Journal of Environment and Earth Science
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol.4, No.4, 2014

Quantification of Heavy Metals in Some Locally Produced Rice (*Oryza Sativa*) from the Northern Region of Nigeria.

[1]Otitoju, O., [2]Otitoju, G.T.O., [2]Iyeghe, L.U and [3]Onwurah, I.N.E.
[1]Department of Biochemistry, Faculty of Pure and Applied Sciences, Federal University Wukari Taraba State Nigeria.
[2]Department of Home Science, Nutrition and Dietetics, University of Nigeria, Nsukka, Enugu state, Nigeria.
[3]Pollution Control & Biotechnology Unit, Department of Biochemistry,University of Nigeria, Nsukka., Enugu State Nigeria.
Otitoju.olawale@gmail.com Phone: +2348025094971; +2348056932653

ABSTRACT
Rice is one of the major staples grown in the northern parts of Nigeria. It has earned itself an important position of a commonly consumed staple by the national populace. Consumption of rice contaminated with heavy metals can pre-dispose individuals to serious health complications. This study determined the levels of some heavy metals (Cd, Cr, As, Pb and Hg) in locally produced rice samples from the northern region of Nigeria. Ten rice samples were obtained from various locations in Benue, Borno, Kaduna and Nasarawa states. The results showed that lead (Pb) ranged from 0.311 – 0.525 mg/kg in the samples. Average lead (Pb) concentration was 0.260 mg/kg. However, Cd, Cr, As and Hg were not detectable at 0.001mg/kg. A calculation of weekly intake of rice by an average Nigerian revealed that weekly consumption of lead (Pb) in this locally produced rice exceeded the 0.025mg/kg WHO/FAO (2002; 2001) provisional tolerable weekly intake of lead (Pb). This is of public health importance as individuals who consume this locally produced rice are at greater risk of lead (Pb) toxicity.
Key words: heavy metals, contamination, food, health, toxicity, rice.

INTRODUCTION

Lack of food safety is a major problem in most developing nations including Africa. Many of our food items are laden with lots of pollutants ranging from fertilizer, pesticides to heavy metals. Consumption of contaminated foods has serious implication on health and economic status of the populace (Cao et al., 2010; Smith, 2009; Fu et al., 2008). Recently, there are increased evidences of trace metal pollution of food samples especially rice. (Fu et al., 2008). Nigeria is the second largest importer of rice in the world, buying at least two million metric tons per year from exporting countries like China and Thailand (USAID, 2012).

Dietary exposure to heavy metals, namely cadmium (Cd), lead (Pb), zinc (Zn), arsenic (As) and copper (Cu), has been identified as a risk to human health through the consumption of contaminated food. (Otitoju et al., 2012). They occur as natural constituents of the earth crust and are also distributed by human activities. These heavy metals contaminate food source and accumulate in both agricultural products and sea food through water, air and soil pollution (Galadima and Garba, 2012).

Most heavy metals are very harmful because of their non-biodegradable nature, long biological half-lives and their potential to accumulate in different body parts. Most of them are extremely toxic because of their solubility in water. Even low concentrations of heavy metals have damaging effects to man and animals because there is no good mechanism for their elimination from the body (Chen, Wang and Wang, 2005; Singh, Mohan, Singh and Dalwani, 2004). Consuming heavy metal-contaminated food can seriously deplete some essential nutrients in the body causing a decrease in immunological defences, intrauterine growth retardation, impaired psycho- social behaviour, disabilities associated with malnutrition and a high prevalence of upper gastrointestinal cancer (Arora et al, 2008). It can also lead to other serious health complications such as kidney disease, damage to the nervous system, diminished intellectual capacity, heart disease, bone fractures and death (Jarup, 2003).

