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Study on trace elements of popular rice varieties in Bangladesh

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Abstract

Rice (*Oryza sativa*) is as staple food in Asian countries and major source of nutrients for mass people especially in Bangladesh. Here different rice varieties are grown in three rice growing seasons per year *viz.* Aus, Aman and Boro. Rice, being a staple in the diet of Bangladeshi people and a source of heavy metal, intake of heavy metal is increasing day by day which is very injurious to health. So it is very important to estimate the elemental analysis of heavy metal present in rice. In this study the Atomic Absorption Spectrophotometry (AAS) method was used where four rice varieties (Minicat, BRRI 28, BRRI 29, Swarna) from field and market were evaluated. The highest amount of calcium, phosphorus, iron and zinc were found 60.62mg/100g in Minicat from market, 276mg/100g in Minicat from field, 5.13mg/kg in Minicat from market, 16.20mg/kg in Minicat from market, respectively. All of the elements detected in the rice were very low in concentration or within normal limits for consumption. Copper (Cu), Manganese (Mn), Chromium (Cr), Lead (Pb) and Cadmium (Cd) content of these rice varieties between field and market rice were found 2.93-5.67, 3.66-9.55, 0.16-0.57, 0.13-0.94, 0.19-0.93 mg/kg respectively. High level of Zinc (Zn) and Iron (Fe) were found in Minicat from market rice than field rice. Manganese content was high in field and market Swarna compared to all other rice varieties. Daily dietary intake of the individual elements supplied through rice were calculated and compared with the available literature values of daily allowances. It can be concluded that Manganese (Mn) and Cadmium (Cd) concentration in rice samples indicate possible health risk to the consumer.

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Introduction

Rice isthe most important staple cereals in human nutrition, consumed by about 75% of the global population. About 90% of the rice is produced in Asia. Considering the increasing demand of rice due to population increase and decreasing land and water resources available for rice cultivation, it is critical to develop and use rice technologies that will result in higher yields (Virmani and Kumar, 2004).Bangladesh is famous for extensive rice biodiversity because geographical and agronomic conditions are favorable for rice cultivation. The total area of rice in Bangladesh is about 10.15 million hectares with a production of 25.23 million tons (BBS, 2010). This increased rice production has been possible largely due to the adoption of modern rice varieties on around 66% of the rice land which contributes to about 73% of the country's total rice production. Although the national average yield of rice in Bangladesh is low (2.77t/ha), while yields of the other rice growing countries of Asia such as, China, Taiwan, Indonesia, and Japan are 5.72, 4.60, 4.38, and 5.97 t/ha, respectively (Quayum *et al.*1996). Hybrid rice was successfully developed in China where about 50% rice area is now under it (Yuan, 1994). Hybrid rice in China produced a yield advantage of 1.0-1.5 t/ha (20-30%) over the conventionally bred varieties (Virmani, 1994).The production of rice depends on both producers' and consumers' preference. It varies from variety to variety and the rice consumption depends on consumers' preference. Usually they were very concerned about the quality and price of the commodity when they made a purchase (Diako *et al.,* 2010).

Many mineral elements occur in living systems in "trace" quantities. Of the 90 naturally occurring elements, whereas for humans 25 elements (C, H, N, O, S, P, K, Mg, Ca, Cl, Na, F, Si, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Se, Mo, Sn and I) are currently known to be essential . In addition, two other elements, Al and Li, have recently been included as possibly essential. The 25 essential elements include 4 light metals (Na, K, Mg and Ca) and 10 heavy metals (Cr, Mn, Fe, Co, Ni, Cu, Zn, Se, Mo and Sn).

