Research in
ISSN : P-2409-0603, E-2409-9325
AGRICULTURE, LIVESTOCK and FISHERIES
An Open Access Peer-Reviewed International Journal

Article Code: 0232/2019/RALF
Article Type: Original Research

Res. Agric. Livest. Fish.
Vol. 6, No. 2, August 2019 : 235-243.

NUTRITIONAL AND COOKING PROPERTIES OF SOME RICE VARIETIES IN NOAKHALI REGION OF BANGLADESH

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ARTICLE INFO

Received
14 July, 2019

Revised
23 August, 2019

Accepted
24 August, 2019

Online
31 August, 2019

Key words
Oryza sativa L.
Nutritional quality
Cooking properties

A B S T R A C T

The experiment was conducted to evaluate the nutritional and cooking properties of some rice varieties collected from the farmers of Noakhali region of Bangladesh. Noakhali district is situated in the coastal belt of the country and this area also termed as 'char' land. All of the selected varieties were grown in saline soil condition. For assessment of nutritional quality, protein, iron and zinc content were estimated. The protein, iron and zinc content ranged from 6.75 to 8.63%, 7.09 to 9.84ppm, 24.52 to 32.34ppm, respectively. The highest amount of protein, iron and zinc were found in Kajalshail variety. All of the rice varieties showed significant variation for all cooking properties studied in this work. The volume expansion ratio (VER) was varied from 1.89 to 2.20. The kernel elongation ratio (KER) was greater than 1.1 in all varieties except Carandol. On cooking Kajalshail variety exhibited highest VER and KER 2.20 and 1.19, respectively. Based on the gel consistency (GC) test, the average GC values ranged from 39.73 to 92.53mm and varieties were categorized as hard, medium and soft. On the basis of alkali spreading value (ASV) the varieties were classified into three groups namely- low, intermediate and high. ASV was found significantly and negatively correlated with gelatinization temperature (GT). The Kajalshail variety was found to have the better nutritional and cooking quality among all varieties.

To cite this article: Anjum KI and MA Hossain, 2019. Nutritional and cooking properties of some rice varieties in Noakhali region of Bangladesh. Res. Agric. Livest. Fish. 6 (2): 235-243.

INTRODUCTION

Rice is the staple food and leading cereal crop in Bangladesh which is cooked and consumed as whole grain. Rice considered as major food for over half of the world population and it is ranked as the number one human food crop in world (Itani et al., 2002). More than 90% world rice is grown and consumed in Asia (Tyagi et al., 2004) where as 60% calories are consumed by 3 billion Asians. Rice is the main food of about 135 million people of Bangladesh. It provides nearly 48% of rural employment, about two-third of total calorie supply and about one-half of the total protein intakes (Matin et al., 2017). It has been estimated that 2.1% of the global dry land agriculture is affected by salinity (FAO, 2008). Bangladesh has a total area of 14.8 M ha, out of that, 70% is affected by different types of flash floods. About 1 M ha land is highly flood prone and 5 M ha moderately flood prone. Out of 2.85 M ha of coastal and off-shore land, about 1 M ha is affected by varying degrees of salinity and about 5.7 M ha by drought (Anon., 2014). The main saline prone area of Bangladesh include the greater districts of Khulna, Patuakhali, Noakahli, Chittagonj and the islands of Bay of Bengal, Bhola, Hatya and Sandip. In Bangladesh, over 30% of the net cultivable area exists in the coastal region covering eight agro-ecological zones of the country. Usually 30-50% yield losses occur depending on the level of soil salinity (Mamun et al., 2019). So, it is very important to screening out the local salt tolerant rice varieties and improves the crop yield in salt affected area.

