European Journal of Food Science and Technology

Vol.6, No.1, pp.1-10, February 2018

Published by European Centre for Research Training and Development UK (www.eajournals.org)

MILLING AND COOKING PROPERTIES OF 129 VARIETIES OF LOCAL RICE GERMPLASM CULTIVARS OF BANGLADESH

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ABSTRACT: *A set of 129 rice cultivars of long, medium and short grain were used to evaluate the rice germplasm for milling and cooking properties. The seeds of rice cultivars were collected from Bangladesh Rice Research Institute (BRRI) Germplasm Bank and were grown in BRRI farm. Milling outturn, head rice recovery, hull content, amylose content, cooking time, elongation ratio, and volume expansion ratio were determined. Milling outturn was highly significant (r = -0.633, -0.760 and -0.496, p < 0.01) and negatively correlated with hull content for long, medium and short grain rice cultivars. Kharmao of long grain rice cultivars had the lowest milling yield (63%) but the highest hull content (27%). Cooking time varied from (15-23) minutes in long grain and (13-23) minutes in both medium and short grain cultivars. Cooking time was highly significant and positively correlated (r = 0.459 and 0.591, p < 0.01) with elongation ratio and volume expansion ratio in long grain cultivars but negatively correlated with elongation ratio(r= -0.02 and -0.309) and volume expansion ratio(r=-0.128 and -0.360) in medium and short grain cultivars. In the case of long grain rice cultivars, amylose content was highly significant (r = 0.466 and 0.640, p < 0.01) and positively correlated with cooking time and volume expansion ratio. This Study identified some cultivars with superior cooking and milling qualities which can be used for further grain quality improvement.*

KEYWORDS: Rice germplasm Milling outturn, head rice, elongation ratio, cooking time

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INTRODUCTION

There are thousands of transplanted Aman rice cultivars grown in Bangladesh. Some of them are popular. There is limited information on the quality characters of these cultivars. Biswas *et al.* (1992) studied quality of few local rice cultivars along with some modern varieties. Rice grain quality means physicochemical properties (Juliano, 1972). Physicochemical properties include milling outturn, head rice recovery, amylose content, alkali spreading value and cooked rice qualities. Rice millers prefer cultivars with high milling yield and high head rice recovery and consumers prefer quality. Head rice is a major determinant of price in the paddy market of many countries (Brorsen *et al.*, 1984). Amylose content of rice is considered as the main parameter of cooking and eating quality (Juliano, 1972). Cooking behavior is one of the important determinants of rice quality (Feillet and Marie, 1979). Higher income group of people prefer varieties that expands more in length than in breadth.

Moreover, market price of rough rice is directly related to its milling quality and the prevailing market demand. Cooking quality of rice is the best choice for the consumers. Cooking characters are the grain elongation, amylose content, gelatinization temperature and aroma (Khush *et al.*, 1979). Golam *et al.* (2004) revealed that grain elongation and aroma are key determinant of high quality rice varieties. It was reported that higher elongation ratio of the cooked rice is preferred by the consumer than that with low elongation ratio (Shahidullah *et al.*, 2009). If rice elongates more length-wise it gives a finer appearance and if it expands girth-wise, it gives a coarse look (Danbana *et al.*, 2011). High volume expansion of cooked rice is still considered to be a good quality by the working class people who do not care whether the expansion is length-wise or cross-wise. On the other hand, urban people prefer the varieties that expand more in length-wise than in breadth (Choudhury, 1979). Furthermore, amylose content can play a significant role in determining the overall cooking and eating properties of a rice variety (Adu-Kwarteng *et al*., 2003; Asghar *et al*., 2012). Therefore, this study was undertaken to evaluate the milling and cooking properties of germplasm rice cultivars for identifying cultivars having superior grain quality.

