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Heavy and Trace Elements in Some Varieties of Rice Consumed in Dhaka City of Bangladesh

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Abstract: Rice is the major staple food for Bangladeshi people for which it is urgent to determine the metal nutritional status as well toxicity of rice available in the local market. Therefore, the content of trace elements and heavy metals such as; Copper (Cu), Zinc (Zn), Iron (Fe), Nickel (Ni), Cobalt (Co), Cadmium (Cd) and Lead (Pb) were analyzed in rice samples purchased from the major markets in Dhaka City using Atomic Absorption Flame Spectrometry (AAFS). Microwave assisted digestion method was used for sample preparation to determine trace and heavy metals. The metals detected in rice samples ranged from 0.5 to 3.5 mg/kg of Cu, 3.63 to 82.38 mg/kg of Zn, 1.13 to 14.38 mg/kg of Fe 1.63 to 12.50 mg/kg of Mn, and 0 to 2.0 mg/kg of Ni. Whereas, the concentration of Pb and Cd were within < 0.05mg/Kg. Overall, the present study reveals that the levels of the trace elements were generally below permissible limits. However, Fe was found to be higher in some samples. Thus it is apparent that the metal concentration in rice of Dhaka is within the safety limit of consumption.

Keyword: Processed Rice, Heavy Metals, Trace Elements, Dhaka City and AAFS

Introduction

Rice (*Oryza sativa*) is one of the most important agricultural crops in Bangladesh. The quality of rice greatly affects human health, as consuming rice contaminated with cadmium (Cd), lead (Pb) and other metals can seriously deplete body stores of iron (Fe), vitamin C and other essential nutrients, leading to decreased immunological defenses, impaired psycho-social disabilities associated with malnutrition. In the past several decades, agrochemicals (phosphorus fertilizers) and organic fertilizers (manure and poultry litter) have been extensively applied. The use of chemical fertilizers and pesticides has increased since the last decade. The repeated applications of these agrochemicals potentially contributed to the accumulation of heavy metals in agricultural soils as some of these fertilizers and pesticides contain heavy metals such as Cd, Pb, Zn [Huang *et al.*, 2007]. These heavy metals ultimately bio-accumulate in the plant and endanger human health.

Heavy metal pollution is of significant ecological/environmental concern because they are not easily biodegradable or metabolized, thus precipitating far reaching effects on the biological system such as humans, animals, plants and soil biota [Yoon, 2003]. The impact of heavy metal on public health has drawn the attention of many researchers due to the fact that crops grown on contaminated soils and with fertilizers especially phosphate fertilizers containing cadmium (Cd) and other potential toxic heavy metals. Rice consumption is one major pathway of heavy metal bioaccumulation in human [Liu *et al.*, 2011]. Human exposures to heavy metals have been the focus of increasing attention among researchers, health and nutrition experts due to their impact in public health [Otitoju *et al.*, 2012]. Some researchers have revealed that rice contains higher heavy metal than other grains such as wheat and cereals. Heavy metal that commonly found in rice are such as iron (Fe), zinc (Zn), manganese (Mn), chromium (Cr), cobalt (Co), copper (Cu), arsenic (As), and cadmium (Cd) [Khairiah *et al.*, 2013]. Heavy metal can enter into the human body through three routes namely ingestion, inhalation and dermal contact, with ingestion as the main route of exposure to human [Cao *et al.*, 2010]. Cadmium is toxic to the kidney and has a long biological half-life in human. Lead has shown to be associated with de-amonification of central nervous system, leading to decrements of intelligence quotients in children [Jianjie *et al.*, 2008]. The major route for heavy metals exposure to human is mainly through soil–crop–food pathway. The residual plant components, including husk, straw and the root are partly returned to the soil and partly used as an ingredient in food for livestock, which is also a possible pathway for heavy metals to enter the human body by ingesting contaminated food.

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The main objective of the study is to assess the nutritional and toxic elements in processed rice samples collected from different markets of the Dhaka city of Bangladesh. The presence of heavy metals content such as Cd, Ni, Pb, Fe, Zn and Cu, reflects rice safety and health risk impact on human being. Along with that, results were compared with the permissible levels of heavy metals stated in FAO/WHO Codex Alimentarius Commission, (CAC) and finding from previous bioavailability of heavy metal study [Emumejaye, 2014 and Sayed *et al.*, 2009].

Materials & Methods

Forty four (44) samples of different varieties of rice have been purchased from different major markets in Dhaka city (**Table 1**). Each sample was collected in a sampling bag and labeled with variety name, market name and sampling date. All chemicals were purchased from Sigma Aldrich as analytical grade.

Table 1: Varieties of rice samples collected from different local market of Dhaka City.