Rice is the synonym for food in Bangladesh and has been the traditional source of carbohydrates and proteins since the prehistoric days (Shozib et al., 2017). Rice quality is off great importance for both the farmers and consumers and it may vary from one region to another. The common quality parameters to all users include appearance, milling and processing, cooking and nutritional quality. Rice is known to have high quantity of carbohydrate; in most of the research work result shows that rice varieties contain more than 80% carbohydrate (Thomas et al., 2013). High carbohydrate content in rice indicates good source of energy. Rice is a poor source of protein but it has high quality protein (lysine) because of its unique nutritional composition (Thongbam et al., 2012). Protein content in most of the studied ranged from 5.3 to 11.5% (Thongbam et al., 2012; Diako et al., 2011). Fat content of rice ranges from 0.5 to 3.5% (Oko and Ugwu, 2011) but the bran of rice is known by its high fat content up to 22.5% in some traditional varieties (Ravi et al., 2012). Indica type of rice has lower fat content than japonica type (Thongbam et al., 2012). Amylose content of rice has inverse relation with lipid content that as amylose content increases fat content decreases and vice versa (Thongbam et al., 2012). Previous results during the past investigations conclude that cooking quality is directly related to the physical and chemical characteristics of the starch in the endosperm; i.e; amylose content, volume expansion ratio, gel consistency, alkali spreading value (Little et al., 1958; Juliano, 1980; Unnevehr et al., 1992; Tan et al., 1999). Keeping in view the above perspectives, the specific objectives of this present work is therefore, to evaluate the nutritional and cooking quality parameters of some rice varieties of Noakhali region.

MATERIALS AND METHOD

Sample collection

The experiment was conducted collaborately at the laboratory of Department of Agriculture, Noakhali Science and Technology University and laboratory of the Department of Biochemistry and Molecular Biology, Bangladesh Agricultural University, Mymensingh. For this purpose, rice samples of five local varieties namely-Boilam, Carandol, Rajashail, Kajalshail and Gigoj were collected from the farmers of Noakhali region (Subornochor). Noakhali region was considered as the coastal area of Bangladesh. All the samples were brought to laboratory and transferred into air tight jar and stored at room temperature for further analysis.

Parameters for evaluation

Parameters for nutritional qualities were protein, iron and zinc content of selected rice varieties and for cooking properties the parameter included amylose and amylopectin content, volume expansion ratio, kernel elongation ratio, gel consistency and gelatinization temperature.

Estimation of protein

Micro-kjeldahl method was used for the estimation of total nitrogen in rice grain. Then the total nitrogen was multiplied by conversion factor to obtained protein content. Three steps were carried out for the estimation of total Nitrogen content. First step was digestion, powdered rice sample (0.2 gram) was taken in a 75 mL Kjeldahl flask and five milliliters of concentrated H_2SO_4, 1 gram of digestion mixture were added. The flask was placed on digestion chamber and boiled until the mixture contained became clear. The flask was cooled slowly and the digested sample was diluted to 75 mL with distilled water. For distillation, twenty-five milliliters of diluted digested sample was taken and 25 mL of 40% NaOH was poured into the flask slowly holding the flask at about 45^0 angle and immediately connected to a distillation set. The distillate was collected in a conical flask containing 10 ml of 2% boric acid solution and 2-3 drops of mixed indicator. Collected volume of distillate was 50 ml. After that total distillate was titrated with 0.1 N HCl and titration value was recorded. Percentage of nitrogen was calculated by the following formula:

$$\% \text{ Nitrogen} = \frac{(Ts - Tb) \times \text{Normality of acid} \times 0.014 \times 100}{\text{weight of sample (g)}}$$

Where,

Ts = Titre value of the sample

Tb = Titre value of the blank

0.014 = Milli equivalent wt. of Nitrogen

% Protein = % Nitrogen x C.F.

C.F. = Conversion Factor (5.5 for plant sample)

Procedure of digestion for the estimation of iron (Fe) and zinc (Zn)

One gram (1g) amount of rice grain powder was taken in 150 ml conical flask and 10 ml of di-acid mixture HNO_3:$HClO_4$=2:1 was added. It was kept overnight at room temperature and then placed on sand bath at a temperature of 180-200^0C for one hour. After a few minutes brown fume evolved which indicated the starting of digestion process. Finally white fume was seen by clearing the solution. About 2-3 ml solution remained at the bottom of the conical flask. Heating was then stopped and the digested sample was cooled for about 20 minutes. Then about 20-30 ml distilled water was added to each conical flask. The obtained solution was filtered into a 100 ml volumetric flask and the volume was made up to the mark (100 ml) by the addition of distilled water. The solution was transferred into a plastic bottle for further use.

