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COMPARISON OF ELEMENTAL CONCENTRATION STUDY IN DIFFERENT VARIETIES OF RICE BY USING THE EDXRF TECHNIQUE

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Abstract: 21 rice samples were collected from the local market belonging to the state of Andhra Pradesh, India and determined concentrations of essential nutrients and toxic elements by using Energy Dispersive X-ray Fluorescence (EDXRF). The elemental profile of Na, Ca, S, P, Mg, Zn, Cu, Ni, Fe, Mn, Cr, As and Pb have been identified in white, parboiled and brown rice samples. Human health potential risk assessment was conducted by considering estimated toxic metals due to rice consumption and compared with provisional tolerable weekly intake (PTWI) values. The objective of the present work is to compare the elemental composition of white and parboiled rice with brown rice, that expected to contain good nutritional values. By comparing these three categories of rice, brown rice was found to exhibit higher compositions of nutritional elements. Surprisingly, higher levels of toxic elements in brown rice relative to the other rice categories and RDA (Recommended Daily Allowable) values were also observed.

Keywords: White; Parboiled and Brown Rice; Elemental composition; EDXRF.

1. Introduction

Rice is a staple feed that occupies a place among one of the widely consumed grains by Asian people. In India, rice usage is very high in daily diets and, to some extent, in other South Asian countries [1]. According to the earlier investigation, the Indian population, on average, rice per person consumes 208 g/day, i.e. 75.9 kg/year [2]. India is the second largest producer of rice in the world, next to China [3]. During recent decades, people have consumed various types of rice in India that provide health benefits, namely anti-diabetes, anti-cancer and anti-cholesterol etc.,[4]. Earlier studies reported that Brown rice contains more nutrients such as vitamins, protein, amino acids, dietary fibre and minerals than the other rice categories [4,5]. Elemental analysis of rice facilitates understanding its nutritional values and levels of toxic elements[4]. In recent years, the elemental concentrations of rice were found to change due to increasing pollution levels because of industrial waste and effluents, mining, transportation etc., causing to release a high amount of heavy metals into the atmosphere, water and soil [6,7,8]. Further, increased fertilizers and pesticide usage alter different rice categories' toxic levels and elemental concentrations [9]. Therefore investigations about changing elemental concentrations and rice toxicity are essential at regional to global scale.

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Several analytical methods, including graphite furnace atomic absorption spectrometry (GFAAS), instrumental neutron activation analysis (INAA), inductively coupled plasma atomic emission spectrometry, inductively coupled plasma mass spectrometry, and energy dispersive X-ray fluorescence, have previously been used to examine the elemental concentrations in rice samples. The ED-XRF has been accepted as an excellent non-destructive technique for multi-elemental analysis that can determine major, minor and trace elements in various samples. Thus, the present study aims to determine the elemental concentrations in different varieties of rice samples using ED-XRF.

2. Materials and methods

In the present study, we have collected three types of rice samples, namely white, parboiled and brown rice, from local markets of Visakhapatnam in Andhra Pradesh, India. The quantity of each sample should be not less than 0.5 Kg. A total of twenty-one samples were utilized in this study. Each rice sample was cleaned and dried for 42 hours in the oven at 50 ^{0}C. These dried samples are thoroughly grounded using clean agate mortar, pestle, and baking powder. A sample of 200 mg was taken from the total powder for further analysis. The elemental analysis was done through the EDXRF spectrometer. For that, we need a pelletized sample. We used a die and pelletizer to make pellet samples by applying a constant pressure of 100-110kg/Cm for five minutes. The thickness of the pellet should be 13mm in diameter, and for rigidity of the sampler, several times applying target pressure several times to remove the air from the sampler. Earlier researchers considered all the precautions in sample preparation [12].