The major entry of trace elements into the body is through diet. Rice (*Oryza sativa* L.), being a staple in the diet of many people in Asian countries, supplies a major proportion of the total daily intake of major and trace elements by these people. Unfortunately, populations of many of the main rice consuming countries suffer from nutrient-deficiency-related diseases, with an insufficient intake of important essential elements in their diet. Moreover, in some cases, diet is also an important source of toxic elements. Brazil is the most important non-Asian producer of rice and the consumption per person is around 86 g/day (31.3 Kg/year).Recently concern has been raised about possible contamination of rice worldwide by heavy metals (Fu *et al.* 2008), which is more acute in Bangladesh. During the postharvest processing, the extent of milling of cereal grains is known to affect the trace element content of cereals such as rice. Milling not only removes the outer layers of the grain which are rich in minerals but also could potentially contaminate the rice grain with trace elements (Jayasekera and Freitas, 2004).

Soils can be contaminated by highly toxic heavy metals (such as As, Cu, Cd, Pb and Hg) from either aerial depositions or irrigation.

The heavy metals are likely to induce a corresponding contamination in paddy (Nan *et al.*, 2002). Paddy in or close to contaminated sites can uptake and accumulate these metals, and then exert potential risk to humans and animals (Fu *et al.*, 2008). Malfunction of organs and chronic syndromes may be caused by ingestion of relatively low doses of toxic heavy metals over a long period present in rice. Lead, cadmium and arsenic are from the prevalent toxic elements in food and environment that have a long half-life after the absorption in humans and animals can make unsought and unpleasant effects such as damage to internal organs, the nervous system, kidneys, liver and lungs (Oliver, 1997; Oymak, 2009) Major disadvantages of these heavy metals are such as neurological disorders (Parkinson's, Alzheimer's, depression, schizophrenia), cancers, nutrient deficiency, imbalance of hormones, obesity, abortion, cardiopulmonary disorders, cardiovascular disease, damage to liver, kidneys and brain, allergy and asthma, endocrine disorders, viral infections, reduces the body's tolerance, dysfunction of enzymes, changes in metabolism, infertility, anemia, fatigue, nausea and vomiting, headache and dizziness, irritability, weakened immune systems, gene damage, premature aging, skin disorders, memory loss, loss of appetite, arthritis, hair loss, osteoporosis, insomnia and even death (Fu *et al.*, 2008). Due to the industrial activity contamination of the ground water will be increases (Kanchana, 2012).

Heavy metal ions are essential micronutrients for plant metabolism but when present in excess, can become extremely toxic (Begum, 2009). Trace elemental analysis of this crop and its products is therefore important on an essential, nutritional and toxicological level.

The present study has been undertaken to determine elemental composition of popular rice varieties of Bangladesh from field and market, to compare the composition of experimental rice varieties between field and market rice, to determine the daily intake metal of rice varieties, to identify health risk index of rice varieties.

Materials and methods

Sampling Site Description

Samples were collected from four different area in Bangladesh. These area were Kushtia, Mymensingh, Gazipur, and Savar, Dhaka. Kushtia (23.89092 ° N, 89.10520° E at decimal minutes) is located at Khulna division of Bangladesh and Gazipur (23.989014° N, 90.418167° E at decimal minutes) is located at Dhaka division in Bangladesh. Mymensingh is located to the northeast site of Bangladesh. Mynensingh located at (24.753889° N, 90.4030559° E decimal minutes) and Savar (23.8583° N, 90.8583° E at decimal minutes) is located at Dhaka division of Bangladesh.

Sample collection and preparation

Different varieties of rice were collected from field and market from different areas of Bangladesh. The varieties were BRRI 28, BRRI 29, Minicat and Swarna.

The four rice varieties (Amannon aromatic) were collected in clean polyethylene bags from three different rice field for each sampling sites and removethehuskanddriedfor24 hrinanovenat35° Cina glass beaker to constant weight. Then their samples were ground to fine powder by using a blender and finally with mortar and pestle, Preserved in a desiccators until analysis.

These rice samples were further dried in an oven at 60°Cuntil constant weight was obtained for elemental analysis. The dried samples were finally ground in acarbidemortar with a pestle and preserved in polye thylene bag sin desiccators until subsequent analysis. Aminimum of 3 pellets of each samples were made to reduce the error in the analysis.

