Research Article Available online www.ijsrr.org ISSN: 2279–0543

International Journal of Scientific Research and Reviews

Effect of Elemental Concentrations on Human Physiology by Various Rice Cooking Methods Using EDXRF Technique

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ABSTRACT:

Nineteen rice samples were collected from north coastal zone of Andhra Pradesh state in India and subjected for elemental analysis by using EDXRF (Energy Dispersive X-Ray fluorescence) Technique. The elemental concentrations of Na, Ca, P, Mg, Zn, Cu, Ni, Fe, M, Cr, Arsenic and Lead have been identified in the raw rice; cooked with Aluminium utensil and earthen pot. Aim of the present work is to understand impact of vessel type that used for cooking rice on elements due to leaching etc. The obtained values of elemental concentrations are compared among above mentioned three types of rice. The obtained results reveal that the concentration of Zinc, Nickel, lead and Arsenic elements found to be higher in their concentration levels of the rice cooked by Aluminium utensils when compared with the rice cooked by the earthen pot cook wear and also raw rice. Daily usage of earthen pots for cooking usually avoid major health issues resembling skin diseases, neurological effects and many other difficulties.

KEYWORDS: Rice, cooking method, EDXRF.

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INTRODUCTION:

Rice is a predominant staple food item that occupied as one of the main sources of intake food materials to Indians and other people of Asian countries [1]. The growing population has forced the governments to take the steps for increase of agriculture activity of rice crop. Rice contains good dietary energy sources along with protein; these facilitated to develop variety of food products in the market during the past five decades[2].Living organisms require varying amounts of major, essential and probable essential elements for biochemical and metabolic processes to their respective physical bodies. Accumulation of toxic elements over a certain time period in the living organisms can cause serious affects on their health[3].

Many researchers, [4,5] Have shown that the nature of cookware, storage and processing methods of rice items can increase trace elemental levels in food product and reported that the type of utensil used for cooking may contribute to considerable levels of trace elements into cooked food items by way of leaching in addition to the ingredients used. The most commonly used cooking vessels are Aluminium utensils; the choice of using these utensils is due to low price and easily found in local markets besides the fact that they can clean easily because of their unique surfaces; which cannot crack easily (impact of cooking utensil on). In ancient days people were using earthen pots for food preparation. These earthen pots are easily breakable and very difficult to clean relative to the other utensils. The aim of the present work is to compare the elemental concentration observed due to the cooking by using two different vessels namely Aluminium utensil that manufactured with Aluminium metal and earthen pot prepared with soil. This will provide knowledge about affects of cooking process on the variation of elemental concentration indicating which method is good for human health.

MATERIALS AND METHODS

In the present study nineteen varieties of white rice samples were collected from the north coastal area of Andhra Pradesh state in India. 500g of each sample rice was cleaned and washed with distilled water, these rice samples were divided as two categories namely raw and cooked rice. Cooking was performed by using two types of vessels such as Aluminium Utensil and earthen pot. Duration of cooking time for Aluminium utensil and earthen pots was 25 and 40 minutes respectively by using gas stove. The raw rice and cooked rice samples were oven dried at 50^0 C for 24 hours and 60^0 C for 48 hours respectively to remove the moisture. These samples were grounded by using a clean agate mortar and pestle to get homogeneity. 200 mg of the each sample powder was pelletized into a thin pellet of

uniform thickness having 13 mm in diameter under the pressure of 100-110kg/Cm for five minutes by using a die and pelletize. X-ray intensity increases with pelletization pressures that applied to enhance sample density. If the target pressure reached too quickly, the sample may crack due to the expansion of the air tapped in the sample when pressure is released. Therefore sample pressure was released several times before reaching the target pressure to let air escape from the sample to avoid sample breakage. Without a binder, fine powder particles may fall off or scatter from the pellet surface and cause contamination of the spectrometer's sample chamber in vacuum and special care was taken to avoid this by adding binder to the present samples [6].

Comparing with the other techniques; EDXRF (Energy dispersive X-Ray Fluorescence) spectrometry exhibits several advantages and detect a wide range of different elements. It is a non-destructive technique, highly accurate and also used to determine the elements present in powder, liquid and gas form[7]. Experimental measurements of the present rice samples have been carried out at UGC-DAE Consortium for Scientific Research, Kolkata Centre by using Xenemetrix EX3600 EDXRF spectrometer, consists an oil-cooled Rhodium anode X-ray tube (maximum voltage 50KV, Current 1mA).The measurements were performed in vacuum by using different filters (between the source and sample) for optimum detection of elements. The validity of the EDXRF experiment arrangement was performed by analyzing standard reference materials (SRM) those obtained from National Institute of Environmental studies (NIES) and National Institute of Standard and Technology (NIST). Rice flour (CRM 10a) and wheat flour (SRM 1567b) were used for quantification of the elements and verifying the reliability of the data obtained by the present system.

