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# Mineral Profiling of HYV Rice in Bangladesh

**Habibul Bari Shozib[1*], Saima Jahan[2], Suman Chandra Das[3], Samsul Alam[3], Rifat Bin Amin[3], Mahedi Hasan[3], Richard Malo[4] and Muhammad Ali Siddiquee[1]**

[1]*Grain Quality and Nutrition Division, Bangladesh Rice Research Institute (BRRI), Gazipur-1701, Bangladesh*

[2]*Department of Applied Statistics, East West University, A/2, Jahurul Islam City Gate, Aftab Nagar, Dhaka, Bangladesh*

[3]*Department of Biochemistry and Molecular Biology, Tejgaon College, Tejgaon 16, Indira Road, Dhaka, Bangladesh*

[4]*Child Health Research Foundation, Mirpur Child Hospital, Borobug, Mirpur 2, Dhaka, Bangladesh*

[*]**Corresponding author:** Shozib HB, Grain Quality and Nutrition Division, Bangladesh Rice Research Institute (BRRI), Gazipur-1701, Bangladesh, Tel: +8801924745991; E-mail: shozib11@gmail.com

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**Abstract**

Bangladesh is rich in genetic diversity of crops specially rice. Thousands of rice cultivars including indigenous, locally popular, aromatic and modern HYVs are available in Bangladesh for many years. Rice is a potential source of micronutrient specially zinc, iron etc and bioavailability of these minerals exclusively depend on the content of Phytic acid (PA) and relative molar ratio of Phytate to minerals accordingly. We aimed to explore for such valuable information for popular rice varieties specially BRRI HYVs in Bangladesh. We profiled mineral composition for Zn, Fe, Ca, P and anti-nutrient components such as PA and molar ratio of PA to minerals for 68 HYVs including Aus, Aman and Boro seasons in Bangladesh. Our data reveals that BRRI dhan43 possess the highest Zn content of 38.4 ppm followed by Fe (17 ppm), Ca (68.1 ppm) and P (2.5 $gKg^{-1}$) at clean rice condition. We also noticed that it's molar ratio to Zn (PA/Zn); Fe (PA/Fe); Ca(PA/Ca) and P(PA/P) are lower among all selected high Zn enriched HYVs by 3.56, 6.93,1.24 and 25.69 respectively. Since there is no single HYV reported yet, BRRI dhan43 might be a potential micronutrient enriched BRRI HYV for Aus season and it could be used as parental source for zinc enriched rice (ZnER) breeding in Bangladesh.

**Keywords:** Zinc enriched rice (ZnER); Phytic acid; Aus season

## Introduction

A better understanding of the factors that contribute to the overall grain quality of rice *(Oryza sativa)* will lay the foundation for developing new breeding and selection strategies for combining high quality, with high yield and high micronutrient enriched. This is necessary to meet the growing global demand for high quality rice while offering producing countries additional opportunities for generating higher export revenues [1]. Humans require at least 49 nutrients for their normal growth and development, and the demands for most nutrients are supplied by cereals, particularly rice due to its staple role [2]. Among these nutrients, mineral elements play numerous beneficial roles due to their direct or indirect effect in both plant and human metabolism and the deficiencies or insufficient intakes of these nutrients leads to several dysfunctions and diseases in humans. Studies have indicated widespread occurrence of deficiencies for mineral elements such as anaemia for iron and osteoporosis for calcium in most developing countries as well as developed countries [3]. The numbers indicate that around two billion people suffer from iron deficiency, while prevalence of zinc deficiency is much harder to quantify due to the lack of a reliable and easy clinical assay [4]. In addition, other mineral deficiencies such as calcium are also associated with malnutrition and have reached worrying levels with data suggesting that roughly three million people over the age of 50 years suffer from osteoporosis [5]. Malnutrition in Bangladesh is alarmingly high. In Bangladesh, 36.2% children are stunted under 5 years of age are stunted, 15% are wasted and 33% are underweight [6]. Malnutrition and poverty hinder access to education and the ability to learn. Only 51 percent of those in school will complete primary education. Children of uneducated mothers are significantly affected. This has a bearing of significant impact on the nutritional status of future generations. Widespread vitamin and mineral deficiencies also exist. One in five preschool/school-aged children suffers from a vitamin A deficiency; 33 percent of preschool children are anaemic; folate and vitamin $B_{12}$ deficiency affect 9 percent and 22 percent of women respectively. The national prevalence of zinc deficiency is 44.6 percent amongst preschool age children and 57.3 percent amongst non-pregnant non-lactating women, according to the National Micronutrients Survey 2011-2012 [7]. Recent epidemiological studies found that whole-grain intake (such as brown rice), is linked to disease prevention against cancer, cardiovascular disease, diabetes and obesity [8]. It is noted to be considered that the adequate nutritional intake of Zn actually depends both on the amount of Zn in the diet and on its availability. Among many factors to affect bioavailability of dietary Zn intake, phytate (inositol hexa phosphate) has been known well to decrease Zn bioavailability [9]. Phytate is present at high levels in unrefined cereals, legumes, nuts, and seeds and most of the phosphorus in these foods is present mostly as phytate. Phytate contains negatively charged phosphate ligands which complex with positively charged ions such as $Zn^{2+}$, $Ca^{2+}$, $Mg^{2+}$ and $Fe^{2+}$. Absorption of these metals in the small intestine is therefore inhibited due to their chelation by phytate [10,11]. Estimation of molar ratio of Phytate to minerals are very important parameter for understanding bioavailability of minerals. Since rice is the synonym for food in Bangladesh and has been the traditional source of carbohydrates and proteins since the prehistoric days. A total of eighty two HYVs including both inbreeds and hybrids have been released by Bangladesh Rice Research Institute (BRRI) till date. At present, total clean rice production is about 34.8 MT which fulfils the domestic requirement to feed more than 160 million populations with the surplus of 2.06 MT