Determination of calcium content

Calcium is precipitated as oxalate. The precipitate dissoluble in dilute H_2SO_4 and titrate with standard $KMnO_4$.

Take 25 ml of the mineral solution .Add 100 ml distilled water. Add few drops (approximately 2 drops) of methyl red indicator. Mixture neutralized with ammonia tillk the pink color change to yellow. The solution was heated to boiling point and added 5 ml of 6% ammonium oxalate .Then allowed to boiling for a few minutes Add glacial acetic acid till the color is distinctly pink. Keep the mixture in a warm place to settle down the precipitation.

The supernatant is tested with drops of ammonium oxalate solution. Then precipitate was filtered through filter paper and washed with warm water till it was free from oxalate.

The precipitate was transferred into a beaker by piercing a hole in the filter paper and dilute about 5-10 ml (2N) H_2SO_4.Solution heated to about 70 c. Then titrated against N/100 $KMnO_4$solution till deep brown color. Calcium content was calculated by the following formula:

$$\text{mg of Ca/100gm} = \frac{\text{Titrate Valu} \times 0.2 \times \text{Total volume of ash solution}}{\text{Volume taken for estimation} \times \text{weight of sample taken for ashing}} \times 100$$

Determination of phosphorus content

Determination of phosphorus carry out by using colorimetric procedure. A blue color formed when the ash solution is treated with ammonium molybdate and the phosphomolybdate thus formed is reduced.

Take 0.1 ml of mineral solution. Add 1 ml ammonium molybdate. Add 1 ml hydroquinone. Add 1 ml of Na_2SO_3 solution. Mixing well after each addition.

The volume is than made up to 15 ml with distilled water and the solution is thoroughly mixed up. After 30 minutes the optical density of the solution is measured in a photoelectric colorimeter against 660 nm. A blank sample run off side by side.

The phosphorus content of the sample was calculated from a standard curve prepared with standard phosphate solution (range 0.01- 0.1).

Elemental (Zn, Fe, Cu, Mn, Cr, Cd, Pb) analysis of rice.

Digestion procedures

For digestion with wet ashing, 1.0 gm of rice samples were used. Wet digestion of samples was performed by using mixtures of two acids, namely, HNO_3–HCl. 6 ml of concentrated HNO_3 was used for 1.0 gm of sample. Each mixture was heated on the hot plate. Gently boil unit 1-2 ml digest remain.

Then 5 ml concentrated HCl was added. Increase heat and boil until 2 ml volume remain.

After cooling the residue was filtered through blue band filter paper. Then the sample was diluted to 25 mL with distilled water (Janati *et al*, 2011).

Calibration Curves

Four external standard curves were constructed using reference standard to qualify the metals (Cd, Pb, Cu, Zn, Cr, Mn, and Fe) content in all samples. Calibration curves were performed with five or six different concentrations.

The square of correlation coefficient (r2) were 0.989, 0.997, 0.996, 0.998, 0.979 and 0.998 for Cd, Pb, Cu, Zn, Cr, Mn and Fe respectively.

Daily intake of metals (DIM)

$$\text{Daily intake of metal(DIM)} = \frac{C(\text{metal}) \times D(\text{food intake})}{B(\text{average weight})}$$

Where Cmetal, D food intake, and Baverage weight represent the heavy metal concentrations in rice (µg/g), daily intake of rice and average body weight, respectively.

The FAO statistics show that each person in Bangladesh Consumes 160kilograms of rice a year, so From that statistics, Daily consumption per person is 438gm (approximately).

The average body weight (Baverage weight) wastakenas70kg for adults according to WHO guide line (WHO1993).

Health risk index (HRI)

Value of Health Risk Index (HRI) depend son the daily intake of metals (DIM) through food stuff and oral reference dose (RfD). Rf Disanestimated per day exposure of metal to human body that has no hazardous effect during lifetime (US-EPAIRIS2006).

The health risk in dex for Cr, Fe, Cu, Pb, Cd, Mnand Zn by consumption of rice was calculated by the following equation (Cui *et al*. 2004).