The energy-dispersive X-ray fluorescence (EDXRF) spectroscopy technique is non-destructive, quick, extremely accurate, and environmentally friendly [13]. The EDXRF spectrometry technique can be applied to various samples, including bulk, liquid, powder, and gas. It operates on the tenet that when an external energy source energises a target's atoms, they release photons with a specific energy and wavelength. Identifying and quantifying the corresponding elements present in a sample is possible by counting the photons it emits for each energy [13]. Radiation is released in the form of X-ray photons, whose distinct intensities make it easier to identify the atoms that are their sources. In the present study, the X-ray spectra of the rice samples were obtained from the EDXRF spectrometer (Xenemetrix EX3600) at UGC-DAE Consortium for Scientific Research Center, Kolkata. For optimum detection of elements in rice samples, we have performed different filters between the source and sample of the target. The Instrumental specifications and accuracies are in detail explained by previous researchers [13]. Analyzing standard reference materials (SRM) received from the National Institute of Environmental Studies (NIES) and the National Institute of Standards and Technology was done to determine the validity of the EDXRF spectrometer (NIST). The elemental concentrations were quantified in the present using standard reference materials for rice flour (CRM 10a) and wheat flour (SRM 1567b), and the results were confirmed using the available experimental data. Each specimen was taken in triplicate for better accuracy, and these three observations were averaged and used for further analysis.

Table:1. Concentrations of elements obtained from NIST (SRM 1567b) Wheat flour and NIES (CRM 10a) Rice flour with our experimental setup.

Elements	NIST (SRM)1567b			NIES (CRM) 10a	
	Certified value	Present work		Certified value	Present work
Na	6.71 ± 0.21	7.04 ±0.22	Na	6.6± 0.8	6.93± 0.84
Ca	191.4 ± 3.3	197.13 ±3.4	Ca	93±3	97.65±3.15
S	1645 ± 25	1677 ±24.7	S	1200± 20	1260± 21
P	1333 ± 36	1359 ±37	P	1530±80	1545.3± 80.25
Mg	398 ± 12	390.04 ±11	K	1280± 8	1344± 8.4
Zn	11.61 ± 0.26	12.15 ±0.27	Mg	1340±80	1273± 76
Cu	2.03 ± 0.14	1.92 ±0.11	Zn	25.2±0.8	26.46± 0.84
Fe	14.11 ± 0.33	13.4 ±0.31	Cu	3.5±0.3	3.325± 0.17
Mn	9.00 ± 0.78	9.45 ±0.81	Fe	12.7±0.7	13.335±0.735
Pb	0.01 ± 0.002	0.0109 ±0.0025	Mn	34.7±1.8	32.96±1.72
Rb	0.67 ± 0.01	0.638 ±0.011	Ni	0.19±0.03	0.18± 0.02

3. RESULTS AND DISCUSSIONS

The obtained elemental concentrations range and mean ± standard deviation about three types of rice samples data are given in table 1. The mean values of Macro, Micro, and trace elemental concentrations are presented in tables 2 and 3, respectively. Obtained Results reveal that the three types of rice samples, namely white rice, parboiled rice and brown rice, were studied and recorded variable levels of elemental concentrations compared with Provisionally Tolerable Weekly Intake and Recommended Daily Intake values.

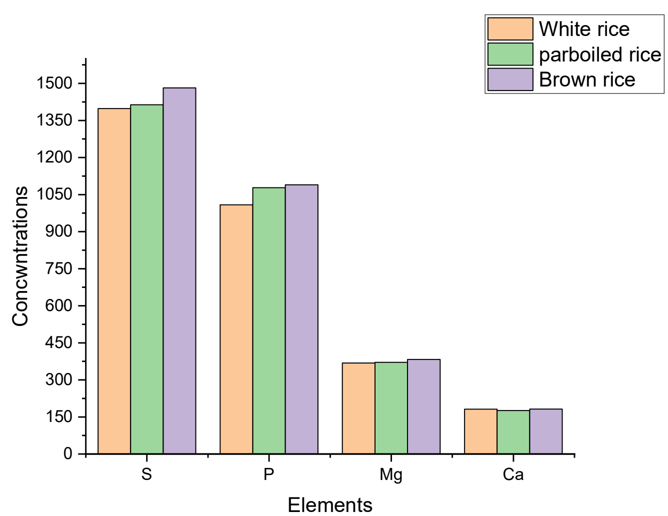

Fig.1: Macro elemental concentration levels in three types of rice samples.