Crop and livestock farming is the major occupation of northern Nigerians. Rice is one of the commonest staples produced in the northern region. In order of production level, Zamfara, Jigawa and Borno states follow very closely, especially with specialization on processing facilities (Oluwatomi, 2011). Rice occupies an important place, being the staple food of Nigerians. According to government statistics, yearly consumption of rice is about 5.5 million tons with local production accounting for about 1.8 million tons (Femi, 2013). Rice is the second largest produced cereal in the world. Nigeria has over 3 million out of about 60 million rural farmers who are rice farmers and has approximately 5 million hectares of arable land suitable for rice production (Oluwatomi, 2011).

Previous studies have shown heavy metal contamination of foods; such as rice containing lead, ranged from 0.00-61.17mg/kg and in other food crops and fruits consumed in Owerri (Orisakwe *et al;*2012). Otitoju *et al;* (2012) also reported high concentration of lead and mercury in samples of pumpkin leaves collected from a construction site in Uyo, Nigeria. Rice is a major staple in the Nigerian populace, being consumed by more than a million people per day. Therefore the need to examine the safety of its consumption is of public health and toxicological importance. Hence the aim of this research paper.

MATERIALS AND METHODS

Study area: The study area was northern Nigeria comprising of rice producing communities in Kaduna (Ikara), located within latitude 10^0 15'N and longitude 11^0 10'E, Nasarawa (Lafia, located within latitude 8^0 32' N and longitude 8^0 18'E), Benue (Otukpo, Aliade, and Gboko; coordinates are: 7^0 52' N, 8^0 19' E'), Borno (Biu, Marte and Zarbamari; coordinates are 11^0 30N, 13^0 00 E), Taraba, coordinates are 8^0 00' 10^0 3' E). Samples were collected from major markets with identification parameters (name and location).

Collection and treatment of samples: Rice samples were collected from different market locations from Borno, Benue, Kaduna, Nasarawa and Taraba into different labeled polyethylene bags. The samples were transported to a Laboratory in the department of Home science, Nutrition and dietetics, University of Nigeria, Nsukka. The samples were washed with deionized water and spread on clean bagco bags to allow the water to drain off. The sample were packed into labelled brown envelops and dried in the Gallenhkamp oven at a temperature of 65^0C for 2days. After drying, the samples were pulverized into fine powdery form. The rice samples were sieved using 2 mm sieve to obtain very fine particles. Drying continued until all the wet samples reached a constant weight. Five gram (5g) of dried samples each was weighed into digestion flasks, 4ml perchloric acid and 8ml nitric acid were added to the respective flasks. The digestion flasks were then put on a hot plate set to 120^0C (gradually increased) until the samples were all digested. After digestion the digested samples were diluted with distilled water appropriately in the range of standards which are prepared from stock standard solution of the metal (Mapanda *et al.*, 2005; UNEP/FOA/WHO, 1992). Heavy metal concentrations in the samples were measured using a Perkin Elmer AS 3100 flame atomic absorption spectrophotometer facility from Divine Concept Laboratories Port Harcourt, Nigeria.

Statistical analysis: Means and standard deviations were calculated using the SPSS (statistical package for social sciences) software package (version 17).

Results

The result of heavy metal analysis in locally produced rice from the northern parts of Nigeria is presented in Table 1. The result shows that lead concentrations range from 0.311 to 0.525mg/kg with Canada Taraba rice having the least value of 0.311mg/kg while Kura Ikara ordinary rice has the highest value of 0.525mg/kg. However, Gboko rice (ezigbocp), Otukpo rice, Lafia rice and Biu rice, (par boiled) had undetectable values of lead. The mean value of lead from the various parts is 0.260 mg/kg.

Table 2 (Fig.1) shows the mean values of lead from Benue, Borno, Taraba, Kaduna and Nasarawa states in northern Nigeria. Samples from Taraba state had the least value of lead (0.16 mg/kg) while samples from Kaduna state had the highest value of lead (0.514mg/kg). Lead concentration in the samples from the various states ranged from 0.16mg/kg to 0.514mg/kg. The result also shows that the concentrations of the heavy metals: chromium, arsenic, cadmium and mercury could not be detected at less than 0.001mg/kg in any of the samples.