HIR= DIM/Rf$_D$

OralreferencedosesForCr,Cu,Pb,Cd,MnandZnwere1.5, 0.04,0.004,0.001,0.033and0.30(mg/kg body w t/day) respectively (USEPAIRIS2006) and 3.01 mg/day for Co(Food and Nutritional Board, 2004).

The Reference Dose (Rf$_D$) for inorganic arsenic is 0.0003 mg/day based on hyperpigmentation, keratosis, and possible vascular complications in humans (USEPA1998).

Estimated exposure is obtained by dividing daily intake of Heavy metals by their safe limit. Anindexmore than 1is considered as not safe for human health (USEPA2002).

Results and discussion

Calcium content

The present observation was showed that the calcium content of all rice varieties varied from 49.16 to 60.26mg/100g. Minicat from market showed highest amount of calcium (60.26mg/100g). Food Standard Agency and Institute of Food Research (2002) observed the calcium content of rice was 51.00 mg/100g, which is close consistency with the study.

Table 1. Calcium content of rice varieties from field and market.

Name of Variety	Field mg/100g	Market mg/100g
BRRI 28	53.94±2.01	54.12±1.87
BRRI 29	49.16±1.66	51.13±2.08
Minicat	58.64±3.56	60.26±0.96
Swarna	51.06±.065	53.69±3.05

*Data presented as mean value ± SD of triplicate determination.

The lowest amount calcium was found in BRRI 29 (49.16 mg/100g) from field shown in Table 1.

Phosphorus content

Phosphorus content of BRRI 28, BRRI 29, Minicat and Swarna from field were 272, 210, 276, 265mg/100g respectively. Maximum amount of phosphorus were found in Minicat (276 mg/100g) from field. Juliano (1985), Pedersen & Eggum (1983) observed the phosphorus content of rice was 80.00-150.00 mg/100g.

The lowest amount was found in BRRI 29 (107mg/100g) from market shown in Table 2.

Table 2. Phosphorus content of rice varieties from field and market.

Name of Variety	Field (mg/100g)	Market (mg/100g)
BRRI 28	272±3.67	247±5.89
BRRI 29	210±1.90	107±1.73
Minicat	276±4.34	130±2.19
Swarna	265±2.98	139±3.08

*Data presented as mean value ± SD of triplicate determination.

Table 3. Zn, Fe, Mn, Cu, content of rice from field and market.

Name of variety	Zn (mg/kg)		Fe (mg/kg)		Mn (mg/kg)		Cu (mg/kg)	
	Field	Market	Field	Market	Field	Market	Field	Market
BRRI 28	14.50±1.73	15.42±1.07	3.71±0.54	5.12±0.34	7.78±0.14	6.56±0.85	5.67±0.08	4.48±0.06
BRRI 29	12.06±1.06	10.34±0.19	3.80±0.29	4.11±0.24	5.59±0.19	3.66±0.19	5.66±0.03	4.72±0.89
Minicat	14.51±2.10	16.20±1.30	4.63±0.71	5.13±0.44	8.93±0.21	7.08±0.48	3.17±0.01	2.93±0.76
Swarna	12.12±1.09	14.25±0.99	3.53±0.13	4.97±0.67	9.55±0.53	7.81±0.37	3.64±0.07	3.61±0.49

*Data presented as mean value ± SD of triplicate determination.

Zinc (Zn), Iron (Fe), Manganese (Mn), Copper (Cu) content

According to this report, Zinc was found in highest amount of Minicat (16.20 mg/kg) from market which is shown in Table 3.

Iron content of present study range from 3.53 to 5.13mg/100g between field and market rice.

The highest amount of iron was observed in Minicat (5.13mg/kg) from which is shown in Table 3.

Shahidur *et al.* (2008) showed iron content in different rice varieties from 0.77 to 0.91 mg/100g. Manganese content by this study ranges from 3.66 to 9.55 mg/kg and maximum amount was found in Swarna from field and market rice shown in Table 3. Manganese content of some sample from different area of Bangladesh was found to be higher than world standard limit of 5.4(FAO/WHO1984).