[12]. So, it is high time to focus our grain quality and nutrition research towards grain nutraceutical properties specially mineral profiling to reveal its aptitude to combat with non communicable diseases (NCD) specially cancer, cardiovascular disease, diabetes and obesity.

## Material and Methods

A total of sixty eight (68) BRRI HYVs including both Aus, Aman and Boro season grown rice varieties such as BR20, BR21, BR24, BR26, BRRI dhan27, BRRI dhan42, BRRI dhan43, BRRI dhan48, BRRI dhan65 for Aus season; BR4, BR5, BR10, BR11, BR22, BR23, BR25, BRRI dhan30, BRRI dhan31, BRRI dhan32, BRRI dhan33, BRRI dhan34, BRRI dhan37, BRRI dhan38, BRRI dhan39, BRRI dhan40, BRRI dhan41, BRRI dhan44, BRRI dhan46, BRRI dhan49, BRRI dhan51, BRRI dhan52, BRRI dhan53, BRRI dhan54, BRRI dhan56, BRRI dhan57, BRRI dhan62, BRRI dhan66 for Aman season and BR1, BR2, BR3, BR6, BR7, BR8, BR9, BR12, BR14, BR15, BR16, BR17, BR18, BR19, BRRI dhan28, BRRI dhan29, BRRI dhan35, BRRI dhan36, BRRI dhan47, BRRI dhan50, BRRI dhan55, BRRI dhan58, BRRI dhan59, BRRI dhan60, BRRI dhan61, BRRI dhan63, BRRI dhan64, BRRI dhan67, BRRI dhan68, BRRI dhan69 for Boro season were selected in this study to evaluate their mineral profiling including zinc, iron, calcium, phosphate, phytic acid and molar ratio of phytate to respective minerals (PA/Zn, PA/Fe, PA/Ca and PA/P). Rice grain were collected from Genetic Resources and Seed (GRS) Division bank of Bangladesh Rice Research Institute (BRRI) and processed milling at cleaned rice (milled) condition for mineral analysis.

### Estimation of iron, zinc and calcium

Sample were digested and estimated by the method of the Association of Official Agricultural Chemists [13]. About 0.5 g rice powder was taken into a 25 mL conical flask and then for extraction of minerals, 5 mL mixture of nitric acid: perchloric acid (5:2) was added to the flask. The sample were heated at 350°C for digestion until the color became clear. Then the digested sample were cooled and filtered through a Whatman filter paper No. 1 and the volume was made up to 25 mL with de-ionized distilled water. Iron, zinc and calcium were determined by the atomic absorption spectrometry (Shimadzu Atomic Absorption Spectrophotometer AA-6800) using a different standard curve for each. For the preparation of standard curve for iron, absorbance of 0.0, 1.0, 2.0, 4.0, 8.0 μg $mL^{-1}$ iron solutions at 348.3 nm, for zinc 0.05, 0.10 0.20, 0.40, 0.80, 1.00 μg $mL^{-1}$ at 213.8 nm and for calcium 1.0, 2.0, 4.0, 8.0, 12.0 μg $mL^{-1}$ at 422.7 nm were taken respectively.

