ORIGINAL RESEARCH ARTICLE OPEN ACCESS

Proximate Nutritional Evaluation of Rice (*Oryza Sativa* L.)

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Received: 26th February, 2015 Accepted: 25th June, 2015

Abstract

In the present study, ninety two rice varieties were evaluated for estimating proximate composition which is useful in the generation of nutritionally rich rice varieties. Analysis of variance showed significant differences in the proximate compositions of the rice varieties studied. The results indicated high percentage of carbohydrate in all the genotypes (73.6 to 83.7%) and the varieties Bhuban and Prachi had the highest carbohydrate content (83.7%). Sahyadri hybrid showed the highest crude protein (11.0 %), while Swarna had the least crude protein (5. 9 %). Pusa basmati 1 and Swarnamukhi (NLR 145) varieties showed the highest moisture content percentage (11.6%) while Bhuban variety (7.13%) contained the lowest percentage moisture content. MTU 1001 and MSS 5 contained highest fat content (3.7%) while Barah Avarodhi possessed the lowest fat content (0.9%). Crude fibre content was low in majority of the samples. Only two varieties *i.e.,* MTU 3626 and MTU 1010 contained highest crude fibre (0.99%) while Pusa Basmati 1 possessed highest ash content (2.3 %). Carbohydrate was significantly and positively correlated with energy and negatively correlated with moisture %. The association of moisture % with carbohydrate and energy is significant but negative. Thus, the results generated in this study provide first hand information in identifying superior quality rice varieties based on their proximate composition.

Key words: Rice, proximate composition, polishing, Genotypes, correlation

Introduction

Rice is one of the most important staple cereals in human nutrition, consumed by about 75% of the global population. India is the second largest producer of rice. The proximate composition of rice includes moisture, carbohydrates, proteins, dietary fibres, fatty acids, ash and dietary minerals. Rice is an excellent source of carbohydrates containing approximately 87 % in grain. It contains 7 to 8 % of protein which has higher digestibility, biological value and more nutritious; possesses 10% moisture, lower crude fibre and lower fat (1 to 2%) and ash (1 to 2%). Nearly twenty percent of the world's dietary energy is provided by rice alone which is higher than either wheat or maize (Anon, 2004). The crude fibre reduces the risk of bowel disorders. The high proportion of unsaturated fatty acids such as oleic and linoleic acid present in rice bran lowers blood cholesterol. Whole grains are good source of iron, thiamine, niacin and riboflavin. In fact, bran is rich in micronutrients like oryzanols, tocopherols, tocotrienols, phytosterols and dietary fibres like betaglucan, pectin and gum which have hypolipidemic, anti-tumor, anti-oxidant, ergogenic and laxative properties. But rice consumers often prefer to have polished white rice despite the valuable food content of brown rice which is lost when bran is removed while polishing.

Knowledge about the nutritional status of rice is becoming increasingly important among consumers in view of nutritional deficiency disorders. Health conscious consumers are interested in having rice with good cooking quality, eating quality and also nutritional quality. There is limited information about the nutritional composition of the different rice varieties available in India. Therefore, the objective of this study is to investigate the proximate composition of selected rice varieties in terms of nutrition.

Materials and Methods

The experimental material consisted of 92 rice genotypes including land races, improved varieties, aromatic varieties and red rices collected from different Institutes of Indian Council of Agricultural Research and State Agricultural Universities (Table 1). The experiment was conducted during *kharif* 2013 in Randomized Block Design with three replications under rain fed conditions on experimental farm of Indian Institute of Rice Research, ICRISAT campus, Patancheru, Hyderabad, Telangana State, India. Seedlings of thirty days old were transplanted in 20 cm apart between rows and 15 cm within the row. All the recommended package of practices and necessary plant protection measures were adopted. The seeds were sun dried, dehulled and divided into two sets. One set was kept as unpolished (Brown rice) and the other set was polished up to 5% and 10%. A portion of the brown and polished rice samples was then ground to obtain rice flour suitable for proximate analysis. The rice flour was analyzed for percentage proximate content of rice grain determined using the AOAC (2000) methods, mentioned hereunder.

