Studies on Grain and Food Quality Traits of Some Indigenous Rice Cultivars of North-eastern Hill Region of India

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Abstract

Searching rice cultivars or variety with good processing and high in important essential nutrients are prime important in the present context of rice research. The north eastern hill region of India which is a mega biodiversity hot spot of the world has numerous cultivars of rice with tremendous potential of high quality rice. Eighteen indigenous cultivars of Tripura, a north eastern hill state of India were subjected to the study. Majority of the cultivars were of short bold grain type. Eleven cultivars were aromatic type with one cultivar of strong aroma comparable to Basmati rice. Eleven cultivars were found to possess higher hulling percentage more than 65% and six cultivars with more than 65% out turn. Majority of the cultivars had low amylose contents (<20%). Four cultivars were having higher total crude protein (>10%), six cultivars were having higher iron contents (>10ppm). In most of the characters, heritability (h^2) was more than the genetic advance indicating more of environmental effect. Amylose, crude fibre and iron, genetic advance was high; selection for these traits will improve the genotypic value of selected plants over the parents. High heritability coupled with high genetic advance was found in iron and amylose. The association of crude protein is significant but negative with carbohydrates and amylose, while with crude fat and zinc, the association is significant and positive. Carbohydrate was significantly and positively correlated with ash percent and iron concentration and negatively associated with total fat. There was no significant correlation between carbohydrate and amylose.

Keywords: Rice, Diversity, Nutrition, Quality, Heritability, Micronutrients

1. Introduction

Despite many efforts, lack of food remains a serious problem still with about 36 million people starving to death every year (UNIS, 2004). Though the problem lack of food is more in the case of under developed and developing countries, hidden hunger which is mainly due to lack of proper intake of vitamins and minerals is very prevalent in developed countries too. Rice can be considered to be the most important cereal which supplies good amount of minerals, vitamins, essential fatty acids and dietary fibre besides energy. It has good digestibility, biological value and good quality protein due to the presence of higher amount of lysine. Rice is also rich in some essential minerals and vitamins. Rice plays a very important role in providing essential nutrients to a large segment of the world's population as it is the staple food of majority of the world's population. 91% of world's rice is produced in Asia and provides 20% of the per capita energy and 13% of the per capita protein worldwide. However, in Asia rice contributes about 35% of the energy and 28% of the protein. Rice is rich in genetic diversity with many varieties and genotypes available throughout the world. More than two thousand varieties are grown worldwide and International Rice Research Institute (IRRI) holds more than 83,000 varieties in its gene bank. India has about 705 varieties (Thongbam *et al.,* 2010). The northeastern hill region of India comprising the states of Manipur, Meghalaya, Arunachal Pradesh, Nagaland, Mizoram, Tripura and Sikkim is endowed with rich source of rice germplasm which may be safely estimated to be about 9,000 accessions (Devi *et al.,* 2008a).

Rice being the most important food of the world, its nutritional value and processing properties are very important for overall health of the people and commercial purposes including economy of rice growers. Quality is very important and is determinant of market price, consumer acceptance and end users. The quality of rice is not always easy to define as it depends on a combination of many subjective and objective factors, largely related to the consumer and the intended end use of the grain. The demand by the consumer for better quality has notably increased in the more economically developed countries of the world giving rice producers the opportunity to increase the total economic value of rice. Quality traits are also related to the taste of the several ethnic groups in the world.

The quality parameters to be evaluated for food rice varieties can be discussed in three broad categories: i. Physical qualities, ii. Processing qualities, iii. Nutritional qualities. Kernel length, bread, length/breadth ratio, grain type, chalkiness percentage, alkali spreading values could be considered under physical qualities. Milling qualities and cooking qualities are under processing quality. Milling parameters include hulling %, milling %, head rice recovery %, cooking qualities including elongation ratio, water uptake, volume expansion ratio, nutritional qualities such as total crude protein, total carbohydrate, total ash, total fat, minerals, vitamins and amino acids. Aromatic rice occupies prime importance in the market and consumer satisfaction and hence, scentedness can be considered as a special parameter to be studied. Enormous variations in size and shape of grain exist among the rice varieties available in the world. Rice kernel length roughly varies from 5.0 to 7.5mm and breadth from 1.9 to 3.0mm (Devi *et al.,* 2008a). Some high yielding varieties from India had 5.2 to 6.8 mm in length and 1.9 to 2.5 mm in breadth. In USA, grains are classified into long (7.0 to 7.5mm), medium (5.9 to 6.1mm) and short (5.4 to 5.5mm). In India grains are classified considering length, breadth and length breadth ratio into long slender(length 6.0mm and above, length/breath ratio 3.0 and above), long bold (length 6.0mm and above, L/B ratio less than 3.0mm), medium slender (length less than 6mm, L/B ratio 2.5 to 3.0mm), short slender (length less than 6mm and L/B ratio 3 and above) and short bold (length less than 6mm, L/B ratio less than 3) types (Ramiah, 1969) . Japonica varieties got shorter and bolder grains. Generally hulling outturn ranged from 71 to 83%. The varietal variation within Indian varieties in respect to hulling is observed to be small, but it is more in the case of Taiwan & Japanese varieties. Many japonica rice give hulling outturns of over 79%. The milling characteristic of a variety directly related to the hulling capability. Chalkiness of more than 10% is considered undesirable for marketing purposes. Alkali spreading value is related to amylose content in the endosperm. More content of amylose results in lower alkali spreading value and low amount of amylose results in higher alkali spreading value. Volume expansion usually ranged from 2.0 to 4.35. When rice is cooked at 70-80^{o}C, the uptake of water is strongly influenced by the gelatinization temperature. The lower the gelatinization temperature of the variety, the higher will be its water uptake and vice versa (Juliano *et al*., 1969).

