Anchor University Journal of Science and Technology (AUJST)
A publication of the Faculty of Science and Science Education, Anchor University Lagos
URL: journal.aul.edu.ng
Vol. 1 No 1, June 2020, Pp. 56 - 60

Determination of Mineral and Toxic Elements in Rice (*Oryza Sativa L.*) Produced in Three Locations of Niger State, North-Central, Nigeria

Maxwell Y. M. O[1]*., Yakubu I[1]., Maude M. M[2]., Zubair A. B[1]., Femi F. A[1]., Jiya M. J[1]

[1]Department of Food Science and Technology, Federal University of Technology, Minna.
[2]Department of Food Science and Technology, Ibrahim Badamasi Babangida University, Lapai.

***Corresponding author:**
E-mail: maxwellyom@gmail.com

Submitted 18 June, 2020
Accepted 28 June, 2020
Competing Interests: The authors declare no competing financial interests.

ABSTRACT

Background: Accumulation of heavy metals in the human body may result in toxic effects. They are universally found in the earth's crust and tend to accumulate in crops grown in heavily contaminated soil and hence enter the food chain. On the other hand, some mineral elements are required in a small amount (micronutrients) or large quantity (macronutrients) for the proper functioning of both plant and animal body systems.
Objectives: This study determined the toxic and mineral elements in rice *(Oryza sativa*) varieties produced in three locations of Niger State, North-Central, Nigeria.
Methods: Toxic and mineral elements analysis was conducted on rice samples obtained from three locations in Niger State. Calcium (Ca), Magnesium (Mg), Phosphorus (P), Copper (Cu), Manganese (Mn), Zinc (Zn), Nickel (Ni), Cadmium (Cd), Chromium (Cr) and Lead (Pb) were analyzed using Atomic Absorption Spectroscopy, while Sodium (Na) and Potassium (K) were determined using a photoelectric flame photometer.
Results: Sodium concentrations ranged from 1.33 mg/kg to 1.41 mg/kg; potassium, 3.22 mg/kg to 3.97 mg/kg; calcium, 0.67 mg/kg to 0.88 mg/kg; magnesium, 7.20 mg/kg to 8.25 mg/kg; phosphorus, 5.82 mg/kg to 7.22 mg/kg; copper, 0.40 mg/kg to 1.35 mg/kg; manganese, 0.15mg/kg to 0.25 mg/kg; zinc, 1.60 mg/kg to 2.90 mg/kg; and nickel, 2.21 mg/kg to 2.24 mg/kg. Lead, cadmium and chromium were not detected in the rice samples.
Conclusions: While the toxic metals (Pb, Cd and Cr) were not detected, the concentrations of heavy metals (Cu, Mn, Zn and Ni) were lower than the FAO and WHO recommended level. It can therefore be concluded from this study that rice produced from these locations at the time of study is safe and may not pose immediate health hazards to consumers.

Keywords: Rice, toxic elements, mineral elements

INTRODUCTION

During the past few decades, the contamination of food items has become common and the sources of pollutants include industrial processes and anthropogenic activities such as the application of fertilizers, pesticides and improper waste disposal (Smith, 2009; Cao et al., 2010). The heavy metals contaminate food sources and accumulate in both agricultural products and seafood through the consumption of water, contact with air and soil (Galadima and Garba, 2012). Some heavy metals are essential elements because the body needs them at a low level (Agha et al., 2019). Example of essential heavy metals are Manganese (Mn), Iron (Fe), Copper (Cu) and Zinc (Zn). Other metals like cadmium (Cd), lead (Pb), arsenic (As) and chromium (Cr), are toxic and may pose a threat to living organisms. Many of these metals, such as cadmium, lead and chromium, are carcinogens and are involved in non-communicable diseases, including Alzheimer's, Parkinson's, multiple sclerosis, osteoporosis, developmental disorders and failure of several organs e.g., heart, kidney, lungs, immune system (Mohamed and Khairia, 2012). Also, different studies have shown varying amounts of heavy metals in various food items in Nigeria (Lanre-Iyanda and Adekunle, 2012; Edward et al., 2013; Iniebiyo and Atieme, 2018).

Rice (*Oryza sativa L.*) is the most widely consumed staple food and main leading dietary energy provider among Nigerians and is an important source of employment and income generation for rural areas in the rice-growing zone (Lenn et al., 2019). It contains the essential nutrients that provide the body with energy and minerals; while some pigments found in rice help to prevent atherosclerosis and anti-inflammatory disorder (USDA, 2011). As the rice crop plays a very important dietary role in Nigeria's economy, so, any degradation in its quality is highly unacceptable. Consumption of contaminated foods has serious implications on the health and economic status of the populace (Agha et al., 2019). This study therefore determined the toxic and mineral elements in rice *(Oryza sativa L.)* varieties produced in three locations of Niger State, North-Central, Nigeria.