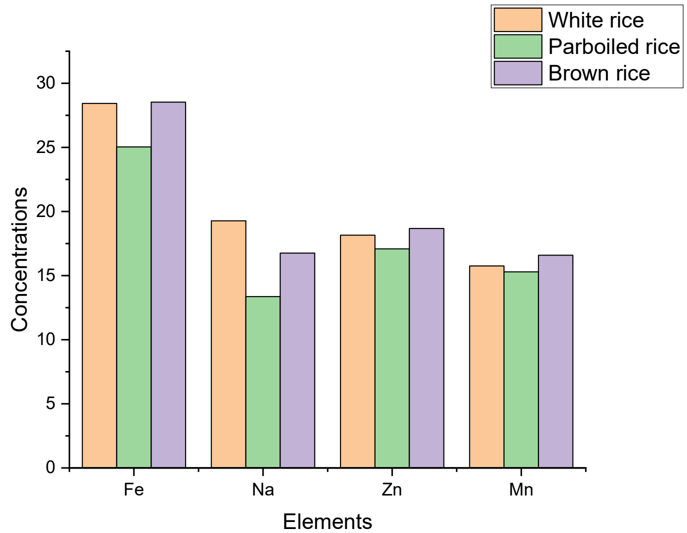

Fig.2: Micro elemental concentration levels in all three types of rice samples.

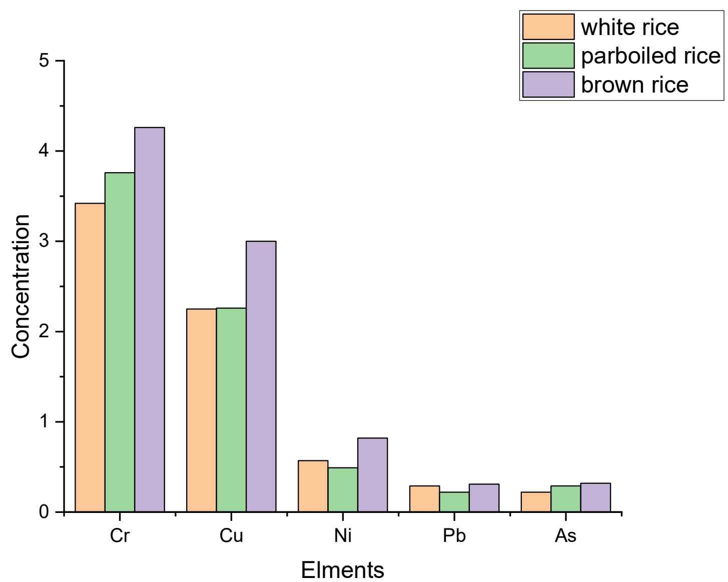

Fig.3: Micro and trace elemental concentration levels in all three types of rice samples. n=number of samples, SD=Standard mean .

3.1. Sulfur

Sulfur levels in White rice samples vary from 1058.54 to1671.31 mg/kg, and in parboiled rice, it shows the range 1323.26 to 1507.53 mg/kg, while the brown rice reflects 1403.9 to 1652.99 mg/kg. Sulphur is a minor constituent of fats, body fluids, and skeletal minerals, but it is essential to life [13]. The highest mean value in brown rice is 1481.87 mg/kg, followed by white rice at 1398.21 mg/kg and parboiled rice at 1413.73 mg/kg. The sulfur content of the present rice samples was higher when compared with the earlier results [13], which also influenced agronomic management and environmental facials. Recommended daily intake of sulfur is 850 mg/day [15]. The mean values for all the rice samples are above the permissible limit but below the toxic levels.

3.2. Phosphorus

Phosphorus Observed phosphorus range in the white rice samples was 809.22 to 1245.55 mg/kg. Parboiled rice is observed to be 901.64 to 1249.72 mg/kg, while brown rice lies in the range of 1028.68 to 1187.819 mg/kg. Phosphorus is an acutely significant element in every cell of the human body [10]. A deficiency of phosphorus can cause rickets [14]. Recommended daily phosphorus intake is 700 mg/day, and tolerable upper intake level (UL) is 3000 to 4000 mg/ day [World Health Organization. (1996)]. The highest mean value in brown rice is 1089.60 mg/kg, followed by white rice at 1008.42 mg/kg and parboiled rice at 1077.89 mg/kg. Present values of Phosphorus content are lower than the earlier reported values [14,15].