Determination of Moisture Content

The moisture content in each sample was determined by drying 4g sample in an air forced draft oven maintained at a temperature of 105 ±5 ^{0}C according to the procedure described in AOAC (2000) method No. 44-15 A.

Crude Protein Content

The nitrogen content in rice flour samples was estimated by following the Kjeldahl's method according to the procedure described in AOAC (2000**)** method No. 46-10. The protein percentage was calculated by multiplying nitrogen per cent with a factor 5.95.

Crude Fat

The crude fat content was determined in each rice flour sample by using petroleum ether as a solvent in a Soxhlet apparatus according to the procedure given in AOAC (2000) method No. 30-10.35

Ash Content

The ash content in each rice flour sample was estimated by putting samples in a muffle furnace at a temperature 550 ± 5^{0}C till white grey residue is obtained by following the method described in AOAC (2000) method No. 08-01.

Crude Fibre

For the determination of fibre content, the rice samples were digested with 1.25 % H_2SO_4 followed by 1.25 % Na OH solution and crude fibre content was determined according to AOAC (2000) method No. 32-10 .

Carbohydrates

The total percentage carbohydrate content in the rice sample was determined by the difference method as reported (Onyeike *et al*., 1995). This method involved adding the total values of crude protein, lipid, crude fibre, moisture and ash constituents of the sample and subtracting it from 100. The value obtained is the percentage carbohydrate constituent of the sample. Thus, % carbohydrate = 100 – (% moisture + % crude fibre +% protein+ % lipid + % ash).

Statistical Analysis

The data were analyzed using SAS software version 9.1 (SAS, 1998). Differences were declared statistically significant at $P < 0.05$. Where significant differences were detected, the means were separated by the least significant difference (LSD) at 5 % probability level. Inter-relationships among traits values were estimated using the Pearson's correlation coefficient.

Results and Discussion

The moisture, crude fat, crude protein, crude fibre, ash content, iron content and zinc content showed highly significant differences among different rice varieties and white and brown rice milling fractions (Table 2).

Moisture

Moisture content, which plays a significant role in determining the shelf-life (Webb, 1985) varied from 7.1 to 11.6 % with a mean value of 9.70 ± 0.13 in brown rice; 7.1 to 11. 2 % with mean value of 9.43 ± 0.13 at 5 % polishing and 7.01 to 11.2 % with a mean value of 9.31 ± 0.10. at 10 % polishing level. Although moisture content varied between brown and milled rice, it did not differ among the rice samples milled to different degrees (5 to 10%). Moisture is dependent on genetic makeup of varieties and agronomic as well as climatic conditions (Butt *et al*., 1997). The results of the present well supported by the findings of several researchers (Awan, 1996) who found the moisture content variation from 7 to 11%. Pusa basmati 1 and Swarnamukhi (NLR 145) varieties showed the highest percentage moisture content (11.6 %) while Bhuban variety (7.13%) contained the lowest percentage moisture content at 0 % polishing; Pooja and Bhuban contained highest moisture % of 11.3 and 7.1 respectively at 5% polishing; KMP 101 and Bhuban displayed highest and lowest moisture % (11.3 and 7.0 respectively) at 10 % polishing. The high percentage moisture content affects the milling characteristics and the taste of cooked rice (Xheng and Lan, 2006). Anjum *et al*., 2007 found moisture content ranging from 8.61 to 11.08% in different milling fractions of rice and the highest moisture content was found in brown rice of different varieties. Ebuehi and Oyewole (2007) reported that the moisture content of rice also affects its storage. It follows that Bhuban rice variety may have a longer shelf life compared to the other rice varieties due to the lower moisture content at all polishing levels. The variation observed in moisture content among rice varieties may be attributed to differences in the genetic make up as well as climatic conditions. The results suggested that the moisture content found in the present study is with in safe limits as in all samples it was below 11%.