Iron (Fe) and zinc (Zn) content determination by Atomic Absorbance Spectrophotometer (AAS)

The principle involves that the atoms of iron (Fe) and zinc (Zn) normally remain in ground state, but under flame condition they absorb energy when subjected to radiation and is proportional to the specific wavelength. The absorption of radiation is proportional to the concentration of the element. Iron content was estimated by using Atomic Absorbance Spectrophotometer (AAS) at 248.33 nm wavelength and zinc content at 213.9 nm wavelengths.

Determination of amylose content

Amylose content was determined by following the method of Robyt (1969). Accurately weighed in duplicate 100 mg of finely powdered sample was taken into an Erlenmeyer flask. 1 ml of 95% ethanol and 9 ml of 1N NaOH were added to it and warmed for 5 minutes in water bath to gelatinize the starch. The content was then transferred quantitatively in 100 ml volumetric flask, cooled and brought to volume with water. Five ml portion of this solution was taken into a 100 ml volumetric flask, 1 ml of 1N acetic acid and 2 ml of iodine solution were added and made up to the volume with water, stirred and allowed to stand for 20 minutes before taking optical density at 590 nm.

Preparation of standard curve

For the preparation of standard curve, 100 mg of anhydrous potato amylose was dissolved in 100 ml of alcoholic NaOH (10 ml ethyl alcohol and 90 ml 1N NaOH). Portions containing 0.25, 0.50, 0.75, 1.00, 1.25, 1.50, 1.75 and 2 mg of amylose were transferred to eight 100 ml flask. The solutions were acidified with 1N acetic acid by adding 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5 and 4 ml respectively to each of above flask and color was developed using iodine solution. Optical density was taken at 590 nm in Spectrophotometer.

Calculation of amylose content of the samples

The amylose content of each sample was calculated by using the standard curve (Figure 1).

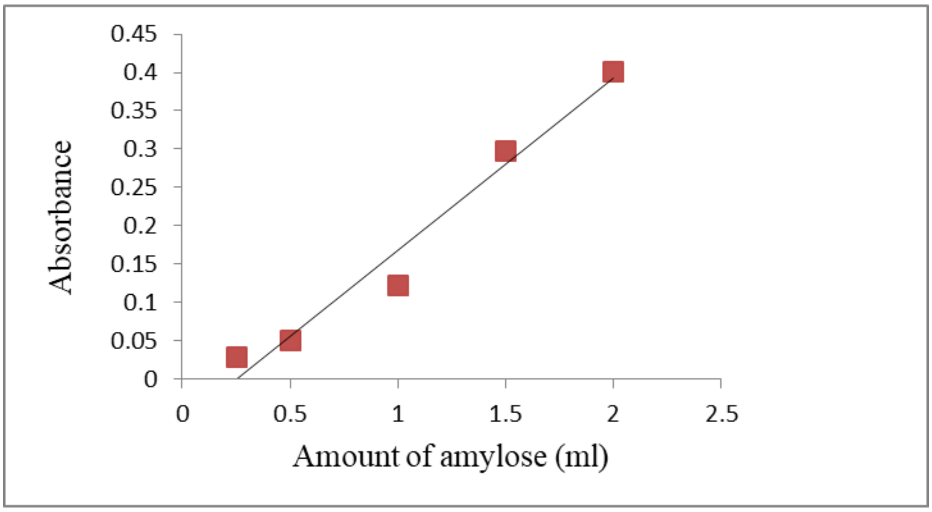

Figure 1. Standard curve for amylose determination

Calculation of amylopectin content

Amylopectin is a calculated value which was obtained from the value of total amylose.

