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Comparative proximate analysis of rice (*Oryza sativa*) from different districts in the northern part of Bangladesh

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Abstract

Oryza sativa, commonly known as rice, was analyzed to determine its proximate composition and to compare its nutritional values. This study aims to investigate the macro- and micronutrient profiles of prominent Bangladeshi rice of same verity produced in different districts, providing a scientific basis for nutritional improvement, value addition, and sustainable rice production.

Though the energy content of the different rice varieties is not significantly different, we can still say rice from Bogra (351.814 kcal/100g) is better than the other rice varieties. The percent of calories came from, on average, 90.2% from carbohydrates, 8.2% from protein, and 1.6% from fats. Rice from Rangpur (77.408g) contains the highest carbohydrates. The protein content of the different rice varieties is almost the same, ranging from 6.975 g (Sirajgonj) to 7.133g (Dinajpur). Rice samples from different districts contain a very negligible amount of fat, ranging from 0.582g (Rangpur) to 0.624g (Dinajpur),

The Miniket from Rangpur contains the highest amount of 0.29mg of Thiamine. Among other B vitamins, Rangpur Miniket rice contains the highest amount of Riboflavin (B2; 0.14mg) and a-Tocopherol (Vitamin E: 2.50mg) and Niacin (B3), which is high in Dinajpur rice (5.60 mg). The highest amount of Calcium, magnesium, and zinc was found in rice from Sirajgonj, and potassium & iron in Bogra rice.

We found that in terms of calorie content, all rice gives almost the same amount of calories, but rice from Bogra gives the highest amount (351.814 K. Cal). If we look at the mineral contents, we found that rice from Sirajgonj is rich in mineral content, and for vitamins, the Miniket rice from Rangpur is better.

Keywords: Rice; Proximate Analysis; Nutritional Value; Bangladesh; Regional Variation; Comparative Study

1. Introduction

The rice plant species Oryza sativa is from the family Gramineae (Grass family). Oryza sativa, a member of the grass family Gramineae, is extensively cultivated in warm climates, especially in East Asia, where it produces seeds that are cooked and used as food. People in Asia and Africa consume it more than people in the European Union (1).

Rice is a staple food and a vital crop for Bangladesh, contributing significantly to the nation's diet, economy, and cultural identity. It is a staple food for nearly half of the world's seven billion people (2). It is mainly produced and consumed in

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the Asian region. Almost 90 % of the population of Bangladesh consumes rice as their staple food (3). Rice is the staple food for the majority of the Bangladeshi population, forming the foundation of daily nutrition and cultural practices. On average, Bangladeshis consume approximately 180-200 grams of rice per person per day, which accounts for about 70-75% of total daily caloric intake (4). This high level of rice consumption underscores its critical role in food security; however, it also raises concerns about nutritional deficiencies, particularly in the intake of proteins, micronutrients, and dietary fiber.

As one of the world's largest rice producers, Bangladesh's diverse rice varieties exhibit unique compositional attributes that influence nutritional quality, cooking properties, and market value. Understanding the detailed chemical and nutritional composition of Bangladeshi rice varieties is essential for enhancing food security, guiding breeding programs, and promoting healthful consumption. This study aims to analyze the compositional profile of popular rice varieties in Bangladesh, providing valuable insights into their macronutrient and micronutrient contents and their implications for human nutrition and agricultural development.

Rice is considered the queen among cereals because of its nutritional quality and higher digestibility (5). Rice (Oryza sativa) serves as the primary staple food for over 160 million people in Bangladesh, accounting for approximately 70% of the total calories consumed annually (4). Bangladesh is one of the top 10 rice-producing countries globally, with an annual production of around 50 million tons of rice across diverse agro-ecological zones, including Aman, Boro, and Aus seasons (6). The country's rice varieties display considerable diversity in their biochemical and nutritional composition, which directly impacts nutritional security and food quality.

Despite its importance, there remains limited comprehensive data on the detailed chemical composition—such as carbohydrate, protein, lipid, vitamin, and mineral content—of locally cultivated rice varieties. Understanding these compositional attributes is essential for improving nutritional intake, developing fortified rice varieties, and supporting sustainable agricultural practices. This study aims to analyze the nutritional and biochemical profile of key rice varieties in Bangladesh, providing valuable insights to enhance food security and meet the nutritional demands of its population.