### Estimation of phosphorus

Estimation of phosphorus is carried out by measuring calorimetrically the blue color formed when the ash solution is treated with ammonium molybdate and the phosphomolybdate thus formed is reduced [14]. About 0.2 g rice powder was taken into a 25 mL conical flask and then for extraction of minerals, 5 mL mixture of nitric acid: perchloric acid (5: 2) was added to the flask. The samples were heated at 350°C for digestion until the color became clear. Then the digested sample was cooled and filtere d through a Whatman filter paper No. 1 and the volume was made up to 50 mL with de-ionized distilled water. One mL of extracted sample was taken into a test tube and 2 mL $HNO_3$ (2N), 4 mL de-ionized water was added. Then 1 mL molybdate-vanadate solution and 2 mL de-ionized water was added to make the volume 10 mL. Mixed the solution with vortex mixture and the absorbance were taken at 420 nm after 15 minutes. For the preparation of standard curve for phosphorus, absorbance of 0.0, 0.5, 1.0, 2.0, 4.0 μg $mL^{-1}$ P solutions were used.

### Estimation of Phytic Acid (PA)

Phytic acid present in rice samples were determined colorimetrically by Wheeler and Ferral method (1971). About 200 mg rice powder was weighed and transferred into a 15 mL centrifuge tube. Then 7.5 mL TCA (5%) solution was added and vortexed the mixture. The mixture was incubated at 60°C for 10 minutes and then centrifuged at 5000 rpm for 10 minutes. The supernatant was transferred into a 25 mL volumetric flask. The extraction was repeated for 2 more times and transferred the supernatant into the volumetric flask and the volume was made up to 25 mL. Twenty mL extracted sample was taken into a 75 mL Technicon tube and then 5 mL ferric chloride solution was added. The tubes were then heated in a block digestor at 95°C for 45 minutes. After cooling the tube, it was made up to 75 mL with de-ionized water and filtered through Whatman filter paper No. 42. Pipetted out 2.5 mL filtrates and then 2 mL potassium thiocyanate (29%) and 5 mL de-ionized water was added in each of the tube for making total volume 9 mL. Then after mixing, the absorbance of the mixture was measured at 485 nm against water as blank. Pipetted out 5 mL of ferric chloride solution into a tube, and then 20 mL de-ionized water and 2 mL TCA (5%) was added. The flask was heated in a block digestor at 95°C for 45 minutes. After cooling the tube, it was made up to 75 mL with de-ionized water and filtered through Whatman filter paper No. 42. Then filtrates were pipetted from 0.5 to 2.5 mL in different tubes. The volume was made up to 7.5 mL with de-ionized water and 2 mL of potassium thiocynate (29%) was added in each tube. After mixing, the absorbance of the solution was measured at 485 nm. A standard graph of ferric ion was plotted. From the graph, the slope was determined and then values for phytic acid was calculated on the assumption that four ferric ion combine with one molecule of phytic acid ($Fe_4P_6C_6H_6O_{24}$). Calculation was done on the basis of dry weight of the sample.

### Molar ratio of phytic acid (PA) to Zn, Fe, Ca and P

The molar ratio of PA/Zn, PA/Fe, PA/Ca and PA/Pwere calculated as follows; the molar intake of phytate (molecular weight, 660) was divided by the molar intake of Zn (molecular weight, 65), molar intake of Fe (molecular weight, 56), molar intake of Ca (molecular weight, 40) and molar intake of P (molecular weight, 31) respectively.

## Results and Discussion

In the present study of mineral profiling of Zn, Fe, Ca and P, our data revealed that there is variation of mineral content among HYVs including Aus, Aman, Boro season grown BRRI HYVs in Bangladesh. All HYVs were grown in West Byed field of BRRI, Gazipur during Aus, Aman and Boro season in 2015-16. BRRI recommended fertilizers dose were applied in field preparation (BRRI, 2015). Field soil was adequate in Zn and there were no symptoms of Zn deficiency in total duration of the experimental. (BRRI, 2016). A total of 30 BRRI Boro HYVs were studied in this experiment and all mineral profiling data are summarized in Table 1 and Figure 1.

Our data reveals that both BR6 and BRRI dhan64 possess the highest Zn content of 24 ppm ($mgKg^{-1}$) followed by BRRI dhan36 and BR7 at 23.7 and 22.7 ppm respectively at clean rice condition.

