Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 4, No. 4, p. 202-207, 2014
http://www.innspub.net

RESEARCH PAPER | OPEN ACCESS

Quantification of heavy metal levels in imported rice (*Oryza sativa*) consumed in the Northern Parts of Nigeria

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Article published on April 18, 2014

Key words: Heavy metal, toxicity, exposure, dietary intake, rice.

Abstract

Dietary exposure to heavy metals, namely Cadmium (Cd), Lead (Pb), Chromium (Cr), Mercury (Hg), Arsenic(As), has been identified as a risk to human health through the consumption of some major food substances. This study was designed to investigate five (5) heavy metals (As, Cd, Cr, Hg, Pb) in ten (10) imported rice *(Oryza sativa)* samples consumed in the Northern parts of Nigeria. The study areas were Kubwa in Abuja (FCT), Jos town in Plateau state, Wukari in Taraba state, Jaba in Kano and Central market in Kaduna town, Kaduna state. The result showed the average mean lead concentration in some imported rice samples to be 0.152mg/kg with variations in different areas which when compared with the Provisional Tolerable Weekly Intake (PTWI) of heavy metals set by WHO/FAO at 25µ/kg (0.025mg/kg) body weight far exceed the permissible limit for human health. All the rice samples had lead concentrations above the permissible limit except for "Par Excellence Premium Long Grain rice" (0.014mg/kg) produced in USA which is below the permissible limit. "Royal stallion" produced in Thailand had the highest lead concentration of 0.383mg/kg which also when compared with the Provisional Tolerable Weekly Intake (PTWI) far exceeded the permissible limit. Other heavy metals such as As, Cd, Cr, Hg was undetectable at 0.001mg/kg. Hence, imported rice consumed in the Northern parts of Nigeria may contain toxic levels of heavy metals which should be monitored as it may be deleterious to health.

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Introduction

Contamination of foods by heavy metals has become an inevitable challenge these days. Air, soil and water pollution are contributing to the presence of these harmful elements, such as cadmium, lead, and mercury in food stuffs (Zukowska*, et al*, 2008), similarly, the use of fertilizers and other farm inputs could also contribute to the presence of heavy metals in soil and consequently in food products.

Rice is the seed of the monocot plants (*Oryza sativa)*, for example Asian rice or (*Oryza glaberrima*), for example African rice of the family, Graminaeae (grass family). As a cereal grain, it is the most widely consumed staple food for a large part of the world's human population, especially in Asia and the West Indies. It is the grain with the second highest worldwide production after maize corn (FAOSTAT, 2006).

Heavy metals occur as natural constituents of earth crust and are persistent environmental contaminants since they cannot be easily degraded or destroyed (Ioan *et al.*, 2008). However, these heavy metals become toxic when they do not get metabolized by the body and end up accumulating in the soft tissue. Digestion is the most common route of exposure to heavy metals. In plants, uptake of heavy metals depends on the plant species and bio-availability of the metal in the soils. Heavy metals enter the body system through food, air and water and bio-accumulate over a period of time (Duruibe *et al.*, 2007). Once they enter the food chain, large concentrations of heavy metals may accumulate in the human body. If the metals are ingested beyond the permitted concentration, they can cause serious health disorders (Babel *et al.*,2004) which can seriously deplete some essential nutrients in the body causing a decrease in immunological defenses, intrauterine growth retardation, disabilities associated with malnutrition and a high prevalence of upper gastrointestinal cancer.

Rice is known for its high nutritional content and provides the majority of the calories in the diet of most Nigerians. Besides rice and other staple foods, recent studies done on green leafy vegetables also show that they contain large amount of heavy metals such as cadmium(Cd), iron(Fe), and Zinc (Zn) which could be deleterious to health (Otitoju *et al.*,2012). Rice consumption in the norther part of Nigeria is high and importation from China and India form the major sources for its supply. Contamination of rice by heavy metals has been a trading word between the American government and China. Hence. the aim of this study is to analyze Northern Nigerian imported rice for the level of some heavy metals (As, Cd, Cr, Pb and Hg).

