested by Kaul *et. al* (1976) Here DBC value calculated on equal N basis was used as protein index (as an indication of protein quality). The protein index value was computed as follows :

$$\text{Protein index (PI)} = \frac{\text{DBC absorbance units} \times 100}{\text{Protein content (\%)}}$$

10. Microscope section scoring :

A microscope screening technique (Kaul *et al.* 1969) was simplified and used to determine the distribution of protein in the rice grain. Grains were soaked in distilled water for 4-5 hours. 14 μ thick sections were cut using a sliding microtome. Several sections from the middle portion of the grain were placed in 0.5% aqueous solution of Bromophenol blue for 1 minute, washed free of excess dye, dehydrated through an ascending alcohol series and mounted in euparol.

The section score for protein distribution in the rice grain was quantified using the following formula.

$$\text{Section score} = \frac{b}{a} \times 100$$

where b=stained area
a=radius of the Kernel.

11. **Total amino acid analysis :**

Total amino acid content of four local rice varieties was determined using an automated Beckman (R) aminoacid analyzer at the National Institute of animal Science, Copenhegan, Denmark, through the kind courtesy of Dr. B.O. Eggum.

12. **Statistical analysis of the data :**

The raw data were analyzed statistically employing the procedures outlined by Steel and Torrie (1960). The IBM Computer—1620, available at the Atomic Energy Centre, Dacca, was used.

RESULTS AND DISCUSSION

Wide range of variation was recorded for all the characters studied. Data for some of the characters of 60 varieties of rice are noted in table 1.

Translucency : Translucency in rice grain is an important factor determining market quality. All popular local rice varieties collected for this study were translucent except Pajam II. Consumers generally prefer translucent types although translucency does not reflect a high nutrient status (Rosario *et al.* 1968). High yielding varieties, namely IR-8, Iratom-24 and Iratom-38 had white belly an undesirable character, which leads to breakage at the time of milling. High protein rices showed both white core and translucency. Improvement of this character is difficult because it shows incomplete penetrance and variable expressivity (Kaul, 1970).

Colour : The pericarp colour was white for 31. cream for 3, amber for 7 and red for 19 varieties. It is interesting to note that no white pericarped variety was obtained among the local Aus and Broadcast Aman varieties and all the Boro varieties were white pericarped. The predominance of red pericarped varieties in the low lying areas and white pericarped varieties in the upland areas is notable. Genetically, red pericarp is dominant over white pericarp (Nagao and Takahashi, 1947). It is probable that the white pericarped genotypes have evolved from the red pericarped genotypes through recessive mutation. Although the red pericarp is neither digestible nor associated with the nutrient status, village people consider red colour to be an index of vitamins and shows preference for it. In general the white pericarped varieties have a higher consumer acceptance, with the exception of Biroi a red pericarped variety, which enjoys high market preference and popularity.

Aroma : Out of the genotypes examined, 4 varieties were highly aromatic and 4 others gave aroma only after cooking. Kalizira, Badshabhog, Tilkaphuli and Ukunmadhu are prefered for their aroma. The aroma is volatile and does not last long during storage.

Kurasawa *et al.* (1969) have reported that the volatile aromatic compounds are mostly low molecular alcohols and carbonyl compounds. With prolonged storage the alcohols may be gradually oxidized to corresponding carbonyl compounds The character is heritable and therefore subject to selection. Juliano (1972) suggested that climatic factors may also have a marked influence on the intensity of aroma.

Size and shape : Grain size and shape are among the important criteria considered by breeders in developing new varieties. The varieties ranged from 4.4 to 8.2mm in length and 1.50 to 2.95 mm in breadth. The same genotypes ranged from extra long slender to short bold types (Table 2). Bangladesh consumers prefer the medium grains though Pakistani and Indian consumers prefer long grain varieties. The L/B ratio was lowest for the Boro varieties and highest for the Aman varieties. Aus varieties were intermediate (Table 3). The popular local rice varieties had a higher L/B ratio, while the high protein varieties had a lower L/B ratio. So the high protein varieties, due to their low L/B ratio have lower consumer preference than the popular low protein varieties like Biroi, Chikon, Nizersail, Pajam II and Ragusail (Table 2).

High CV% for L/B ratio among the fine as well as the high protein rices indicate that fineness and high protein character is not associated with or dependent on L/B ratio. So there is a chance of combining the desirable grain dimensions with various cooking and nutritional qualities.

Hulling recovery % : Hulls make up about 20% of rough rice (Adair, 1972). Fine local rices had the highest hulling recovery % while the popular local rice varieties had the lowest. The hulling recovery was not significantly different among the four consumer quality classes. The longer grain types tended to have lower out turn of brown rice.

Grain weight : The TKW of 60 varieties ranged from 8.54 to 26.36 g, the mean being 17.1 g and the coefficient of variability being 22% (Table 2). The Boro varieties had a higher TKW than the Aus and Aman varieties. The Aman varieties among themselves had the highest CV% i e. 26%. The high yielding varieties had the highest and the fine local varieties the lowest TKW. The high protein rices covered a good range of variation. The mean TKW of popular local varieties was 14.7 g with a range from 13.3 to 19.7 g. The high yielding varieties had a mean TKW of 19.9 g which is far higher the mean of popular local varieties (Table 2) The TKW of IR-8 was 23.0 g.

Amylose content : The amylose content is the best measurable characteristic for describing and predicting the cocking quality. Amylose content ranged from 5.5 to 32.8%. Only one variety Binni was a waxy type, the rest were nonwaxy. The nonwaxy types ranged from 17.68 to 32 8% in amylose content. The amylose content of rice samples from South Korea and Japan and of Japonica rice samples from Australia, Taiwan and China is usually below 25% Rice of Sreclanka, Vietnam and parts of Thailand generally have amylose contents of more than 25% (Juliano, 1968). The Bangladesh rice varieties were found to contain more than 26% amylose. The high value indicates the preference of consumers for high amylose types in this area.

Aman season varieties had a higher amylose content than the local Boro varieties. The clear sunshine and low temperature, during grain development period of Aman varieties (Nov,-Dec.) may favour more amylose synthesis.

The amylose content of popular local varieties ranged from 24.7 to 30.0%, the mean being 26.32%. The popular local varieties had a higher amylose content and the high protein varieties had the lowest amylose content. Among the popular local rice types Biroi had high amylose (30.0%) but others in the same group were only in the range of 24.4 to 26.8% (Table 2). Amylose content of IR-8 and Iratom-24 was nearly the same but Iratom-38 had a lower value. The rice varieties that are used for Chira, Muri puffed rice, cakes and sweatmeat preparation had a low amylose that is below 25%.