Crude protein

The nutritional quality of rice depends on the protein content which is the second major component of grain next to starch. The protein is a key factor influencing the eating quality of rice. Rice contributes 24.1% of dietary protein out of 207.9 grams of rice consumed per day per person (FAOSTAT, 2001). The rice protein is superior because of its unique composition of essential amino acids (Eggum, 1979). The present results showed appreciably high protein content (> 6 %) in brown rice. Studies on protein content in different Pakistani varieties reported a range of 7.38 to 8.13% protein content (Awan, 1996) which is lower than those obtained in the current study. These levels of proteins in rice are very essential as proteins form the basic building blocks for cells and tissue repairs in the body. Protein content for all the rice varieties evaluated ranged between 5.9 (Swarna) to 11.0 % (Sahyadri) in brown rice with a mean value of 7.4 ± 0.1 in brown rice; 5.3 (Swarna) to 10.8 (Swarna) with a mean value of 7.3 ± 0.13 (at 5% polishing) and 5.2 (Swarna) to 10.3% (Sahyadri) with a mean value of 7.1 ± 0.12 (at 10% polishing). Overall high protein content was recorded in Sahyadri (11.0, 10.9 and 10.3 at 0 %, 5 % and 10 % polishing levels respectively). There was not much variation observed in protein content among different polishing levels. However it varied between brown rice and polished rice (5%). Usually, the average value of total crude protein content is taken as 7.00 % in rice seed. Analyzing the protein in test genotypes will help the nutritionist to assess the protein intake and deficiency of protein among the people of rice consuming countries. In another study, similar range of 6.7 to 11% protein in brown rice as found in present study was observed in 74 varieties from India (Guha and Mitra, 1963). Some varieties from Himachal Pradesh, India were reported to have 6.61 to 7.28% total crude protein (Sing *et al*., 1998). Indigenous cultivars of the north eastern hill states of India possess high protein content with a range of 6.14 to 12.07% (Devi *et al.,* 2008a; Premila Devi *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). Govindaswami *et al.* (1996) 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. Ahmed *et al.* (1998) reported that the crude protein content of nine aromatic rice cultivars ranged from 9.17 to 11.77 %. Swarna showed lowest protein (5.89 %, 5.74% and 5.89%) content at all polishing levels among the samples. The traditional cultivars are known to possess higher protein in crops. The protein in *Chahou angouba*, a local rice cultivar from Manipur was reported as high as 12.07% (Devi *et al.,* 2008a). In the present study genotypes, CN-1233-33-9-117, Karjat-2, Sahyadri, Sahyadri-2, Yamini, Aishwarya, Amulya, AS-100, Birupa, Bhudeb, Dandi, Jaya, Kranti, Madhukar,Dharitri, DL-184, and Jalapriya recorded more than 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, low protein content reported in both brown and milled rice from rice collections of Assam and Himachal Pradesh respectively (Singh *et al.,* 1998). Crude protein values of 1.17 to 7.94 % were noticed in a set of rice varieties (Oko and Ugwu, 2011) whereas Oko *et al.,* (2012) reported 1.6 to 7.9 % which appear to be bit lower than many of the published reports. The variation in protein content observed between brown and white rice is because of bran portion, which is higher in protein and significantly increase the protein content of brown rice as reported earlier (Pederson and Eggum, 1983) and (Anjum *et al*. 2007).

Carbohydrates

Rice is the starchy staple food and a major source of carbohydrates. Carbohydrate content was found to be high in all varieties (> 70%) in the present experiment. The results obtained in this study are in line with those given by Oko and Ugwu (2011) who have reported similar kind of increased carbohydrates in widely cultivated Nigerian rice varieties. The mean carbohydrates in the 92 samples studied ranged from 73.6 to 83.7 % with a mean of 79.6 ± 1.1 at 0 % polishing, 76.7 to 84.0% with a mean of 81.3 ± 1.1 at 5% level and 78.2 to 85.2% with a mean of 82.3 ± 0 .15 at 10 % level of polishing. It is observed that carbohydrate content increased as the level of polishing increases.