RESULTS AND DISCUSSION:

The samples were taken in triplicate and the obtained results were compared as mean ± standard deviation values. In the present study concentration levels of major elements, essential and probably essential elements besides toxic elements were observed in the raw and cooked rice's of all the specimens. The evaluated values of elemental concentrations belong to raw rice along with the cooked rice of both the types are displayed in the Tables 1, 2 and 3.

Table-1: The mean values of essential and probably essential elemental concentrations are present in ppm levels.

S.no	Elements	Raw rice	Earthen Pot	Aluminium utensil
1	Zn	26.31±5.07	26.85±3.63	27.178±4.57
2	Cu	8.65±0.76	9.18±1.45	8.84±0.74
3	Ni	0.63±0.49	0.714±0.46	0.725±0.56
4	Fe	85.52±10.1	90.04±9.01	79.38±4.5
5	Mn	23.44±2.18	24.17±8.2	25.65±3.65
6	Cr	3.63±2.3	4.46±0.3	4.43±0.89

Table-2: The mean values of Toxic elemental concentrations are present in ppm levels.

	Elements	Raw rice	Earthen Pot	Aluminium utensil
1	Pb	2.51±0.5	2.84±0.58	2.92±0.34
2	As	0.26±0.07	0.3±0.17	0.31±0.13

Table-3: The mean values of major elemental concentrations are present in ppm levels

S.No	Elements	Raw rice	Earthen Pot	Aluminium utensil
1	Ca	1216.822±83.74	1238.006±48.24	1417.906±81.445
2	P	14310.03±312.02	16679.9±112.92	16578.38±267.298
3	Mg	61758.2±548.47	66777.09±862.2	64211.5±535.11

The obtained results reveal that the concentration of Zinc, Nickel, lead and Arsenic elements found to be higher in their concentration levels of the rice cooked by Aluminium utensils when compared with the rice cooked by the earthen pot cook wear and also raw rice. Zinc found to be in the range of 26.3mg/kg -27.17mg/kg. Aluminium utensils may contain composite of Zinc[8] and it might be the reason for the Zinc recorded in higher levels. Zinc is an important trace element that involves in many biological reactions in the human body [9]. In all the samples the range of Zn is within the permissible limit (99.4ppm) as suggested by FAO/WHO (2001)[10] and more than the Recommended Daily Allowable value (RDA).

Aluminium utensil does not impart Nickel and Chromium into the rice samples during the cooking process[11]. Therefore no significant difference in the concentration levels of Nickel 0.714 (mg/kg) - 0.725(mg/kg) and chromium 4.46(mg/kg)-4.43(mg/kg) is observed in the rice cooked by Aluminium and earthen pot vessels. The lowest concentrations of Nickel 0.63 (mg/kg) and chromium 3.63 (mg/kg) is observed in the raw rice. The obtained results reveal that the range of these two elements are above the permissible limit (Ni (67ppm) and Cr (2.3ppm)) that set by FAO/WHO (2001)[10]. Excess amount of Nickel causes heart attacks, low blood pleasure, skin problems, vomiting and many other health problems[12].

Lead is not an essential element. Even in micro levels of lead uptake from surroundings like air, water and also food can cause serious injury to the brain, red blood cells, nerve system and kidneys in human beings [9]. The recorded range of Pb 2.51(mg/kg) -2.92(mg/kg) in the present study is below the tolerable daily intake value (3 mg/kg) that set by the Joint [9] and Expert Committee on Food Additives and Contaminants. In both the cooking methods, the higher value of lead present in the rice cooked with Aluminium pot while the lower value of lead is present in the rice cooked with earthen pot cook wear. Aluminium utensils may be a major contributor to lead poisoning throughout the developing world[13].

Arsenic (As) is known to be potentially toxic element since ancient days. Exposure of As leads to its accumulation in the human body particularly in skin, hair and nails resulting in various clinical symptoms such as hyper pigmentation and keratosis[14]. Arsenic recorded range in the present study is 0.26(mg/kg)-0.31(mg/kg). The lowest concentration of As observed in raw rice while its highest value is obtained in cooked rice and there is no significant variation observed due to cooking methods. A limit of arsenic has not been established[15], however the obtained level of arsenic is higher than the provisionally weakly tolerable intake for adults 0.015mg/kg as set by [9].