Some local vaireties popular with urban communities, had an amylose content around 25% These varieties remain soft after cooking. Farming communities prefer rice which is more flaky, with an amylose content exceeding 27%. Amylopectin is degraded only about 55%. since α-1-6. glucosidic linkages constitute a barrier beyond which the enzyme phosphorylase is inactive. The amylose is however fully degraded (Conn and Stumpf, 1971). The high amylose types preferred by the farming community should therefore supply more energy to consumers through a higher degradation, Juliano *et al.* (1964) have shown that amylose content in rice is influenced less by the environment than is protein content. Therefore there is more chance of selecting varieties with higher amylose content.

Values reparted in this repaort are consistently lower than those reperted by IRRI and BRRI. However, relative standing still holds good.

Alkali digestion test: The waxy types completely dispersed into a clear mass in the alkali solution, while other varieties ranged widely in their capacity to disintegrate (Fig.1). The texture preferred by consumers varies. The waxy rices, which are sticky and expand less are preferred in Laos and North East Thailand, whereas the flaky high amylose rices are favoured in most of tropical Asia. In the philippines and Indonesia softer rice is preferred. The people of Japan, Korea and China prefer sticky, low amylose rices which can readily be handled with chopsticks. Since rice storage reduces the stickiness of the cooked product, aged rice receives a premium in tropical countries (Chichester *et al.* 1969).

The popular local varieties had a mean spreading index of 3.8 with a range of 3.1 to 4.6. The high protein varieties had the highest spreading index and the high yielding varieties the lowest indicating a hard texture after cooking These varieties differed markedly from the popular local rices (Table 2). Biroi although having a high amylose content gave a much higher spreading index (4.6) which is indicative of its soft texture after cooking, in contrast to the hardy and flaky texture of cooked rice in the case of high yielding varieties. Iratom-24 had a higher spreading index (3.6) than IR-8, its parent. It was nearer to the popular local rices indicating its superior cooking quality. Amylose content was negatively correlated with spreading index (Fig. 2, table 4). Like amylose, the Alkali Spreading Value reported here are lower than reported by IRRI and BRRI.

Protein content: Protein content among the sixty varieties was found to range from 6.1 to 12.8%, the mean being 8.46% and coefficient of variability 16% (Table 3). Protein content was significantly and positively correlated with DBC values (Fig.3) but negatively with amylose content (Fig. 4).

The local Boro varieties had higher protein content than the Aus and Aman verieties (Table 3). The crude protein content was lowest in the popular local varieties The high yielding rice varieties namely IR-8, Iratom-24 and Chandina had a low protein content. The other high yielding varieties IR-20 and BR-4 had a relatively high protein content. These high yielding varieties were collected from the agricultural research stations. It is likely that their high protein might have arisen from high nitrogen fertilization. When the same varieties were collected from the Agronomy farm, BAU, during the recent harvest a lower protein content of 7.4% for IR-8, 8.3% for IR-20

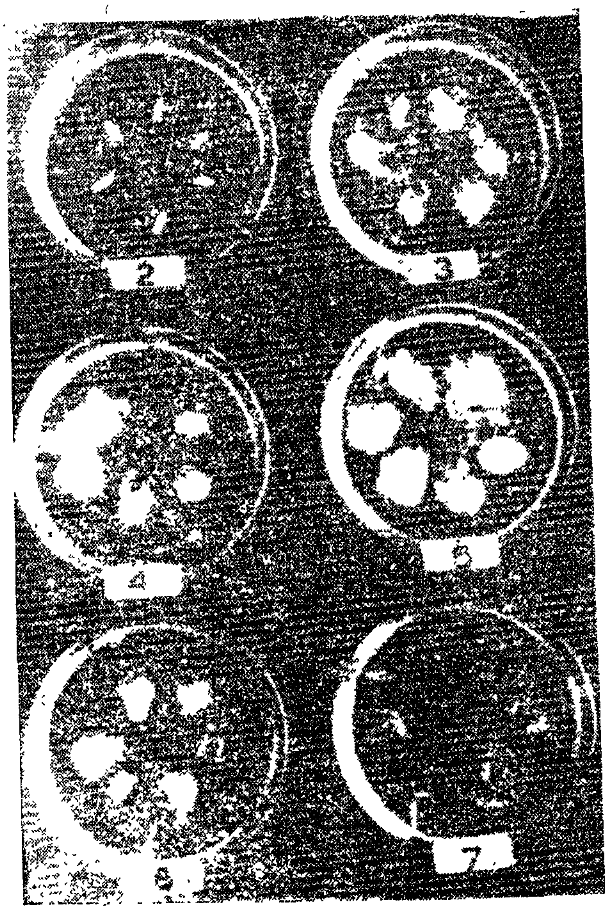


Fig. 1. Photograph showing differences in the degree of kernel swelling and dispersion in dilute KOH solution of different rice varieties.

and 8.1% for BR-4 was found. This indicates a large environmental affect on crude protein content. The protein content of fine rices were usually lower. A large difference in the protein content of popular local rices, particularly that of high protein rices, is noteworthy (Table 2).

The inheritance of protein quantity is polygenic (Swaminathan *et al.* 1970) and it may vary as much as 6% within a single variety (Juliano *et al.* 1964. It is generally lower in grains from plants with close spacing (De Datta, 1972) and higher in border hills and in hills next