Rice grains contain starch as the principal component and protein as the second highest component. Milled rice has been shown to contain about 78% carbohydrate. Many reports on variability in protein content in rice are available. Usually, the average value of total crude protein content is taken as 7%. Rice having more than 10% total crude protein is considered to be of high protein type (Resurrection *et al.,* 1979). A range of 6.7 to 11% protein in brown rice was observed in 74 varieties from India by Guha and Mitra (1963). Some varieties from Himachal Pradesh, India were reported to have 6.61 to 7.28% total crude protein (Singh *et al*., 1998). Indigenous cultivars of the north eastern hill states of India were having total protein contents ranged from 6.14 to 12.07% (Devi *et al*., 2008a; Thongbam *et al.,* 2010). Rice with high proteins provides better growth and development as shown by feeding trials on growing rats (Blackwell *et al.,* 1966; Bressani *et al.,* 1971; Eggum and Juliano 1973, 1975; Murata *et al.,* 1978; Hegsted and Juliano 1974; Pereira *et al.,* 1981; Roxas *et al.,* 1980) and the NPU of cooked rice in rats is about 70 percent which is higher than those of maize and wheat (Eggum and Juliano 1973, 1975). Waxy type rice has more protein than high amylose types and it has been hypothesized that waxy endosperm is more favorable for the accumulation of protein than high amylose endosperm. Govindaswami *et al.,* (1969) reported 6 to 12.6% crude protein content in three hundred improved rice varieties in India. Even a wide range of 6.56 to 12.86% protein content was reported in 40 rice varieties grown in Kashmir. Some rice varieties of Assam, a north eastern state of India had been reported to have amylose contents from 19.7 to 20.9 % (Borua *et al.,* 2004). Most of the indigenous rice cultivars of north eastern hills of India have lower amylose contents and Devi *et al.,* (2008a) reported some indigenous cultivars of this region having amylose content from 2.27% to 24.5%. Thongbam *et al.,* (2010) found some medicinal rice cultivars of Manipur, a north eastern hill state of India having amylose contents ranging from 14.33 to 29.47% and most of the cultivars falling under the intermediate amylose content category (20- 25%). Amylose content in rice ranges from 0 to about 37%. Higher amylose contents (about 20 to 30%) are associated with many south Asian varieties. Lower amylose levels (10 to 20%) are more common in East Asia, where a more cohesive cooked grain is often preferred. Glutinous or waxy rice has no or very little amylose. The fat contents of milled rice have been reported to be about 0.2 to 2.0% (Tahira and Chang, 1986). Devi *et al.,* (2008a) reported a range of total fat contents from 1.2 to 4.2 % for the local cultivars with low and intermediate amylose contents. The japonica type (low amylose) of rice showed higher fat content and high amylose rice showed lower fat content (Tahira and chang, 1986). Reports on the contents of crude fibre and total ash in milled rice kernels are meager. One report showed low protein milled rice had 0.36% crude ash and high protein had 0.55% ash (Resurrection *et al.,* 1979). Crude fibre content ranged from 0.6% to 1.1% in milled rice of low and high protein types (Resurrection *et al.,* 1979). Some indigenous cultivars of India showed crude fibre contents ranging from 0.3 to 0.84% and total ash contents from 0.84 to 1.8% (Devi *et al.,* 2008a; Thongbam *et al.,* 2010).

Iron and zinc are very important limiting trace minerals in rice grains. Enhancing or finding out rice genotypes having higher content of these two minerals are thrust areas of many rice research workers. Rice usually has upto 10 ppm iron and 15 ppm zinc in its kernel. The International Rice Research Institute, Philippines, developed the rice variety, IR68144 which has 20 ppm iron and 34 ppm zinc. Their human trial showed increased level of ferritin in the blood of the anemic subjects (Annual Report, IRRI) which is an indication of improving helping eradicating anemia for the rice eating population in the world.

Rice is the main crop of Tripura, a north eastern hill state of India which stretches between 22^o 56$'$ and 24^o 32$'$ North latitude and 91^o 09$'$ and 92^o 20$'$ East longitudes occupying 91.41% of net cropped area. Tripura is rich in indigenous germplasm which have been conserved since time immemorial by the traditional culture of the aboriginal people. So far 191 genotypes of rice have been collected from this state (Hore, 2005). However the processing and nutritional qualities of such genotypes are still not studied. Thus the present worked aim to analyze the processing and nutritional quality of some indigenous rice genotypes from Tripura in order to identify the better genotypes for processing and nutritional fulfillment of worldwide consumers. The study also aimed at finding out the genotypes with good processing quality and rich in essential and important nutrients which will be useful as parents for future breeding researches.

2. Material and methods

2.1 Plant material and Study Area

The study included eighteen cultivars from Tripura, *Aditya, Aduma, Annanda, AR-11, Binni Mereng, Biswas Gora, Ful Badam, Garumalati, Guriya, Jhum Binni Black, Kalikhasa, Katak tara, Ma Kum My Mukul, My Casak, My My Yath Lock, NDR 97, Rasi* and *White Gora*. Three hundred seeds each of these rice germplasm accessions collected from Tripura were raised in three replications during the rainy season of 2004 in their respective ecosystem at ICAR Research complex for North Eastern Hill Region, Umiam, India. Off types and other variety plants in the particular accession were removed in order to purify them. Five uniform looking plants from each replication were harvested and threshed to get the sample seeds for each replication.

2.2 Analysis of physical and cooking properties

The rice seed samples of eighteen genotypes grown during the rainy season of 2004 were taken for the study. The samples were of three months old after harvest at the time of analysis. Samples were cleaned and dried to reach a moisture content of 13-14 per cent. They were husked in a Rubber roll laboratory Sheller, Stake, Japan. The husked kernels were polished to 5 percentage by Osaw rice polisher. Kernel length and kernel breadth were recorded using a digital slide calliper. Percentage of hulling and milling were estimated by the method of Khush *et al.,* 1979. Alkali spreading value was estimated following the method (Little *et al.,* 1958) by soaking polished kernels in 1.7 % potassium hydroxide solution for 23 hours at room temperature. Percentage of head rice recovery was calculated using the following formula. Head rice recovery percentage = (Weight of whole polished grains ÷ Weight of paddy taken) X 100.

Grain classification was done following the method of Ramiah committee (1969) appointed by Government of India, for the classification of rice for trade and commerce considering the classification by the FAO. Chalkiness of endosperm was determined by counting the chalky kernels per 100 seeds. The data on cooking quality traits namely water uptake, elongation ratio and volume expansion were estimated according to Murthy (1965).