Although these values are higher than the values obtained by Eggum, (1982), they are a bit lower than the values (75.37 to 76.37%) reported by Edeogu *et al*., (2007) who analysed the proximate compositions of staple food crops in Ebonyi State. Sipi variety had the lowest carbohydrate content. This low carbohydrate content may be attributed to its high moisture content which also affects the milling quality and other environmental factors (USA Rice Federation, 2002). The high percent carbohydrate contents of the rice varieties show that rice is a good source of energy. Aishwarya, Bhuban, BPT11711, BR-2655, CN-1039-9,GR-103, Dandi, High iron rice, Prachi, PSD-1, IR-64, NLR-33359,Swarna, Taroari Basmati and VRS-3 contained highest carbohydrates of 82.17% at all polishing levels. The cultivar Sahyadri and Dharitri had lowest carbohydrates of 73%. But most of the samples recorded more than 80 % of the carbohydrates on an average. Such high amount of carbohydrate signifies high level of starch. In the present study most of the cultivars with high carbohydrates had intermediate desirable amylose content resulting in soft textured rice upon cooking. Sahyadri possessed lowest carbohydrates (73.63%) manifested high amylose content (30.1%) which may result dry, fluffy and hard cooked rice.

Fat

Fat in rice is a good source of linoleic acid and other essential fatty acids and rice does not contain cholesterol (Eggum *et al.,* 1982). The mean total fat content was 1.58 %, 0.93 % and 0.54 % at 0 %, 5 % and 10 % level of polishing respectively with the range of 0.50 to 3.77 % at 0 % polishing, 0.30 to 2.42 % at 5 % polishing and 0.10 to 1.46 % at 10 % polishing. The fat content (0.5 to 3.77 %) of brown rice recorded in this study is in agreement with earlier results reported by Oko and Ugwu (2011) and Oko *et al*., (2012). The fat content in brown and polished rice was found to be significantly highest in rice variety MTU 1001 followed by MSS 5, Nalini and Sahyadri. Excess intake of saturated fats is the most important dietary factor causing increased cholesterol and obesity. In this regard, PR 115, SGT 1 and Barah Aavarodhi could be better preferred owing to their lowest fat content in brown rice as well as polished rice.

Juliano (1985) reported that fat content ranged from 0.9 to 1.97 % in different milling fractions. However, this range is lower than the range obtained by Edeogu *et al.,* (2007). This difference may be attributed to the degree of milling which removes the outer layer of the grain where most of the fats are concentrated (Frei and Becker, 2003). The fat content of milled rice has been reported to be about 0.2 to 2.0% (Tahira and Chang, 1986). In contrary, a study on 14 varieties of Manipur and Nagaland reported a total fat content ranging from 1.2 to 4.2% with the mean of 2.49% for the local cultivars with low and intermediate amylose contents (Devi *et al*., 2008b). In the present study the genotypes having total fat above the mean (1.04%), had low amylose content. However Singh *et al.,* (1998) observed narrow range of 0.31 and 1.06% of total fat in their samples studied. Further, they found that *indica* type of rice (high amylose) had low lipid content than *japonica* type (low amylose).

Crude fibre

The presence of fibre in diet increases the bulk of feaces, which has a laxative effect in the gut. The standard content of fibre in rice is 0.5 – 1.0% for well milled rice (Oko and Onyekwere, 2010). The crude fibre (g%) ranged from 0.22 to 0.95 with a mean value of 0.5 ± 0.02 in brown rice, 0.08 to 0.78 with a mean value of 0.31 ± 0.02 at 5 % polishing and 0.01 to 0.58 with a mean value of 0.1 ± 0.01 at 10 % polishing. Although this range is a bit lower than the range (1.93 to 4.3 g %) obtained by Edeogu *et al.,* (2007), it is similar to the mean value obtained in the studies of Sotelo *et al.,* (1990). Milling of rice generally decreases the fibre content of rice. The highest fibre content was found in MTU 3626 and MTU 1010 (0.95 %). The lowest fibre content was observed in DL 184 (0.22 %) followed by Dharitri (0.23 %) and Basmati 386 (0.24 %). It has been recommended by the experts to consume at least 25g of fibre every day to decrease the risk of chronic diseases. Fibre-rich foods help to promote proper bowel function and reduce risk of developing intestinal disorders. In the present study, the brown rice contained significantly higher crude fibre content (0.22 to 0.95 %) as compared to white rice which can help reduce chronic diseases. In another study by Sotelo *et al.,* (1990) dietary fibre content was found to be 1.9 ± 0.6% in brown rice fraction whereas Awan, (1996) and Tufail (1997) recorded the fibre content of different Pakistani white rice in the range of 0.20 to 0.35%. The present study showed that preference should be given to brown rice to improve the intake of fibre in the daily diet. The higher fibre content in brown rice fraction may be due to bran portion which is higher in fibre content.