| Boro HYVs data for mineral profiling. | | | | |
|---|---|---|---|---|
| **HYVs** | **Zn (mgKg-1)** | **Fe (mgKg-1)** | **Ca (mgKg-1)** | **P (gKg-1)** |
| BR1 | 21.3 | 7.8 | 41.1 | 2.7 |
| BR2 | 19.9 | 8.6 | 42.1 | 2.0 |
| BR3 | 17.5 | 5.9 | 26.3 | 2.1 |
| BR6 | 24.0 | 9.5 | 34.2 | 2.4 |
| BR7 | 22.7 | 7.8 | 48.1 | 1.7 |
| BR8 | 19.6 | 6.1 | 37.6 | 1.5 |
| BR9 | 16.3 | 7.8 | 35.6 | 1.8 |
| BR12 | 19.8 | 9.8 | 26.7 | 2.3 |
| BR14 | 16.8 | 8.1 | 22.3 | 1.8 |
| BR15 | 17.6 | 7.3 | 33.7 | 2.3 |
| BR16 | 18.4 | 6.2 | 32.4 | 1.3 |
| BR17 | 19.8 | 17.5 | 37.2 | 1.9 |
| BR18 | 19.0 | 6.6 | 36.4 | 1.4 |
| BR19 | 18.2 | 9.6 | 39.9 | 2.0 |
| BRRI dhan28 | 18.8 | 7.8 | 41.8 | 2.0 |
| BRRI dhan29 | 18.8 | 8.2 | 30.3 | 1.8 |
| BRRI dhan35 | 21.6 | 14.5 | 26.8 | 2.4 |
| BRRI dhan36 | 23.6 | 9.6 | 35.1 | 1.8 |
| BRRI dhan47 | 21.3 | 8.9 | 34.8 | 1.4 |
| BRRI dhan50 | 19.6 | 8.7 | 33.2 | 2.2 |
| BRRI dhan55 | 18.1 | 8.0 | 28.1 | 1.9 |
| BRRI dhan58 | 17.8 | 9.9 | 31.9 | 2.1 |
| BRRI dhan59 | 16.3 | 7.5 | 25.7 | 1.8 |
| BRRI dhan60 | 19.6 | 8.7 | 33.2 | 2.2 |
| BRRI dhan61 | 19.1 | 8.0 | 30.2 | 1.3 |
| BRRI dhan63 | 18.8 | 7.3 | 37.3 | 1.7 |
| BRRI dhan64 | 24.0 | 11.1 | 18.7 | 3.1 |
| BRRI dhan67 | 18.0 | 8.9 | 35.3 | 1.3 |
| BRRI dhan68 | 16.7 | 9.6 | 18.0 | 2.1 |
| BRRI dhan69 | 18.2 | 9.1 | 32.4 | 1.7 |
| **Mean** | 19.4 | 8.8 | 32.9 | 1.9 |
| **STDEV** | 2.2 | 2.3 | 6.8 | 0.4 |
| **Max** | 24.0 | 17.5 | 48.1 | 3.1 |
| **Min** | 16.3 | 5.9 | 18.0 | 1.3 |
| **Ranges** | 16.3-24.0 | 5.9-17.5 | 18.0-48.0 | 1.3-3.1 |

**Table 1:** Mineral profiling of 30 Boro season grown BRRI HYVs in Bangladesh.

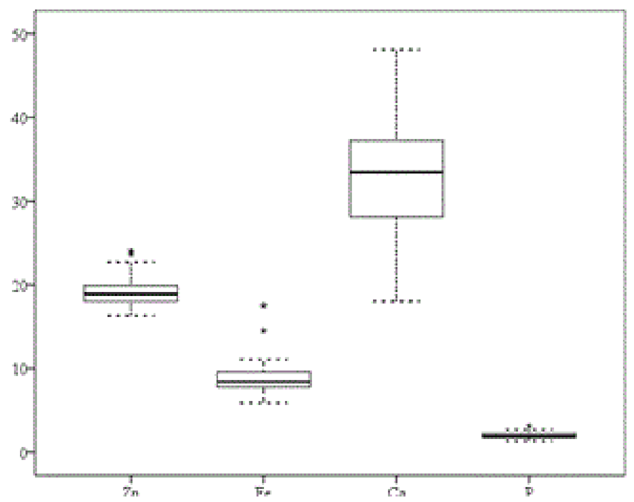


**Figure 1:** Mineral profiling data representation of 30 BRRI HYVs for Boro season.

| Aus HYVs data for mineral profiling. | | | | |
|---|---|---|---|---|
| **HYVs** | **Zn (mgKg-1)** | **Fe (mgKg-1)** | **Ca (mgKg-1)** | **P (gKg-1)** |
| BR20 | 17.5 | 19.1 | 26.1 | 3.1 |
| BR21 | 22.1 | 18.0 | 76.0 | 2.2 |
| BR24 | 20.7 | 7.9 | 82.0 | 1.9 |
| BR26 | 18.7 | 10.7 | 84.9 | 3.3 |
| BRRI dhan27 | 16.1 | 7.8 | 32.2 | 1.6 |
| BRRI dhan27 | 16.1 | 7.8 | 32.2 | 1.6 |
| BRRI dhan42 | 27.0 | 3.9 | 85.0 | 2.5 |
| BRRI dhan43 | 38.4 | 17.0 | 68.1 | 2.5 |
| BRRI dhan48 | 13.2 | 8.5 | 83.1 | 2.7 |
| BRRI dhan65 | 17.1 | 15.4 | 86.0 | 2.8 |
| **Mean** | 20.7 | 11.6 | 65.6 | 2.4 |
| **STDEV** | 7.3 | 5.3 | 25.0 | 0.6 |
| **Max** | 38.4 | 19.1 | 86.0 | 3.3 |
| **Min** | 13.2 | 3.9 | 26.1 | 1.6 |
| **Ranges** | 13.2-38.4 | 3.9-19.1 | 26.1-86.0 | 1.6-3.3 |