3.3. Magnesium

Magnesium concentration in White rice was found to lie in the range 345.06 to 389.27 mg/kg and parboiled rice the same has the range from 357.13 to 384.47 mg/kg and brown rice contain the values in between 373.29 to 386.79 mg/kg. It plays a major role in metabolic reactions those take place in human beings[10]. Toxicity due to magnesium higher levels either by daily intake food items or its parenteral administration consider as improbable because excessive magnesium can be excreted [13]. The highest mean value of Mg present in the white rice 368.22mg/kg followed by brown rice 382.79 mg/kg and parboiled rice 371.05 mg/kg reflecting lower2 levels when compared with the earlier investigations [14,22]. Maybe it is depending upon the chemical properties, weathering, and anthropogenic factors and, in agricultural systems.

3.4. Calcium

Calcium concentration of white rice ranges from 167.52 to 199.7 mg/kg, parboiled rice ranges from 166.99 to 184.54 mg/kg while brown rice values lie from 171.23 to 190.07 mg/kg. Calcium is the most abundant mineral required for the human body and stored mostly in the bones and teeth[13]. Depending on the age and gender (NIH) adequate intake of Ca for adults is 1000-1300 mg/kg. The highest mean value present in parboiled rice 175.81 mg/kg followed by brown rice 182.04mg/kg and white rice is 181.27 mg/kg. Calcium content of the present study found to be higher when compared with the earlier investigations [5,9,15].The mean values for all samples were within the permissible limit.

3.5. Iron

Iron concentration range of white rice varies in between 23.63 to 31.73 mg/kg and parboiled rice from 20.34 to 27.44 mg/kg whereas brown rice concentration ranges from 25.37 to 30.94. Iron can assist in the oxygen delivery to red blood cells and is necessary for the composition of haemoglobin. Children's rapid growth and poor nutrition can both contribute to iron deficiency. Iron insufficiency in women is caused by the continuous blood loss that occurs during menstruation. A lack of iron is harmful, especially during pregnancy [17]. Ten to thirty milligrammes of iron each day are required. A daily intake of 200 mg, however, has a hazardous effect [18]. The highest mean value present in par boiled rice 25.04 mg/kg followed by brown rice 28.53 mg/kg and white rice 28.43 mg/kg indicating about the present rice samples are not hazardous as these values are below 200 mg.

3.6. Sodium

The concentration of sodium in the present white rice samples ranges from 12.0 mg/kg to 33.34 ;in the case of par boiled rice samples range it found to lie in between 12 to 17.5 mg/kg while brown rice contain the values 12 to 19.87 mg/kg. Sodium is an essential element to human beings that used for regulating body blood pressure and also blood volume, and critical for muscle and nerve functions. Excess dietary might lead to hypertension; serious implications might arise with congestive heart failure, cirrhosis or renal disease in people. Sodium present naturally in majority of food items. But in processed food materials like ready to eat items sodium will be added at higher levels longer period storage. In developed countries like US, as much as 75% food items belong to processed food materials category (United States Department of Health and Human Services, HHS, 2005). Recommended daily intake of sodium is 2300 mg/kg for healthy adults [15].The observed highest average mean value of Na in white rice is 19.27mg/kg followed by brown rice 16.76 mg/kg and parboiled rice 13.36 mg/kg. Sodium content of the brown rice samples found to be closer to the earlier research works [13].

3.7. Zinc

In this present study the white rice zinc composition ranges in between 13.28 to 24.69 mg/kg, parboiled rice Zn concentration found to lie in the range 14.71 to 20.58 mg/kg while brown rice contain the values from 17.24 to 19.73 mg/kg. Due to its role as a structural and functional component of various metallic proteins and its involvement in cellular metabolic processes, zinc is crucial for human nutrition. Zn also functions as an antioxidant by lowering free radicals [19]. There is no significance difference between white rice18.49 mg/kg and brown rice. The zinc content of the rice samples undertaken in the present work is closer to the earlier investigations [4,5,14,15]. The observed concentrations of Zinc in all the rice samples found to be higher than the permissible level 11 mg/day and 8mg/ day.