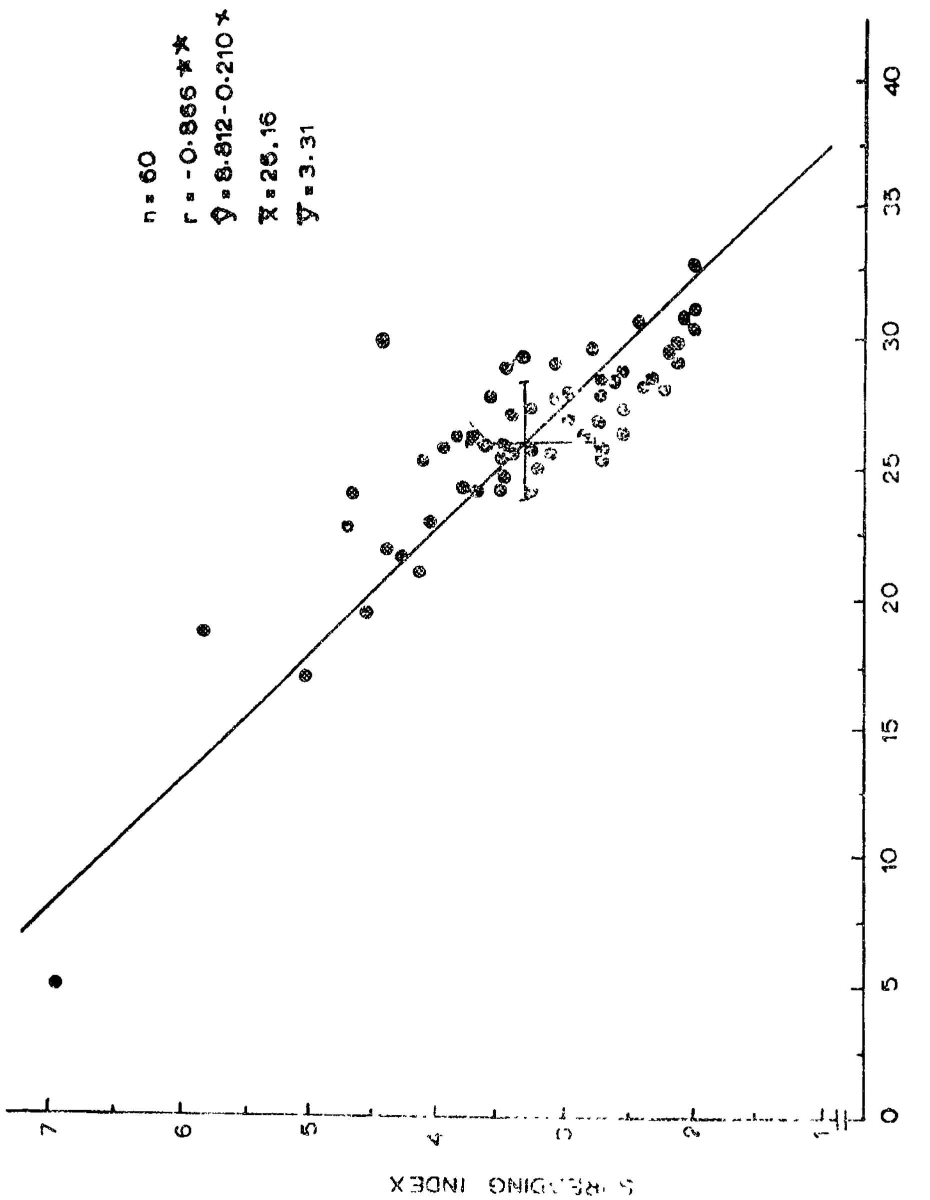


Fig. 2. Scatter diagram showing correlation between amylose content and spreading index

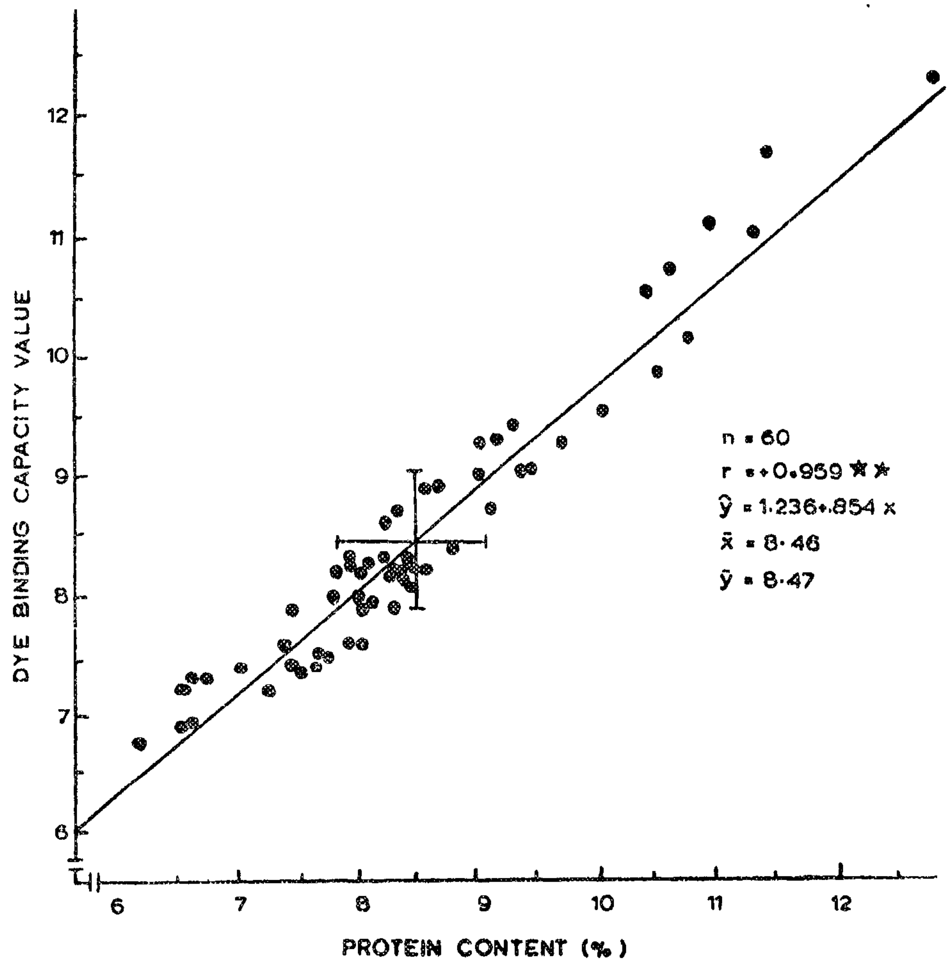


Fig. 3. Scatter diagram showing correlation between DBC values and protein content

to missing hillis (Juliano, 1972). Protein content tends to be lower if high solar radiation occurs during the grain development stage (Sato, 1971). Higher application rates of nitrogen fertilizer particularly during the reproductive stage tend to increase protein content (IRRI, 1971 ; Kaul and Raghaviah, 1975). Aman varieties had low protein (8.15%) while Boro varieties generally had high protein (10.33%), the low protein content in Ama varieties may be due to the presenc of high solar radiation favouring a hig starch synthesis relative to protein.

DBC value : The DBC values we found to conform well with the prote content of the varieties (Table 4. Fig 3)