MATERIALS AND METHODS

The seeds of 129 Bangladeshi germplasm cultivars and modern varieties were collected from BRRI gene bank at Genetic Resource and Seed Division of BRRI, Gazipur and were grown in T. Aman season, 2015. The harvested rice samples were analyzed for milling and cooking properties. Duplicate 200g rough rice was dehulled by Satake THU-35A sheller to brown rice. The resulting brown rice was milled in Satake TM-05, milled with #5330 abrasive discs at 1730 rpm to obtain approximately 10.0% by weight bran-polish removal for all samples. The broken grains were separated manually. Milled rice yield and head rice recovery were expressed as percentage of rough rice and milled rice basis. Milled rice and head rice outturn were expressed as percentage of rough rice and milled rice respectively. Rice powder was prepared by grinding milled rice in Udy Cyclone Mill (Udy Corporation, USA) to pass through the sieve of 60 meshes.

Alkali spreading value was determined according to procedure of Little *et al.* (1958) and classified as alkali spreading value of 1.0-3.0 corresponds to high, >3.0-5.0 corresponds to intermediate and >5.0-7.0 corresponds to low gelatinization temperature.

Amylose content was determined by the procedure of Juliano (1971). 0.1g of starch was weighed into a test tube, 1ml of 95% ethanol and 9ml 1N NaOH was added. The tube was covered with paraffin to mix content very well. 0.5ml of aliquot was used in the analysis. 0.1m of acetic acid solution and 0.2ml of standard solution was added to make up 10ml of solution of distilled water and allowed for 20minutes for colour development and the % amylose was calculated. Based on amylose content, milled rice was classified as waxy (1-2) % amylose, very low (more than 2-9)% amylose, low (more than 9-20)% amylose, intermediate (more than 20-25)% amylose and high (more than 25-30)% amylose.

Cooking time for rice is the times when starch granules are fully disappear in the boiling water (Ranghino method). Elongation ratio was calculated by measuring the length of cooked and uncooked milled rice by slide calipers. Twenty whole uncooked grains of known length were soaked in water for 30 minutes and cooked for 10 minutes in hot water. Then 20 cooked rice lengths were measured. Elongation ratio is the ratio of length of cooked rice over the

ISSN 2056-5798(Print), ISSN 2056-5801(online)

length of raw milled rice. Volume expansion is the ratio of volume of cooked rice over the volume of raw milled rice. Volume of cooked and uncooked milled rice was measured by water displacement method. A sample of 5g rice grains was poured into a beaker containing 15ml of water and the total volume was measured. Rice grain sample was cooked for 20min in a thermostatically controlled heating mantle at 90°C then; the cooked rice was dipped into 50ml water. The volume of cooked rice after dipping was measured (Sidhu *et al*.1975).

Statistical analyses

All data were arranged for computation in Microsoft Excel software. The data for all parameters were analyzed for ANOVA by CropStat software of IRRI (www.irri.org). Least Significant Difference test was carried out for separating means. Correlation coefficient was done through SPSS v17.0 software for Pearson correlation (Gomez and Gomez, 1984).

RESULTS AND DISCUSSIONS

Milling outturn (%) and head rice recovery (%)

Milling outturn is the total quantity of head rice and broken rice recovered from unit quantity of rough rice. Milling outturn of long grain cultivars varied from 63-71%, medium grain from 59-74% and short grain from 59-72% with the mean value of 68±1.76%, 69±2.47% and 68±2.66% respectively. Coefficient of variation in milling outturn was 3% for long grain and 4% for both medium and short grain cultivars (Table 1). Milling outturn was highly significant and negatively correlated with hull content of long grain($r= -0.633$, $p<0.01$), medium grain ($r= -0.760$, $p<0.01$) and short grain ($r= -0.496$, $p<0.01$) cultivars (Table 2). Among the cultivars, 5.6% long grain and 19.4% medium grain cultivars had at the level of more than 70% milling outturn (Figure 1). More than 70% milling outturn had for 5 long grain cultivars of Harilaxmi, Dudsar Tapi-146, Binni-1, Binni-2, and Molladigha. Milling outturn over 70% is satisfactory for millers and farmers. Less than 67% milling outturn is not acceptable. The milling outturn in high yielding varieties ranged from (69-73)% and those of aromatic rice ranged from (70-72)% reported by Biswas *et al.* (1992).