**Table 2:** Mineral profiling of 10 Aus season grown BRRI HYVs in Bangladesh.

BR17 showed the highest content of Fe (17.5 ppm) followed by BRRI dhan35 (14.5 ppm), BRRI dhan64 (11.1 ppm), BRRI dhan58 (9.9 ppm) and BR12 (9.8 ppm). BR7 showed the highest content of Ca (48.1ppm) followed by BR2 (42.1 ppm), BR1 (41.1 ppm), BRRI dhan28 (41.8 ppm) and BR19 (39.9 ppm). BRRI dhan64 showed the highest content of P (3.1 $gKg^{-1}$) followed by BR1 (2.7 $gKg^{-1}$) and BR6 (2.4 $gKg^{-1}$) in Boro season (Table 1). A total of 10 BRRI Aus HYVs were studied in this experiment and all mineral profiling data are summarized in Table 2 and Figure 2.

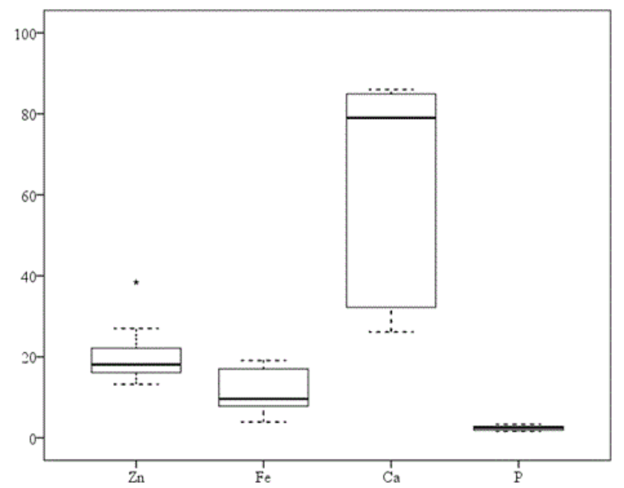


**Figure 2:** Mineral profiling data representation of 10 BRRI HYVs for Aus season.

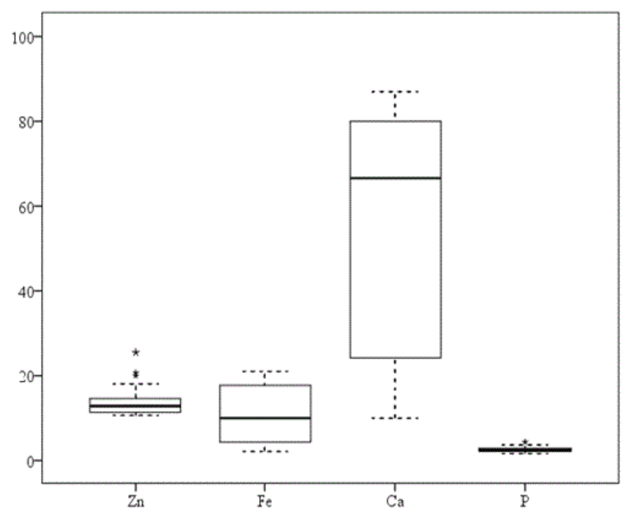


**Figure 3:** Mineral profiling data representation of 28 BRRI HYVs for Aman season

| **Aman HYVs data for mineral profiling** | | | | |
|---|---|---|---|---|
| **HYVs** | **Zn ($mgKg^{-1}$)** | **Fe ($mgKg^{-1}$)** | **Ca ($mgKg^{-1}$)** | **P ($gKg^{-1}$)** |
| BR4 | 12.0 | 16.1 | 17.8 | 2.7 |
| BR5 | 12.6 | 2.1 | 71.2 | 1.6 |
| BR10 | 14.0 | 4.1 | 56.0 | 1.7 |
| BR11 | 11.0 | 19.0 | 34.0 | 2.3 |
| BR22 | 11.0 | 19.0 | 66.0 | 1.9 |
| BR23 | 12.8 | 17.6 | 14.5 | 2.1 |
| BR25 | 20.7 | 3.8 | 81.0 | 1.7 |
| BRRI dhan30 | 14.4 | 9.9 | 81.0 | 3.0 |
| BRRI dhan31 | 11.0 | 17.3 | 81.0 | 2.9 |
| BRRI dhan32 | 25.4 | 3.5 | 83.0 | 1.7 |
| BRRI dhan33 | 18.1 | 3.0 | 74.9 | 2.4 |
| BRRI dhan34 | 17.4 | 19.0 | 38.1 | 3.6 |
| BRRI dhan37 | 13.1 | 17.9 | 86.0 | 3.2 |
| BRRI dhan38 | 11.0 | 20.0 | 25.4 | 2.8 |
| BRRI dhan39 | 11.0 | 9.8 | 69.0 | 2.5 |
| BRRI dhan40 | 11.4 | 2.6 | 74.0 | 2.4 |
| BRRI dhan41 | 12.0 | 21.0 | 17.3 | 2.2 |
| BRRI dhan44 | 11.6 | 16.2 | 9.8 | 2.4 |
| BRRI dhan46 | 14.4 | 5.3 | 78.6 | 4.3 |
| BRRI dhan49 | 12.5 | 10.6 | 86.9 | 3.3 |
| BRRI dhan51 | 10.5 | 8.4 | 67.0 | 2.7 |
| BRRI dhan52 | 12.7 | 5.0 | 85.0 | 2.1 |
| BRRI dhan53 | 12.0 | 10.7 | 59.6 | 3.2 |
| BRRI dhan54 | 12.7 | 6.9 | 13.4 | 2.5 |