MATERIALS AND METHODS

Materials

Parboiled rice samples were sourced from three locations in Niger State. Kwakuti rice was obtained from Kwakuti village in Paiko Local Government Area of Niger State; Yankpakochi rice was obtained from Sidi-Agba village in Katcha Local Government Area of Niger State; and Manbechi rice was obtained from Dadi village in Bida Local Government Area of Niger State. The samples were transported to Step-B laboratory, Bosso Campus of the Federal University of Technology, Minna for heavy metals/trace elements analysis.

Methods

The assessment of heavy metals was performed using the method described by (USDA, 2011). The parboiled rice samples were oven-dried at 105 ^{o}C to constant weight for 2 hours, cooled to room temperature and ground to a fine powder using Kenwood electric miller. Exactly 1g of the ground sample was quantitatively transferred into a well-glazed porcelain crucible, placed in a muffle furnace and ashed at 450 ^{o}C for 12 hours. The resultant ash was cooled to room temperature and dissolved to a clear solution with 5 mL of 5M HNO_3. The residue was then filtered into a calibrated 50 ml volumetric flask using Whatman No. 41 filter paper and the solution was made up to mark with deionized water. The concentrations of the metals in the digests were determined by aspirating the solution into a Perkin Elmer AS 3100 flame atomic absorption spectrophotometer while Sodium (Na) and Potassium (K) were determined using a photoelectric flame photometer after the necessary standardization procedures.

Statistical Analysis

The analyses were conducted in triplicates. Data obtained were subjected to one-way Analysis of Variance (ANOVA) and differences among the means were determined using Duncan multiple range tests (DMRT). Statistical Package for the Social Sciences (SPSS) version 23.0 was used to analyse the data and $p<0.05$ was considered to be statistically significant.

RESULTS AND DISCUSSION

Living organisms require varying amounts of mineral elements. Sodium, potassium, calcium, magnesium, phosphorus, copper, manganese, zinc, and nickel are required for biochemical processes. Excessive levels can be harmful to human health. Other elements such as cadmium, chromium, and lead are toxic and their accumulation over time in the living organisms can cause serious effects (Onsanit et al., 2010).

The results of the toxic and mineral elements analysis of the samples are shown in Table 1. The result shows that sodium concentrations range from 1.33 mg/kg to 1.41 mg/kg; potassium, 3.22 mg/kg to 3.97 mg/kg; calcium, 0.67 mg/kg to 0.88 mg/kg; magnesium, 7.20 mg/kg to 8.25 mg/kg; phosphorus, 5.82 mg/kg to 7.22 mg/kg; copper, 0.40 mg/kg to 1.35 mg/kg; manganese, 0.15 mg/kg to 0.25 mg/kg; zinc, 1.60 mg/kg to 2.90 mg/kg; and nickel, 2.21 mg/kg to 2.24 mg/kg. The result also shows that the concentrations of the heavy metals: lead, cadmium and chromium were not detected in the rice samples.

The average values of Na, K, Ca, and Mg were lower compared with the studies of Zhang (2009) and Yap et al. (2009). The variety and the environmental condition can be the reason for the difference. The obtained results showed that the average values of trace elements Zn, Cu, Mg and Mn were less than the similar data reported by Usman and Filli (2011) and Nwachoko et al. (2012). Nickel is known to be responsible for cancer, depression, heart attacks, kidney dysfunction, low blood pressure, malaise, muscle tremors and paralysis, nausea, skin problems and vomiting (Lokeshappa et al., 2012; Mahmood et al., 2015). The nickel level was observed to be lowest compared with the literature reviewed. Umar et al. (2013) found an average of 3.3 mg/kg in wild rice samples collected in Kaduna State and Emumejaye (2014) reported nickel was in the range of 0.05–2.37 mg/kg in rice samples consumed in Delta State. Lead is a very toxic element and chronic exposure, even at low levels, is associated with several health risks (Batista, 2012). The commission regulation of the European Union (2006) stated the intake of nickel and chromium from the average diet is estimated to be about 75 and 150 μg/day (about 1.25 and 2.5 μg/kg body weight/day) respectively. Some studies have indicated excessive amount of heavy metals including Zn, Cu, Pb, Mn, Ni, Cr, Cd in crops and vegetables; and this is associated with sewage and industrial wastewater used for irrigation in agriculture activities (Sinha et al., 2006; Sharma et al., 2007; Gupta, et al., 2008; Mahmood et al., 2015). However, chromium, cadmium and lead were not detected from the rice samples; this may be a result of total dependence on rainfall agriculture and low or none anthropogenic activities in the three locations. The result showed that for all metals, at the 95% confidence level, the means were significantly different ($p<0.05$). The source for this significant difference between sample means may be the difference in mineral contents of soil, pH of soil, pesticides and insecticides used during cultivation.