Total ash

The ash content of a food sample gives an idea of the mineral elements present in the food sample. The total ash content varied significantly among different rice varieties and polishing fractions. Ash content was low in majority of the samples. Pusa Basmati-1 showed 2.34 % ash, highest in the lot and 0.17 % was reported in High iron rice.

The ash content ranged significantly from 0.43 to 2.34 % with a mean of 1.19 ± 0.03 in brown rice, 0.28 to 1.22 % in polished rice (5% polishing) with a mean of 0.74 ± 0.01, 0.12 to 1.01 % with a mean value of 0.5 ± 0.02 in polished rice (10 % polishing). The highest ash content (1.69 %) was observed in PusaBasmati1 (2.34%) followed by Sabita (1.72%), Taroari basmati and MTU 1010 (1. 67%) and Vasumati (1.66%) and while the lowest ash content (0.43%) was found in Shakti and Sashi. In earlier studies ash content varied from 1.46 to 1.61% for brown rice and 0.48 to 0.67% for white rice, respectively (Sotelo *et al.,* (1990), Tufail (1997) and Adu-Kwarteng *et al.*, (2003). Anjum *et al.,* (2007) also found the similar trend for ash content 1.42 % and 0.66 % for brown and white rice respectively. The difference in ash content among rice varieties may be due to difference in the genetic architecture of rice varieties as reported by Butt *et al.*, 1997.

In the present findings, the ash content was higher in brown rice than white rice. The variation among milling fractions suggests that the brown rice contains bran portion which increased the ash content as reported by Anjum *et al.,* (2007) as compared to white rice.

The correlation coefficients among the proximate values for carbohydrate, moisture, fat, protein, fibre, ash and energy are presented in Table 3. As expected, the carbohydrate and energy value were quite high and positively correlated ($r = 0.948$, $p < 0.0001$). It suggests correlated response for high energy value when rice cultivars are selected on the basis of high carbohydrate content. The association between carbohydrate with moisture and fat content were significantly negative which indicates that rice cultivars high in moisture and fat may likely to be low in carbohydrate value. Similarly between moisture and carbohydrate, moisture and energy are also strongly but negatively correlated, implying that carbohydrate and energy are highly correlated traits. Fibre content was also significantly correlated with moisture ($r= 0.246$, $p = 0.071$) and protein ($r = -0.366$, $p = 0.006$), though the observed values were low (Table 3). The negative correlation value between protein content and fibre suggest that rice cultivars high in fibre content may likely be low in protein. Positive correlation between carbohydrate and energy but negative correlation between carbohydrate and moisture, moisture and energy, fibre with protein and carbohydrate with fibre was also reported (Oko *et al.,* 2012).

The correlation between energy and fat was negative in direction, as also was the correlation between percentage fibre and protein among the varieties studied. This suggests a negative relationship occurring between energy and fat as well as fibre and protein content. The percentage carbohydrate and energy value was strongly correlated and positive in direction, suggesting correlated response for high energy value when rice cultivars are selected on the basis of high carbohydrate content.

The present research work was carried out to compare different rice varieties and their polishing fractions for proximate composition. The moisture, fat, crude protein, crude fibre and ash content showed highly significant differences among different rice varieties in brown and polished rice. This work has revealed that the genotypes showed considerable amount of nutrients such as carbohydrate, a good source of energy, protein for body maintenance and the repair and replacement of worn out or damaged tissues; crude fibre for effective digestibility of food as well as fat which contribute to the recommended dietary allowance. Brown rice has more nutritional quality than white rice due to more availability of proximate nutrients.