2.3 Analysis of nutritional properties

The rice kernel polished to 10 % was ground into fine powder and sieved through 100 mesh sieve for nutritional analyses. Total crude protein content was determined by micro kjeldahl method using Elite EX, Kelplus automatic nitrogen analyzer of Pelican Equipments, Chennai, India. One hundred milligram sample was mixed with catalyst mixture (copper sulphate: potassium sulphate: selelium :: 10:50:1) and digested with 10 ml concentrated sulphuric acid. The digest was distilled and ammonia released was captured in 4 % boric acid solution. Then it was titrated with 0.1 N HCl. The resulting N_2 content was multiplied by a factor 5.95 to convert into crude protein content. Official method of analysis of the AOAC (1980) was used to study the total fat, ash and crude fibre. The total carbohydrate was estimated by anthrone method according to Sadashivam and Manickam (1996). Fifty milligram of the fine powdered sample was digested with 1 N HCl overnight at 25ºC and neutralized with solid sodium carbonate. Then the resulting neutral extract was diluted in 100 ml of distilled water and filtered through Whatman No. 1 filter paper. The filtrate was reacted with anthrone reagent for eight minutes in boiling water bath and absorbance was recorded with systronics 119 spectrophotometer at 630 nm. D-glucose was taken as the standard. The amylose content was determined by the method of Juliano Bo (1971). Standard AOAC methods were applied to determine iron and zinc using di-acid mixture HNO_3 + $HClO_2$ and standard 100 ppm Fe and Zn solutions were used. The presence of aroma was tested by the method described by Sood and Siddiq (1978) with slight modification. Five gram of fine powder was incubated in a closed petridish for 10 minutes with 20 ml of 1.7 % KOH solution. The petridish was opened and smelt immediately with a panel of judges. The sign (-) was assigned to those which did not posses aroma, that (+) to those which had mild aroma, (++) to those which had strong aroma and (+++) to those had very strong aroma. Basmati-370 was taken as the check for analyzing aroma of the cultivars. The cultivars having comparable aroma with this check have been given (+++).

2.4 Statistical analysis

Mean values arrived at for each replication were utilized for estimation of genetic parameters of variation *viz*., phenotypic coefficient of variation and genotypic coefficient of variation as per Burton (1952), heritability in broad sense, genetic advance as percentage of mean as suggested by Johnson *et al.,* (1955a) and correlation studies among the proximate components as per Johnson *et al.,* (1955b). All the above analyses were carried out using statistical software from INDOSTAT Services, Hyderabad, India.

The study involved eighteen rice varieties collected from Tripura and grown. The sample consisted equal number of red and white kernels. Most of the cultivars were short and bold, red and white kernel type except *Binni Mereng* and *Rasi* in red grain type and *Guriya, Katak tara* and *White Gora* in white kernel type. Rice is Tripura's principle crop and sown in 91% (Annonymous, 2009) of the cropped area. Many local rice and improved cultivars among eighteen cultivars *NDR-97* and *AR-11* are introduced improved varieties, popular and widely grown in Tripura along with other local cultivars. The cultivars were hard rice irrespective of grain colour except *Guriya* which is soft grain type.

North Eastern Hill region is the hot spot for rice diversity, the same diversity is found in the preferences of cooked rice among the people. People of some part of North Eastern Hill region prefer sticky and soft rice while the other patch may prefer hard and non sticky rice. Tripura is dominated by hard and non sticky rice.

3. Results and Discussion

The physical properties studied are presented in table 1. The sample studied constituted equal number of red and white kernel colour, *NDR 97* was longest and the breadth was 2.11mm while L/B ratio was also highest in the group (3.13mm). Most of the red kernels were short and bold type except *Binni Mereng* and *Rasi*. Out of hundred seeds 99 seeds were chalky in *Guriya* but chalkiness was very low in *Katak tara* incidently both are long and bold grain type. Alkali spread is an indirect measure of gelatinization temperature of starch varied from 1.97 – 5.90 indicating a wide range of gelatinization temperature. This finding is in agreement with the reports of Tan *et al*., 2001. The gelatinization temperature is correlated with the extent of disintegration of milled rice in dilute alkali solution (Little *et al.,* 1958). Volume expansion ratio and elongation ratio had a narrow range of 4.07 – 5.57 and 1.1 – 1.97, the mean was 4.76 and 1.59 respectively. *NDR 97* (390.67 ml) had highest water uptake and *Rasi* (70 ml) was lowest, while the mean was 238.56 ml. Eight of eighteen cultivars were aromatic, *Katak tara* had strong aroma. Scent /fragrance is much valued quality factor because of which premium price is given in international market irrespective of kernel colour and grain size. Most of the aromatic cultivars in the group were glutinous type hence less preferred in the international market but these cultivars are popular among the local people to prepare special savouries and desserts.

3.1 Proximal composition

There was a significant level of variation for all the proximal composition studied among the cultivars. The results of the proximal nutritional proportionate present in the rice cultivars studied is presented in table 2. The nutritional quality of rice depends on the protein content and rice is the poor sources of protein among cereals. But the quality of protein depends on the composition of amino acids (FAO, 1970). The rice protein is superior because of its unique composition of essential amino acids (Eggum, B.O. 1979). The protein ranges from 7.77 to 11.48% in the samples studied. Rice being the staple food of India contributes 24.1% of dietary protein out of 207.9 grams of rice consumed per day per person (FAOSTAT, 2001). Analyzing the protein in local germplasm will help the nutritionist to assess the protein intake and deficiency of protein in the people of rice consuming countries. The eighteen varieties had an average of 9.18% protein, cultivar *Guriya* had (11.48%) highest and *My My Yath Lock* was lowest protein (7.77%) among the samples. Devi *et al.,* (2008a) reported as high as 12.07% protein in *Chahou angouba*, a local cultivar from Manipur. *Jhum Binni Black, Ma kum My Mukul, Biswas Gora* had around 10% crude protein. These cultivars are classified as high protein cultivars of rice, with 10% or more total crude protein following the classification of Resurrection *et al*., 1979. However, Saikia and Bains (1990) and Singh *et al.,* 1998 reported low protein content in both brown and milled rice from rice collections of Assam and Himachal Pradesh (An Indian state of similar altitude) respectively.