The obtained results also revealed that phosphorus, Magnesium, Cupper and Iron elements are present in high concentrations in rice cooked with earthen pot cook wear.

Phosphorus is a major element and together with calcium, it contributes for teeth and bone development. For energy processing, it plays a major role[16]. In the present research work, Phosphorus observed in a range of 14310.03 (mg/kg)-16679.9 (mg/kg) with the highest value present in rice cooked with earthen pot while the lowest value present in raw rice. The recommended quantity of Phosphorus (P) is 700 milligrams per day, and the tolerable upper intake level (UL) is 4,000 milligrams per day for adults and if the age is above 70 years, 3,000 milligrams per day may be taken[9]. The obtained concentration of Phosphorus is above the permissible limit, probably due to contribution of phosphorous

present in the water that used cooking purpose. It could be authenticated due to not having much variation in the concentration of phosphorous obtained in both the rice cooked with Aluminium utensil and earthen pot.

Magnesium is a major essential element for human beings. This element is involved in many biochemical reactions in the human body[9]. The Mg concentration observed to be in the range 61758.2(mg/kg) -66777.09(mg/kg). The obtained highest value found to be in rice cooked with earthen pot while raw rice shows lowest value. This confirms that the earthen pot contribute to enhance its value as it may contain magnesium because magnesium is a clay mineral[17].

Copper (Cu) presents in the structure of various enzymes; which also participates in cleaning up free oxygen radicals from the intracellular environment[18].The Cu recorded concentration is within the range of 8.65(mg/kg)-9.18(mg/kg) in the present obtained values; the highest value recorded in rice cooked with earthen pot while the lowest value present in raw rice. This shows that Cu as leachates in rice cooked in earthen pots. Required maximum limit of Cu in food (73.3 ppm) that set by FAO/WHO (2001)[10]. In the present study the concentration of Copper is within the permissible limit.

Iron is essential for the composition of hemoglobin and it can help to carry the oxygen to red blood cells. In children, iron deficiency can be caused by improper nutrition and fast growth of the organism. In women, iron deficiency arises from the constant loss of blood in the course of menstruation. Iron deficiency is dangerous, particularly during pregnancy period[9].The Fe concentration found to be in the range of 79.38(mg/kg)-90.04(mg/kg). In the present work the highest value recorded in rice cooked with earthen pot while the lowest value present in rice cooked with Aluminium pot. The necessary intake of iron is 10 to 30 mg per day However; a dose of 200 mg per day produces a toxic effect. The permissible limit of Fe as set by FAO/WHO (2001)[10] is 425.5 ppm. The obtained value of Iron is below the permissible limit.

Manganese is one of the important element to human beings and it can function as an enzyme activator for several enzymes and also important for bone growth, carbohydrate and lipid metabolism[13]. Mn recorded in the range of 23.4(mg/kg)-25.6(mg/kg) having the lowest value observed in raw rice and rice cooked with earthen pot and the highest value found to be in the rice cooked with Aluminium utensil. Manganese is an alloying element of Aluminium; hence it contributed to rise the Mn concentration due leaching during cooking with the Aluminium utensils[19]. The daily intake value of Mn is estimated as 2.3 mg/day and 1.8mg/day for male and female respectively. It is only estimated value not required value. An upper limit of 11 mg per day for adults has been determined by National Institute

of Health (NIH). In the present study the concentration of Mn is found to be higher than the permissible limit.