The varieties Madhukar, Aishwarya Amulya, Bhuban,Jaya, Dandi, Sahyadri, Sahyadri-2, Karjat, Yamini and CN-1233-33-9-117 possessed significantly highest content of protein (10-12 g%). The varieties BPT11711, BR-2655, CN-1039-9, GR-103, Dandi, High iron rice, Prachi, PSD-1, IR-64, NLR-33359, Swarna, Taroari Basmati, Aishwarya and Bhuban contained highest carbohydrates(>80 g%), the sources of energy whereas MTU1001 showed the highest high fat content (2.3 g%). The rice variety MTU 3626 and MTU 1010 possessed the highest content of fibre (0.95%). The result of this study can be exploited by rice consumers in their choices regarding proximate compositions.

References

Adu-kwarteng, E., Ellis, W.O., Oduro, I. and Manful, J.T. 2003. Rice grain quality: A comparison of local varieties with new varieties under study in Ghana. *Food Control* 14: 507-514.

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

Anjum, F.M., Pasha, I., Bugti, M.A. and Butt, M.S. 2007. Mineral composition of different rice varieties and their milling fractions. *Pakistan Journal of Agricuture and Science* 44 (2): 332-336

Anon. 2004. International year of rice. Rice and Human Nutrition.

AOAC. 2000. Official Methods of Analysis. *Association of Official. Analytical Chemists.* Washington, D.C. USA.

Awan, I.A. 1996. Physical and biochemical characterization of some of the Pakiatani rice varieties. M.Sc. (Hons.) Thesis. Dept. of Food Tech., Univ. Agric. Fsd.

Blackwell, R.Q., Yang, T.H. and Juliano, B.O. 1966. Effect of protein content upon growth rates of rats fed highrice diets(Abstr.) Proc. 11th Pacific Science Congress, Tokyo, 8, 15.

Bressani, R., Elias, L.G. and 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.

Butt, M.S., Anjum, F.M., Rehman, A. and Ali, V. 1997. Physicochemical characteristics of spring wheats. *Journal of Agricultural Research*. 35 (6): 413-422.

Devi, Th. P., Durai, A., Singh, Th. A., Gupta, S., Mitra, J., Pattanayak, A., Sarma, B.K. and 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.

Devi, Th.P. and 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.

Ebuehi, O.A. and Oyewole, A.C. 2007. Effect of cooking and soaking on Physical characteristics, nutrient composition and sensory evaluation of indigenous and foreign rice varieties in Nigeria. *Nigerian African Journal of Biotechnology* 6 (8):1016-1020.

Edeogu, C.O., Ezeonu, F.C., Okaka, A.N.C., Ekuma, C.E. and EIom, S.O. 2007. Proximate Compositions of Staple Food Crops in Ebonyi State, South Eastern Nigeria. *International Journal of Biotechnology Biochemistry* 1: 1-8.

Eggum, B.O. and 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.

Eggum, B.O. and 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.

Eggum, B.O., Juliano B.O. and Magnificat, C.C. 1982. Protein and energy utilization of rice milling fractions. *Journal of Human Nutrition* 31: 371-376.

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.

FAOSTAT 2001. FAOSTAT Statistical Database. Food and Agriculture Organization.

Frei, M. and Becker, K. 2003. Studies on the *in vitro* Starch Digestibility and the Glycemic Index of six Different Indigenous Rice Cultivars from the Philippines. *Food Chemistry* 83: 395-402.

Govindaswami, S., Ghosh, A.K. and Nanda, B.B. 1996. Varietal differences in hulling and cooking qualities. Annual Report of Central Rice Research Institute, Cuttack, India, p 64.

Guha, B.C. and 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* 23:69-72.