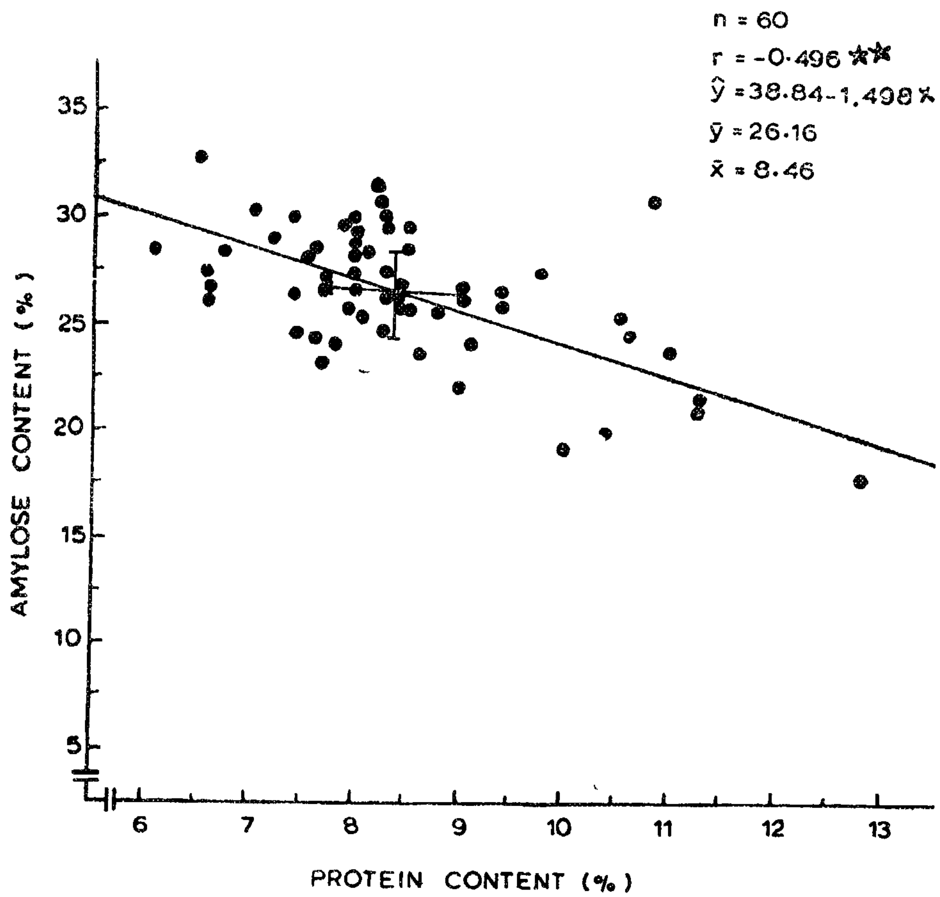


Fig. 4. Scatter diagram showing correlation between protein content and amylose content

The varieties with the lowest and highest protein values also appear to be lowest and highest in the DBC range. Moreover some of the varieties having a low protein content were found to have relatively higher DBC value reflecting a higher amount of basic amino acids. The DBC values like protein content were also found to be negatively correlated with the amylose content (Fig. 5).

The popular local rices had the lowest DBC values and the high protein varieties the highest. The DBC values of the popular local rices indicate a serious deficiency of protein in the diet of consumers.

Udy protein : Udy protein showed a range of 6 83 to 12.63% having a mean of 8.63%. The coefficient of variability was 15·/.. The mean of Udy protein was

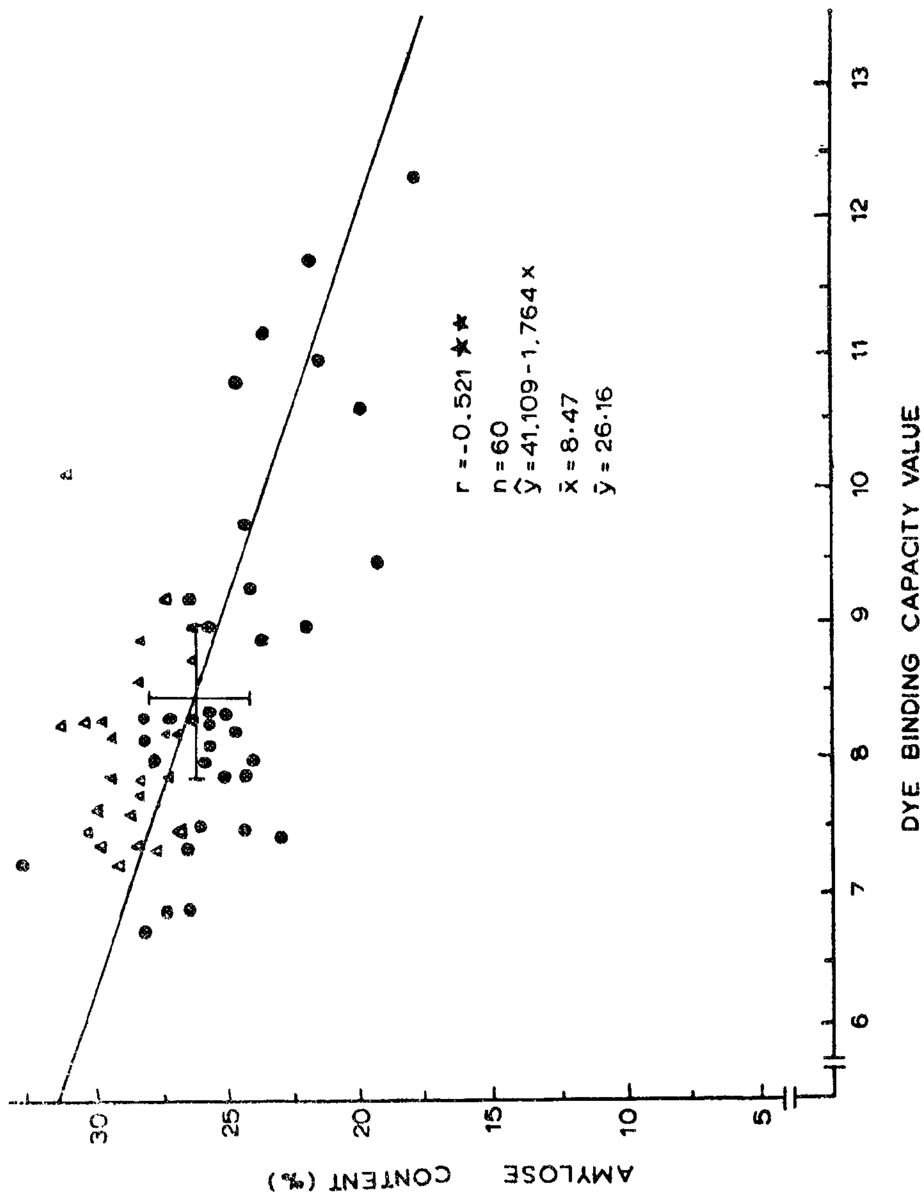


Fig. 5. Scatter diagram showing correlation between DBC values and amylose content (Triangles indicate red peircarped Varieties)