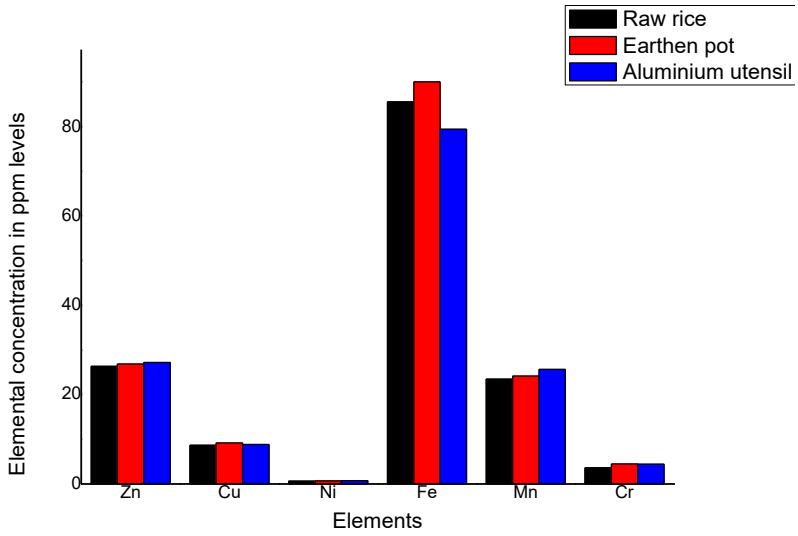

Fig-1: Mean concentrations of the detected elements in three treatments

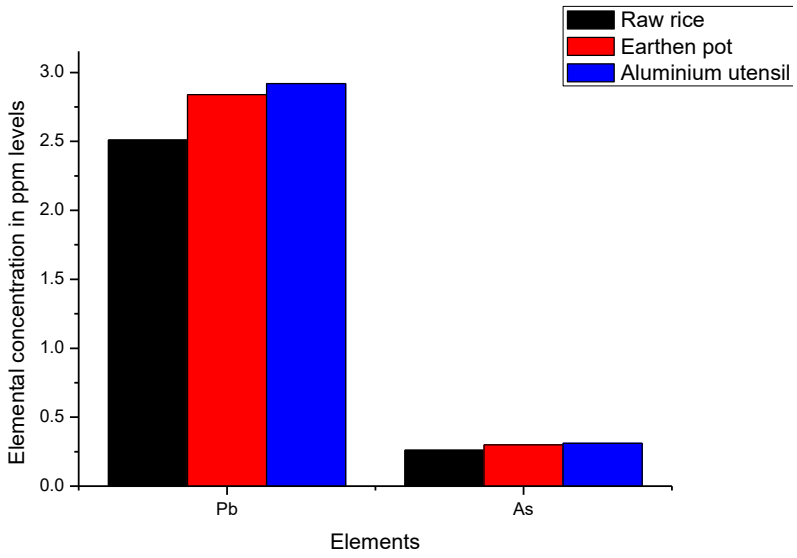

Fig-2: Mean concentrations of the detected elements in three treatments

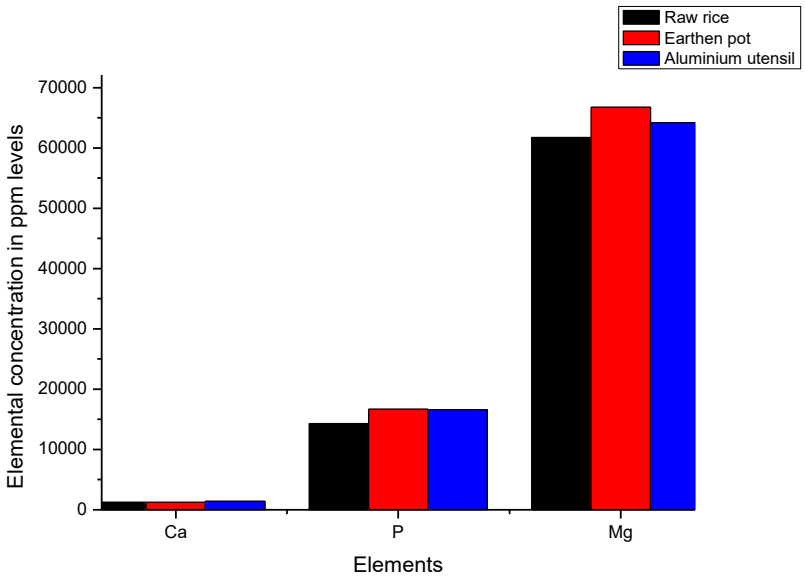

Fig-3: Mean concentrations of the detected elements in three treatments

CONCLUSIONS:

The concentrations of major, essential, probably essential and toxic elements present in 19 varieties of rice samples processed by three treatments namely raw rice, rice cooked in Aluminium and earthen pot cook wears. These samples were collected from north coastal zone of Andhra Pradesh state in India. Analysis of the samples have been done by EDXRF technique. According to this study; the results revealed the impact of cook wears; which commonly used in food processing. Zn, Mn, Pb and As were not in leachable forms due to cooking in the clay pots. The concentrations of these elements are relatively higher in Aluminum utensil when compared with rice cooked in the earthen pot cook wears.The earthen pot may contain Mg, Cu, and Fe elements these are essential nutrients and play important roles in biological systems. No significance difference in the concentrations of Ni and Cr due to two cooking methods is observed. Using of earthen pot cook wears for food processing may avoid the effect of toxic elements through our daily dietary intake. This method is may be the best solution to avoid the major health effects particularly contact skin diseases, neurological effect for some sensitive people.

ACKNOWLEDGMENTS:

The authors are thankful to Dr.M.Sudarshan, UGC-DAE CSR Kolkata center, for granting the necessary permissions and providing EDXRF facility to carry out this work successfully.

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