Rice is a rich source of carbohydrate, and it contains a moderate amount of protein and fat, and is also a source of vitamin B complex, such as thiamine, riboflavin, and niacin (7). A highly nutritious weaning food prepared from rice and milk, which is locally available in Bangladesh, and the safety & nutritional aspects of it were compared to imported commercial weaning foods (8,9,10)

Historically, Bangladeshi rice has been characterized by high carbohydrate content, predominantly in the form of starch, but also varies in protein, lipid, fiber, and micronutrients such as iron, zinc, and vitamins. Despite rice's central role in Bangladeshi diets, comprehensive data on the detailed biochemical and nutritional profiles of regional rice varieties remain limited. This gap in knowledge poses challenges for nutritional planning, breeding programs aimed at nutrient enhancement, and the development of rice-based functional foods.

Rice alone constitutes 92% of the total food grains produced annually in Bangladesh. It provides about 80% of people's energy intake, the majority of their protein intake, and a considerable proportion of several micronutrients in their average daily diet. (11) Rice quality parameters are increasingly scrutinized in the context of global nutritional security, bio-fortification initiatives, and climate resilience. There is an urgent need to quantify and compare the compositional differences between traditional and modern cultivars to inform breeding strategies and consumer choices.

According to the Global Nutrition Report 2023, over 36% of Bangladeshi children under five suffer from stunted growth, partly due to reliance on a predominantly carbohydrate-based diet with limited diversification (12). The demand for rice has remained relatively stable over recent decades, despite efforts to diversify diets and promote alternative grains. Consumption patterns vary regionally and seasonally, with higher intake during the Aman season and in rural areas. Given Bangladesh's heavy dependence on rice, understanding the nutritional composition and quality of locally produced rice varieties is essential to address malnutrition and support sustainable agricultural and nutritional policies.

It is a very rich source of carbohydrate with substantial amounts of protein, fat, fibre, minerals, and vitamins. Composition and nutrient contents of rice vary with varieties and especially processing method. There are two main types of rice mills in Bangladesh –husky and automatic rice mills. The milling procedure of husky and automatic mills differs. Husky rice mills do some polishing in addition to husking, mostly by using two or more passes through hullers to grind off some of the bran after husking. (13).

This study aims to investigate the macro- and micronutrient profiles of prominent Bangladeshi rice of same verity produced in different districts, such as Dinajpur, Rangpur, Sirajgonj, and Bogra, providing a scientific basis for nutritional improvement, value addition, and sustainable rice production. By elucidating these compositional parameters, the research will contribute to better utilization of indigenous rice resources for improving public health and ensuring food sovereignty in Bangladesh.

2. Materials and methods

2.1. Collection of rice samples from different districts

The four rice samples were collected from the different locations of the Northern part of Bangladesh with the variety of parboiled Miniket, a popular, premium variety of rice known for its fine grains and delicate aroma. The rice samples R-1 collected from Dinajpur, R-2 from Rangpur, R-3 collected from Sirajgonj, and R-4 collected from Bogra, where a huge amount of rice is produced. The rice samples are collected from the same cultivation season and parboiled and milled in the same way.

2.2. Chemical analysis of Rice

2.3. Nutrient analysis

The nutrient compositions of the Miniket rice from four districts were carried out as follows:

2.3.1. Determination of moisture content

Moisture content was determined by the oven-dry method as the loss in weight due to evaporation from the sample at a temperature of 105 °C. The weight loss in each case represented the amount of moisture present in the sample:

Moisture (%) = (Weight of the original sample- weight of the dried sample) / weight of the original sample × 100

2.3.2. Determination of crude protein

The crude protein content was determined following the micro Kjeldahl method (AOAC, 2005) **(14)**. The percentage of nitrogen (N) was calculated using the following equation:

$$\text{Nitrogen (\%)} = (S - B) \times N \times 0.014 \times 100 / W$$

Where,

S= Titration reading for sample,
B= Titration reading for blank,
V= titration volume = (S-B), N= Strength of N/70 H_2SO_4, W= Weight of the sample, 0.014 = Constant value.

Crude protein was obtained by multiplying the corresponding total nitrogen content by a conventional factor of 6.25. Thus, crude protein (%) = % of N × 6.25.