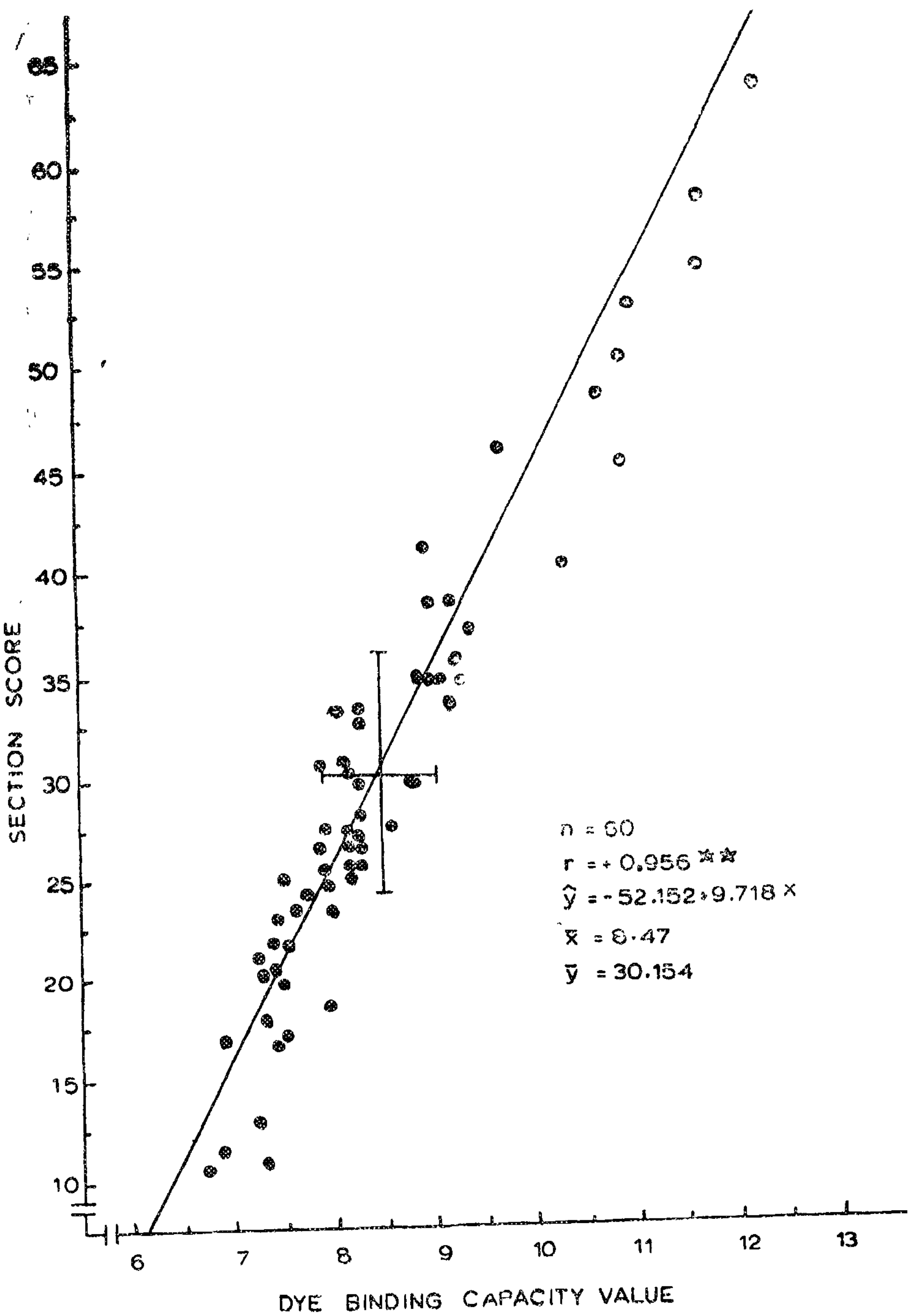


Fig. 6. Scatter diagram showing correlation between section score and DBC values

Fig, 7. Low protein variety (Butasail) ; peripheral distribution of protein

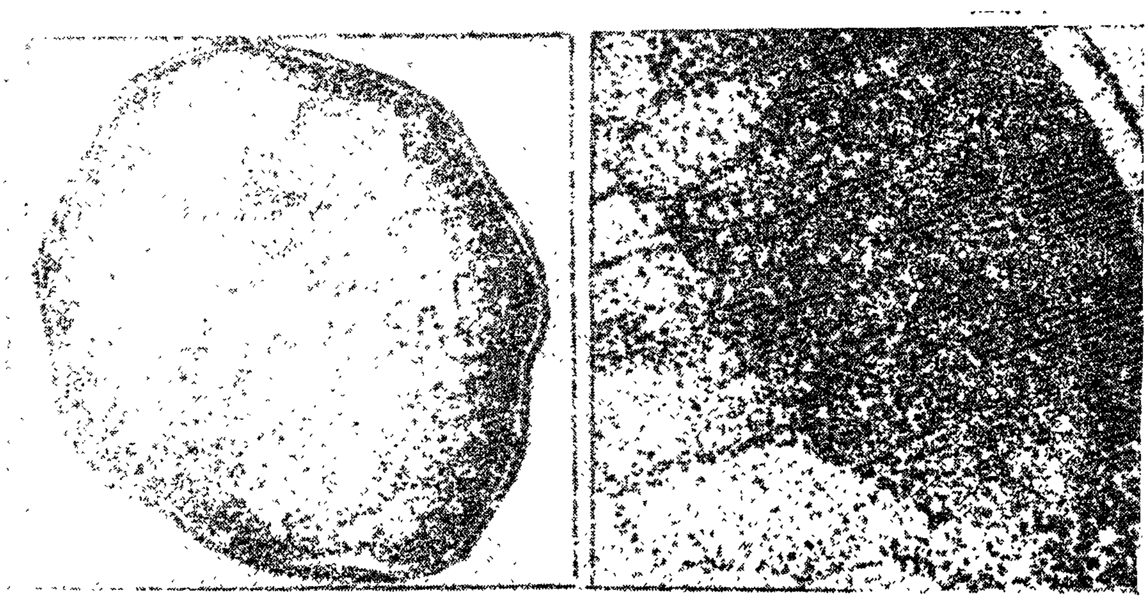
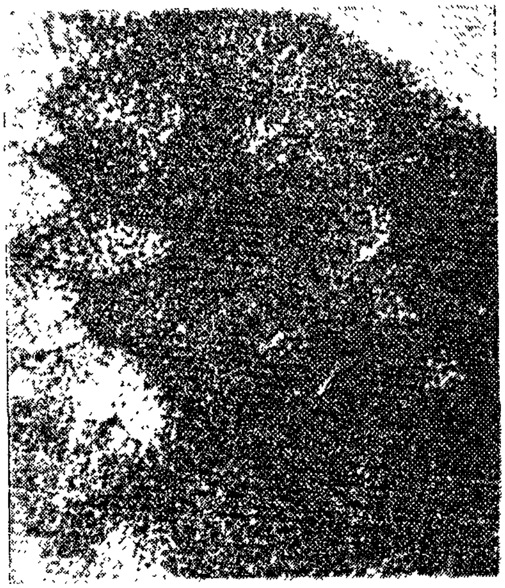


Fig. 8. Medium protein variety (Basmati) ; better protein distribution.