Rice is the main source of carbohydrates for more than 1/3 rd of the people in world. The mean carbohydrates in the eighteen samples studied are 81.47%. *White Gora* contains highest carbohydrates of 89.25%. The cultivar *Ma kum My Mukul* and *Aditya* had lowest carbohydrates of 70%. But most of the samples had more than 80% of the carbohydrates and above the average. The cultivars *My My Yath Lock* and *Aditya* had 30.1% amylose, the range was 4.2% to 30.1 of amylose content. According to the classification of Kumar and Khush (1986) five cultivars were grouped into high (more than 25%) and four cultivars were intermediate amylose (20-25% groups), nine cultivars are low amylose content (less than 20%). Cooked rice becomes moist and sticky due to low amylose content. Most of the cultivars with high carbohydrates had intermediate amylose, while *Aditya* had lowest carbohydrates but amylose as high as 30.1% making the rice hard and nonsticky. The fifty percent of our samples were as low as 4.2% in *NDR 97*. These cultivars are sticky and moist. The sticky rice is most preferred in North Eastern region of India. Amylose content ranged from 2.27% to 24.50% in *Chahou poireiton* and *Ngoba* respectively was reported by Devi *et al.,* (2008a). However, Singh *et al.,* (1998) reported narrow range of amylose content in Himachal Pradesh rice collection (19.32 – 22% in brown rice and 22 – 25% in milled rice).

The mean total fat content was 1.04% with the range of 0.67% to 1.4% in *White Gora* and *Aduma* respectively. There were nine cultivars having total fat content above the average (1.042%). In contrary, a study conducted by Devi *et al.,* (2008b) on 14 varieties of Manipur and Nagaland reported total fat ranging from 1.2 to 4.2% with the mean of 2.49%. However, Saikia and Bains (1990) and Singh *et al.,* (1998) respectively reported narrow range of 0.31 and 1.06% of total fat in their samples studied. In the present study the cultivars having total fat above the mean (1.04%), had low amylose content. Further, they found that indica type of rice (high amylose) had low lipid content than japonica type (low amylose). *Aduma* had low amylose of 10.4% with fat recording 1.4%, highest among the samples studied. The crude fibre ranged from 0.13 to 0.59 and mean was 0.32%. Ash content was low in all the samples. *Garumalati* reported 1.34% ash, highest in the lot and 0.42% was reported in *Aditya*. The mean ash content was 0.90%.

Two important micronutrients iron and zinc was 8.5 mg/1000g and 2.44 mg/1000g respectively. The highest iron concentration was found in *Rasi* (15.42 mg/1000g) and lowest in *White Gora* (2.32 mg/1000g). The range was wide however, six of eighteen cultivars had iron content more than 10mg/1000g. Borua *et al.,* (2004) reported 2.8 to 4.60 mg/1000g of iron in 64 scented rice cultivars of North East India. Zinc ranged from 1.33 to 3.42 mg/1000g in *Aditya* and *Guriya* respectively. Ahmed *et al*., (1998) reported the crude protein content of nine aromatic rice cultivars ranged from 9.17 to 11.77% and iron content from 1.5 to 5.0 mg/1000g.

3.2 Genetic parameters of variation

Historically, improvement in rice breeding focused on increasing the quantity of the food sources; the importance of the quantity of the food source in reducing micronutrient deficiencies is now coming in the forefront (Ruel and Lewin, 2000). There is greater recognition of the global prevalence of many forms of micronutrient malnutrition such as iron, vitamin A and Zinc deficiencies. Improvements in rice enhancing nutritional quality through plant breeding, increasing micronutrient content of the grain through genetic modification and improving rice fortification techniques.

The study of genetic parameters of variation is important to know the amount of variability present in the genetic material, which in turn necessary for further improvement. The genetic components of different characters studied are given in table 3. All the characters studied were in close agreement with genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) except fibre and iron percent. All physical characters studied had highest heritability and moderate genetic advance except volume expansion ratio and elongation ratio (Figure 1). In most of the characters, heritability (h^2) was more than the genetic advance indicating more of environmental effect. But amylose and iron, genetic advance was high; selection for these traits will improve the genotypic value of selected plants over the parents. High heritability coupled with high genetic advance was found in iron and amylose. The moderate high level of h^2 with high genetic advance manifested by total fat, crude fibre and ash content might be assigned to additive gene action controlling the expression of these traits. The heritability for carbohydrates and protein was moderately high; however genetic advance was very low. The genetic advance was very low because of low genotypic variance (GCV) more influence of environmental factors so simple phenotypic selection will not bring its genetic improvement. For improvement of carbohydrates and crude protein, there is a need for genetic enhancement of variability either through collection of new genetic resources or through creation by hybridization. Selection followed by progeny test must be done to improve crude protein and carbohydrates. Swin and Nagaraju, 2004 reported preponderance of additive gene action for amylose content in rice. Hence, phenotypic selection for their improvement can be affected by simple selection methods like pure line, mass selection and single seed descent methods.

The genotypic correlation coefficients among the nutritional traits are given in table 4. The association of crude protein is significant but negative with carbohydrates and amylose, while with total fat and zinc, the association is significant and positive. However, carbohydrate was significantly and positively correlated with ash percent and iron concentration. While, negative association was found with total fat; carbohydrate had no significant correlation with amylose. This result was in agree with the study conducted by Devi *et al*., (2008a) in 14 rice cultivars of North eastern hill region. Crude fat had strong and negative correlation with amylose. Tahira and Chang, 1986 reported the influence of glutinous and non glutinous character on lipid contents of rice where they found 3.58% fat content in low amylose rice. Iron had significant and positive correlation with ash percentage and carbohydrates but there was negative and insignificant relation with rest of the parameters studied including zinc. Selection for high L/B ratio, alkali spread and ash % will indirectly select for high iron (Figure 2). The association of zinc with crude protein and ash was strong and positive, while it was negative with amylose. Therefore selection made for high protein will indirectly select high zinc and fat but with low ash percentage which intern has strong positive correlation with iron, crude fibre, carbohydrates and zinc.

4. Conclusion

The quality analysis of the eighteen indigenous cultivars of Tripura state of India discovered some cultivars with good processing quality and some cultivars with higher nutrient contents than average of what rice use to content. As higher crude protein contents in rice showed positive health benefit by some previous experiments done elsewhere in the world, the rice cultivars having higher crude protein content (*Guriya, Jhum Binni Black, Ma Kum My Mukul, Biswa Gora*) could be recommended for consumption and quality enhancement. Similarly the six cultivars having more than 10 ppm iron can be used for consumption and future rice improvement programmes. However selection for both high protein and high iron in a single cultivar will be difficult as these two parameters are negatively correlated.