2.3.3. Determination of crude fat

Crude fat was determined by the Soxhlet extraction technique, followed by AOAC (2005) **(14).** The fat content of the dried samples was easily extracted into an organic solvent (petroleum ether) at 60 to 80°C and then refluxed for 6 h. The percentage of fat content was calculated using the following formula:

Crude Fat (%) = Weight of the fat in the sample/ Weight of the dried sample × 100

2.3.4. Determination of ash

Ash content was determined by combusting the samples in a muffle furnace at 600°C for 8 h according to the method of AOAC (2005) **(14)**:

Ash Content (%) =Weight of ash / Weight of sample × 100

2.3.5. Determination of Crude Fiber

The bulk of roughage in food is referred to as fiber and is called crude fiber. The milled sample was dried, defatted with an ethanol-acetone mixture, and then the experiment was carried out using the standard method as described in AOAC (2005) **(14)**:

Crude Fiber (%) = (Weight of the residue- Weight of the Ash)/ Weight of the sample × 100

2.3.6. Determination of carbohydrate

The carbohydrate content was estimated by the difference method. It was calculated by subtracting the sum of the percentage of moisture, fat, protein, and ash contents from 100% according to AOAC (2005) **(14)**:

Carbohydrate (%) = 100 – (moisture% + fat% + protein% + ash %)

2.3.7. Determination of total energy

The total energy value of the food formulation was calculated according to the method of Mahgoub (1999) using the formula as shown in the following equation **(15)**:

Total energy (kcal/100 g) = [(% available carbohydrates × 4.1) + (% protein × 4.1) + (% fat × 9.3)]

2.3.8. Determination of vitamin B complex

10 g of each sample was weighed and made into a homogenate in a mortar with a pestle and transferred into a conical flask, and 25 mL of extraction solution was added, kept on shaking water bath at 70˚C for 40 min. Thereafter, the sample was cooled down, filtered, and finally, the volume was made up to 50 mL with extraction solution. The sample was filtered through 0.45 µm filter tips, and aliquots of 20 µL from this analytical reversed-phase C-18 column (ODS column, 250 × 4.6 mm, 5 µm, Phenomenex, Inc.) were used for the separation. Mobile phase consisting of a mixture of buffer and methanol in the ratio of 96:4 (v/v) was delivered at a flow rate of 1 mL/min with UV detection at 210 nm. The mobile phase was filtered through a 0.22 µm membrane filter, sonicated, and degassed before use. Analysis was performed at room temperature (~26˚C). All the prepared sample solutions were first chromatographed to ensure that interfering peaks were not present. 20 µL aliquots of the standard solutions and sample solutions were injected. The solution was injected into the HPLC by using an autosampler.

2.3.9. Determination of vitamin E(α-Tocopherol)

The determination of Vitamin E, primarily in the form of α-tocopherol, is commonly conducted using High-Performance Liquid Chromatography (HPLC) due to its high sensitivity and specificity. The process typically involved sample extraction with organic solvents such as hexane, followed by saponification to remove interfering lipids. The extract was then subjected to HPLC analysis using a fluorescence detector or a UV detector, with suitable mobile phases like methanol or a methanol-water mixture. This method allowed for accurate quantification of Vitamin E in various biological samples, foods, and supplements.

2.3.10. Determination of minerals

The mineral contents were determined after the ash content determination. The ash residue of each formulation was digested with perchloric acid and nitric acid (1:4) solution. The samples were left to cool, and the contents were filtered through Whatman filter paper 42. Each sample solution was made up to a final volume of 25 ml with distilled water. The aliquot was used separately to determine the mineral contents of Calcium, magnesium, potassium, iron, and zinc by using an Atomic Absorption Spectrometer (Spectra AA 220, USA Varian).

2.4. Statistical analysis

The data were analyzed using SPSS version 17.0. The mean and standard deviations of the triplicate analyses were calculated. The analysis of variance (ANOVA) was performed to determine significant differences between the means using Dunnett's T3 tests.

3. Results and discussion

3.1. Nutritional composition

The nutritional compositions (g/100 g dry weight) of the Miniket rice from different districts were summarized in Table 1.