Name of Local Market	Varieties of Rice Samples Collected
Sanir Akhra Bazar	Miniket, Najirshair, Festival Rice
Banasree Bazar	Miniket, Najirshair
Anondo Bazar	Miniket, Najirshair, 28, Festival Rice
Kawran Bazar	Miniket, Najirshair, 28, Festival Rice
Sewrapara Bazar	Miniket, Najirshair, 28, Festival Rice
Agargaon Bazar	Miniket, Najirshair, 28

Exactly 0.5g of rice sample was weighed separately into the Teflon vessel. 10ml of conc. nitric acid (HNO_3) and 2ml of hydrogen peroxide (H_2O_2) was added and left for half an hour. Then the vessels were placed in a microwave digestion chamber (CEM MARS Xpress) for about 15minutes by following heating program as mentioned in **Table 2**. Then digests were cooled, filtered and diluted to 25ml in a volumetric flask. This extract was used for the determination of heavy and trace elements in rice samples.

Table 2: Microwave heating program (ramp to temperature control system).

Stage	Power		Ramp Time mm:ss	Pressure (psi - limit)	Temp °C	Stir	Hold Time mm:ss
	Level	%					
1	1600W	100	15:00	800	200	Off	15:00

Digested samples were volume as required and analyzed for copper (Cu), Iron (Fe), Zinc (Zn), Nickel (Ni), Cobalt (Co), cadmium (Cd) and Lead (Pb) by Atomic Absorption Spectrometer (Perkin Elmer 200) as per following standard procedure in the Environmental & Analytical Chemistry Research Laboratory (EACL) of the Centre.

Result and Discussions

The result obtained from the digested rice samples that are consumed in Dhaka City is shown in Appendix 1.

Heavy metals content of the investigated 44 samples were in the range of 0.50 to 3.50 mg/kg for Cu, 0 to 2.0 mg/kg for Ni, 1.13 to 14.38 mg/kg for Fe, 3.63 to 82.38 mg/kg for Zn and 1.63 to 12.50 mg/kg for Mn (**Table 3**). The concentration of Pb and Cd was in trace quantity in rice samples and considered as below detection limit of the instrument. According to these data, copper (Cu) was highest in the festival rice of Anondo Bazar, while lowest concentration was found in the same rice of Sewrapara Bazar, Sanir Akhra Bazar and Najirshair of Kawran Bazar. Ni content was found to be <0.5 mg/kg in most of the rice samples. Again, iron (Fe) content was highest in the Najirshair of Sewrapara Bazar and lowest in the Miniket of the SanirAkhra Bazar and Agargoan Bazar. Zinc (Zn) is highest in variety 28 of Agargoan Bazar and lowest in the Miniket rice of Banasree Bazar. Bangladesh Research Institute (BRRI) already released four rice varieties containing different levels of zinc content. These varieties are competitive with superiority to other existing mega varieties having potential high yield, earliness and tolerance to tidal flooding and strong winds, and above all additional nutrients. These are: (a) BRRI dhan 62 (contains 20mg zinc/kg of milled rice); (b) BRRI dhan 64 (contains 24mg zinc/kg of milled rice); (c) BRRI dhan 72 (contains 22.8mg zinc/kg of milled rice); (d) BRRI dhan 74 (contains 24.2mg zinc/kg of milled rice) [Web-2]. The higher amounts of Zn in some varieties may be due to this kind of Zinc fortified rice that was collected unwillingly. Furthermore, manganese (Mn) content of the samples was found to be higher in the festival rice of Sewrapara Bazar and lowest was found in the Miniket rice of Banasree Bazar.

Table 3: Descriptive statistics of the analyzed data of the rice samples collected from different bazaars of Dhaka city.

	Minimum	Maximum	Mean		Std. Deviation
			Statistical	Std. Error	
Cu	0.50	3.50	2.06	±0.11	0.75
Ni	0.00	2.00	0.36	±0.10	0.67
Fe	1.13	14.38	6.06	±0.55	3.64
Zn	3.63	82.38	19.74	±2.70	17.89
Mn	1.63	12.50	5.07	±0.39	2.59

Table 4: The comparison of our results with the recommended maximum permissible Limits of the metals in food [Emumejaye, 2014].

Metal	Concentration of Collected samples (mg/Kg)	WHO Recommended Permissible Limit in Food (mg/Kg)
Iron (Fe)	1.13-14.38	5.0
Lead (Pb)	BDL	5.0
Cadmium (Cd)	BDL	0.3
Nickel (Ni)	0.00-2.00	1.5
Copper (Cu)	0.50-3.50	40
Zinc (Zn)	3.63-82.38	60
Mn	1.63-12.50	-
Cr	0.02-0.74 [Sayed *et al.*, 2009]	20

According to the analyzed data, Zn had the highest concentration, followed by Fe, Cu, Mn, Ni respectively and then Pb and Cd. The current data exhibited that the levels of Cu was found to be below than the permissible limits (**Table 4**) in all the tested samples analyzed. Zinc levels showed remarkable variation (3.63 to 82.38 mg/kg) and below the permission limits except three samples. Moreover, most of the rice samples have high amount of Zn. The concentrations of Ni in the samples were also below the permission limits except five samples. Fe content of analyzed samples was found higher values than the maximum permissible values for seventeen samples. Most of Najirshair rice samples collected from all market contain higher value of Fe. The more iron that is absorbed from the diet, the higher the level of stored iron. About one person in 250 inherits a genetic disorder called hemochromatosis that increases iron absorption and results in a gradual, organ-damaging buildup of stored iron, although symptoms of the problem usually don't become apparent until midlife or later [Web-1]. Cr was studied by previous researcher in the same lab and found a range of 0.02-0.74 mg/kg in different varieties of market rice [Sayed *et al*., 2009].