References

Ahmed, S. A., Baraua, I. & Das, D. (1998). Chemical composition of scented rice. *Oryza*, 35(2), 167-169.

Annonymous. (2009). Economic Review of Tripura 2008-2009. Directorate of economics & statistics planning (statistics) department government of Tripura, Agartala. http://destripura.nic.in/review20078.pdf.

AOAC. (1980). *The official methods of analysis of association of official analytical chemist*, 14th Edition, Washington, DC, USA.

Blackwell, R.Q., Yang, T.H. & Juliano, B.O. (1966). *Effect of protein content upon growth rates of rats fed highrice diets* (Abstr.) Proc. 11th Pac. Sci. Congr., Tokyo, 8, 15.

Borua, I., Ahmed, S.A, Sarkar, C.R. & Das, D. (2004). Biochemical evaluation of scented rice of northeastern India. Bioprospecting of commercially important plants. Proceedings of the national symposium on "Biochemical approaches for utilization and exploitation of commercially important plants. Indian Society of Agricultural Biochemists. Jorhat, India, 79-85.

Bressani, R., Elias, L.G. & Juliano, B.O. (1971). Evaluation of the protein quality of milled rices differing in protein content. *Journal of Agricultural and Food Chemistry*, 19, 1028-1034. http://dx.doi.org/10.1021/jf60177a043

Burton, G.W. (1952). *Quantitative inheritance in grass.* Proc. 6th Internat. Grassland Conf., 1, 277-283.

Devi, Th. P., Durai, A, Singh, Th. A., Gupta, S., Mitra, J., Pattanayak, A., Sarma, B. K. & Das, A. (2008a). Preliminary studies on physical and nutritional qualities of some indigenous and important rice cultivars of north eastern hill region of India. *Journal of Food Quality*, 31, 686-700. http://dx.doi.org/10.1111/j.1745-4557.2008.00228.x

Devi, Th. P. & Pattanayak, A. (2008b). Medicinal rice of Manipur, their ethnopharmacological uses and preliminary biochemical studies. *Asian Journal of Microbiology, Biotechnology and Environmental Sciences*, 10(1), 139-141.

Eggum, B.O. & Juliano, B.O. (1973). Nitrogen balance in rats fed rices differing in protein content. *Journal of the Science of Food and Agriculture,* 24, 921-927. http://dx.doi.org/10.1002/jsfa.2740240809

Eggum, B.O. & Juliano, B.O. (1975). Higher protein content from nitrogen fertilizer application and nutritive value of milled rice protein. *Journal of the Science of Food and Agriculture*, 26, 425-427. http://dx.doi.org/10.1002/jsfa.2740260407

Eggum, B.O. (1979). The nutritional value of rice in comparison with other cereals. In Proceedings, *Workshop on Chemical Aspects of Rice Grain Quality*, Los Baños, Laguna, the Philippines, IRRI. pp. 91-111.

FAO. (1970). Amino acid content of foods and biological data on proteins. Nutr. Div. Pub. 24. Rome, FAO, p 122. http://food.oregonstate.edu/ref/culture/native/native_benson.html

FAOSTAT. (2001). FAOSTAT Statistical Database. Food and Agriculture Organization. http://www.fao.org/ [Geo-2-196].

Govindaswami, S., Ghosh, A.K. & Nanda, B.B. (1969). *Varietal differences in hulling and cooking qualities.* Annual Report of Central Rice Research Institute, Cuttack, India, p 64.

Guha, B.C. & Mitra, N.R. (1963). Studies on the consistency of thiamine and protein contents of pure-bred strains of rice. *Annals of Biochemistry and Experimental Medicine*, 23(2), 69–72.

Hegsted, D.M. & Juliano, B.O. (1974). Difficulties in assessing the nutritional quality of rice protein. *Journal of Nutrition*, 104, 772-781.

Hore, D.K. (2005). Rice diversity collection, conservation and management in north eastern India. *Genetic Resources and Crop Evolution,* 52, 1129-1140. http://dx.doi.org/10.1007/s10722-004-6084-2

Johnson, H. W., Robinson & Comstock, R. E. (1955a). Estimates of genetic and environmental variability in Soybean. *Agronomy Journal*, 47, 314-318. http://dx.doi.org/10.2134/agronj1955.00021962004700070009x

Johnson, H. W., Robinson & Comstock, R. E. (1955b). Genotypic and phenotypic correlations in soybeans and their implication in selection. *Agronomy Journal,* 47, 477-483. http://dx.doi.org/10.2134/agronj1955.00021962004700100008x

Juliano, B.O. (1971). A simplified assay for milled rice amylose, *Cereal Science Today*, 16 (10), 334-339.

Juliano, B.O., Nazareno, M.B. & Ramos, N.B. (1969). Properties of waxy and isogenic nonwaxy rices differing in starch gelatinization temperature. *Journal of Agricultural and Food Chemistry,* 17, 1364-1369. http://dx.doi.org/10.1021/jf60166a062

Khush, G. S., Paule, C. M. & de la Cruz, N. M. (1979). Rice grain quality evaluation and improvement at IRRI. pp. 21-31. In: *Proceedings of the Workshop on Chemical Aspects of Rice Grain Quality.* International Rice Research Institute, Los Banos, Laguna, Philippines.

Kumar, I. & Khush, G. S. (1986). Genetics of amylose content in rice. *Journal of Genetics*, 65(1-2), 1-11. http://dx.doi.org/10.1007/BF02923530

Little, R. R., Hildre, G. B. & Dawson, E. H. (1958). Differential effect of dilute alkali on 25 varieties of white milled rice. *Cereal Chemistry,* 35, 111-126.

Murata, K., Kitagawa, T. & Juliano, B.O. (1978). Protein quality of high protein rice in rats. *Agricultural and Biological Chemistry*, 42, 565-570. http://dx.doi.org/10.1271/bbb1961.42.565

Murthy, P. S. N. (1965). Genetic studies in rice (*Oryza sativa* L.) with special reference to contain quality features-M.Sc. (Botany) thesis, Orissa University of Agriculture & Technology, Bhubaneswar, p 68.

Pereira, S.M., Begum, A. & Juliano, B.O. (1981). Effect of high protein rice on nitrogen retention and growth of preschool children on a rice-based diet. *Qualitas Planatarum - Plant Foods for Human Nutrition,* 31, 97-108. http://dx.doi.org/10.1007/BF01094034

Ramiah, K. (1969). Grain Classification page No 629 - Rice Research in India, ICAR Publication, 1985.