The range of Cu content was found 2.93 to 5.67which islowerthanworldstandardlimitof10mg/kg(FAO/WHO1984).

Table 4. Daily intakeof metal (DIM) by consumption ofrice from field and market.

	DIM mg/person/day											
Name of variety	Cu		Zn		Mn		Cd		Cr		Pb	
	Field	Market	Field	Market	Field	Market	Field	Market	Field	Market	Field	Market
BRRI 28	0.035	0.028	0.090	0.096	0.048	0.041	0.004	0.004	0.001	0.003	0.004	0.003
BRRI 29	0.034	0.029	0.075	0.065	0.034	0.022	0.003	0.003	0.001	0.002	0.005	0.002
Minicat	0.019	0.018	0.090	0.101	0.055	0.044	0.004	0.005	0.002	0.003	0.002	0.001
Swarna	0.022	0.028	0.076	0.085	0.059	0.048	0.001	0.005	0.001	0.004	0.003	0.005
Recommend	2.00-3.00		12.00-15.00		2.00-5.00		0.00-5.00		0.05-0.2		0.001-2.00 Value	

Reference of recommend value: Farid *et Al.* (2004); Huang *et al.* (2009); Dawd, G(2010); Ogabiela *et al.* (2011).

Table 5. HRI of heavy metal by consumption of rice from field and market rice.

Name of variety	Cu		Zn		Mn		Cd		Cr		Pb	
	Field	Market	Field	Market	Field	Market	Field	Market	Field	Market	Field	Market
BRRI 28	0.875	0.701	0.301	0.320	1.454	1.243	4.00	4.00	0.006	0.002	1.00	0.75
BRRI 29	0.850	0.722	0.250	0.212	1.0301	0.661	3.00	3.00	0.007	0.001	1.25	0.50
Minicat	0.475	0.450	0.300	0.334	1.667	1.334	4.00	5.00	0.013	0.002	0.50	0.02
Swarna	0.550	0.701	0.253	0.281	1.788	1.450	1.00	0.50	0.006	0.003	0.75	0.12

Lead content

The Lead content of this study varied from 0.13 to 0.94 mg/Kg shown in Fig 1. The amount of Lead content was highest in Swarna (0.94mg/Kg) from field and lowest in Minicat (0.13mg/Kg) from market and this range is lower than world safe limitof1mg/kg (FAO/WHO1984).