% Amylopectin = 100 - % Amylose

Determination of Volume expansion ratio

The volume expansion ratio of the samples was determined by water displacement method by using a measuring cylinder. A sample of 5g rice grains was poured into a measuring cylinder containing 15 ml of water and the total volume was observed. The initial increase in volume after adding 5g of rice was recorded (Y) and soaked for 10 min. Rice grain sample was cooked for 20min in a water bath at 90^0 C. All the 5g of cooked rice were placed in 50 mL water taken in 100 mL measuring cylinder and the increase in volume of water was measured (X). The volume raise was recorded (X-50). The volume expansion ratio was calculated by using the following equation:

$$\text{Volume Expansion Ratio} = \frac{(X-50)}{(Y-15)}$$

Where

(x–50) is the volume of cooked rice (ml) and

(y-15) is the volume of raw rice (ml)

Determination of kernel elongation ratio (KER)

Kernel elongation ratio (KER) was determined by following the method of Juliono 1971. The length of 10 whole rice kernels after cooking (20min in a water bath at 90^0 C) as in the volume expansion ratio (ten cooked rice kernels were selected, intact at both ends) was measured by using slide calipers and average kernel length was determined. Kernel elongation ratio was calculated by dividing the average length of cooked kernel by the average length of the raw (uncooked) rice.

$$\text{Kernel Elongation Ratio (ER)} = \frac{\text{average length of the cooked kernel}}{\text{average length of the uncooked kernel}}$$

Determination of gel consistency

Gel consistency was measured by following the method of Cagampang, 1993. The rice grain samples were ground into fine flour (about 100 mesh) and samples were stored for 2 days in the air-conditioned laboratory to have a constant moisture content of 12%. Hundred milligrams of rice powder was taken into test tubes and 0.2 ml of 95% ethanol containing 0.025% thymol blue was added and mixed well by using a Vortex Genie Mixture. The test tubes were covered with glass marbles and boiled for 8 minutes in a boiling water bath to reflux and then the test tubes were removed and kept at room temperature for 5 minutes. After cooling for 15 minutes in an ice water bath the test tubes were laid horizontally over a millimeters graph paper. The length of the gel was measured from the bottom to top of the gel front after 1 hour. The ranged of gel consistency was categorized as hard, medium and soft (Table 1).

Table 1. Categorization of gel consistency of rice grain according to the mentioned method

Category	Gel consistency (mm)
Hard	26-40
Medium	41-60
Soft	61-100

Determination of Alkali spreading value and gelatinization temperature

Gelatinization temperature (GT) was measured by determining the alkali spreading value (ASV). Rice genotypes were scored based on Standard Evaluation System (SES) for Rice by IRRI 1996. Six whole grains were selected randomly from each five rice genotypes and the grains were placed in glass petri-dish containing 10 ml of 1.7% potassium hydroxide (KOH) solution. The petri-dishes were covered and incubated for 23 hours at 30^0 C. The degree of Spreading due to alkali was measured by using a seven-point numerical scale. Gelatinization temperature was determined from the value presented in Table 2.

Table 2. Standard Evaluation System (SES) was used for scoring alkali spreading value and gelatinization temperature (GT) of rice genotypes

Alkali Spreading Value			Gelatinization value	
Features	**Inference**	**Scale**	**Inference**	**GT (^{0}C)**
Not affected but chalky	Low	1	High	75-79
Swollen	Low	2	High	75-79
Swollen with collar incomplete and narrow	Low or intermediate	3	Intermediate	70-74
Swollen with collar incomplete and wide	Intermediate	4	Intermediate	70-74
Split or segmented with collar incomplete and wide	Intermediate	5	Intermediate	70-74
Dispersed, merging with collar	High	6	Low	65-69
Completely dispersed and clear	High	7	Low	65-69

Source: IRRI, 1996

RESULT AND DISCUSSION

Protein, Iron and Zinc content of the rice varieties

In nutritional point of view protein content of rice is an important quality trait. The present study analysis revealed significant differences (Table 3) of protein content among the selected rice varieties. The protein content ranged from 6.75 to 8.63%. The highest protein content was found in Kajalshail and lowest in Carandol. This result agrees with earlier findings by Ojha et al. (2018), they found that protein content ranged from 6.50 to 7.74% and 7.77 to 11.48% on evaluation of indigenous rice cultivar in India. Matin et al. (2017) conducted an study on 19 Bangladeshi HYV rice varieties released by BRRI and observed protein content varied from 6.2 to 9.3% that also similar to our present study. Although the protein content of rice is very low compared to other cereals, it has high quality protein because of its unique composition of essential amino acids such as lysine (Rani, 2006).

