COOKING AND EATING QUALITY PROFILING OF SOME POPULAR RICE CULTIVARS IN BANGLADESH

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Abstract: Eating and cooking quality of rice plays major role in consumer's preference for any cultivar. In the present investigation 21 popular rice cultivars were analyzed for their cooking and eating quality traits. Moderate variations were observed for all the traits studied except solid in cooking water. Among the cultivars, cooking time ranged from 14.02 to 21.37 minutes, water uptake ratio from 2.24 to 3.324 %, solid in cooking water from 1.027 to 1.049 gm, volume expansion ratio from 2.8 to 4.28 %, % amylose content from 17.367 (low) to 27.387(intermediate), protein content 6.28 to 8.96 (%), and most of the cultivars were found with intermediate gelatinization temperature. Solid in cooking water was found positively correlated with cooking time, but negatively with water uptake ratio. Considering the preferences for cooked rice, high amylose content and low to intermediate gelatinization temperature of BRRI rice29, BRRI rice49 and Binarice-11 justified their popularity among the farmers and consumers.

Keywords: Rice, cooking quality, eating quality

INTRODUCTION

Rice is one of the most important sources of calories consumed by 3 billion Asians (Dogara and Jumare, 2014). It is mainly eaten as whole cooked grains (Hossain et al., 2009). However, for rice, grain quality is as important as yield, which is usually processed as food or feed. Accordingly, consumer's inclination for grain quality has taken as the major objective for rice quality breeding (Anne et al., 2018).

Eating quality indicates to the sensory sensitivity of consumers for the cooked rice which is associated to glossiness, flavor, and stickiness (Champagne et al., 2010). These quality traits indicate the chemical reaction that occurs during cooking of the rice grain, affected by cooking time, volume expansion ratio and gelatinization (*Bhattacharya* and *Sowbhagya*, 1971; Juliano and Perez, 1983). The gelatinization temperature (GT), and amylose content (AC) are another set of traits, which are directly related to cooking and eating quality (Little et al., 1958). It has been asserted that higher the value of gelatinization temperature, the longer time it takes to cook rice (Frei and Becker, 2003; Dipti et al., 2003), though *Bhattacharya* and *Sowbhagya* (1971) found that cooking time is primarily related to the surface area of the milled rice and unrelated to other grain properties. Furthermore, variation in cooking time may be due to genotypic difference and it has been reported that rice with high protein content or a high gelatinization temperature requires more water and longer time to cook (Juliano, 1971). Besides, amylose content (AC) is the most important chemical characteristics determining eating quality and affecting some physical traits.

Rice is a major source of food protein in Asia and other countries, though it contains only 6-8% protein (Jayaprakash et al., 2017). Its value as a protein source is enhanced by its high lysine content relative to other cereal grains (Mosse et al., 1988). Although, eaten rice contains about 7% protein and do not fluctuate widely form this level (Chen et al., 1999), but still considered important because the daily intake of rice is higher than other cereals in Asian countries.

As a prime staple, there is a consistent demand for improved quality rice which varies by cultivars and its environment, as determined in terms of the cooking and eating quality properties. Bangladesh is very near to attain self-sufficiency in rice production (Chen and Lu, 2018), therefore, breeding focus should be given more on qualitative improvement of rice. The present investigation was undertaken to evaluate cooking and eating quality of selected rice cultivars which will assist in enlightening the consumer's preferences for rice in Bangladesh as well as scope of improvement in future breeding program.

MATERIAL AND METHOD

The experiment was carried out at the Grain Quality and Nutrition Division of the Bangladesh rice research institute (BRRI), Joydebpur, Gazipur and Plant Stress Breeding Lab, Bangladesh Agricultural University, Mymensingh. Twenty-one rice cultivars were studied for cooking and eating quality traits (Table 1).

Table 1.