Resurrection, A. P., Juliano, B. O. & Tanaka, Y. (1979). Nutritional content and distribution in milling fractions of rice grains. *Journal of the Science of Food and Agriculture*, 30, 475-481. http://dx.doi.org/10.1002/jsfa.2740300506

Roxas, B.V., Intengan, C.LI. & Juliano, B.O. (1980). Effect of zinc supplementation and high-protein rice on the growth of preschool children on a rice-based diet. *Qualitas Planatarum - Plant Foods for Human Nutrition*, 30, 213-222. http://dx.doi.org/10.1007/BF01094026

Ruel, M.T. & Levin, C. E. (2000). *Assessing the potential for food-based strategies to reduce vitamin A and iron deficiencies: a review of recent evidence*. FCND Discussion Paper No. 92. Food Consumption and Nutrition Division. Washington, DC, International Food Policy Research Institute. p 62.

Sadashivam, S. & Manickam, A. (1996). *Biochemical Methods*, New Age International Publishers, New Delhi, India pp. 8-9.

Saikia, L. & Bains, G. S. (1990). Studies of some Assam rice varieties for processing and nutritional qualities. *Journal of Food Science and Technology,* 27 (5), 345-346.

Singh, S., Dhaliwal, Y. S., Nagi, H. P. S. & Kalia, M. (1998). Quality characteristics of six rice varieties of Himachal Pradesh. *Journal of Food Science and Technology*, 27 (5), 345-348.

Sood, B.C. & Siddiq, A. (1978). A rapid technique for scent determination in rice. *Indian Journal of Genetics and Plant Breeding,* 38(2), 268-271.

Swain & Nagaraju, M. (2004). Diallel analysis for amylose content in rice. *Oryza*, 41(3&4), 125–127.

Tahira, H. & Chang, W. (1986). Lipid content and fatty acid composition of *Indica* and *Japonica* of nonglutinous brown rice. *Journal of Agricultural and Food Chemistry*, 34, 542-545. http://dx.doi.org/10.1021/jf00069a043

Tan, Y. F., Sun, M., Xing, Y. Z., Hua, J. P., Sun, X. L. & Zhang, Q. F. (2001). Mapping quantitative trait loci for milling quality, protein content and colour characteristics of rice using a recombinant inbred line population derived from an elite rice hybrid. *Theoretical and Applied Genetics*, 103, 1037–1045. http://dx.doi.org/10.1007/s001220100665

Thongbam, Premila D., Durai, A. Anna, Singh, Th. Anand, Taorem, Bidyapati Devi, Gupta, S., Mitra, J., Pattanayak, A., Dhiman, K.R., Bhadana, V.P., Hore, D.K. & Ngachan, S.V. (2010). Grain and food quality traits of some indigenous medicinal rice cultivars of Manipur. *International Journal of Food Properties*, 13(6), 1244-1255. http://dx.doi.org/10.1080/10942910903034833

UNIS. (2004). Independent expert on effects of structural adjustment, Special reporter on right to food present reports: Commission continues general debate on economic, social and cultural rights. United Nations, http://www.fao.org/righttofood/kc/downloads/vl/docs.

Table 1. Mean values of physical and cooking qualities of rice cultivars

Cultivars	Length (mm)	Breadth (mm)	L/B	Chalkiness (%)	Alkali spread	Hulling (%)	Milling (%)	Head Rice Recovery	Volume Expansion ratio	Elongation ratio	Water Uptake (ml)	Grain Type	Aroma
Aditya	5.65	2.49	2.27	84	2.13	58.07	55.97	16	4.9	1.97	309.67	SB	-
Aduma	4.33	2.61	1.66	9.4	2.53	64.8	62.17	25.2	4.97	1.87	248.33	SB	+
Annanda	5.37	2.56	2.1	93	2.2	64.9	61.4	21.47	5.33	1.57	267.33	SB	-
AR-11	5.67	2.23	2.54	72.33	2.17	74	70.73	33.67	4.67	1.1	130	MS	+
Binni Mereng	6.38	2.41	2.65	9.77	2.73	65.17	57.1	32.63	4.97	1.57	281	LB	-
Biswas Gora	5.92	2.71	2.19	1.1	1.97	37.18	35.1	17.77	4.77	1.5	155	SB	-
Ful Badam	5.15	2.34	2.2	7.53	2.43	75.5	71.97	34.97	4.07	1.57	155.33	SB	++
Garumalati	5.3	2.54	2.09	18.23	2.7	73.5	69.27	14.5	4.4	1.83	201.67	SB	-
Guriya	6.51	2.5	2.61	98.6	2.5	66.33	62.57	7	5.57	1.27	381.67	LB	+
Jhum Binni Black	5.84	1.98	2.97	95.17	3	57.67	53.53	9.87	4.83	1.57	235	MS	++
Kalikhasa	4.26	2.34	1.83	5.8	2.27	50.93	47.8	25.6	4.3	1.5	265.33	SB	++
Katak tara	6.36	2.12	3	0.83	3	67	65.13	18.2	5.43	1.7	265.67	LB	+++
Ma Kum My Mukul	4.23	2.4	1.76	6.43	3	71.47	69.93	26.77	4.27	1.67	187.33	SB	+
My Casak	5.73	2.41	2.37	3.13	4.53	70.27	68.5	43.7	4.23	1.53	256	SB	-
My My Yath Lock	5.33	2.61	2.04	36.43	2.9	66	62.1	5.07	4.2	1.97	308.33	SB	-
NDR-97	6.65	2.11	3.13	45	2.43	66.53	62.3	18.2	4.63	1.53	390.67	LS	-
Rasi	6.45	2.29	2.83	32.37	5.9	66.37	62.73	22.87	4.73	1.5	70	LB	-
White Gora	6.01	2.58	2.33	16.8	3	56.9	54.77	6.2	5.5	1.37	185.67	SB	-
Mean	5.62	2.4	2.37	35.33	2.86	64.03	60.73	21.09	4.76	1.59	238.56		
S.E.	0.07	0.05	0.07	0.36	0.14	0.47	0.34	0.16	0.26	0.1	12.63		
C.D. 5%	0.21	0.14	0.19	1.03	0.39	1.35	0.99	0.45	0.76	0.29	36.31		
C.D. 1%	0.29	0.19	0.26	1.38	0.52	1.81	1.32	0.61	1.02	0.38	48.75		
C.V.	2.28	3.58	4.89	1.75	8.19	1.27	0.98	1.29	9.62	10.85	9.17		