The Bangladeshi diet is dominated by rice and as staple cereal it accounts for the bulk of iron (Fe) intakes (Sharma, 2006). A wide varietal difference in iron content was observed in the present study (Table 3) and the quantity varied from 7.09 (Boilam) to 9.84 (Kajalshail) ppm. Nagesh et al., (2012) found that the range of iron concentration in brown rice was 6.3-24.4 ppm that supports our present study. Martinez et al., (2010) evaluated 11,400 rice samples of brown and milled rice for Fe during the period 2006-2008. They found that brown rice had 10-11 ppm Fe while milled rice had 2-3 ppm Fe. The Zinc content of rice varieties included in the present investigation ranged from 24.51 to 32.34 (ppm). Liang et al.(2007), Banerjee et al.,(2010) and Agarwal et al.,(2012) reported that Zn concentration in rice cultivars varied from 13 to 39 ppm, 13.95 to 41.73 ppm, 26.2 to 67.3 ppm respectively. The result obtained in the present study was in close agreement with those findings reported earlier in esteemed journals. The proximate analysis of Kajalshail variety showed nutritionally rich characteristics in comparison to other varieties.

Table 3. Protein, Iron and Zinc content of the selected rice varieties

Name of the variety	Protein content (%)	Iron content (ppm)	Zinc content (ppm)
Boilam	7.56 ± 0.04^{b}	7.09 ± 0.04^{a}	24.52 ± 0.03^{a}
Carandol	6.75 ± 0.17^{a}	7.18 ± 0.04^{b}	26.09 ± 0.02^{c}
Rajashail	8.14 ± 0.04^{c}	8.41 ± 0.04^{d}	29.13 ± 0.02^{d}
Kajalshail	8.63 ± 0.12^{d}	9.84 ± 0.01^{e}	32.35 ± 0.01^{e}
Gigoj	7.69 ± 0.02^{b}	7.89 ± 0.06^{c}	25.87 ± 0.03^{b}
$LSD_{0.05}$	0.145983	0.062494	0.034853
P-values	$5.22E^{-09}$	$1.08E^{-14}$	$1.02E^{-21}$

Superscript letters (a-e) indicate significant differences ($p < 0.05$) among different rice varieties. Means with same letter within column are not significantly different ($p < 0.05$), means ± SD

Table 4. Amylose and amylopectin content of the selected rice varieties

Name of the variety	Amylose Content (%)	Amylopectin content (%)
Boilam	21.98 ± 0.18^{a}	78.02 ± 0.18^{a}
Carandol	21.79 ± 0.26^{a}	78.21 ± 0.26^{a}
Rajashail	24.14 ± 0.03^{b}	75.86 ± 0.03^{b}
Kajalshail	25.45 ± 0.29^{d}	74.55 ± 0.29^{d}
Gigoj	24.63 ± 0.23^{c}	75.37 ± 0.23^{c}
$LSD_{0.05}$	0.333627	0.333627
P-values	$4.28E^{-09}$	$4.28E^{-09}$

Superscript letters (a-d) indicate significant differences ($p < 0.05$) among different rice varieties. Means with same letter within column are not significantly different ($p < 0.05$), means ± SD

Amylose and amylopectin content

Amylose consists of linearly linked glucose molecules and is relatively resistant to digestion (Oko et al., 2012). It has a major influence on the characteristics of cooked rice. Amylose content is positively correlated with hardness and negatively correlated with stickiness (Juliano et al., 1980; Windham et al., 1997) of cooked rice. In this study there is no significant variation observed in Boilam and Carandol variety for amylose and amylopectin content but rest of the three varieties showed significant variation (Table 4). Matin et al. (2017) found amylose content of the 19 rice varieties ranged from 19 to 27.0%. This result agrees with our findings where amylase content varies from 21.79 to 25.45%.