Head rice recovery is the proportion of the whole grain in the milled rice. Head rice recovery of long grain cultivars varied from 41-96%, medium grain from 26-98% and short grain from 75-98% with the mean value of 86±13.07%, 87±13.28% and 93±6.08% respectively (Table 1). Among the cultivars, 6.3% long grain, 17.7% medium grain and 48.4% short grain cultivars had at the level of more than 96% head rice recovery (Figure 2). Head rice recovery of Jingasail-1 and Cylindrical Tapi-629 had (96±0.39)% and (96±0.59)% for long grain; Hathazi and Kanaklata had (96±0.65) and (97±0.65) for medium grain as well as Chunikanai, Dudsail, Gurdoi, Nurior, Pajam, Sorukamini and Surjymukhisangla had (97±0.67), (97±1.11), (98±0.46), (97±0.45), (97±0.80), (97±0.57) and (97±0.90), respectively for short grain cultivars. Head rice recovery of Binni-1, Binni-2 and Harilaxmi had (92.±0.89)%, (91±.0.61)% and (93±0.55)% respectively in long grain cultivars. Head rice recovery depends on varietal characters as well as drying conditions (Wasserman and Calderwood, 1972; Witte, 1972; Adair *et al.*, 1973).

ISSN 2056-5798(Print), ISSN 2056-5801(online)

Table 1: Estimates on the basis of milling and cooking properties of 129 rice cultivars of T. Aman season

Parameter	Long grain (36)				Medium grain (62)				Short grain (31)			
	Mean	Range	CV %	LSD	Mean	Range	CV%	LSD	Mean	Range	CV %	LSD
Milling outtern %	68±1.76	63- 71	3	1.3348	69±2.47	59-74	4	1.4596	68±2.66	59-72	4	1.794
Head rice recovery %	86±13.07	41- 96	15	1.2779	87±13.28	26-98	15	1.114	93±6.08	75-98	7	0.9093
Hull %	23±1.57	21- 27	7	1.13806	23±1.64	19-26	7	1.119	23±1.43	20-26	6	1.0486
Amylose %	23±7.29	5.0- 29	32	1.7455	25±3.62	5.2-29	14	0.9426	23±2.15	20-27	9	1.271
ASV	5.2±0.95	3.2- 7.0	18	0.2562	5.2±0.76	3.8-7.0	14	0.2153	4.9±0.75	3.7-6.4	15	0.2823
Cooking time (min)	18±1.87	15-23	10	1.172	18±2.57	13-23	14	0.7764	16±2.87	13-23	18	0.6440
Elongation Ratio (ER)	1.7±0.13	1.5-2.0	8	0.1895	1.9±0.19	1.5-2.2	10	0.1958	2.0±0.15	1.8-2.3	7	0.2751
Volume expansion ratio (IR)	3.6±0.24	3.1- 4.0	7	0.1358	3.7±0.23	3.1-4.3	6	0.1351	3.8±0.20	3.4-4.0	5	0.1128

Milling outturn of the cultivars is important quality character for evaluating rough rice. Rough rice with more than 70% milling yield is expected for long grained cultivars. Long grain cultivars of Harilaxmi, Dudsar Tapi-146, Binni-1, Binni-2 and Molladigha had more than 70% milling yield. Long grain cultivars with at least 70% milling yield is preferred. Biswas *et al.* (1992) reported the milling yield of (69-73)% for modern rice varieties. Zhou *et al*. (2002) also reported the range of milling yield of (64-70)% for rice varieties. On the other hand, Palacpac (1982) reported the range of milling yield of (60-73)%. Milling yield of cultivars depends on hull thickness, size and shape of kernel and moisture content of the grain (Adair *et al.*, 1973). In this study, head rice recovery of Harilaxmi, Dudsar Tapi-146, Binni-1, Binni-2 and Molladigha ranged from (41-93)%. Higher head rice recovery in long grain attracts the consumer and fetches higher market price. Head rice recovery depends on variety, moisture content of rough rice, defects developed in grain during drying of rough rice and finally milling process. Matthews *et al*. (1970) and Jongkaewwattana *et al*. (1993) noted that long grain cultivars were more susceptible to crack than medium grain rice during milling. Similar result was shown in the report of Zhou *et al*. (2002).