3.8. Manganese

The Concentrations of obtained manganese in the present white rice; parboiled rice; brown rice are in the ranges 8.97 to 24.02 mg/kg; 11.05 to 18.93 mg/kg and 13.26 to 20.48mg/kg respectively. Manganese functions as an enzyme activator for several enzymes besides its requirement for bone growth, carbohydrate and lipid metabolism [20]. Daily intake value of Mn was estimated earlier [13] having the value 2.3 and 1.8 mg/day for male and female people. An upper limit of 11 mg per day for adults has been set (NIH) beyond which it turns to toxicity. In the present studies observed highest average mean value present in brown rice is 16.59 followed by parboiled 15.29 mg/kg and white rice 15.75 mg/kg. Manganese content of the rice samples found to be high when compared to the earlier studies[4,14,15].

3.9. Chromium

Chromium is a vital nutrient essential for the human body to stimulate the insulin in the human body tissue hence helping in the utilization of glucose, protein and fat within the allowable limit [17]. Calcium presents in white rice in the 1.83 to 4.74 mg/day and in parboiled rice it ranges from 3.06 to 4.62 mg/kg while brown rice contains the calcium range from 2.75 to 5.57 mg/kg. The highest mean value 4.265 mg/kg present in brown rice followed by parboiled rice 5.35 and white rice. In the present study the obtained chromium content of the rice samples found to be higher relative to the earlier studies [15,17] may be the anthropogenic activities. Permissible level of Cr that set by (NIH) is 35µg. Mean values of all the rice samples are above the Recommended Daily Intake value (RDI).

3.10. Copper

Copper concentration of white rice ranged from 2.01to 2.56 mg/kg, parboiled rice range from 1.92 to 2.42 mg/kg and brown rice present in the range from 2.22 to 3.97 mg/kg. Copper is an essential micronutrient required in the growth of both plants and animals. In human begins, it helps for the production of blood haemoglobin [21] The highest mean value present in brown rice is 3.0 mg/kg. There is no significant difference between white rice2.25 mg/kg and parboiled rice 2.26 mg/kg values. Copper content of the present study found to be closer to the earlier investigation [5, 14, 15]. The obtained results are above the RDI value (0.9 mg/day).

3.11. Led

Led concentration in white rice found to lie in the range 0.16 to 0.64 mg/kg, in parboiled rice it varies between 0.11 to 0.43 mg/kg and brown rice it found to be 0.21 to 0.42 mg/kg. There is no significance difference between white rice (0.29 mg/kg) and parboiled rice (0.22 mg/kg). The obtained values of the toxic elements belong to present studies found to be closer when compared with the earlier studies [18,19]. Lead is one of the toxic element and Plant food may be contaminated with led through its uptake from ambient air, soil and water [23].

3.12. Nickel

Nickel content of the white rice found to lie in the range 0.22- 1.38 mg/kg and for the parboiled rice it is 0.18 to 1.03 mg/kg while for brown rice obtained range exists in between 0.41 to 1.106 mg/kg. The mean values of the present studies are closer when compared with the other studies [14,18]. Nickel concentration is depending on the nature of the paddy soils also. Due to its content values exceeding the recommended limit, it is known to be the cause of cancer (oral and in-testinal), depression, heart attacks, kidney dysfunction, low blood pressure, muscular tremors and paralysis, skin disorders, and vomiting [6]. The WHO also suggested a PTWI of 0.365 mg/kg Body weight. All the rice samples are formed to be above the prescribed limit.