Volume expansion ratio, kernel elongation ratio and gel consistency of rice varieties

The result revealed significant difference among the varieties studied, indicating considerable variability among the genotypes for volume expansion ratio, kernel elongation ratio and gel consistency (Table 5). Volume expansion values of selected varieties varied from a maximum of 2.20 in Kajalshail and minimum in 1.89 in Gigoj. VER is a positive character for the lower income group for whom quantity is an important criterion. However, the higher the volume expansion ratio, the lower the energy content per unit volume (Tamu et al., 2017). Length-wise expansion without increase in girth is considered a highly desirable trait of high quality rice (Hossain *et al*., 2009). The Kernel elongation ratio (KER) of rice varieties varied from 1. 09 to 1.19 and the highest ratio occurred in Kajalshail. Gel consistency (GC) measures the cold paste viscosity or stickiness of cooked milled rice flour (Cagampang et al., 1973). GC varies from soft to hard. In this present work 2 rice varieties had soft GC, another 2 had medium GC and only one variety had hard GC. Accumulation of starch polymers in the aqueous phase determines weak and rigid gels. Rice with soft gel consistency has a higher preference amongst the consumers. Rice having soft GC remains soft and fluffy for long time after cooking.

Table 5. Volume expansion ratio, kernel elongation ratio and gel consistency of the selected rice varieties

Name of the variety	Volume expansion ratio	Elongation ratio	Gel consistency (mm)	
			Mean ± SD	Category
Boilam	2.01 ± 0.02^{b}	1.12 ± 0.01^{b}	49.91 ± 0.66^{b}	Medium
Carandol	2.12 ± 0.01^{c}	1.09 ± 0.01^{a}	39.73 ± 0.03^{a}	Hard
Rajashail	2.09 ± 0.01^{c}	1.17 ± 0.01^{c}	84.60 ± 0.04^{d}	Soft
Kajalshail	2.20 ± 0.01^{d}	1.19 ± 0.01^{d}	92.53 ± 0.04^{e}	Soft
Gigoj	1.89 ± 0.03^{a}	1.12 ± 0.01^{b}	56.25 ± 0.04^{c}	Medium
$LSD_{0.05}$	0.026136	0.013005	0.046809	
P-values	$9.06E^{-09}$	$4.29E^{-07}$	$4.85E^{-15}$	

Superscript letters (a-e) indicate significant differences ($p < 0.05$) among different rice varieties. Means with same letter within column are not significantly different ($p < 0.05$), means ± SD

Table 6. Alkali spreading value and Gelatinization temperature of the selected rice varieties

Name of the variety	Alkali Spreading Value		Gelatinization Temperature	
	Scale	Category	GT(^{0} C)	Category
Boilam	2	Low	75 - 79	High
Carandol	1	Low	75 - 79	High
Rajashail	4	Intermediate	70 - 74	Intermediate
Kajalshail	6	High	65 - 69	Low
Gigoj	3	Intermediate	70 - 74	Intermediate

Alkali spreading value and Gelatinization temperature of rice varieties

Alkali spreading value can directly determine the cooking quality of varieties. Alkali spreading value is negatively correlated with GT, hence GT values were used in discussion. Cultivars with GT 55-69, 70-74 and 75-79°C are categorized as low, intermediate and high GT, respectively (Khush et al., 1979). Rice with high GT takes a longer time to cook and the cooked rice has a harder texture, while low-GT rice takes a shorter time to cook and has softer to intermediate texture. There is a wide variation was observed GT value of five rice varieties used in this experiment. The variety Boilam and Carandol had high GT value and Rajashail and Gigoj had Intermediate GT value and only one variety Kajalshail had low GT value (Table 6). Chemutai et al. (2016) mentioned that genotypes that were least affected by the alkali solution had a low ASV, which could be attributed to the presence of more long amylopectin chains (B2 and B3) than the short (A and B1) amylopectin chains.

CONCLUSION

The present research work was conducted to investigate the nutritional and cooking properties of five salt tolerant local rice cultivars in Noakhali region of Bangladesh. Information on rice genotypes having better nutritional and cooking properties is very important for breeding and screening purpose. Actually, database on above properties of locally cultivated salt tolerant rice varieties could be pre-requisite for developing high yielding varieties for saline prone area due to presence of wide genetically variation.

ACKNOWLEDGEMENT

The authors gratefully acknowledge the constructive suggestions of Professor Bishan Lal Das Chowdhury (Retd.), Department of Biochemistry and Molecular Biology, Bangladesh Agricultural University, during manuscript preparation.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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