Materials and methods

Study areas

The study was carried out in Kubwa (a town in Abuja (FCT) lying between latitude 8.25 and 9. 020 north of the equator and longitude 6.45 and 7.39 east of Greenwich Meridian), in the central region of Nigeria. Jos town in Plateau, lying between latitude 9° 56'N and longitude 8° 53'E (a city in the middle Belt of Nigeria). Jaba (in Kano lying between latitude 13°N in the North and 11°N in the South and longitude 8°W in the West and 100 in the East). Wukari (a town in Taraba lying between latitudes 6°25'N and 9°30'N and longitudes 9°30'E and 11°45'E) in the north eastern part of Nigeria. Finally, central market Kaduna-Kaduna State (Lying between latitudes 9° and 14 north of the equator and longitude 70 and 100 east of Greenwich meridian) at the centre of Northern Nigeria. Samples were collected from the major markets with proper identification parameters (name and locations).

Collection and treatment of samples

Rice samples were collected from different marked locations from Abuja, Jos, kano, Taraba and Kaduna State, into different labeled polyethylene bags. The samples were transported to the laboratory in Home Science, Nutrition and Dietetics, Department, University of Nigeria, Nsukka. Two hundred (200) g each of rice samples were washed with de-ionized water and spread on clean plastic trays to allow the water to drain off. The samples were packed into a labeled brown envelops and dried in the Gallenhkamp oven at a temperature of 65°C for 2 days. After drying, the samples were pulverized into fine powdery form. The rice samples were sieved using 2mm sieve to obtain very fine particles. Drying continued until all the wet samples reach a constant weight. Five (5) g of dried samples each was transferred into digestion flasks, 4ml perchloric acid and 8ml nitric acid was added to the respective samples. The digestion flasks were put on a hot plate set at 120°C (gradually increased) until the samples were digested. After digestion, the digested samples were diluted with distilled water appropriately in the range of standards which was prepared from stock standard solution of the metals. (APHA and WCPF, 1998; IAEA/UNEP/FOD/IOC, 1984). Heavy metal (arsenic, cadmium, mercury, chromium, zinc, lead, nickel, copper) concentrations, in the samples were measured using a Perkin Elmer AS 3100 Flame atomic absorption spectrophotometer, a facility of Divine Concept Laboratories Port Harcourt Nigeria.

Statistical analysis

Mean and standard deviation were determined using the SPSS (Statistical package for social sciences) Software package (version 17, 2008).

Results

The result of heavy metals analysis of rice samples consumed in the Northern parts of Nigeria is hereby presented. Table 1 shows results of lead concentration in some imported rice samples consumed in Northern parts of Nigeria. The result shows that "Royal stallion" produced in Thailand had the highest lead concentration of 383µg/kg (0.383mg/kg) while "Excellence Premium Long Grain rice" produced in USA had the least lead concentration of 14µg/kg (0.014mg/kg). However, "Royal umbrella" produced in Thailand and "Unity rice" produced India had undetectable levels of lead. The result also shows that these imported rice samples had an average mean of 152µg/kg (0.152mg/kg) lead concentration. Table 2 shows result of lead concentration in some imported rice samples with their specific locations. The result shows "Royal Stallion" produced in Thailand had the highest lead concentration of 383µg/kg (0.383mg/kg) while "Excellence Premium Long Grain rice" produced in USA had the least lead concentration of 14µg/kg (0.014mg/kg).

Table 1. Lead concentrations in some imported rice samples consumed in Northern parts of Nigeria.