Table 1 Nutritive Value of the rice from different districts of northern Bangladesh (100 g)

Rice Sample	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	CHO (%)	Fiber (%)	Energy (K.Cal)
R-1	14.021	0.501	0.624	7.133	77.077	0.644	351.064
R-2	13.842	0.526	0.582	7.064	77.408	0.578	351.748
R-3	13.906	0.513	0.595	6.975	76.820	1.191	349.093
R-4	13.773	0.530	0.612	7.039	77.381	0.665	351.814

Moisture content invariably affects the quality and palatability of rice grains (16), which plays a significant role in determining the shelf life. All accessions were found to possess the moisture content almost within the acceptable limit (12%) for long-term storage of rice (17) when compared with the other accessions. The difference in moisture content among the rice from different districts might be due to the variation in moisture content in paddy after harvesting (18). The moisture content (13.773%–14.021%) in this study was under the range of values reported by Mbatchou and Dawda (2013), and Thomas et al (2013) for other rice accessions (19,20).

The nutritional compositions (g/100 g dry weight) of the different types of rice were summarized in Table 1. The energy content of rice was 351.064, 351.748, 349.093, & 351.814 kcal/100g for R-1, R-2, R-3, & R-4, respectively. Though the energy content of the different rice varieties is not significantly different, we can still say rice from Bogra (R-4) is better than the other rice varieties.

The carbohydrate content in the different rice are varies from 76.820g to 77.408g. Rice from Rangpur (R-2) contains the highest carbohydrates, and Rice (R-3) from Sirajgonj contains the lowest carbohydrates. The other two rice varieties from Dinajpur (R-1) and Bogra (R-4) contain 77.077g and 77.381g, respectively.

Protein in rice is very essential as proteins form the basic building blocks for cells and tissue repairs in the body **(21).** Protein is one of the most important nutrients that provides some energy. The protein content of the different rice varieties is almost the same, ranging from 6.975 g (Sirajgonj; R-3) to 7.133g (Dinajpur: R-1), and the other two varieties contain 7.064g (R-2) and 7.039g (R-4).

Fat in rice is a good source of linoleic and other essential fatty acids, but does not contain cholesterol **(22).** Fat content influences the taste of cooked rice because rice with high fat content tends to be tastier and have less starch **(23).** Rice samples from different districts contain a very negligible amount of fat, ranging from 0.582g (R-2) to 0.624g (R-1), fiber ranging from 0.578g (R-2) to 1.191g (R-3), and ash ranging from 0.501g (R-1) to 0.530 g (R-4).

3.2. Quality evaluation

After the proximate analysis calculated the percentage of calories that come from the different food components, such as carbohydrates, protein, and fat, we found that around 90% calories came from carbohydrates, 8.2% from protein, and 1.6% from fats. The Miniket rice from Dinajpur, Rangpur, Sirajgonj, and Bogra gave 90.02%, 90.23%, 90.22% & 90.16% calories from carbohydrates, respectively. Other hand, Dinajpur rice gave calories of 8.33% from protein, and 1.65% from fats; Rangpur one gave calories of 8.19% from protein, 1.59% from fats; Sirajgonj rice gave calories of 8.19% from protein, 1.59% from fats, and rice of Bogra gave calories of 8.20% from protein, 1.62% from fats.

Table 2 Percent calories from different nutrients of the rice

Rice Sample	Percent calories		
	Protein	Carbohydrate	Fat
R-1	8.33%	90.02%	1.65%
R-2	8.23%	90.23%	1.54%
R-3	8.19%	90.22%	1.59%
R-4	8.20%	90.18%	1.62%

- % Protein calories = Protein% X 4/ Total energy of formulations.
- % Carbohydrate calories = Carbohydrate% % X 4/ Total energy of formulations.
- % Fat calories = Fat% % X 9 / Total energy of formulations.

Table 3 Vitamin B Content in the locally produced different rice varieties (100 mg)

Rice Sample	Thiamine (mg)	Riboflavin (mg)	Niacin (mg)	a - Tocopherol (mg)
R-1	0.26	0.11	5.60	2.00
R-2	0.29	0.14	5.30	2.50
R-3	0.11	0.06	2.40	0.30
R-4	0.19	0.09	4.30	1.90

Rice is a rich source of the Vitamin B complex for people whose staple food is rice. The vitamin B1 (Thiamine) varies from 0.11 mg to 0.29mg, and Miniket from Rangpur contains the highest amount of 0.29mg of Thiamine. Among other B vitamins, Rangpur Miniket rice contains the highest amount of Riboflavin (B2; 0.14mg) and a-Tocopherol (Vitamin E: 2.50mg) and Niacin (B3), which is high in Dinajpur rice (5.60 mg)

Table 4 Minerals Content in the locally produced different rice (mg/100 g).