| BRRI dhan56 | 14.3 | 3.8 | 79.0 | 2.5 |
| BRRI dhan57 | 11.0 | 6.1 | 22.9 | 2.4 |
| BRRI dhan62 | 20.0 | 21.0 | 14.0 | 2.7 |
| BRRI dhan66 | 16.8 | 4.5 | 62.0 | 1.6 |
| Mean | 13.8 | 10.9 | 55.3 | 2.5 |
| STDEV | 3.6 | 6.8 | 27.8 | 0.6 |
| Max | 25.4 | 21.0 | 86.9 | 4.3 |
| Min | 10.5 | 2.1 | 9.8 | 1.6 |
| Ranges | 10.5-25.4 | 2.1-21.0 | 9.8-86.9 | 1.6-4.3 |

**Table 3:** Mineral profiling of 28 Aman season grown BRRI HYVs in Bangladesh.

Our data reveals that BRRI dhan43 possess the highest Zn content of 38.4 ppm ($mgKg^{-1}$) followed by BRRI dhan42 (27.0 ppm), BR21(22.1 ppm) and BR24 (20.7) at clean rice condition. BR20 showed the highest content of Fe (19.1 ppm) followed by BR21 (18 ppm) and

BRRI dhan43 (17.0 ppm). BRRI dhan65 showed the highest content of Ca (86.0 ppm) followed by BRR1 dhan42 (85.0 ppm), BR26 (84.9 ppm), BRRI dhan48 (83.1 ppm), BR24 (82.0 ppm) and BR21(76.0 ppm).

BR26 showed the highest content of P (3.3 $gKg^{-1}$) followed by BR20 (3.1 $gKg^{-1}$) and BRRI dhan65 (2.8 $gKg^{-1}$) in Aus season (Table 2). A total of 28 BRRI Aman HYVs were studied in this experiment and all mineral profiling data are summarized in Table 3 and Figure 3.

Our data reveals that BRRI dhan32 possess the highest Zn content of 25.4 ppm ($mgKg^{-1}$) followed by BR25 (20.7 ppm) and BRRI dhan62 (20.0 ppm) at clean rice condition. BRRI dhan62 showed the highest content of Fe (21.0 ppm) followed by BRRI dhan38 (20 ppm), BRRI dhan34 (19.0 ppm), BR11 (19.0 ppm), BR22 (19.0 ppm), BRRI dhan37 (17.9 ppm), BR23 (17.6 ppm), BRRI dhan31 (17.3 ppm), BR4 (16.1 ppm), BRRI dhan53 (10.7 ppm) and BRRI dhan49 (10.6 ppm). BRRI dhan49 showed the highest content of Ca (86.9 ppm) followed by BRR1 dhan37 (86.0 ppm), BRR1 dhan52 (85.0 ppm), BRR1 dhan32 (83.0 ppm), BRR1 dhan31 (81.0 ppm), BRR1 dhan30 (81.0 ppm) and BR25 (81.0 ppm). BRRI dhan34 showed the highest content of P (3.6 $gKg^{-1}$) followed by BRRI dhan49 (3.3 $gKg^{-1}$), BRRI dhan53 (3.2 $gKg^{-1}$), BRRI dhan37 (3.2 $gKg^{-1}$) and BRRI dhan30 (3.0 $gKg^{-1}$) in Aman season (Table 3).