Table 2. Mean values of different nutritional characters studied

Cultivars	Total Carbohydrates (%)	Total Crude Protein (%)	Amylose content (%)	Total Fat (%)	Crude Fibre %	Ash %	Iron (mg/1000g)	Zinc (mg/1000g)
Aditya	70	8.43	30.1	0.94	0.28	0.42	4.93	1.33
Aduma	78.32	9.16	10.4	1.4	0.13	1.17	11.87	3.37
Annanda	73.57	9.3	22.4	1.26	0.21	0.32	2.63	2.47
AR-11	86.75	7.91	25.2	0.99	0.59	0.94	3.7	2.42
Binni Mereng	78.45	9.02	22.37	0.77	0.24	0.81	8.93	2.73
Biswas Gora	85.11	10	27.3	0.67	0.25	0.85	11.27	2.3
Ful Badam	78.19	8.9	7.36	1.17	0.37	1.23	9.53	2.3
Garumalati	87.62	8.37	25.2	1.02	0.23	1.34	13.58	2.07
Guriya	76.66	11.48	6.3	1.3	0.29	0.91	4.01	3.42
Jhum Binni Black	84.92	10.61	9.33	1.37	0.4	0.81	8.93	2.4
Kalikhasa	87.15	8.66	10.12	1.19	0.38	0.74	4.1	2.3
Katak tara	87.24	8.25	10.8	1.23	0.46	1.15	14.77	2.03
Ma Kum My Mukul	70	10.27	9.6	1.3	0.32	0.78	6.5	2.7
My Casak	75.27	8.74	11.04	0.79	0.5	1.26	8.67	2.57
My My Yath Lock	87.63	7.77	30.8	0.88	0.23	1.11	8.8	2.4
NDR-97	85.67	9.36	4.2	1.12	0.25	0.6	12.97	1.9
Rasi	84.67	9.42	21.7	0.69	0.49	1.2	15.42	2.67
White Gora	89.25	9.57	24.5	0.67	0.18	0.65	2.32	2.62
Mean	81.47	9.18	17.15	1.04	0.32	0.9	8.5	2.44
S.E.	1.81	0.26	1.58	0.06	0.03	0.07	0.65	0.17
C.D. 5%	5.19	0.74	4.55	0.16	0.09	0.21	1.87	0.48
C.V.	3.84	4.88	15.98	9.15	16.21	14.15	13.29	11.92

Table 3. Genetic Parameters of different characters studied

Characters	ECV	GCV	PCV	h^2 (Broad Sense)	Genetic Advancement 5%	Genetic Advancement as % of Mean 5%
Length	2.284	13.507	13.699	97.2	1.542	27.435
Breadth	3.58	7.989	8.754	83.3	0.361	15.018
Length/Breath (L/B)	4.89	18.295	18.937	93.3	0.862	36.409
Alkali spread	8.188	32.948	33.95	94.2	1.881	65.868
Hulling (%)	1.271	14.486	14.541	99.2	19.035	29.727
Milling (%)	0.978	15.067	15.099	99.6	18.808	30.972
Head Rice Recovery	1.289	51.005	51.021	99.9	22.155	105.036
Volume expansion ratio	9.619	8.179	12.626	42	0.52	10.914
Elongation ratio	10.855	12.787	16.773	58.1	0.319	20.081
Water uptake	9.174	34.658	35.852	93.5	164.649	69.019
Total Carbohydrates (%)	3.841	7.556	8.477	79.5	11.305	13.876
Total Crude Protein (%)	4.88	10.087	11.205	81	1.717	18.705
Amylose content (%)	15.978	51.873	54.278	91.3	17.515	102.124
Total Fat (%)	9.148	23.526	25.242	86.9	0.471	45.169
Crude Fibre %	16.212	38.015	41.328	84.6	0.232	72.033
Ash %	14.148	31.485	34.517	83.2	0.535	59.16
Iron (mg/1000g)	35.074	45.361	57.34	62.6	6.257	73.924
Zinc (mg/1000g)	11.923	18.48	21.992	70.6	0.782	31.989

Environmental coefficient of variation (ECV), Genotypic coefficient of variation (GCV), Phenotypic coefficient of variation (PCV), Broad sense heritability (h^2).

Table 4. Genotypic correlation between physical and nutritional characters

	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
A	-0.312*	0.888**	0.280*	0.265	-0.038	-0.09	-0.237	0.594**	-0.379**	0.183	0.267	0.186	0.085	-0.428**	0.18	-0.061	0.275*	-0.14
B		-0.709**	-0.193	-0.216	-0.279*	-0.257	-0.156	0.058	0.287*	-0.034	-0.232	-0.02	0.540**	-0.335*	-0.664**	-0.041	-0.296*	0.270*
C			0.308*	0.290*	0.084	0.037	-0.135	0.426**	-0.382**	0.164	0.328*	0.156	-0.198	-0.136	0.423**	-0.029	0.379**	-0.236
D				-0.202	0.053	0.03	-0.388**	0.465**	-0.218	0.325*	-0.22	0.305*	0.088	0.309*	0.036	-0.512**	-0.478**	-0.045
E					0.252	0.263	0.192	-0.151	-0.028	-0.384**	0.05	0.034	-0.046	-0.385**	0.442**	0.463**	0.446	0.229
F						0.989**	0.344*	-0.276*	0.019	-0.014	-0.215	-0.274*	-0.245	0.279*	0.284*	0.423**	0.129	0.135
G							0.345*	-0.286*	0.028	-0.049	-0.235	-0.276*	-0.262	0.296*	0.320*	0.432**	0.11	0.115
H								-0.535**	-0.225	-0.312	-0.366**	-0.300*	-0.239	-0.06	0.490**	0.256	0.06	0.061
I									-0.396**	0.316*	-0.037	0.427**	0.042	0.076	-0.296*	-0.468**	-0.224	0.278*
J										0.257*	-0.275*	-0.417**	0.241	0.135	-0.513**	0.163	0.505**	-0.400**
K											-0.202	0.119	-0.296*	0.363**	-0.404*	-0.363**	-0.171	-0.043
L												-0.323*	0.162	-0.276*	0.118	0.329*	0.350**	-0.128
M													-0.459**	0.269*	-0.216	-0.251	-0.187	0.572**
N														-0.679**	-0.192	-0.133	-0.149	-0.343*
O															-0.06	-0.095	-0.119	0.237
P																0.365**	0.086	-0.139
Q																	0.645**	0.292*
R																		-0.157