TABLE 1: Lead concentrations in locally produced rice samples from Northern parts of Nigeria.

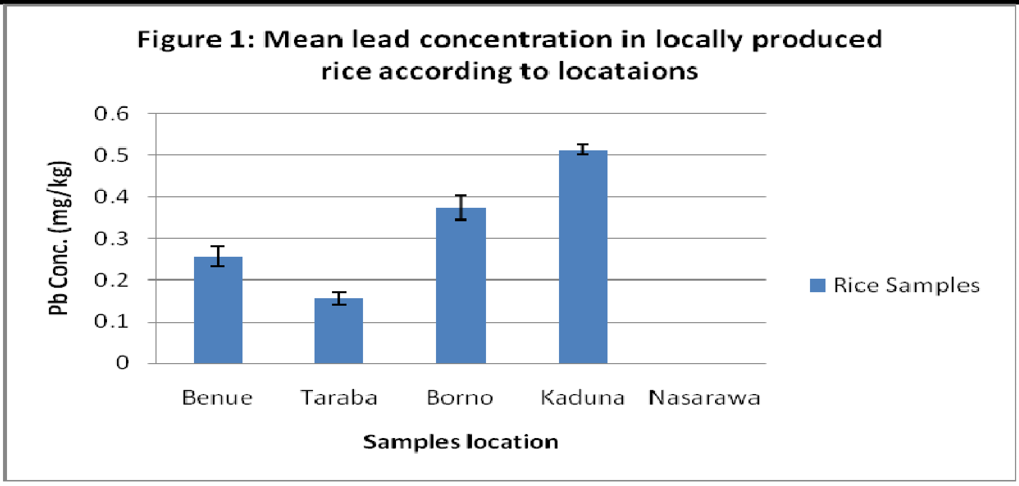
Identity	State	Mean (mg/kg)	Mean (µg/kg)
Gbokorice,ezigbocp	Benue	ND	ND
Aliade rice	Benue	0.510±0.002	510±2
Canada Taraba rice	Taraba	0.311±0.002	311±2
Marte rice (par boiled)	Borno	0.348± O.002	348± 2
Kura,Ikara meal rice	Kaduna	0.502±0.002	502±2
Kura, Ikara ordinary rice	Kaduna	0.525±0.001	525±1
Lafia rice	Nasarawa	ND	ND
Zabarmari rice (par boiled)	Borno	0.408±0.003	408±3
Mean of all samples		0.326	

Mean ±SD

ND=Not detectable

Table 2: Lead concentrations in locally produced rice samples according to their locations (states)

State	Mean (mg/kg)	Mean (μg/kg)
BENUE	0.256±0.024	256±2.40
BORNO	0.374±0.03	156±1.60
TARABA	0.156±0.016	374±3.0
KADUNA	0.514±0.012	514±1.2
NASARAWA	ND	ND



DISCUSSIONS

As a response to the prevailing rice supply deficit situation in Nigeria, successive Nigerian governments intervened in the rice sector by increasing tariffs so that local production could be encouraged. (Bamidele, Abayomi and Esther, 2010). The results of this study have shown that lead (Pb) is the predominant contaminant of locally produced rice from the northern region as it was the only heavy metal found in the samples. The other heavy metals: cadmium (Cd), chromium (Cr), mercury (Hg) and arsenic (As) were not detectable at 0.001 mg/kg. The trend in the lead (Pb) concentration of the samples followed the sequence KIO (Kura, Ikara ordinary rice) > ARB (Aliade rice, Benue) > KIM (Kura, Ikara meal rice) > ZRB (Zabarmari rice, Borno) > MRB (Marte rice, Borno) > CTR (Canada Taraba rice) with lead (Pb) values of 0.525, 0.510, 0.502, 0.408, 0.348 and 0.311 mg/kg respectively. These values were found to be 95.2, 95.1, 95, 94, 93, and 92 % higher than the WHO/FAO (2002) provisional tolerable intake regulations (PTWI) of 0.025 mg/kg lead. However, the lead content of the samples: GRE (Gboko rice,ezigbo cp), ORB (Otukpo rice, Benue), LRN (Lafia rice, Nasarawa) and BRB (Biu rice, Borno) were below detectable limit of 0.001mg/kg. These findings should arouse the attention of researchers and government; since, on the average, it has been revealed that locally produced rice from the northern region are contaminated with high levels of heavy metals and that rice is one of the commonest staples produced in the northern region. (Oluwatomi, 2011).