CONCLUSION

The results showed that the concentrations of heavy metals and trace elements were lower than the FAO and WHO recommended levels. It can therefore be concluded from this study that rice produced from these locations are safe, and may not pose immediate health hazards to consumers.

Table 1: Concentrations of toxic and mineral elements in the rice samples

Toxic and Mineral Elements	KR (mg/kg)	YR (mg/kg)	MR (mg/kg)
Na	$1.33^{b}\pm0.76$	$1.38^{b}\pm0.45$	$1.41^{a}\pm0.24$
K	$3.97^{a}\pm3.50$	$3.22^{c}\pm2.00$	$3.61^{b}\pm0.50$
Ca	$0.88^{a}\pm0.01$	$0.67^{b}\pm0.04$	$0.86^{a}\pm0.03$
Mg	$8.25^{a}\pm0.00$	$7.20^{c}\pm0.00$	$8.07^{b}\pm0.03$
P	$5.82^{c}\pm0.01$	$6.83^{a}\pm0.00$	$7.22^{a}\pm0.02$
Cu	$1.35^{a}\pm0.15$	$0.40^{a}\pm0.00$	$0.40^{a}\pm0.00$
Mn	$0.15^{b}\pm0.05$	$0.20^{b}\pm0.00$	$0.25^{a}\pm0.05$
Zn	$2.90^{d}\pm0.01$	$1.60^{d}\pm0.02$	$2.00^{d}\pm0.01$
Ni	$2.24^{b}\pm0.01$	$2.32^{b}\pm0.10$	$2.21^{a}\pm0.02$
Pb	ND	ND	ND
Cd	ND	ND	ND
Cr	ND	ND	ND

Values are mean ± standard error. Means on the same column with different superscript letter are significantly different ($p<0.05$) while those with the same superscript letter are not significantly different ($p>0.05$).
KEYS: KR- KWAKUTI RICE; YR- YENKPAKOCHI RICE; MR- MANBECHI RICE; ND- NOT DETECTED

Table: 2 Concentrations of toxic and mineral elements in the rice samples compared with FAO/WHO Standards

Toxic and Mineral Elements	KR (mg/kg)	YR (mg/kg)	MR (mg/kg)	FAO/WHO (mg/kg)
Na	$1.33^{b}\pm0.76$	$1.38^{b}\pm0.45$	$1.41^{a}\pm0.24$	-
K	$3.97^{a}\pm3.50$	$3.22^{c}\pm2.00$	$3.61^{b}\pm0.50$	-
Ca	$0.88^{a}\pm0.01$	$0.67^{b}\pm0.04$	$0.86^{a}\pm0.03$	-
Mg	$8.25^{a}\pm0.00$	$7.20^{c}\pm0.00$	$8.07^{b}\pm0.03$	-
P	$5.82^{c}\pm0.01$	$6.83^{a}\pm0.00$	$7.22^{a}\pm0.02$	-
Cu	$1.35^{a}\pm0.15$	$0.40^{a}\pm0.00$	$0.40^{a}\pm0.00$	10
Mn	$0.15^{b}\pm0.05$	$0.20^{b}\pm0.00$	$0.25^{a}\pm0.05$	40
Zn	$2.90^{d}\pm0.01$	$1.60^{d}\pm0.02$	$2.00^{d}\pm0.01$	50
Ni	$2.24^{b}\pm0.01$	$2.32^{b}\pm0.10$	$2.21^{a}\pm0.02$	-
Pb	ND	ND	ND	0.2
Cd	ND	ND	ND	0.5
Cr	ND	ND	ND	-

**Source; FAO/WHO, 2011; AL-Rajhi, 2014.*
Values are mean ± standard error. Means on the same column with the different superscript letters are significantly different ($p<0.05$) while those with the same superscript letter are not significantly different ($p>0.05$).
KEYS: KR- KWAKUTI RICE; YR- YENKPAKOCHI RICE; MR- MANBECHI RICE; ND- NOT DETECTED

REFERENCES

Agha A. W., Sumaira N Muhammad N. K. and Saba F. R. (2019). Assessment of Heavy Metals in Rice Using Atomic Absorption Spectrophotometry – A Study of Different Rice Varieties in Pakistan. Pak. J. Anal. Environ. Chem. Vol. 20, No. 1 67 – 74. http://doi.org/10.21743/pjaec

AL-Rajhi, M.A. (2014). Study of Some Heavy Metals and Trace Elements. *Physics International* 5 (2): 128-131. (http://www.thescipub.com/ pi.toc)

Batista, B. L. (2012). Determination of essential (Ca, Fe, I, K, Mo) and toxic elements (Hg, Pb) in Brazilian rice grains and estimation of reference daily intake. Food and Nutrition Sciences, 3, 129–134.