* Significant at $p<0.05$; ** Significant at $p<0.01$

(A) Grain length; (B) grain breadth; (C) L/B ratio; (D) chalkiness (%); (E) alkali spreading value; (F) hulling%; (G) Milling%; (H) Head rice recovery; (I) volume expansion ratio; (J) elongation ratio; (K) water uptake; (L) carbohydrate content (%); (M) crude protein (%); (N) amylose content (%); (O) total fat (%); (P) crude fibre (%); (Q) Ash (%); (R) iron content; and (S) zinc content.

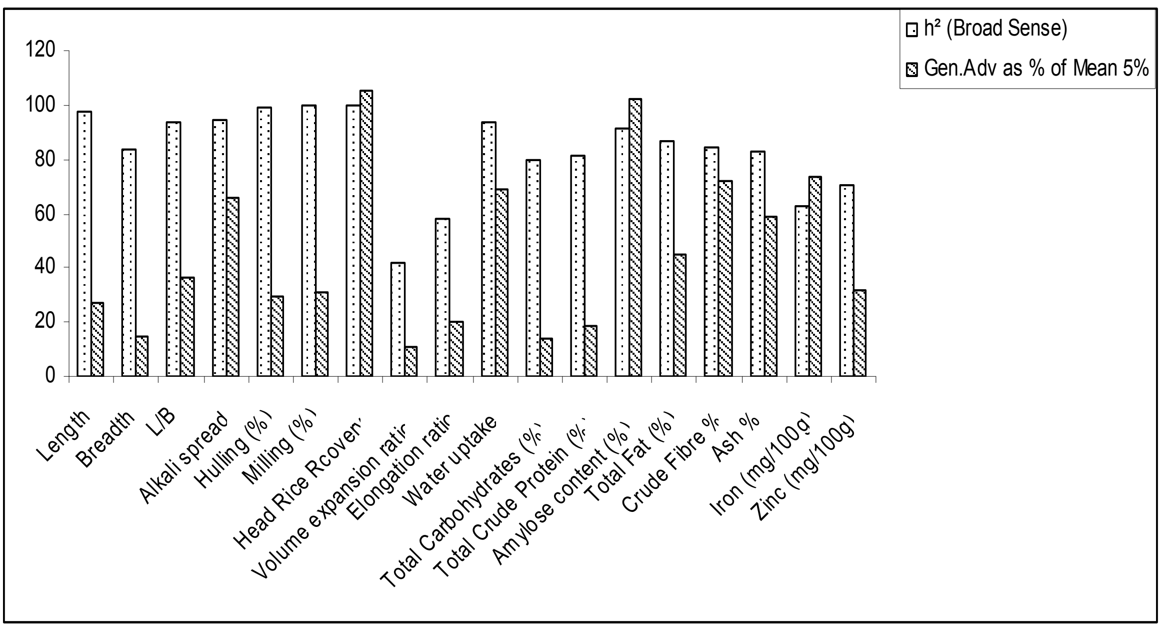

Figure 1. Comparison of heritability and genetic advance for different characters studied

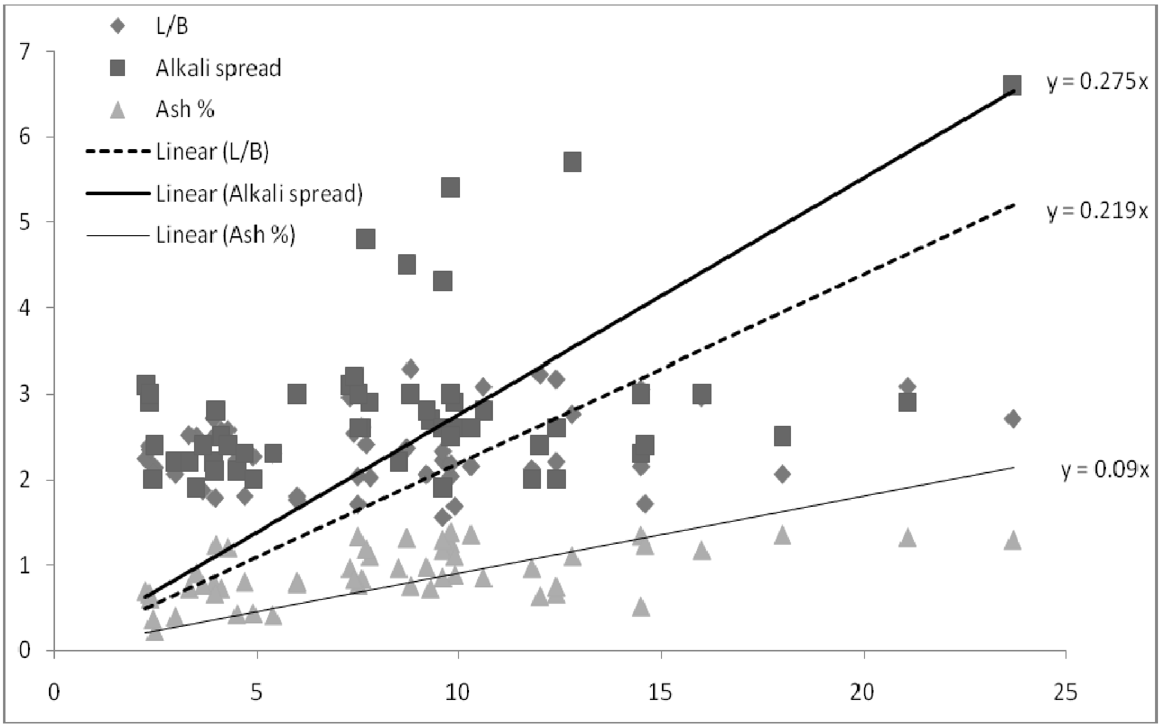

Figure 2. Relation trend between iron content with L/B ratio (diamond & dotted line), Alkali spread (square blocks & thick line) and Ash % (triangles & thin line)