List of 21 rice cultivars used in the study

Cultivars	Sources / Courtesy	Status
BR 26, BRRI rice29, BRRI rice35, BRRI rice38, BRRI rice46, BRRI rice49, BRRI rice50, BRRI rice59, BRRI rice61, BRRI rice64, BRRI rice66, BRRI rice67, BRRI rice69, BRRI rice72, BRRI hybrid rice2, BRRI hybrid rice4	Bangladesh Rice Research Institute (BRRI)	Released variety
Kalijira, Tulsimala	Dept. of Genetics and Plant Breeding, BAU	Landraces (aromatic)
Binarice-11, Binarice-13, Binarice-16	Bangladesh Institute of Nuclear Agriculture (BINA)	Released variety

Preparation for recording data:

Cooking time: The cooking time was determined by the procedure described by Ranghino (1966). 5 gm of milled rice was taken in a wire case. Then it was kept in 50 ml vigorously boiled water in 100 ml beaker. Starting after 10 minutes of cooking in excess boiling water, at least 10 grains were pressed between two petri-dish in every minute. The grains were considered cooked when at least 90% of the pressed grains no longer show an opaque center. Optimum cooking time was taken until no white core was left.

Water uptake ratio: Water uptake ratio was determined according to the method used in Oko et al. (2012) by cooking 2.0 g of whole rice kernels from each cultivar in 20 ml distilled water for a minimum cooking time in a boiling water bath. Then drain out the superficial water from the cooked rice. Cooked samples were then weighed accurately. After that water uptake ratio was calculated as follows:

$$\text{Water uptake ratio} = \frac{\text{Weight of cooked rice}}{\text{Weight of uncooked rice sample}}$$

Solids in cooking water: Solid in cooking water was determined according to the method followed by Oko et al. (2012). This was determined by drying an aliquot of the cooking water in a tarred evaporating dish to steam out the water. The weight of the empty petri dish was measured and recorded as W_1. This was followed by measuring the weight of the petri dish and aliquot as W_2. The weight of the petri dish and the dry aliquot was measured as W_3. The amount of solid in cooking water was now calculated as: $W_3 – W_1$; where W_1 = weight of empty petri dish, W_2= weight of empty dish + dry aliquot (W_3).

Volume expansion ratio (VER): The volume expansion was calculated with the method by Sidhu et al. (1975). 50 ml water was taken in 100 ml measuring cylinder and 5 gm raw milled rice sample was added. Initially, increase in the volume of water after adding 5 g of raw milled rice was measured and noted. Raw milled rice sample was soaked for 30 minutes and cooked for 10 minutes in a water bath. Then cooked rice was transferred into the petri dish and allowed to stand for 15 minutes before analysis. Again 50 ml of water was taken in 100 ml measuring cylinder and cooked rice was added. Finally, increase in the volume of water after adding cooked rice was measured and recorded. The volume expansion ratio was calculated by using following equation:

$$\text{Volume expansion ratio} = \frac{(x-50)}{(y-15)}$$

Where: (x – 50) is the volume of cooked rice (ml); (y-15) is the volume of raw rice (ml).

Category	% Amylose Content
Waxy	1-2
Non-waxy	>2
Very low	3-9
Low	10-20
Intermediate	20-25
High	25-33

Amylose content (%): Amylose in rice is released by the treatment with dilute alkali. By the addition of Tri-iodide ion, amylose produces a blue color. The absorbance of blue color produced in aqueous solution was measured by UV-spectrometer at 620 nm as described by Williams et al. (1958) as modified by Juliano (1971).

Samples are categorized for amylose content based on the following grouping (Choudhury, 1979).

Protein content (%): Micro Kjeldahl procedure was used for the determination of rice grain protein content (Ma and Zuazaga, 1942).

Gelatinization Temperature (GT): Gelatinization temperature (GT) was indexed by alkali spreading value test (Little et al., 1958). The degree of spreading of individual milled rice kernel in a weak alkali solution (1.7% KOH) at room temperature (32±2^{o}C) was evaluated on a 7-point numerical scale (Jennings et al., 1979 and Khush et al., 1979).

RESULTS AND DISCUSSIONS

The results of the cooking and eating quality traits considered for the study were presented in Table 2, 3 & 4.

Table 2.