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3.13. Arsenic

The obtained mean values of arsenic contents belong to white rice 0.22 mg/kg, Parboiled rice 0.29 mg/kg and brown rice 0.32 mg/kg seems to be in the increasing order. Hence Arsenic content of white rice samples shows the range from 0.03-0.47 mg/kg relative to the range 0.11-0.69 mg/kg of Parboiled rice and brown rice 0.22-0.4 mg/kg. Highest value present in brown rice when compared with the white rice and parboiled rice values. The present values of arsenic content found to be closer when compared with the earlier studies [4,10,14]. Water used to flood paddies is the most likely source of arsenic [13]. Although CODEX has not set a limit for arsenic in rice, the WHO has set a PTWI of 0.015 mg/kg. The majority of the systems connected to the human body may experience clinical manifestations as a result of ongoing arsenic exposure caused by frequent eating of rice. Because of the high amounts discovered in some nations, arsenic in ground water has received extensive media coverage [24]. When As is exposed, it builds up in the body, especially in the skin, hair, and nails, causing a variety of clinical signs as hyperpigmentation and keratosis [10]. All the values of present rice samples arsenic contents are found to be above the permissible levels. Now a day’s consumers are shifting towards brown rice from white rice due to diabetic management and other health challenges but the present findings indicating the health hazardness associating the arsenic, so again consumers need to take precaution about balancing arsenic intake.

The chemical composition of white, parboiled and brown rice is listed in Tables 2 and 3. Compared to the three varieties of rice samples, Brown rice and parboiled rice shows a slight variation in elemental composition than white rice. White rice is a variety of milled rice which has gone through a process of removing the husk, bran and germ. Because of this process, white rice has a different flavour, texture and firmness when compared to parboiled rice. On the other hand, parboiled rice goes through a whole different process of being partially boiled in its husk. This process involves three stages, soaking, steaming and drying. Unlike white rice, parboiled rice boosts and improves its nutritional value, making parboiled rice similar to brown rice regarding health benefits. Besides affecting the nutritional values, parboiling changes the texture of rice and makes them easier to polish. Para-boiled and brown rice samples had higher chemical content and slightly uniform results than white rice.

Table: 2. Obtained range of elemental concentration (mg/Kg) and their mean ± SD values in three types of rice samples

S.No	Element	white rice (n=10)		parboiled rice (n=5)		Brown rice (n=4)	
		Range	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD
1	S	1058.54 - 1671.31	1398.21±168.32	1323.26 - 1507.53	1413.73 ± 74.5	1403.9-1652.99	1481.87 ±115.2

2	**P**	809.22-1245.55	1008.42 ±151.10	901.64-1249.72	1077.89 ±136.2	1028.68 - 1187.81	1089.60 ± 76.6
3	**Mg**	345.06-389.27	368.22 ±11.54	357.13-384.47	371.05 ± 10.88	373.29-386.45	382.79 ± 6.37
4	**Ca**	167.52-199.70	181.27 ± 10.16	166.99-184.54	175.81 ± 7.06	171.23-190.07	182.04 ±8.35
5	**Ba**	67.27-94.97	78.1±8.43	80.23-90.37	84.13±3.98	67.3-86.5	79.91±8.61
6	**Fe**	23.63-31.73	28.43±3.22	20.34-27.44	25.04 ± 2.7	25.37-30.94	28.4 ±2.41
7	**Zn**	13.28-24.69	18.15 ± 2.98	21.49-38.68	17.09 ± 2.79	17.24-19.73	18.49 ± 1.04
8	**Na**	12.0 - 33.34	19.27 ± 7.48	12-17.5	13.36±2.4	12.0 - 19.87	16.76±3.59
9	**Mn**	8.97-24.02	15.75 ± 4.14	11.05-18.93	18.93 ± 3.22	13.26-20.48	16.59 ± 3.10
10	**Sr**	6.69-9.47	7.79±0.91	6.61-8.11	7.21 ±0.55	7.23-9.43	8.55±0.99
11	**Rb**	2.8-13.39	5.85±1.98	2.71-1.8	6.98±1.44	6.23-11.28	8.25±2.18
12	**Cu**	2.01-2.56	2.25 ± 0.17	1.92-2.42	2.26 ± 0.2	2.22-3.97	3.0 ± 0.72
13	**Cr**	1.83-4.74	3.42 ± 0.89	3.06-4.62	3.76 ± 0.62	2.75-5.57	4.26±1.22
14	**Br**	0.76-19.79	2.81±0.06	0.70 - 2.58	1.63±0.81	0.8-1.81	1.31±0.41
15	**Ni**	0.22-1.38	0.57 ± 0.43	0.18-1.38	0.50 ± 0.41	0.29-1.11	0.82±0.29
16	**Pb**	0.16-0.64	0.29 ± 0.15	0.11 -0.43	0.22 ± 0.13	0.21-0.42	0.31±0.10
17	**As**	0.08-0.45	0.22 ± 0.16	0.11 - 0.69	0.29 ± 0.22	0.2-0.4	0.32±0.07