Comparing the results of this work with similar studies, a work carried out on locally produced wild rice in Kaduna by Umar and Umazi (2013) showed that the mean lead (Pb) content of the wild rice samples was 0.183 mg/kg and was lower than the mean lead (Pb) content of those of our own study. This may be due to difference in the specie of the samples under consideration; total content of soil heavy metal, soil chemical and physical properties; which affect bioavailability of heavy metals in plants (Cheng *et al*, 2006; Rubio *et al*, 1994).

Investigation of the lead (Pb) content of rice from other locations revealed a mean lead (Pb) concentration of 0.01mg/kg in Taiwanese rice (Haw-Tarn *et al*, 2004) and of 61.17mg/kg in Owerri rice, Imo state (Orisakwe *et al*, 2012). Mean lead (Pb) concentration of Taiwanese rice is lower than the mean (Pb) concentration of our study samples, while that of Owerri rice is amazingly higher than it. The Taiwanese rice (Pb) level is below the PTWI (provisional tolerable weekly intake), while that of the study samples and the Owerri rice are higher than the PTWI.

According to the food consumption survey we carried out, an average Nigerian of 68kg body weight eats 28.5kg rice in a year, equivalent to 0.5kg / week (Bamidele *et al*, 2010). An individual who consumes 0.5 kg of the samples KIO, ARB, KIM, ZRB, MRB and CTR per week would ingest 0.263, 0.255, 0.251, 0.204, 0.174 and

0.155mg/kg lead respectively. This weekly lead (Pb) intake would be 90.5, 90.2, 90, 88, 86 and 84% higher than the recommended tolerable weekly intake. These figures arouse a whole lot of concern considering the fact that acute heavy metals poisoning are rare while chronic poisonings of accumulated metals in tissues are more common with their adverse health effects. Other researchers have reported that contaminated food is a major source of heavy metal intake for humans. For instance, rice was shown to be a major source of cadmium and lead intake for Asians (Fangmin *et al*, 2006), vegetables grown along construction site in Uyo were recorded laden, with heavy metals (Otitoju *et al*, 2012).

Similarly, the trend in lead (Pb) concentrations followed the sequence Kaduna > Taraba > Borno > Benue whose mean values are 0.513, 0.311, 0.252 and 0.170mg / kg respectively. Consuming rice of 0.5kg/week according to these locations will result to lead (Pb) weekly intake of 91, 84, 81, and 71% higher than the PTWI of 0.025mg/kg/week. Kaduna state samples recorded the highest mean lead (Pb) value. This is similar to the results of Umar and Wuzani (2013) where wild rice samples from Kaduna Metropolis had the highest lead concentration compared to wild rice from other locations in the state. This was attributed to so many industrial and human activities common to the area. The inhabitants of this area are at greater risk of heavy metal toxicity. A previous study conducted in Kaduna by Nriagu *et al;* (1997) investigated blood lead levels in 87 children aged 1 - 6 years from Kaduna state. An average of 10.6 μg/dl was found, with some children having up to 30 μg/dl. The values exceed the maximum allowed limit of 10 μg/dl recommended by Centre for Disease Control (CDC) and correlated linearly with the distance of house from high traffic roads.