Phytic acid (PA) and molar ratio of phytate to respective minerals such as Zn, Fe, Ca and P were analyzed for 15 HYVs including Aus, Aman and Boro season. All of the selected HYVs Zn content were ≥ 20.0 ppm at clean rice condition. PA content and PA/Zn, PA/Fe, PA/Ca and Pa/P data were presented in tabular form in Table 4. In Aman season, BR25, BRRI dhan32 and BRRI dhan62 possess higher Zn content (≥ 20 ppm) and their PA values are 19.1,19.9 and 19.1 $mgg^{-1}$ respectively. Molar ratio of PA/Zn, PA/Fe, PA/Ca and PA/P ranges from 7.7 to 9.4, 7.7 to 48.5, 1.4-8.3 and 33.2-56.6 respectively. Lower in molar ratio of PA to respective minerals (Zn, Fe, Ca and P) indicate higher bioavailability of minerals (Table 4). In Aus season, BR21, BR24, BRRI dhan42 and BRRI dhan43 possess higher Zn content (≥ 20 ppm) and their PA values are 14.98,19.07, 14.30 and 13.89 $mgg^{-1}$ respectively. Molar ratio of PA/Zn, PA/Fe, PA/Ca and PA/P ranges from 2.1 to 9.1, 6.9 to 30.8, 1.02-1.4 and 8.7-47.4 respectively. Lower in molar ratio of PA to respective minerals (Zn, Fe, Ca and P) indicate higher bioavailability of minerals. Considering above parameters, BRRI dhan43 seems the best HYV for micronutrient enriched HYV in Aus season in Bangladesh whose PA/Zn (3.56), PA/Fe (6.93), PA/Ca (1.24) and PA/P (25.69) values are also the lowest among other HYVs. Lower in molar ratio of PA to respective minerals (Zn, Fe, Ca and P) indicate higher bioavailability of minerals (Table 4). In Boro season, BR1, BR6, BR7, BRRI dhan35, BRRI dhan36, BRRI dhan47 and BRRI dhan64 possess higher Zn content (≥ 20 ppm) and their PA values are 20.4, 23.0, 28.6, 21.7, 15.0, 24.2 and 24.1 $mgg^{-1}$ respectively. Molar ratio of PA/Zn, PA/Fe, PA/Ca and PA/P ranges from 6.3 to 12.4, 12.7 to 31.1, 1.7-7.8 and 20.0-81.3 respectively. Lower in molar ratio of PA to respective minerals (Zn, Fe, Ca and P) indicate higher bioavailability of minerals. Considering above parameters, BR7, BRRI dhan47 and BRRI dhan64 had shown better HYV for micronutrient enriched HYV in Boro season in Bangladesh. Lower in molar ratio of PA to respective minerals (Zn, Fe, Ca and P) indicate higher bioavailability of minerals (Table 4). Both BRRI dhan62 and BRRI dhan64 were released as two high zinc enriched HYVs in Bangladesh in 2013 and 2014 for Aman and Boro season respectively.

Since detailed mineral profiling of Zn, Fe, Ca and P were not taken into account earlier until this present report, so, mineral profiling of these selected 68 BRRI HYVs are potentially very important for maintaining database. We have reported 15 HYVs are having Zn content more than 20 ppm including BRRI dhan62 and BRRI dhan64. Interestingly our data reveals BRRI dhan43 possess the highest Zn content (38.4 ppm) among all HYVs. BRRI dahn43 is a Aus season grown HYV and it shows lower Phytate to mineral molar ratio such as PA/Zn (3.56), PA/Fe (6.93), PA/Ca (1.24) and PA/P (25.69) which resembles that it may show higher bioavailability of minerals (Table 4).

| Season | HYVs | PA ($mg^{-1}$) | PA/Zn | PA/Fe | PA/Ca | PA/P |
|---|---|---|---|---|---|---|
| Aman | BR25 | 19.1 | 9.1 | 42.9 | 1.4 | 52.4 |
| | BRRI dhan32 | 19.9 | 7.7 | 48.5 | 1.5 | 56.6 |
| | BRRI dhan62 | 19.1 | 9.4 | 7.7 | 8.3 | 33.2 |
| | Mean | 19.3 | 8.7 | 33.0 | 3.7 | 47.4 |
| | STDEV | 0.4 | 0.7 | 18.1 | 3.2 | 10.2 |
| | Range | 19.1-19.9 | 7.7-9.4 | 7.7-48.5 | 1.4-8.3 | 33.2-56.6 |
| Aus | BR21 | 14.98 | 6.68 | 7.06 | 1.19 | 31.70 |
| | BR24 | 19.07 | 9.06 | 20.42 | 1.41 | 47.39 |
| | BRRI dhan42 | 14.30 | 5.21 | 30.81 | 1.02 | 26.76 |
| | BRRI dhan43 | 13.89 | 3.56 | 6.93 | 1.24 | 25.69 |
| | Mean | 15.56 | 6.13 | 16.31 | 1.22 | 32.89 |
| | STDEV | 2.06 | 2.02 | 10.01 | 0.14 | 8.68 |
| | Range | 13.9-19.1 | 3.6-9.1 | 6.9-30.8 | 1.2-1.4 | 25.7-47.4 |
| Boro | BR1 | 20.4 | 9.5 | 22.2 | 3.0 | 35.6 |
| | BR6 | 23.0 | 9.5 | 20.6 | 4.1 | 45.1 |
| | BR7 | 28.6 | 12.4 | 31.1 | 3.6 | 79.0 |
| | BRRI dhan35 | 21.7 | 9.9 | 12.7 | 4.9 | 42.4 |
| | BRRI dhan36 | 15.0 | 6.3 | 13.2 | 2.6 | 39.1 |
| | BRRI dhan47 | 24.2 | 11.2 | 23.1 | 4.2 | 81.3 |
| | BRRI dhan64 | 24.1 | 9.9 | 18.4 | 7.8 | 36.5 |
| | Mean | 22.4 | 9.8 | 20.2 | 4.3 | 51.3 |
| | STDEV | 4.2 | 1.9 | 6.3 | 1.7 | 20.0 |
| | Range | 15.0-28.6 | 6.3-12.4 | 12.7-31.1 | 2.6--7.8 | 35.6-81.3 |