Cao, H., Chen, J., Zhang, J., Zhang, H., Qiao, L. and Men, Y. (2010). Heavy metals in rice and garden vegetables and their potential health risks to inhabitants in the vicinity of an industrial zone in Jiangsu, China. J. Environ. Sci. 22(11):1792-1799.

Edward JB, Idowu EO, Oso JA, et al. Determination of heavy metal concentration in fish samples, sediment and water from odo-ayo river in Ado-Ekiti, Ekiti-State, Nigeria. International Journal of Environmental Monitoring and Analysis. 2013; 1(1):27–33.

Emumejaye, K. (2014). Heavy and trace elements in some brands of rice consumed in Delta State, Nigeria. IOSR *Journal of Applied Physics*, 6(2), 1–5.

European Union (2006). B Commission regulation (EC) No. 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs. Official Journal of the European Union, 1881, 1–35.

FAO/WHO, 2011. Joint FAO/WHO food standards programme codex committee on contaminants in foods. FAO/WHO, Nether lands.

Galadima, A. and Garba, Z. N. (2012). Heavy metals pollution in Nigeria: causes and consequences. Elixir Pollution 45. 7917-7922 www.elixirjournal.org

Gupta, N., Khan, D. K., & Santra, S. C. (2008). An assessment of heavy metal contamination in vegetables grown in wastewater-irrigated areas of Titagarh, West Bengal, India. *Environmental Contamination and Toxicology*, 80, 115–118.

Iniebiyo F. and Atieme J. O. (2018). Assessment of heavy metals concentration in selected foods sold in markets within port-Harcourt city, Nigeria. Open Access J Sci. 2(4):233–236.

Lanre-Iyanda TY, Adekunle IM. (2012). Assess ment of heavy metals and their estimated dai ly intakes from two commonly consumed foods (kulikuli and robo) found in Nigeria. African Journal of Food, Agriculture, Nutrition and Development. 12 (3):6156–6169.

Lenn G.G., Rafael S.N., and Ray B.V. (2019). Dietary Exposure to Heavy Metal Contaminated Rice and Health Risk to the Population of Monrovia. *Journal of Environ mental Science and Public Health* 3(3): 474-482 DOI: 10.26502/jesph.96120077

Lokeshappa, B., Shivpuri, K., Tripathi, V., & Dikshit, A. K. (2012). Assessment of toxic metals in agricultural produce. *Food and Public Health*, 2(1), 24–29.

Mahmood N., Arya V., Robabeh K. and Farnaz Z. (2015). Concentration of some heavy metals in rice types available in Shiraz market and human health risk assessment. *Food Chemis try*, 175 243–248. www.elsevier.com/locate/foodchem

Mohamed H.H.A and Khairia M.A. (2012) As sessment of some heavy metals in vegetables, cereals and fruits in Saudi Arabian markets. *Egyptian Journal of Aquatic Re search*. 38(1):31-35

Nwachoko, N.C., U.A. Ibiam, K.N. Agbafor and P.M. Aja, (2012). Determination of asernic, lead, cadmium, zinc and iodine in some salt samples sold in south-east Nigeria and of these metals on protein and haemoglobincon tent of albino rats. IJABR, 2: 599-601.

Onsanit, S., Ke, C., Wang, X., Wang, K.-J., & Wang, W.-X. (2010). Trace elements in two marine fish cultured in fish cages in Fujian province, China. Environmental Pollution, 158(5), 1334–1342.

Sharma, R. K., Agrawal, M., & Marshall, F. M. (2007). Heavy metals contamination of soil and vegetables in suburban areas of Va ranasi, India. *Ecotoxicology and Environ mental Safety*, 66, 258–266.

Sinha, S., Gupta, A. K., Bhatt, K., Pandey, K., Rai, U. N., & Singh, K. P. (2006). Distribu tion of metals in the edible plants grown at Jajmau, Kanpur (India) receiving treated tan nery wastewater, relation with physicochemi cal properties of the soil. *Environmental Monitoring and Assessment*, 115, 1–22.

Smith, S.R. (2009). A critical review of the bioavailability and impacts of heavy metals in municipal solid waste composts compared to sewage sludge. Environ Int. 35(1):142-156.
Umar, M. A., Ugonor, R., & Kolawole, S. A. (2013). Evaluation of nutritional value of wild rice from Kaduna state, central Nigeria. *International Journal of Scientific & Technology Research*, 2(7), 140–147.
Usman, M.A. and K.B Filli, (2011). Determination of essential elements and heavy metals contained in table salt. *J. Res. Nat. Dev.*, 9: 1596-8308.
USDA. (2011). Department of Agriculture, Agricultural Research Service: USDA National Nutrient Database for Standard Reference Downloaded from http://ndb.nal.usda.gov/ndb/foods/list.