In the Taiwanese study mentioned earlier, Taiwanese rice had 0.08, 0.01 and 0.10 mg/kg mercury (Hg), cadmium and chromium respectively while the samples in our study had undetectable levels of these metals at 0.001 mg/kg detection limit. However, constant check and implementable regulations should be ensured to prevent mercury (Hg), cadmium (Cd), chromium (Cr) and arsenic (As) heavy metals contamination of the samples in future. Heavy metal contamination of foods and their corresponding intake through the contaminated food is a major concern to nutritionists, toxicologists and other health researchers. Consumption of such foods may lead to serious health implications due to heavy metals toxicity.

In conclusion lead (Pb) is the primary heavy metal contaminant of locally produced rice from the northern region of Nigeria. Its mean concentration in all the samples was found to be higher than the FAO/WHO (2002) recommended limit of lead in cereals. Consumers of locally produced rice from the northern region are at greater risk of lead (Pb) toxicity. The result of these are dangerous health effects of lead (Pb) toxicity which include cancer, decreased nervous function, weakness in fingers, wrists, or ankles; small increases in blood pressure; and anaemia, brain and kidney damage, death, pregnancy miscarriage, damage of reproductive organs for sperm production. Martin and Griswold (2009). The opinion of Otitoju *et al;* (2012) that monitoring and systematic gathering of information on heavy metal levels in the environment are essential components of any pollution control system is well supported. It is essential for agricultural activities and other human activities that increase heavy metal contamination of food stuffs be controlled. We recommend that the federal ministry of agriculture should take action on how to control heavy metal contamination of our locally produced food. Also, blood samples of individuals who consume this rice should be analysed for lead (Pb) toxicity and appropriate action taken by the federal ministry of health. We also suggest that further research be carried out to find out the exact factors that were responsible for heavy metal contamination of the samples for specific remedial actions to be taken.

REFERENCES

Arora, M., Bala, K., Shweta, R., Anchal, R., Barinder, K. and Neeraj, M. (2008). Heavy metal accumulation in vegetables irrigated with water from different sources. *Food Chem*., 111: 811- 815.

Bamidele, F.S., Abayomi, O.O. and Esther, O.A. (2010). Economic Analysis of Rice Consumption Patterns in Nigeria *J. Agr. Sci. Tech. Vol. 12: 1-11*

Bennett, J.P. E., Chiriboga, J., Coleman and Waller, D. M. (2000). Heavy metals in wild rice from Northern Wisconsin. *Sci. of Total Environ., 246, 261-269*

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. (China).* 22(11):1792-1799.

Chen, Y., Wang, C. and Wang, Z. (2005). Residues and source identification of persistent organic pollutants in farmland soils irrigated by effluents from biological treatment plants. *Environment International*, vol. 31: 778–783.

Cheng, W., Zhang, G., Yao, H., Wu,W. and Zu, M. (2006). Genotypic and environmental variation in cadmium, chromium, arsenic, nickel, and lead concentrations in rice grains. *J Zhejiang Univ. Sci. B* 7: 565 – 571.

Fangmin, C.Z., Ningchum, H.X., Yi, L., Wenfang, Z., Zhiwei, Z. and Mingxue, C. (2006). Cadmium and lead contamination in Japonica rice grains and its variatio among the different locations in southeast China. *Sci. Total Environ* 359: 156 – 166.

FAO/WHO (2001). Evaluation of certain food additives and contaminants (Fifty-fifth report of the Joint FAO/WHO Expert Committee on Food Additives). WHO Technical Report Series, No. 901 p 78f.

FAO/WHO (2002) Codex Alimentarius - General standards for contaminants and toxins in food. Schedule 1 Maximum and Guideline levels for contaminants and toxins in food. Joint FAO/WHO Food Standards Programme, Codex Committee, Rotterdam. Reference CX/FAC 02/16.