Performances of 21 rice cultivars based on cooking quality traits

Sl No.	Cultivar	Cooking time (min)	Water uptake Ratio	Solid in cooking water (gm)	Volume expansion ratio
1	BR 26	19.35	2.251	1.049	4.03
2	BRRI rice29	18.43	2.24	1.045	4.28
3	BRRI rice35	18.52	3.312	1.045	4.08
4	BRRI rice38	19.16	2.84	1.040	3.81
5	BRRI rice46	15.51	3.136	1.028	3.36
6	BRRI rice49	19.46	3.104	1.043	3.60
7	BRRI rice50	17.09	3.314	1.027	3.47
8	BRRI rice59	16.49	3.252	1.028	3.19
9	BRRI rice61	15.2	3.295	1.030	3.40
10	BRRI rice64	20.57	3.245	1.044	3.12
11	BRRI rice66	15.50	3.204	1.030	4.00
12	BRRI rice67	16.30	3.146	1.029	4.00
13	BRRI rice69	21.37	2.946	1.031	3.50
14	BRRI rice72	17.47	3.324	1.042	3.37
15	BRRI hybrid rice2	14.49	2.408	1.037	3.85
16	BRRI hybrid rice4	14.08	2.62	1.035	3.37
17	Kalizira	14.40	3.312	1.031	4.00
18	Tulsimala	13.53	2.712	1.028	2.80
19	Binarice-11	16.58	3.084	1.033	3.11
20	Binarice-13	15.01	2.602	1.037	3.00
21	Binarice-16	18.25	2.54	1.046	4.28

Cooking time: The time required for cooking of the rice samples are shown in Table 2 and ranged from 14.02 minutes to 21.37 minutes. The cultivar with lowest cooking time was found in Tulsimala and longest was BRRI rice69.

Water uptake ratio: The water uptake ratio ranged from 2.24% to 3.324 % (Table 2). The highest water uptake capacity was found in BRRI rice 35, BRRI rice 72 and Kalizira, which are graded as short to medium grain size category.

Solid in cooking water: Solid in the cooking water of the rice samples ranged between 1.027gm to 1.049 gm (Table 2) with BR 26 having the highest values and the lowest solid in cooking water was found in BRRI rice50, respectively (Table 2) in water.

Table 3.

Performances of 21 rice cultivars based on protein content and amylose content

SL No.	Cultivar	Protein Content (%)	Amylose Content (%) and grade	
1	BR 26	8.57B	22.61F-H	Intermediate
2	BRRI rice29	7.05G	27.38A	High
3	BRRI rice35	7.86CD	26.12BC	High
4	BRRI rice38	8.81AB	21.69H	Intermediate
5	BRRI rice46	8.02CD	24.50DE	Intermediate
6	BRRI rice49	8.81AB	25.50CD	High
7	BRRI rice50	8.16C	26.69AB	High
8	BRRI rice59	7.27FG	24.48DE	Intermediate
9	BRRI rice61	7.03G	19.30I	Low
10	BRRI rice64	7.05G	22.35F-H	Intermediate
11	BRRI rice66	7.20FG	23.05FG	Intermediate
12	BRRI rice67	7.68DE	24.60DE	Intermediate
13	BRRI rice69	6.28H	17.36J	Low
14	BRRI rice72	8.82AB	26.50A-C	High
15	BRRI hybrid rice2	8.96A	23.00FG	Intermediate
16	BRRI hybrid rice4	8.72AB	22.20GH	Intermediate
17	Kalizira	8.64AB	21.49J	Intermediate
18	Tulsimala	8.62B	23.50EF	High
19	Binarice-11	7.73DE	25.83BC	High
20	Binarice-13	7.79D	19.50I	Low
21	Binarice-16	7.43EF	26.87AB	High

Legends, Cultivars with same letter are statistically similar.

Volume expansion ratio: In the present study, volume expansion ratio of cooked rice has in the present investigation was ranged from 2.8 to 4.28 % among 21 rice varieties. The cultivar with highest volume expansion ratio was recorded in BRRI rice29 and Binarice-16 (Table 2).

Amylose content: In this study, 11 cultivars were found as intermediate, 7 were high and 3 cultivars were with low amylose content (Table 2). The cultivars with the highest amylose were found in BRRI rice29 (27.38) and the lowest amylose content was found in BRRI rice69 (17.36).

Protein content: In the present study, 20 cultivars were found to have intermediate (7%-9%) and one cultivar has low (<7%) protein content. The cultivars with the highest protein was found in BRRI hybridrice2 (8.96%) and the lowest protein content was found in BRRI rice69 (6.28%).

Gelatinization temperature: In the present observation, 13 cultivars exhibited intermediate gelatinization temperature and rest of the cultivars exhibited low GT. In this context, the best performer were recorded as BR 26, BRRI rice29, BRRI rice35, BRRI rice46, BRRI rice59, BRRI rice61, BRRI rice64, BRRI rice67, BRRI rice69, BRRI hybrid rice2, Kalizira, Tulsimala and Binarice-16.

Table 4.