According to Emumejaye, 2014, some brands of rice consumed in Nigeria have higher amount of Fe and Pb. Again Rivero-Huguet *et al.*, 2006 analyzed the Uruguayan rice and found Fe, Cu, Zn, Cd, Pb, Ni and others heavy metals fall within the typical range of rice grown around the world. Machiwa, 2010 found Cd, Cr, Cu, Pb, Zn and Hg in rice of Tanzania within the acceptable levels for human food. Rice from the East Coast of India showed more accumulation of micronutrients like Zn, Fe and less accumulation of nonessential toxic heavy metals [Satpathy *et al*,. 2014]. The present study showed similar results of Tanzanian, Uruguayan and Indian rice except for the rice of Nigeria.

Conclusion

Considering the mean concentrations of the heavy and trace metals contain in the rice samples, none of the concentration of metals exceeded the relevant maximum permissible levels (MPLs) recommended by WHO, except Fe in some rice samples. Iron overload can damage internal organs and may increase the risk of diabetes, heart attack and cancer, particularly in older people. In future, we intend to conducted research on the cause of higher Iron and Copper content in the rice and as well as Zn fortified rice varieties available in our market.

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Appendix 1

S/N	Location	Rice varieties	Cu (mg/L)	Ni (mg/L)	Fe (mg/L)	Zn (mg/L)	Mn (mg/L)
1	Sanir Akhra Bazar	Miniket	1.63	BDL	2.75	8.75	1.88
2			2.38	BDL	1.13	15.63	2.88
3	Banasree Bazar		2.13	0.13	4.88	6.63	2.63
4			2.38	BDL	4.63	7.38	4.13
5			3.13	0.13	7.00	5.50	4.25
6			2.25	BDL	9.25	7.25	3.13
7			2.00	BDL	4.50	3.63	1.63
8	Anondo bazar		3.00	BDL	9.50	16.25	3.25
9			2.50	0.63	4.13	6.88	3.13
10			2.38	0.13	8.00	15.0	8.38
11	Kawran Bazar		2.38	BDL	6.75	9.75	3.88
12			2.25	BDL	8.63	11.63	3.63
13			1.75	1.25	8.00	49.25	3.25
14	Sewrapara Bazar		2.13	1.88	1.50	5.88	2.63
15			2.13	2.00	1.88	15.0	3.0
16	Agargaon Bazar		1.88	BDL	2.63	34.25	3.88
17			3.13	BDL	1.13	28.38	4.63

S/N	Location	Rice varieties	Cu (mg/L)	Ni (mg/L)	Fe (mg/L)	Zn (mg/L)	Mn (mg/L)
1	SanirAkhra Bazar	Najirshair	1.50	BDL	4.25	34.13	7.25
2	Banasree Bazar		2.00	BDL	6.63	9.63	6.13
3	Anondo bazar		2.00	0.38	5.13	23.50	4.75
4	Kawran Bazar		0.50	BDL	9.13	16.0	5.13
5			1.63	BDL	14.13	12.25	5.0
6	Sewrapara		2.00	1.75	14.38	11.50	5.50

	Bazar						
7	Agargaon Bazar		2.38	BDL	4.88	9.50	6.50
8			3.00	BDL	6.63	9.63	4.0

S/N	Location	Rice varieties	Cu (mg/L)	Ni (mg/L)	Fe (mg/L)	Zn (mg/L)	Mn (mg/L)
1	Anondo bazar	28	1.75	BDL	10.75	9.88	4.63
2			2.00	BDL	2.63	9.38	3.63
3	Kawran Bazar		2.50	BDL	6.50	27.38	4.38
4	Sewrapara Bazar		3.00	1.88	10.13	18.38	5.0
5			2.75	0.50	11.38	6.38	2.25
6	Agargaon Bazar		2.50	BDL	4.25	82.38	4.25
7			2.63	BDL	6.13	71.63	5.88

S/N	Location	Rice varieties	Cu (mg/L)	Ni (mg/L)	Fe (mg/L)	Zn (mg/L)	Mn (mg/L)
1	SanirAkhra Bazar	Festival Rice	0.50	BDL	2.50	13.75	2.00
2			1.88	BDL	2.25	33.63	3.38
3	Anondo bazar		3.50	1.63	8.88	18.63	7.38
4			2.00	BDL	13.50	16.50	7.75
5			0.75	BDL	1.50	14.88	11.13
6	Kawran Bazar		2.38	BDL	8.38	7.75	4.0
7			1.63	BDL	10.00	22.38	7.50
8			0.75	BDL	5.13	14.50	9.13
9	Sewrapara Bazar		1.25	1.88	3.88	70.63	7.25
10			1.00	1.50	4.25	19.50	12.0
12			0.50	BDL	2.13	9.25	12.50