Table: 3. Macro and Micro Elemental concentrations of different types of rice compared with the RDI values.

Elements	**White rice (mg/Kg)**	**Parboiled rice (mg/Kg)**	**Brown rice(mg/Kg)**	**RDI(mg/day) Male**	**RDI(mg/day) Female**

S	1398.21	1413.73	1481.87	850	850
P	1008.42	1077.89	1089.60	700	700
Mg	368.22	371.05	382.79	420	320
Ca	181.27	175.81	182.04	1000	1300
Fe	28.43	25.04	28.53	8	18
Na	19.27	13.36	16.76	2300	2300
Zn	18.15	17.09	18.49	11	8
Mn	15.75	15.29	16.59	2.3	1.8
Cr	3.42	3.76	4.26	35	25
Cu	2.25	2.26	3.0	0.9	0.9

The concentrations of each element in the various rice varieties are displayed in Tables 2 and 3. Using white rice as a baseline, the data were provided in mg/kg of wet rice and are listed in ascending order of concentration. In white rice, Mg was the most prevalent element, followed by P, S, and Ca among microelements, Fe, Mn, Zn, Na, Cu, Cr, Pb, Ni, and As were particularly abundant.

The nutritionally essential minerals and toxic elements are shown in Table 3, the higher values observed in brown rice compared to parboiled rice and white rice. The contents of most elements are comparable in brown and par-boiled rice, except Ni content, which is higher in brown rice. White rice had significantly lower Cr, Fe, and Mn contents than brown rice. It depends upon their grain milling process.

Correlation coefficient for all the observed macro, micro, and trace elements has been evaluated and presented in Tables 4, 5 and 6 for all three types of rice samples. Table 4 shows the linear correlation of white rice. The highest positive and significant correlation has been determined between the content of Zn - Mn (r = 0.75). Mn and Zn are both significant elements and essential for maintaining good health. The presence of one element reflecting its impact on the other element is a good sign. Iron was found to have a significant positive correlation with Zn (r=0.70), and Pb has a significant positive correlation with As (r=0.95). In parboiled rice, the content of Zn has the highest positive significant correlation with Ni (r=0.99), Pb -As (r=0.99), Mg-Cu (r=0.89), S-Zn (r=0.89) as shown in table 5. Brown rice samples were found to have the highest positive and significant correlation between Zn and As (r= 1.00), Mn-Pb (r=0.96), and Mg-Fe (r=0.89), as shown in table 6.

Table: 4 Different rice varieties' Micro and Trace elemental composition compared to the provisionally tolerable weekly intake values.

Elements	**White rice (mg/kg)**	**Parboiled rice (mg/kg)**	**Brown rice (mg/kg)**	**PTWI (mg/day)**
Ni	0.57	0.49	0.82	0.365
Pb	0.29	0.22	0.31	0.3