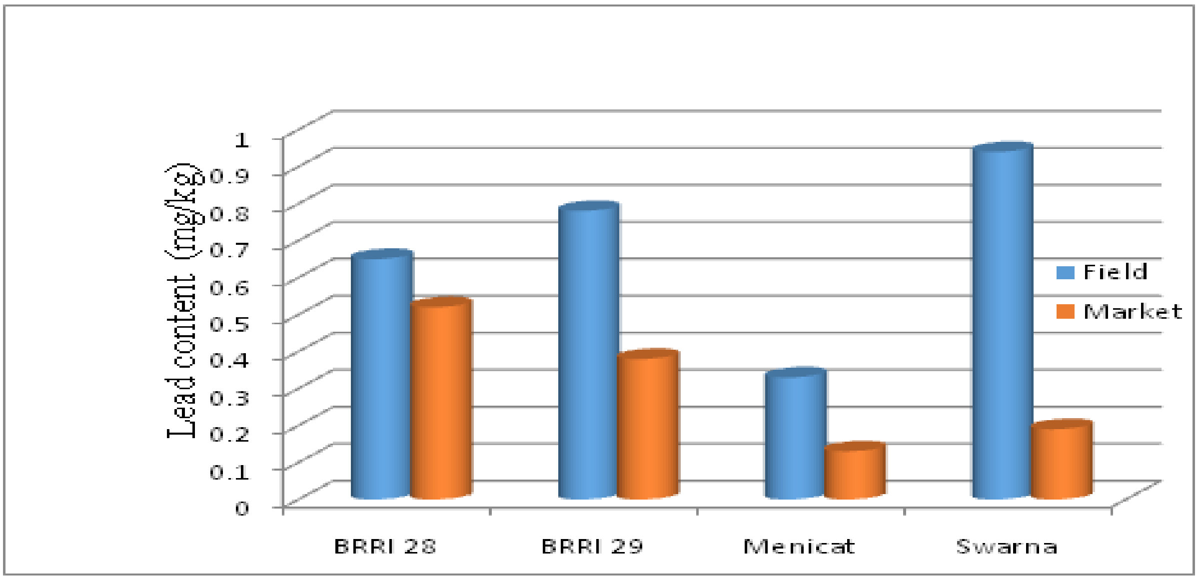

Fig. 1. Lead content of rice varieties from field and market.

Cadmium content

The present study reported that the range of cadmium from 0.19 to 0.93 mg/Kg (Fig. 2) followed rice varieties.

The amount of cadmium was highest in Minicat (0.93mg/Kg) from field and lowest in Swarna (0.19mg/Kg) from field.

Iimura *et al.*, (1981) observed Cadmium (Cd) content in un-polished rice grain of 0.75 and 4.85 mg /kg for rice.

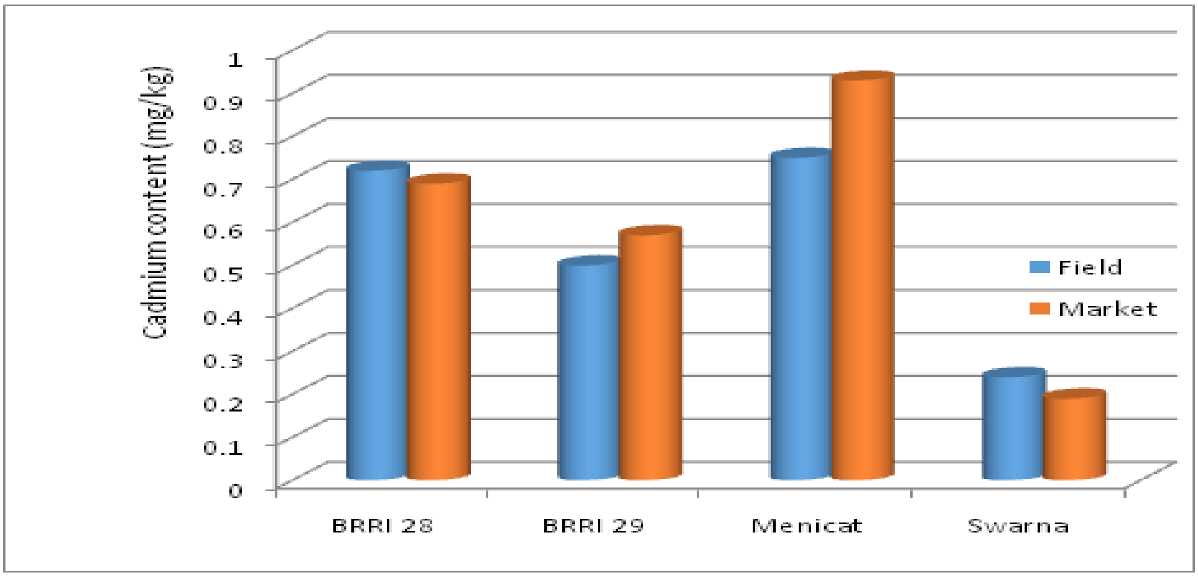

Fig. 2. Cadmium content of rice varieties from field and market.

Chromium content

The chromium content of this study was varied from 0.16 to 0.57 mg/Kg. The amount of chromium was highest in Swarna (0.57mg/Kg) from market and lowest in BRRI 29 (0.16mg/Kg) from field shown in Fig. 3. Higher level of chromium was found in all market rice than field rice.

Daily intake of metal (DIM)

Values for DIM calculated for adult(70 kg) are presented in Table4.