ISSN 2056-5798(Print), ISSN 2056-5801(online)

Hull content (%)

Hull content varied from 21-27% in long grain, 19-26% in medium grain and 20-26% in short grain cultivars. The corresponding mean values of hull content in long, medium and short grains were 23±1.57%, 23±1.64% and 23±1.43% (Table 1). Among the cultivars, 25% of Long grain cultivars, 13% of Medium grain cultivars ans 19.4% of short grain cultivars had less than 25% hull content (Figure 3). Hull content of rough rice influences the milling yield of rough rice. Higher the weight of the hull lowers the milling yield of the rice. Kharmao of long grain cultivars had the lowest milling yield (63%) due to its highest hull content (27%). The range of hull content of tested varieties had (16-28)% found by Juliano (1972).

Hull is the outer covering of the rice kernel. Its content varied (19-27)% among the cultivars but for long grain cultivars varied (21-24)%. The hull of rough rice varied from a low of 14.6% (Sadanandeswara Rao and Bhattacharya, 1977) to a high of 26.0% (Juliano *et al*., 1964). Hull content depends on the variety. Low hull content increased the milling yield of rice cultivars.

Amylose content (%)

Amylose content in rice starch influences the cooking and eating quality. It varied from 5-29% in long grain, 5.2-29% in medium grain and 20-27% in short grain cultivars with mean values of (23±7.29)%, (25.0±3.62)% and (23.0±2.15)% respectively (Table 1). The long grain cultivars of Bhorochalam, Boradudhkalam, Depa, Dudhkalam, Dudsar Tapal-146, Jingasail-1, Joalbagh, Jol, Pakhisail, Patnai-231, Redpiebald-219, Sadajira Tapl-321, Shata, Shithabhog, T.R.Aman, TK deep straw Tapl-773, Lathamona, Molladigha and Karailadhan had more than 25% amylose content but Kanaibansi, Khorma, Athabinni, Binni-1, Binni-2, Cylindrical Tapi-629, Gohatibinni and Kalabinni had less than 10% amylose content. Amylose content was highly significant and positively correlated ($r = 0.466$ and 0.640, $p < 0.01$) with cooking time and volume expansion ratio in long grain cultivars as well as highly significant and positively correlated ($r = 0.522$, $p < 0.01$) with cooking time in short grain cultivars. It was significant and positively correlated ($r = 0.355$ and 0.305, $p < 0.05$) with both elongation ratio and volume expansion ratio in medium grain cultivars (Table 2). Among the cultivars, 58% in long, 64% in medium and 19% in short grain cultivars had at the level of (>25%) high amylose content. In contrast, 17% in long and 2% in medium grain cultivars had at the level of (<10%) very low amylose content (Figure 4). Long grain cultivars with 20-25% amylose are preferred by well off people and that with less than 10% amylose are popular among tribal people.

Differences observed in the amylose content between different rice varieties can also affect the cooking properties (Singh *et al*., 2005). Cooking and eating qualities mainly stickiness and hardness rice of cultivars is influenced by its amylose content. Higher amylose content in the milled rice increases the cooked rice hardness and decreases the stickiness of the cooked rice. The rice starches with high amylose: amylopectin ratio take up more water during boiling and are considered more desirable for cooking purpose. Amylose content affect the cooking and eating properties and difference in rice varieties such as grain whiteness, grain shape. The rice cooking and eating properties are greatly subjective to amylose content. The range of amylose content of this study had higher than that data reported by Singh *et al*. (2005), who reported that the amylose content of the milled rice from different cultivars ranged between (2.3-15.4) %.

ISSN 2056-5798(Print), ISSN 2056-5801(online)

Table 2: The Pearson correlation coefficient of milling-cooking properties for long, medium and short grain Aman rice cultivars.