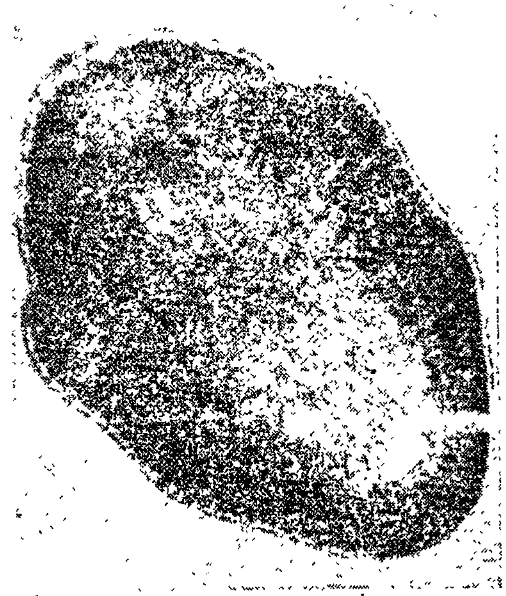


Fig. 9. High protein variety (Hbj. B VI); deep seated protein distribution

higher than that of DBC and Kjeldahl protein.

Protein index value: The protein index was lower for the high yielding varieties and higher for the common local varieties. The high protein varieties were found not to lose their better amino acid quality at high protein levels (Table 5). It is therefore clear that the high protein varieties should be nutritionally superior. Also it is important to emphasize the high nutritive value of local varieties as evidenced by high protein index value.

Histochemical properties : The microscope section score showed a considerable variation, ranging from 11.11 to 63.63, the mean being 30.15 with a high coefficient of variability (40%). Section score was highly positively correlated with the DBC values (Table 4, Fig. 6). Butasail and Hbj. BVI recorded the lowest and highest values respectively, medium values for Basmati and welformed protein bodies were found in Mugimalsara (Figs. 7-10). Section score was highest for high protein varieties and lowest for the popular local varieties. The section score of high protein local rice was very much higher than that of the high yielding varieties. Some varieties like Ashini, Chaprash and Hashikalmi were found to possess well formed as well as large protein bodies in the subaleurone layers (Fig. 10). The most important characteristic of these varieties is their ear-

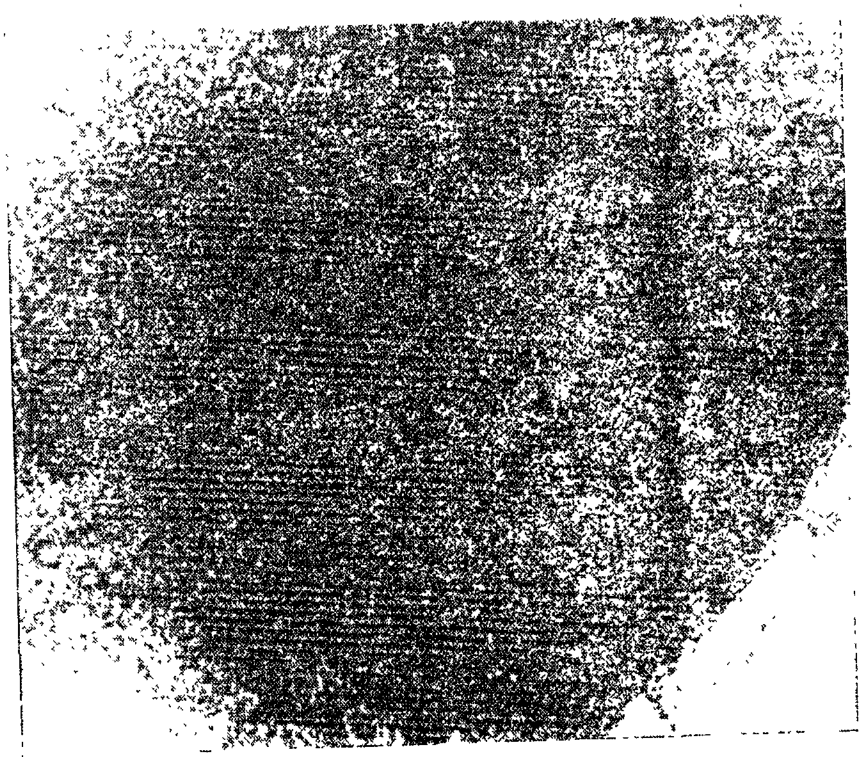


Fig. 10. Well formed protein bodies

liness in their respective growing seasons. Shadamoota a late transplant Aman variety showed very small protein bodies in its sublearone layer.

IR-8 and Iratom-24 had almost the same section score but Iratom-38 was distinctly higher, indicating that Iratom-38 has a genetically higher protein potential than its mother variety, IR-8 and the sister mutant, Iratom-24.

As protein bodies are concentrated near the periphery of the rice grain, this leads to their loss during milling and polishing. Though overmilling should be avoided and parboiling encouraged, it would be of value to breed for varieties having deep seated proteins in the grain and even distribution of protein bodies. A concentration of protein bodies towards the periphery was more marked for the high yielding varieties, as IR-8 and Iratom-24 had lower section scores. Although BR-4 and IR-20 had a high crude protein content, they had a comparatively low section score. The depth of protein zone being a varietal feature (Kaul *et al.* 1968), leads to the conclusion that BR-4 and IR-20 do not have a high protein potential. Hbj. BVI, Tepiboro,

TABLE 1. Some physicochemical and histochemical properties in sixty rice varieties of Bangladesh.