The range of daily intake of metal from field and market rice for Copper 0.018-0.035, Chromium 0.001-0.004, Zinc 0.075-0.101, Led0.001-0.005, Cadmium 0.001-0.005 and Manganese 0.022-0.059mg/person/day respectively.

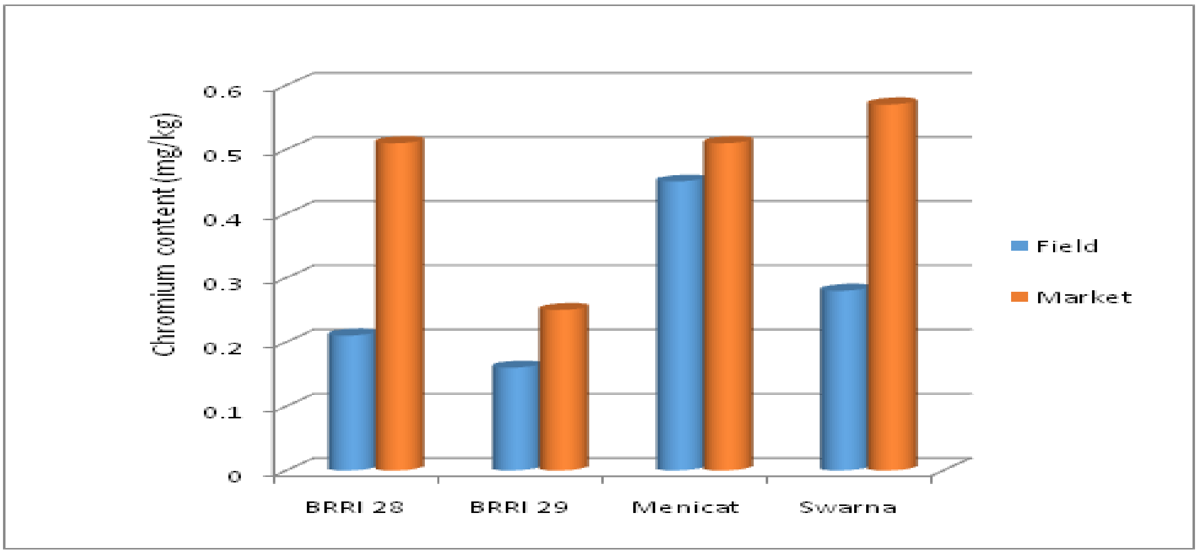

Fig. 3. Chromium content of rice varieties from field and market.

Health Risk Index (HRI)

The health risk in dex for heavy metals by consumption of rice from field and market different area of Bangladesh for adult was calculated and values are given in the Table 5.

HRI of Zn ranging from (0.212-0.33) which are acceptable level. The result revealed that Health Risk Index (HRI) for Cu 0.450-0.875and Cr 0.006-0.013 for rice from field and market are concernlowerthan1indicatingnorisk.

Conclusion

Maximum amount of calcium were found in all rice varieties from market than field rice. Lower level of phosphorus was found in all market rice than field rice. Highest amount of zinc and iron were measured in Minicat from market than field Minicat. Manganese content was highest in both field and market Swarna compare to all other rice varieties. Maximum amount of lead content was found in all field rice varieties than market rice. The level of cadmium was highest in Minicat from market than all others varieties. Chromium levels were found higher in market rice compare to field rice in respects of all varieties. Toxic element such as lead, chromium which are lower than the recommended value of WHO. It was found that in case of Daily Intake, the concentration of Cd was greater than 1 in all rice varieties from field and market except Swarna which is alarming for consumer's health. Concentration of Manganese was also greater than 1 in all varieties except BRRI 29. The present results revealed that Health Risk Index (HRI) for Cd and Mn are of public health concern among all rice varieties except Swarna and BRRI 29.

However, from over all study it can be concluded that Mn and Cd concentration in rice samples indicate possible health risk to the consumer. Further study on all other rice varieties for elemental analysis can be carried out.

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