Correlations								
Parameters	Milling outtern (%)	Head rice recovery (%)	Hull (%)	Cooking time (min)	Elongation ratio	Volume Expansion ratio	Alkali Spreading Value	Amylose (%)
Head rice recovery (%) (long)	-.032							
Head rice recovery (%) (medium)	.137							
Head rice recovery (%) (short)	.326							
Hull (%) (long)	-.633**	.409*						
Hull (%) (medium)	-.760**	-.257						
Hull (%) (short)	-.496**	-.296						
Cooking time (min) (long)	.167	-.578**	-.184					
Cooking time (min) (medium)	.313*	-.396**	-.167					
Cooking time (min) (short)	.308	-.142	.144					
Elongation ratio (long)	.149	-.436*	-.238	.459**				
Elongation ratio (medium)	.361*	.195	-.413**	-.020				
Elongation ratio (short)	.056	.459*	-.254	-.309				
Volume Expansion ratio (long)	-.042	-.331	.027	.591**	.389*			
Volume Expansion ratio (medium)	.058	.049	-.068	-.128	.219			
Volume Expansion ratio (short)	.390*	.530**	-.421*	-.360	.340			
Alkali Spreading Value (long)	.172	.445*	-.213	-.598**	-.110	-.688**		
Alkali Spreading Value (medium)	-.155	-.002	.112	-.318*	.029	-.151		
Alkali Spreading Value (short)	.019	-.002	.096	.288	.044	-.210		
Amylose (%) (long)	.039	-.296	-.161	.466**	.325	.640**	-.427*	
Amylose (%) (medium)	.169	.086	-.215	.206	.355*	.305*	-.310*	
Amylose (%) (short)	-.035	-.207	.222	.522**	-.308	-.429*	-.003	
**. Correlation is significant at the 0.01 level (2-tailed).								
*. n is sigCorrelationificant at the 0.05 level (2-tailed).								

ISSN 2056-5798(Print), ISSN 2056-5801(online)

Alkali spreading value and cooking time

Alkali spreading value has the inverse relationship with gelatinization temperature. It varied from (3.2-7.0) in long grain, (3.8-7.0) in medium grain and (3.7-6.4) in short grain cultivar with mean values of (5.2±0.95), (5.2±0.76) and (4.9±0.75) respectively (Table 1). Alkali spreading value was highly significant and negatively correlated ($r = -0.598$, $p < 0.01$) with cooking time in long grain and it was significant and negatively correlated ($r = -0.318$, $p < 0.05$) with cooking time in medium grain as well as positively correlated with cooking time in short grain cultivars (Table 2). The results also revealed that most of the cultivars had intermediate alkali spreading value having the range of (4-5) and (5-6) in (Figure 4). The range of alkali spreading value of rice cultivars had (3.2-7.0) in this study, which was almost similar to (3.1-7.0) reported by Asghar *et al*. (2012).

Cooking time varied from (15-23) minutes in long grain and (13-23) minutes in both medium and short grain cultivars with mean cooking time of (18±1.87) for long grain, (18±2.57) for medium grain and (16±2.87) for short grain cultivars (Table 1). Cooking time was highly significant and positive correlation ($r = 0.459$ and 0.591, $p < 0.01$) with elongation ratio and volume expansion ratio in long grain cultivars but negative correlation with elongation ratio ($r= -0.02$ and -0.309) and volume expansion ratio ($r=-0.128$ and -0.360) in medium and short grain cultivars (Table 2). Among the cultivars, 6% in long, 13% in medium and 58% in short grain cultivars had at the level of less than 15 minutes cooking time (Figure 5). Cultivars with short cooking time are preferred by the consumer.