Variety	Season of planting*	L/B ratio	TKW (g)	Amylose (%)	Spreading index	Protein % Kjeldahl	Section score %
1 Ashini	TA	2.55	12.5	26.5	2 5	9.0	33.3
2 Badabunia	TA	1.92	20.6	26.5	3.7	8.4	26.6
3 Badshabhog	TA	2.17	8.6	19.9	4.5	10 3	50 0
4 Bashikalam	TA	3.14	18.8	27.3	2.7	6.5	14.5
5 Bashphul	TA	3.43	9.5	24.1	4.7	7.7	24.4
6 Basmati	TA	4.07	19.1	27.8	2.5	7.5	20.0
7 Begarsail	TA	2.22	17.0	29.4	2.3	8.3	25.4
8 Binni	TA	3.40	19.1	6.5	7.0	9.2	34.6
9 Biroi	TA	2.88	14.0	30 0	4.6	8.0	23.6
10 Boiragi	BO	1.94	15.2	21.4	4.2	11 3	56.7
11 BR-4	TA	2.50	16.4	23.6	3.0	10.9	39.5
12 Butasail	TA	2.45	15.6	28.3	2.6	6.1	11.1
13 Chandina	Aus & Bo	2.41	16.7	25.4	2.7	8.9	28.7
14 Chaprash	TA	2.42	20.2	25.7	4.1	8.4	23.3
15 Chikon (Balam)	TA	2.81	19.7	24 6	3 8	7.8	28.0
16 Chinisagar	TA	1.98	8.5	24.2	4.7	7.6	23.0
17 DA-29	TA	3.40	24.6	24.1	3.3	9.1	34.4
18 DA-31	TA	2.87	22.8	19.1	5.9	10.0	48.3
19 Deshijhulon	TA	2.56	17.9	26.7	2.9	7.7	19.6
20 Dharial	Aus	2.11	17.2	29.0	2.2	7.1	21.0
21 Dingamoni	TA	2.62	19.7	25.2	3.2	8.1	30 5
22 Dudshar	TA	2.97	19.5	29.9	2.8	7.3	16.3
23 Dular	Aus	2.74	16.9	31.1	2.0	8.2	33.3
24 Gabura	BA	2.23	18.3	30.4	2.0	8.2	32.2
25 Gimi	Aus	1 92	16.3	28.3	2.3	8.1	27.4
26 Gopalbhog	Aus	2.76	14.9	28.3	2.3	6.7	17.8
27 Hado	Aus	2.33	17.8	30.2	2.1	7.0	20 3
28 Harinmoda	Aus	2.28	18·9	29.7	2.2	7.7	21.8
29 Hashikalmi	Aus	2.24	17 9	30.7	2.5	10.6	55.3
30 Hbj. A-v	BA	1.98	17.7	26.2	3.8	9.4	38.0
31 Hbj. B-VI	BO	1.75	18.6	17.5	5.1	12.7	63.6
32 Indrasail	TA	2.27	18.7	27 4	3 3	7.7	25.4

Table 1. continued

Variety	Season of planting*	L/B ratio	TKW (g)	Amylose (%)	Spreading index	Protein % Kjeldahl	Section score %
33 IR-8	Bo & Aus	2.46	23 0	27.8	3.1	7 9	22.4
34 IR-20	TA	2.68	15 0	24,6	3.5	10.5	40.2
35 Iratom-24	Bo & Aus	2.59	22.2	28.1	3 6	8 0	24.5
36 Iratom-38	Bo & Aus	2.57	21.1	25.2	3.5	10 4	40.9
37 Kajalsail	TA	2,23	22.8	26.2	4.0	8 3	28.1
38 Kalizira	TA	2.22	8,9	25.3	3.4	8 3	26.0
39 Kalogaria	Aus	2.24	17.6	29.7	2.2	7.8	25.5
40 Kataktara	Aus	2.81	14.7	27.4	3.3	9.7	41.8
41 Kuriagrani	TA	1.97	19.1	25.7	3.5	9.4	41,3
42 Lalindrasail	TA	2.48	16.3	25.7	3.4	8.8	26.4
43 Lalmugi	TA	2.51	15.6	26.7	3,0	6.6	16.9
44 Latisail	TA	2.33	20.6	28 0	3.0	8.5	30.1
45 Mahishlal	Aus	2.32	18.43	28.3	2.4	7.6	24 1
46 Mugimalsara	TA	2.51	15.9	28.8	3.5	7.9	21.5
47 Netna Aman	BA	1.97	18.0	28.3	2.7	8.5	34 4
48 Nizersail	TA	2.58	13.3	24.6	4.1	8.2	27.4
49 Paijra	TA	2.61	12.8	24.5	3.8	7.3	18.3
50 Pajam II	TA	2.51	11.9	24.3	3 1	7.3	17.0
51 Panbira	Aus	1.94	16.0	27.3	2 6	8.0	26.6
52 Ragusail	TA	2.83	14.8	24.7	3.2	6.6	11.3
53 Sakalpuri	TA	2.46	16.3	32.8	2.0	6.4	12.9
54 Sarbati	TA	2.70	15.5	23.6	3,7	8.5	34.5
55 Shada indrasail	TA	2.54	18.7	29.5	3.1	8.4	30 1
56 Shada moota	TA	1.94	26.3	25.9	3.4	8.4	35 3
57 Tepi boro	BO	1.90	17.2	21.7	4.3	11.3	58.0
58 Tilbadgar	BA	2.19	21.1	26.7	2.5	8.0	25 0
59 Tilkaphuli	TA	2.93	12.1	22.0	4.4	9.0	35.6
60 Ukun madhu	TA	2.16	9.2	23.1	4.0	7,7	29.0

* BO=Boro, TA=Transplant Aman, BA=Broadcast Aman,

TABLE 2. Variability in the physicochemical and histochemical characters of rice varieties sampled on the basis of consumer's preference and other important characteristics

		Length (mm)	L/B ratio	Hulling recovery (%)	TKW (g)	Amylose (%)	Spreading index	Protein content (%)	DBC	Udy protein	Protein index	Section score
Popular local	Range	5.3-6.8	2.5-2.9	77-84	13.3-19.7	24.7-30.0	3.1-4.6	6 6-8 2	7.4-8.3	7 0-8.7	96-111	11.3-28 0
Varieties	$\bar{x}$	6.0	2.72	79 06	14 74	26 32	3 80	7.6	7.83	7 98	102.6	21.48
Biroi, chikon.	δ	0 05	0.16	1.93	2.97	2.26	0 64	0.64	0 39	0.71	5.77	7.13
Nizersail, Pajam II, Ragusail	CV%	9	6	2	20	6	17	8	5	9	6	33
Fine local	Range	4.2-6.0	1.98 3.4	82.5-86.0	9.0-12 1	22 0-25 3	3.4 4.7	7.7-9.0	7 4-9 0	7.3-9.2	9[illegible]-102	20 0-35.0
varieties	$\bar{x}$	4.9	2.53	83.70	9.68	23.76	4.26	8.10	8.13	8.40	98 60	27.60
Bashphul Chinisagar,	δ	0.07	0.60	1,40	1.41	1.25	0 54	0,5	0.63	0.51	2.17	4 80
Kalizira, Tilkaphuli Ukunmadhu	CV%.	15	24	2	15	5	13	7	8	6	2	17
High Yielding	Range	5.7-6.8	2.4-2.6	78.5-83.7	16.5-23.0	23 6-28.4	2.8-3 6	8 0-10.9	8.0-10.7	8.4-11.0	93-103	22 4-40.0
varieties	$\bar{x}$	6.4	2.52	81.2	19 92	25.88	3 20	9.3	9.18	9.68	98 4	30 94
BR-4, Chandina, IR-8, Latom-24,	δ	0.05	0.08	1 86	3.10	1.92	0 36	1.34	1.09	1.12	4.22	8.24
Iratom-38	CV%.	8	3	2	13	7	11	14	12	12	4	27
High Protein	Range	4.4-7.3	1.8-2.9	75.7-84.5	8.6-22 8	17.6-21 8	4.2-5 9	10.1-12.8	9.6-12 3	10.2-12.6	95-103	48.4 63.6
varieties	$\bar{x}$	5.6	2.14	80.36	16.52	20.02	4.82	11.20	11.18	11.50	100.3	56 34
Badshabhog, Boiragi	δ	0.11	0.45	3.25	5.23	1 72	0.70	1 06	2.03	0.89	4.28	6 2
DA-31, Hbj. B-VI Tepi boro	CV%.	20	21	4	32	9	14	9	9	8	4	11

TABLE 3. Variability in some consumer's and nutritional quality characteristics of 60 varieties and also in the varieties sampled on the basis of seasons of planting.