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

Juliano, B.O. 1985. Criteria and tests for rice grain qualities. 2nd ed. In E. T. Champagne, Rice Chemistry and Technology American Association of Cereal Chemists, Inc., Minnesota, U. S. A.

Murata, K., Kitagawa, T. and Juliano, B.O. 1978. Protein quality of high protein rice in rats. *Agricultural and Biological Chemistry* 42: 565-570.

Oko, A.O. and Onyekwere, S.C. 2010. Studies on the Proximate Chemical Composition and Mineral Element Contents of Five New Lowland Rice Varieties in Ebonyi State. *International Journal of Biotechnology Biochemistry* 6(6): 949-955.

Oko, A.O. and Ugwu, S.I. 2011. The proximate and mineral compositions of five major rice varieties in Abakaliki, South-Eastern Nigeria. *International Journal of Plant Physiology and Biochemistry* 3(2): 25-27

Oko, A.O., Ubi, B.E., Efisue, A.A. and Dambaba, N. 2012. Comparative Analysis of the Chemical Nutrient Composition of Selected Local and Newly Introduced Rice Varieties Grown in Ebonyi State of Nigeria. *International Journal of Agriculture and Forestry* 2(2):16-23

Onyeike, E.N., Olungwe, T. and Uwakwe, A.A. 1995. Effect of heat treatment and defatting on the proximate composition of some Nigerian local soup thickeners. *Food Chemistry* 53:173-175

Pereira, S.M., Begum, A. and 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.

Pederson, B. and Eggum, B.O. 1983.The influence of milling on the nutritive value of flour from cereal grains. *Plant foods Human Nutrition* 33: 267-278.

Premila Devi, T., Anna Durai, A., Anand Singh, Th., Bidyapati Devi, T., Gupta, S., Mitra, J., Pattanayak, A., Dhiman, K.R., Bhadana, V.P., Hore, D.K. and

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.

Resurrection, A.P., Juliano, B.O. and Tanaka, Y. 1979. Nutritional content and distribution in milling fractions of rice grains. *Journal of the Science of Food and Agriculture* 30: 475-481.

SAS 1998. SAS/STAT users guide, version 9.1.SAS institute Cary, North Carolina, USA

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

Sotelo, A., Saisa, V., Montolvo, I., Hernandez, M. and Hernandez, L. 1990. Chemical composition of different fractions of 12 Mexican varieties of rice obtained during milling. *Cereal Chemistry* 67(2): 209-212.

Tahira, H. and Chang, W. 1986. Lipid content and fatty acid composition of *Indica* and *Japonica* of non glutinous brown rice. *Journal of Agricultural and Food Chemistry* 34: 542-545.

Tufail, S. 1997. Cooking and Eating Quality of Some Cultivars of Rice. M.Sc (Hons) Thesis, Dept.of Food Tech. Univ. of Agri. Faisalabad.

USA Rice Federation. 2002. The natural history of rice. Online Food Cult. Encyclopedia, pp. 1-4.

Webb, B.D. 1985. Criteria of rice quality in the U.S. In B.Juliano (ed) Rice: Chemistry and technology. St. Paul, Minnesota, *Association of Cereal Chemistry* Inc., 774.

Xheng, X. and Lan, Y. 2007. Effects of drying temperature and moisture content on rice taste quality. *Agricultural Engineering International* 49: 24-277.

Table 1. List of genotypes studied

S.No	Genotype
1	Aishwarya
2	Amulya
3	As 100
4	Basmati 386
5	Bhuban
6	Bhudeb
7	Barah Avarodhi
8	Birupa
9	BPT 11711
10	BR 2655
11	Chittimutyalu
12	CN 1039-9
13	CN 1233-33-9-117
14	Dandi
15	Dharitri
16	DL 184
17	Gajapathi
18	Giri
19	Gouri
20	GR 103
21	Harsha
22	High iron rice

S.No	Genotype
23	Indravati
24	IR 64
25	Jaya
26	Jalpriya
27	Jagabandu
28	Jalmagna
29	Jalnidhi
30	Jyothi (PTB 39)
31	Kanchana
32	Kalanamak (ASG 4022)
33	Khitish
34	KHP - 2
35	Konark
36	KMP-101
37	Kranti
38	Karjat-2
39	Kavya
40	Lalat
41	Madhukar
42	Mahamaya
43	Mandya Vijaya