Performances of 21 rice cultivars based on Gelatinization temperature (GT)

Sl No.	Cultivar	Gelatinization temperature (GT)
1	BR 26	Intermediate
2	BRRI rice 29	Intermediate
3	BRRI rice 35	Intermediate
4	BRRI rice 38	Low
5	BRRI rice 46	Intermediate
6	BRRI rice 49	Low
7	BRRI rice 50	Low
8	BRRI rice 59	Intermediate
9	BRRI rice 61	Intermediate
10	BRRI rice 64	Intermediate
11	BRRI rice 66	Low
12	BRRI rice 67	Intermediate
13	BRRI rice 69	Intermediate
14	BRRI rice 72	Low
15	BRRI hybridrice 2	Intermediate
16	BRRI hybridrice 4	Low
17	Kalizira	Intermediate
18	Tulsi mala	Intermediate
19	Binarice-11	Low
20	BINA rice 13	Low
21	BINA rice 16	Intermediate

Table 5.

Correlations coefficient between cooking quality traits

	CT	WUR	SCW	VER	PC
WUR	0.002 ^{NS}				
SCW	0.570**	-0.446*			
VER	0.255 ^{NS}	-0.255 ^{NS}	0.428 ^{NS}		
PC	-0.347 ^{NS}	-0.152 ^{NS}	0.149 ^{NS}	-0.020 ^{NS}	
AC	0.051 ^{NS}	0.036 ^{NS}	0.259 ^{NS}	0.277 ^{NS}	0.221 ^{NS}

Legends, CT= Cooking time, WUR= Water uptake ratio, SCW= Solid in cooking water and VER= Volume expansion ratio, AC= Amylose content and PC= Protein content

* and ** indicate significant at 5% and 1% level of probability, respectively

NS indicates non-significant.

Cooking time: Cooking time is critical as it plays major role to determine tenderness and stickiness of cooked rice (Asghar et al., 2012). Less cooking time is preferable for consumer demand (Custodio et al., 2016); therefore, Tulsimala was considered as the best. Besides, rice differ in optimum cooking time in excess water between 15 to 25 minutes without pre-soaking (Juliano and Perez., 1983), whereas, presoaking helps rice to cook in shorter time (Hirannaiah et al., 2001). Furthermore, gelatinization temperature (GT) have a positive direct effect on cooking time (Frei and Becker, 2003), however, in the present study, cultivars with the shortest and might play the lead role for cooking time differences (Chukwuemeka et al., 2015).

Water uptake ratio: According to Hogan and Plank (1958), the hydration characteristics of rice is influenced by variety and drying method, where, short and medium grain varieties have higher water absorption than long grain types. In the present study, the highest water uptake capacity was found in BRRI rice35, BRRI rice72 and Kalizira, which are graded as short to medium grain size category. Furthermore, inverse relationship between water uptake rate and amylose content was found by Metcalf and Lund (1985), BRRI rice29 demonstrated similar performances in the present study with lower water uptake ratio but higher amylose content. By contrast, BRRI rice72 demonstrated both higher water uptake ratio and amylose content same as Juliano (1972), but overall, no correlation was found between water uptake ratio and amylose content (Table 6) as suggested by Bhattacharya and Sowbhagya (1971). This could be, therefore, concluded that, grain water uptake ratio not solely depends on grain morphology or physiology but resulted as a complex interaction between grain chemical composition with water as suggested by Bergman et al. (2004).

Solid in cooking water: Solid in cooking water indicated loss of solids from grain, which is not desirable because in South Asia, rice is cooked in excess water and water is poured off after cooking (Choudhury, 1979), which eventually caused nutrient loss. Saleh and Meullenet (2013) have found that continuous heating increases the solubilization of more starch molecules which eventually leached out in to water, even in the present study, positive correlation was found between solid in cooking water and cooking time (Table 3) as suggested. During cooking, the starch of the cooking rice grain usually absorbs water and swells due to its gelatinization. In the present study, the irregular pattern of variation in respect of cultivars observed was due to effect of cultivars as suggested by Borasio (1985). As solid in cooking water indicates loss of solids, therefore, BRRI rice46, BRRI rice50, BRRI rice59 and Tulshimala are better among all. Besides, similar to Ruan and Mao (2004) and Ke-xin et al (2014), positive correlation was found between solid in cooking water and water uptake ratio which indicates that if more rice get cooked, more solid is released in water (Table 5).