		L/B ratio	TKW (g)	Amylose (%)	Spread index	Protein % (Kjeldahl)	DBC value	Section score
All varieties (60)	Range	1.7-4.1	8.5-26 3	5.5-32.8	2.0-7.0	6,1-12.8	6.7-12.3	11.1-63 6
	$\bar{x}$	2 47	17 10	26.17	3,32	8.46	8.47	30 15
	δ	0.43	3.83	4.02	0.97	1.33	1.18	12.00
	CV %	17	22	15	29	16	14	40
Aus varieties (12 varieties)	Range	1.9-2 7	14.8-18 4	26.4-31.2	2 0-4.1	6.7-10.8	7 3-10.1	17.8 55.3
	$\bar{x}$	2.34	17 00	28.79	2.41	8.19	3.23	28.66
	δ	0.33	1.29	1.63	0.35	1.18	1.5	10,59
	CV %	13	8	6	15	14	18	37
Aman varieties (42 varieties)	Range	1.9-4 1	8.9-26.3	5'5-32.8	2 0-7.0	6.1-10.6	6.7-10 8	11.1-50.0
	$\bar{x}$	2.55	16.78	26 09	3.49	8.15	3.17	27 74
	δ	0.46	4.31	2.72	1.06	1.07	0 94	9.29
	CV %	18	26	10	30	13	11	33
Boro varieties (6 varieties	Range	1.7-2.6	15.2-23 0	17.6-28.1	3 1-5.1	8.0-12.8	7 9-12.3	22.4-63.6
	$\bar{x}$	2.19	20.35	23.66	3 97	10.33	10.27	44.37
	δ	0.38	2.91	4.12	0.71	1 94	1 87	17.89
	%	17	14	17	18	19	18	40

TABLE 4. Correlation between different nutritional and consumer's quality characters of rice (Data based on 60 varieties)

	Hulling recovery (·/.)	TKW (g)	Amylose (·/.)	Spread index	Protein (·/.) (Kjdl.)	DBC value	Udy Protein	Protein index	Section score
L/B ratio	—0.09	0.02	—0.14	0.11	—0.24	—0.22	—0.23	0.07	—
Hulling recovery		—0.22	—0.18	0.23	0.11	0.16	0.18	0.06	—
TKW			0.07	—0.07	0.08	0.05	—0.03	—0.15	0.14
Amylose (·/.)				—0.87**	—0.50**	—0.52**	0.58**	0.13	—0.46**
Spreading index					0.49**	0.45**	0.53**	—0.30*	—
Protein ·/. (Kjdl.)						0.96**	0.95**	—0.50**	0.97**
DBC value							0.96**	—0.24	0.96**
Udy protein								—0.31*	—

r value at 58 d. f. at 5·/. and 1·/. probability levels are 0.255 and 0.331, respectively.

TABLE 5. Amino acid content of four local rice varieties

Amino acid g/16g Nitrogen	VARIETIES			
	Hbj. B. VI (white core	Tepi boro (white core)	Boiragi (White core)	Binni (Waxy)
Aspartic acid	8.89	8.87	8.89	8.19
Threonine	3.03	3.18	3.25	3.11
Serine	4.17	4.10	4.27	4.02
Glutamic acid	17.43	16.61	17.40	17.57
Proline	4.76	4.95	4.98	5.10
Glycine	4.27	4.54	4.41	4.22
Alanine	5.63	5.67	5.72	5.65
Valine	6.09	6.11	6.18	5.82
Isoleucine	4.08	4.01	4,11	4.04
Leucine	8.44	7.85	8.16	8.12
Tyrosine	5,36	4.74	5.01	4.73
Pheny lalanine	5.03	4 75	4 91	4.82
Lysine	3.34	3,94	3 51	3.34
Histidine	2.10	2.31	2.25	2.10
Ammonia	2.31	2.08	2.21	2,35
Arginine	8,08	8.23	8 14	7.64
Methionine	1.80	2·31	3.35	2.85
Cystine	1.50	1.88	1.95	2 37
Tryptophan	1.27	1.15	1.35	1.23
Protein content (%) at 10% moisture level.	12.69	8.61	11.09	9.54

Badshabhog, Boiragi and DA-31 had more or less evenly distributed protein bodies deep seated in the mid endosperm region. These varieties may be classified as genetically high protein sources with good promise as donors in a breeding programme.

The amino acid analysis of 4 varieties (Table 5) showed a relatively uniform aminogram irrespective of protein levels. This is encouraging since in wheat, protein content has been reported to be negatively correlated with the essential amino acid content (Johnson *et al.* 1969). Detailed studies need to be conducted on a large number of samples to examine the relation between the crude protein content and essential amino acids in rice.

Juliano (1973) has pointed out that protein is a secondary factor affecting texture. It is important in countries where the range in the amylose content of rice is narrow. Protein is the major quality factor in Spain, although the preferred variety is higher in both protein and amylose levels than other varieties. In Bangladesh no attention has been paid directly either to protein or to amylose. High protein high amylose types are likely to provide more nutrition and energy for consumers. From the data it is evident that such combinations are available though rare between protein content and amylose ($r = -0.49^{**}$) (Fig. 4) and between DBC value and amylose ($r = -0.52^{**}$) (Fig. 5). The red pericarped variety Hashikalmi retained high amylose and high protein content at the same time.

As was found by other workers the significant high correlation between DBC value and protein content indicates the value of DBC technique as an index of protein content (Udy, 1956, Mossberg, 1969 Kaul, 1970 and Johnson *et. al.* 1969).

Recently the concept of 'Protein index value' has been introduced by Sharma and Kaul (1976) as a parameter of protein quality The correlation of protein index with protein content and DBC value indicates that protein quality will fall if selection is made for high protein content. But if DBC value were used as a primary index of protein, the quality may not be so affected.

The development of suitable methods for determining protein quality is essential in any breeding programme. Selection of lines with deep seated protein would help conserve the valuable protein. Now that the microscopic screening test is available, it should be possible to select superior genotypes. A breeder can effectively handle upto 30 analyses in one working day.

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