S.No	Genotype
44	Manohar Sali
45	Matta Triveni
46	MSE-9
47	MSS - 5
48	MTU -1001 (Vijetha)
49	MTU-1010 (C. Sannalu)
50	MTU-3626 (Prabhat)
51	Nagari Dubraj
52	Nalini
53	NLR 145 (Swarnamukhi)
54	NLR 33654 (Apurva)
55	NLR 33359 (Shravani)
56	Pant Dhan -16
57	Prachi
58	Pooja
59	Pratap
60	Pusa Basmati
61	PR 111
62	PR113
63	PR 114
64	PR 115
65	PR 116
66	PR 118
67	PSD 1
68	RAU 3043 (ASG 4013)
69	Ranbir Basmati
70	Ranjeet
71	Sabita
72	SGT 1
73	Sashi
74	Shakthi
75	Sahyadri
76	Sahyadri 2
77	Sunandana
78	Suraksha
79	Swarna
80	Type 3
81	Taroari Basmati
82	Varsha
83	Vasumathi
84	Vikas
85	VRM 3
86	VRM 31
87	VRS 3
88	VRS 19
89	VRS 25
90	WGL 14 (W. Samba)
91	White Ponni
92	Yamini

Table 2. **Mean values of Proximate composition in rice genotypes**

Nutrients	**Polishing levels**		
	0%	**5%**	**10%**
1.Moisture			
Mean	9.70 ± 0.13	9.43 ± 1.11	9.34 ± 0.10
CD 5%	0.16	0.15	0.11
Range	7.13 – 11.60	7.11 - 11.29	7.01 - 11.25
2. Protein			
Mean	7.43 ± 0.13	7.32 ± 0.13	7.18 ±0.12
CD 5%	0.02	0.03	0.02
Range	5.89 - 11.01	5.26 - 10.86	5.22 - 10.29
3.Fat			
Mean	1.58 ± 0.06	0.93 ± 0.03	0.54 ± 0.03
CD 5%	0.13	0.14	0.12
Range	0.50 -3.77	0.30 - 2.42	0.10 -1.46
4. Ash			
Mean	1.19 ± 0.03	0.74 ± 0.01	0.50 ± 0.02
CD 5%	0.03	0.05	0.04
Range	0.43 - 2.34	0.28 -1.22	0.10 -1.01
5. Crude Fibre			
Mean	0.51 ± 0.02	0.31 ±0.02	0.15 ± 0.01
CD 5%	0.09	0.06	0.08
Range	0.20 - 0.95	0.08 - 0.78	0.01 - 0.58
6.CHO			
Mean	79.60 ± 1.12	81.28 ± 1.12	82.29 ±0.15
CD 5%	1.12	1.00	1.01
Range	73.63 -83.73	76.71 -84.05	78.42 -85.18
7. Energy(kcal)			
Mean	362 ±0.59	363 ± 0.46	363 ± o.42
CD 5%	0.54	0.51	0.49
Range	347 -376	354 -373	355 -373

Table 3. Correlation coefficients among proximate composition values

	CHO	Moisture	Fat	Protein	Fibre	Ash	Energy
CHO	1	-0.763 (<0.0001)	-0.293 (0.045)	-0.173 (0.249)	-0.246 (0.071	-0.018 (0.906)	0.948 (<0.0001)
Moisture		1	0.164 (0.244)	0.002 (0.991)	0.236 (0.72)	-0.058 (0.683)	-0.963 (<0.0001)
Fat			1	-0.129 (0.357)	0.209 (0.118)	0.177 (0.222)	-0.043 (0.746)
Protein				1	-0.366 (0.006)	0.059 (0.668)	-0.098 (0.452)
Fibre					1	0.012 (0.934)	-0.189 (0.134)
Ash						1	0.067 (0.609)
Energy							1

Values in parenthesis indicate probability levels