Volume expansion ratio: High volume expansion of rice is a positive quality factor for low- income group of people (Choudhury, 1979) which indicates higher volume of the rice after cooking either lengthwise or crosswise (Chukwuemeka et al., 2015). Furthermore, length-wise expansion without a corresponding increase in girth is considered highly desirable for fine rice quality (Sood and Sadiq, 1979; Choudhury, 1979). The cultivar with highest volume expansion ratio was recorded in BRRI rice29 and BINA rice16 (Table 2). It should be mentioned here that, BRRI rice29 is well known for its medium slender grain quality, and popular among middle class consumers.

Amylose content: Amylose content is considered as the most important factors to determine the cooking quality of rice (Balindong et al., 2018) as well as with gelatinization temperature (Hettiarachchy et al., 1997), Cooked rice become harder with increasing amylose contents, whereas, low amylose content makes rice sticky, and intermediate amylose makes rice firm and fluffy (Bao et al., 2006, Pandarinathan, 2015). Therefore, intermediate level of amylose rice are the preferred types in most of the rice growing areas of the world, except where low amylose *japonica* are cultivated. Hence, development of improved germplasm with intermediate amylose content should be always in the consideration in the grain quality improvement program. In this study, 11 cultivars were found as intermediate, 7 were high and 3 cultivars were low amylose content. The cultivars with the highest amylose were found in BRRI rice29 and the lowest amylose content was found in BRRI rice69. Varieties with higher amylose content can used for diabetes treatment (Ohtsubo et al., 2016).

Protein content: Rice grain protein content is related to nutritional quality (Balindong et al., 2018) as well as taste (Lee et al., 2014). Rice with good taste generally bears less than 7% protein after cooking (Lee et al., 2014). Rice with high protein content is hard, less elastic, and less viscous (Lee et al., 2014) and low sticky (Primo et al., 1962). Besides proteins seemed to influence the flavour and colour of cooked rice (Juliano, 1972) and found to have inverse relationship to viscographic breakdown of rice grain (Yanase et al., 1984). In the present study, 20 cultivars were found to have intermediate (7%-9%) and one cultivar has low (<7%) protein content. The cultivars with the highest protein was found in BRRI hybrid rice2 (8.96%) and the lowest protein content was found in BRRI rice69 (6.28%). Unconsciously, people in major rice eating area prefer intermediate protein rice as in Bangladesh (Choudhury, 1979).

Gelatinization temperature: Gelatinization temperature (GT) is also closely related to the eating and cooking quality of rice (Juliano, 1972) through association with cooking time and texture of cooked rice and cool cooked rice (Maningat and Juliano, 1978) and molecular size of starch function (Li et al., 2008). Rice varieties with high GT require more water and cooking time than those possessing low or intermediate GT, therefore, intermediate GT is preferred in most rice-producing country as high quality (Pang et al., 2016). In the present observation, 13 cultivars exhibits intermediate gelatinization temperature and rest of the cultivars exhibit low GT. In this context, the best performer were recorded as BR 26, BRRI rice29, BRRI rice35, BRRI rice46, BRRI rice59, BRRI rice61, BRRI rice64, BRRI rice67, BRRI rice69, BRRI hybrid rice2, Kalizira, Tulsimala and BINA rice16.

Considering the preferences for rice to consumers of Bangladesh, rice with high amylose content with low to intermediate gelatinization temperature are more popular (Choudhury, 1979). All the rice varieties studied have low to intermediate GT, but only eight varieties have high amylose content. Among them, varieties which developed later, have lower GT. BRRI rice29, BRRI rice49, Binarice-11 are very much popular among the farmers and consumers, which have the preferred amylose content and GT. Although high amylose content makes cooked rice hard, but parboiling decreases amylose content of rice grain as well as hardness of cooked rice (Alary et al., 1977). Average protein content of the rice varieties is ~7%, which should be taken in to consideration to increase upto 10% in newly developed varieties as qualitative improvement.

CONCLUSIONS

Rice is the major staple food for half of the people of the earth. Therefore, cooking and eating qualities of rice grain are very much crucial in consumer's perspective and rice-dependent business. Among the cultivars studied in the present investigation is, moderate to high variations were found for different quality traits like cooking time, water uptake ratio and amylose content. The profiling of varieties for different quality traits shall be of great help the consumers to choose the desired one, as well as for the breeders to choose parents for creating variations for future qualitative improvement program.

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