**Table 4:** Phytic acid (PA) content of 15 selected HYVs (≥ 20 ppm Zn) and molar ratio of Phytate to minerals (Zn, Fe, Ca and P).

## Conclusion

BRRI has released four Zn enriched HYVs in Bangladesh such as BRRI dhan62, BRRI dhan72 for Aman season and BRRI dhan64, BRRI dhan74 for Boro season in Bangladesh. Since there is no reported high Zn enriched HYV in Aus season yet, we would like to conclude that

BRRI dhan43 has the highest Zn content (38.4 ppm) at Aus season in Bangladesh. BRRI dhan43 is also enriched with Fe (17 ppm), Ca (68.1 ppm) and P (2.5 $gKg^{-1}$). Since it's molar ratio to Zn (PA/Zn); Fe (PA/Fe); Ca (PA/Ca) and P (PA/P) are lower among all 15 selected high Zn enriched HYVs by 3.56, 6.93,1.24 and 25.69 respectively, so essential micronutrients will be maximum bio available by consuming BRRI dhan43 in Bangladesh. BRRI dhan43 can be used as a potential parental source or donor for further micronutrient specially zinc (ZnER) breeding program in Bangladesh.

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## References

1. Melissa AF, Susan RM, Robert DH (2009) Review: Not just a grain of rice: the quest for quality. Trends in Plant Science 14: 133-139.
2. Welch RM, Graham RD (2004) Breeding for micronutrients in staple food crops from a human nutrition perspective. J Exp Bot 55: 353-364.
3. Welch R, Graham RD (1999) A new paradigm for world agriculture: meeting human needs. Productive, sustainable, nutritious. Field Crops Res 60: 1-10.
4. Food and Agriculture Organization of the United Nations (2004) Undernourishment around the World. The state of food insecurity in the world website.
5. Van Staa TP, Dennison EM, Leufkens HG, Cooper C (2001) Epidemiology of fractures in England and Wales. Bone 29: 517-522.
6. Sunanda D, Jahida G (2017) Different forms of malnutrition among under five children in Bangladesh: a cross sectional study on prevalence and determinants. BMC Nutrition 3:1.
7. National Micronutrient Survey 2011-12 (2013) Final Report ICDDR,B UNICEF, Bangladesh GAIN Institute of Public Health and Nutrition.
8. Slavin J (2003) Why whole grains are protective: biological mechanisms. Proc Nutr Soc 62: 129-134.
9. Rimbach G, Brandt K, Most E, Pallanf J (1995) Supplemental phytic acid and microbial phytase change zinc bioavailability and cadmium accumulation in growing rats. J Trace Elements in Medical Biology 9: 117-122.
10. Sandstead HH (1991) Assessment of Zinc Nutriture. J Labor and Clini Medi 118: 299-300.
11. Graf E, Eaton JW (1984) Effects of Phytate on Mineral Bioavailability in Mice. J Nutr 114: 1192-1198.
12. Kabir MS, Salam MU, Chowdhury A, Rahman NMF, Iftekharuddaula KM, et al. (2015) Rice Vision for Bangladesh: 2050 and Beyond. Bangladesh Rice J 19: 1-18.
13. AOAC (1995) Official procedure of mineral estimations (Zn, Fe and Ca,) of Association of Official Agricultural Chemists (AOAC).
14. Yoshida SD, Forno DA, Cock J, Gomez K (1976) Laboratory Manual for Physiological Studies of Rice. International Rice Research Institute (IRRI), Philippines, pp: 17-18.