Femi, A. (2013) Smuggling as bane of local rice production. *The Guardian Nigeria Newspaper* (Mon, Jan 7th).

Fu, j., Zhou, Q., Liu, J., Liu, W., Wang, T., Zhang, Q. and Jiang, G. (2008). High levels of heavy metals in rice (Oryza sativa L.) from a typical E-waste recycling area in southeast China and its potential risk to human health. Chemosphere 71 (2008) 1269–1275

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

Haw-Tarn, L., Wang, M.C. and Li, G. (2004). Complexation of arsenate with humic substance in water extract of compost. *Chemosphere* 56: 1105–1112.

Hazardous Substance Research, issue 15. www.engg.ksu.edu/CHSR

Jarup, L. (2003). Hazards of heavy metal contamination. British Medical Journal, 68: 167-182 Kaduna, Nigeria. *The Science of the Total Environment*, 197, 13-19.

Lowe, J. (1989). The Flora of Nigeria Grasses. 2nd edition. Ibadan University Press. Ibadan, Nigeria. In Umar M.A and Wunzani, D.K. (2013). Heavy Metals In Wild Rice From Gure, Kagoro and Kaduna, Kaduna State, Nigeria. *International Journal of Scientific & Technology Research* 2(5) ISSN 2277-8616-252.

Mapanda, F., E.N. Mangwayana, J. Nyamangara and K.E. Giller, 2005. The effect of long-term irrigation using wastewater on heavy metal contents of soils under vegetables in Harare, Zimbabwe. Agric. Ecosyst. Environ., 107: 151-165.

Martin, S. And Griswold, W. (2009) Human Health Effects of Heavy Metals.b Center for

Nriagu, J., Oleru, N.T., Cudjoe, C., Chine, A (1997) Lead poisoning of children in Africa, III.

Oluwatomi, O. (2011) About rice production and processing. *http://tribune.com.ng/index.php/wealth-creation-thru-agric/26645-about-rice-production-and-processing*.

Orisakwe, O.E., Nduka, J.K., Amadi, C.N., Dike, D.O. and Bede, O. (2012). Heavy Metals Health Risk Assessment for Population Via Consumption of food crops and fruits in Owerri, South Eastern, Nigeria. *Chemistry Central Journal* vol. 6:77.

Otitoju, O., Akpanabiatu, M.I., Otitoju, G.T.O., Ndem, J.I., Uwah, A.F., Akpanyung, E.O., and Ekanem, J.T. (2011) Heavy metal contamination of green leafy vegetable Gardens in Itam Road Construction site in Uyo, Nigeria. *Research Journal of Environmental and Earth Sciences* 4(4): 371-375.

Rubio, M.I, Escrig, I., Martinez- Cortina, C., Lopez- Benet, F.J., Sanz, A. (1994). Cadmium and nickel accumulation in rice plant. Effects on mineral nutrition and possible interactions of abscisic and gibberellic acids. *Plant Growth Regulation* 14: 151 – 157.

Singh, K. P., Mohan, D., Sinha, S., and Dalwani, R. (2004). Impact assessment of treated/untreated wastewater toxicants discharged by sewage treatment plants on health, agricultural, and environmental quality in the wastewater disposal area. *Chemosphere*, 55, 227–255.

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 and Wunzani, D.K. (2013). Heavy Metals In Wild Rice From Gure, Kagoro and Kaduna, Kaduna State, Nigeria. *International Journal Of Scientific & Technology Research* Volume 2, Issue 5, ISSN 2277-8616 252.

UNEP/FAO/WHO, 1992. Assessment of dietary intake of chemical contaminants. United Nations Environmental Program, Nairobi.

USAID (2013). Increasing competitiveness and food security in Nigeria. www.nigeriamarket.org. (visited 13th September 2013).

WHO, World Health Organization, 1993. Evaluation of certain food additives and contaminants (41st report of the joint FAO/WHO expert committee on food additives). WHO Tech. Reports Series No. 837.