Variety	R-1	R-2	R-3	R-4
Ca (mg)	28.20	26.20	29.20	27.40
Mg (mg)	24.10	24.64	24.65	24.74
P (mg)	119.40	116.30	120.40	115.19
Fe (mg)	4.55	4.25	4.15	4.60
Zn (mg)	1.10	1.35	1.98	1.51

Minerals are well-known essential nutrients and play a vital role in the effective functioning of the body's activity **(24)**. Though the amount of minerals in parboiled rice is very low, there are several minerals found in parboiled rice, especially in the Miniket rice from Dinajpur, Rangpur, Sirajgonj, and Bogra. The common minerals in the Miniket rice are calcium, magnesium, potassium, iron, and zinc. The highest amount of Calcium, magnesium, potassium, iron, and zinc was found in rice from Sirajgonj, Bogra, Sirajgonj, Bogra, and Sirajgonj, respectively. So, the Miniket rice from Sirajgonj has a fairer amount of minerals compared to the Miniket other districts.

3.3. Comparison of the nutritional value

After the proximate analysis, the calculation of the percentage of calories from the different food components and analysis of vitamins and minerals of the rice from the different districts of Dinajpur, Rangpur, Sirajgonj, and Bogra, we evaluated and compared the nutritional value of the Miniket rice.

Table 5 Comparison of the nutritional value of the Miniket rice from different districts (XX/100g)

Nutrients	**R1**	**R-1**	**R-3**	**R-4**
Macronutrient				
Fat (%)	0.624	0.582	0.595	0.612
Protein (%)	7.133	7.064	6.975	7.039
CHO (%)	77.077	77.408	76.82	77.381
Energy (K.Cal)	351.064	351.748	349.093	351.814
Vitamin B complex				
Thiamine (mg)	0.26	0.29	0.11	0.19
Riboflavin (mg)	0.11	0.14	0.06	0.09
Niacin (mg)	5.6	5.3	2.4	4.3
a - Tocopherol (mg)	2	2.5	0.3	1.9
Minerals				
Ca (mg)	28.2	26.2	29.2	27.4
Mg (mg)	24.1	24.64	24.65	24.74
P (mg)	119.4	116.3	120.4	115.19
Fe (mg)	4.55	4.25	4.15	4.6
Zn (mg)	1.1	1.35	1.98	1.51

In terms of calorie content, all rice gives almost the same amount of calories, but rice from Bogra (R-4) gives the highest amount (351.814 K. Cal). If we look at the mineral contents, we found that rice from Sirajgonj is rich in mineral content, and for vitamins, the Miniket rice from Rangpur is better.

4. Conclusion

This comparative proximate analysis of Miniket rice from various districts in Bangladesh shows that while the energy content in the samples is fairly consistent, clear differences in mineral and vitamin bioavailability are present. Rice from Bogra had the highest calorie content, while rice from Sirajgonj was noted as the most mineral-rich, with higher amounts of calcium, magnesium, iron, and zinc. In contrast, rice from Rangpur contained higher levels of key vitamins, including thiamine, riboflavin, niacin, and vitamin E. These findings emphasize the nutritional diversity of local rice varieties and highlight their potential for targeted dietary strategies and value-added approaches. The results provide a scientific foundation for the thoughtful selection and promotion of district-specific rice cultivars to enhance nutritional health, support public health efforts, and promote sustainable rice production in Bangladesh. We can also conclude that because of the change of area and the characteristics of soil, the nutritional value differs from each other, though it's very tiny. So, in the future, it could be a subject of analysis the soil quality as well.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of ethical approval

This study was approved by the ethics committee of the Bangladesh Council of Scientific and Industrial Research (BCSIR), Dhaka, Bangladesh. Animals were not captured, restrained, sedated, or anesthetized solely for this study.

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