Elongation ratio and Volume expansion ratio

Higher elongation ratio is desirable character. Range of elongation ratio had (1.5-2.0) in long grain, (1.5-2.2) in medium grain and (1.8-2.3) in short grain cultivars with the mean values of (1.7±0.13), (1.9±0.19) and (2.0±0.15) respectively (Table 1). Molladiga and T.R. Aman were found in long grain cultivars with 2.0 elongation ratio. Changai, Ganjia, Hashfol, Jhingasail-2, Kanaklata, Kataribhog-2, Kumragoir, Lalbinni, Lalmota, Lohasail, Maloti, Nijarsail, Nakchi, Nizersail, Poushmoricha, Putidepa, Sadamota, Shamrosh, Somondori and Tilokkajal were found in medium grain as well as Baoijhaki, Binniphul, Chinisagor, Chinigura, Chunikanai, Dudsail, Gurdoi, Kalijira, Khasha, Lalsaru, Uknimadhu, Minki, Murchmut, Pajam, Rahikhama, Sorukamina, Surjya mukhisangla, Tutsimala and Malagrosa were found in short grain cultivars with more than 2.0 elongation ratio. Among the cultivars, 18% in medium and 48% in short grain cultivars had at the level of more than 2 elongation ratio (Figure 6).

Volume expansion is another preferred quality factor**.** Volume expansion ratio varied from (3.1-4.0) in long grain, (3.1-4.3) in medium grain and (3.4-4.0) in short grain cultivars with mean values of (3.6±0.24), (3.7±0.23) and (3.8±0.20) respectively (Table 2). Hashfol of medium grain had 4.3 volume expansion ratio. Molladigha in long, Bariksail, Bolonga, Dadkhani, Jhingasail-2, Kataribhog-232, Kumragoir, Najirsail and Shamrosh in medium and Chunikanai, Gurdoi and Pajam in short grain cultivars were found with 4.0 volume expansion ratio. Among the cultivars, 8% in long, 24% in medium and 16% in short grain cultivars had the volume expansion ratios more than 3.9 (Table 1).

Cooking and eating qualities of a rice cultivar is important. The range of cooking time had (15-23) minutes in long and (13-23) minutes in both medium and short grain cultivars in the present study, which was almost similar to that data reported by Diako *et al*. (2011). Diako *et*

ISSN 2056-5798(Print), ISSN 2056-5801(online)

al. (2011) reported that the range of cooking time was (15.31-23.27) minutes and elongation ratio was (1.45-1.48). Length-wise grains elongation is preferred more than girth-wise expansion. Long grain of Harilaxmi, Joalbagh, T.R.Aman and Molladigha has shown higher length-wise elongation ratio. Among the cultivars, rang of elongation ratio of (1.5-2.3) and rang of volume expansion ratio of (3.1-4.3) were found in this study. The range of elongation ratio of this study had higher than Diako *et al*. (2011) but lower than Shilpa *et al.* (2010). The range of volume expansion ratio of this study had higher than that data reported by Shilpa *et al.* (2010), who reported that the range for kernel elongation ratio and volume expansion ratio of rice varieties was (1.83-4.78) and (2.0-4.23) in traditional rice. Cooking time was highly significant and positively correlated with elongation ratio and volume expansion ratio in long grain cultivars.

Amylose content was highly significant and positively correlated with cooking time and volume expansion ratio in long grain cultivars. It was significant and positively correlated with both elongation ratio and volume expansion ratio in medium grain cultivars. It was highly significant and positively correlated with cooking time in short grain cultivars. Some relationship of this study had similar to those relationships of Yadav *et al.* (2007). Yadav *et al.* (2007) reported that the elongation ratio of rice kernels was observed to show highly significant and positive correlation with amylose content. Cooking time also had a highly significant and positive correlation with amylose content.

In Bangladesh, rice alone constitutes about 92% of the total food grains produced annually. Consumers in our country take more rice for daily consumption. Consumer demand for rice grain quality depends on socio-economic, traditional culture and customs of Bangladesh as well as it is also a complex phenomena. Different consumer may have variation in preference for different properties of rice grain quality. Nevertheless, high head rice yield, high amylose content and high elongation ratio are vital properties of superior rice grain quality for most of the consumers in our country to mitigate their demand. So, studying of post harvest operation is very important for rice grain quality assessment. Milling and cooking quality of rice are the major part for post harvest operation view point. Therefore, this study was undertaken to evaluate the milling and cooking properties of germplasm rice cultivars for identifying cultivars having superior grain quality. These superior varieties will be further used to improve the quality of high yield farmer popular rice varieties.

Acknowledgements

We acknowledge Ministry of Science and Technology, Government of Peoples Republic of Bangladesh for partial funding of this study.

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