As	0.22	0.29	0.32	0.012

Table 5: Correlation of macro, micro and trace elements for White rice samples

	Mg	P	S	Ca	Fe	Zn	Mn	Cu	Cr	Pb	Ni	As
Mg	1.00											
P	0.32	1.00										
S	-0.28	0.04	1.00									
Ca	0.28	-0.27	-0.14	1.00								
Fe	-0.20	-0.24	0.07	0.56	1.00							
Zn	-0.05	-0.38	0.41	0.48	0.70	1.00						
Mn	-0.11	-0.59	-0.20	0.42	0.65	0.75	1.00					
Cu	0.03	0.14	-0.43	0.40	0.43	-0.13	-0.01	1.00				
Cr	-0.57	-0.27	0.22	0.14	0.18	0.24	0.28	-0.13	1.00			
Pb	-0.11	0.19	-0.22	-0.28	0.04	0.03	0.24	0.31	0.25	1.00		
Ni	0.09	-0.06	-0.17	0.15	0.32	0.24	0.43	-0.25	0.40	-0.02	1.00	
As	-0.25	0.03	-0.24	-0.33	-0.06	0.01	0.30	0.13	0.43	0.95	0.07	1

Table 6: Correlation of macro, micro and trace elements for Parboiled rice samples.

	Mg	P	S	Ca	Fe	Zn	Mn	Cu	Cr	Pb	Ni	As
Mg	1.00											
P	0.05	1.00										
S	-0.70	0.50	1.00									
Ca	0.36	0.64	0.19	1.00								
Fe	-0.38	0.28	0.82	0.42	1.00							
Zn	-0.94	0.12	0.89	-0.20	0.64	1.00						
Mn	-0.71	-0.12	0.13	-0.32	-0.26	0.44	1.00					
Cu	0.89	-0.36	-0.79	-0.04	-0.42	-0.86	-0.71	1.00				
Cr	-0.20	-0.33	0.23	0.34	0.64	0.26	-0.04	-0.14	1.00			
Pb	0.50	-0.73	-0.70	0.00	-0.21	-0.58	-0.28	0.68	0.51	1.00		

Ni	-0.95	0.21	0.88	-0.18	0.57	0.99	0.51	-0.91	0.17	-0.67	1.00	
As	0.44	-0.76	-0.71	-0.04	-0.25	-0.55	-0.18	0.63	0.51	0.99	-0.63	1.00

Table 7: Correlation of macro, micro and trace elements for Brown rice samples.

	Mg	**P**	**S**	**Ca**	**Fe**	**Zn**	**Mn**	**Cu**	**Cr**	**Pb**	**Ni**	**As**
Mg	1.00											
P	0.45	1.00										
S	0.49	-0.40	1.00									
Ca	0.27	-0.68	0.58	1.00								
Fe	0.89	0.19	0.38	0.59	1.00							
Zn	-0.59	-0.86	-0.07	0.59	-0.19	1.00						
Mn	-0.83	-0.21	-0.81	-0.20	-0.56	0.61	1.00					
Cu	-0.92	-0.12	-0.79	-0.47	-0.80	0.43	0.94	1.00				
Cr	-0.31	0.18	-0.86	-0.10	0.00	0.35	0.79	0.59	1.00			
Pb	-0.91	-0.15	-0.80	-0.41	-0.76	0.48	0.96	1.00	0.64	1.00		
Ni	-0.26	0.73	-0.89	-0.86	-0.37	-0.39	0.49	0.59	0.58	0.57	1.00	
As	-0.64	-0.88	-0.05	0.56	-0.26	1.00	0.62	0.45	0.30	0.50	-0.39	1.00

4. Conclusions

In the present study, determining nutrient and toxic elements concentration in the three varieties of rice samples, namely white rice, parboiled rice and Brown rice samples, has provided valuable information and data on the elemental concentration of the rice samples. The present investigation revealed that brown rice is one of the sound sources of nutrient elements as well as toxic elements too. The concentration of the 17 elements was analyzed in the three varieties of rice samples. After the analysis, the brown rice found to have higher concentrations of and (1481.87mg/kg), P (1089.60mg/kg), Mg (382.79 mg/kg), Zn (18.49mg/kg), Mn (16.59mg/kg), Cu (3.0mg/kg), Cr (4.265mg/kg), Pb (0.31mg/kg) Ni(0.82 mg/kg) and As (0.324mg/kg) compared to white rice and parboiled rice samples. The concentrations of some of these elements in brown rice seem to be above the permissible limit. This study highlights that white rice is poorer in toxic elements based on the concentrations found for toxic elements. Still, nutritional elements were lower, while these were higher for parboiled and brown rice samples.

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