Samples	Identity	Mean (mg/kg)	Mean (µg/kg)
S_{21}	People choice, India	0.283±0.002	283±2
S_{22}	Lune Darfraque, Vietnam	0.308±0.001	308±1
S_{23}	Golden Gold, Brazil	0.082±0.002	82±2
S_{24}	Royal Umbrella, Thailand	ND	ND
S_{25}	Unity rice, India	ND	ND
S_{26}	Royal Stallion, Thailand	0.383±0.002	383±2
S_{27}	Mama Americano ,South America	0.104±0.002	104±2
S_{28}	Xtra Special, Brazil	0.287±0.003	287±3
S_{29}	Crystal rice, India	0.057±0.002	57±2
S_{30}	Par Excellence Premium Long Grain rice, USA	0.014±0.001	14±1

Mean ±SD
ND-Not Detectable

Table 2. Lead concentration in some imported rice samples consumed in Northern parts of Nigeria.

Location	*Mean (mg/kg)*	*Mean (µg/kg)*
People choice, Unity rice, Crystal rice (India)	0.113±0.150	113±150
Golden Gold, Xtra Special (Brazil)	0.185±0.145	185±145
Lune Darfraque (Vietnam)	0.308±0.001	308±1
Mama Americano (South America)	0.104±0.002	104±2
Par Excellence Premium Long Grain rice (USA)	0.014±0.001	14±1
Royal Stallion (Thailand)	0.383±0.002	383±2

Mean ±SD

Discussions

Rice is seen as a staple food widely consumed for a large part of the world's human population especially in developing nations like Nigeria. Consumption of rice contaminated with heavy metals, especially those imported from other countries may pose adverse health challenges in the general populace. In this study, the trend of lead concentrations in imported rice samples consumed within the Northern parts of Nigeria were in the descending order: Royal stallion>Lune Darfraque>Xtra special>People choice>Mama Americano>Golden Gold>Crystal rice>Par Excellence Premium Long Grain rice. . Lead concentrations in these rice samples were 0.383mg/kg, 0.308mg/kg, 0.287mg/kg, 0.283mg/kg, 0.104mg/kg, 0.082mg/kg, 0.057mg/kg, and 0.014mg/kg respectively. The concentration in these rice samples are high and when compared with the Provincial Tolerable Weekly Intake (PTWI) of heavy metal set by WHO/FAO(1999) at 25µg/kg bw, lead concentrations are far greater than the permissible limit except for sample Par Excellence Premium Long Grain rice produced in USA which has lead concentration below the permissible limit. This result indicates that USA rice particularly "Excellence Premium Long Grain" have acceptable concentration of lead. However, "Royal Umbrella" produced in Thailand and "Unity rice" produced in India had undetectable levels of lead. According to the Maximum Recommended Levels of Contaminants in foods of China (MHPRC, 2005), the average lead concentration of 1.44mg/kg in rice grains is also far greater than the permissible limit. Some results revealed high lead concentration in rice, for example the average lead concentration of polished rice in Lake Victoria Basin, Tanzania shows 0.10µg/g which is higher than the worldwide mean (0.02µg/g) reported by Watanabe et al., (1989). In a survey of heavy metal concentration in rice from E-waste recycling area in Southeast China, 2008, the Geometric mean (GM) of lead for 13samples was 0.69µg/g which exceeded the Maximum Allowable concentration (MAC) of 0.20µg/g by 3.5 folds indicating serious contamination of lead in rice samples.

Similarly, some previous studies also reported that lead concentration in rice sample grown in China was 355.5ng/g (Cheng *et al.*,2006). From this study, lead concentration in rice samples produce in Thailand and Vietnam have the highest concentration compared to other countries mentioned earlier which are far greater than the permissible limit. In general, "Royal stallion" produced in Thailand highly exceeds the PTWI seconded by "Lune Darfraque" produced in Vietnam. The latter is one of the world's richest agricultural regions and the second largest (after Thailand) exporter worldwide as well as the world's seventh-largest consumer of rice (Xinhua, 2010). Furthermore, from literature, the most economic and famous plant in Thailand is rice field which is also one of the main components of Thailand exports. Increasing rice production to support the export has created problems of toxic heavy metal contamination in the environment thereby endangering the lives of the populace (Kingsawat, *et al.*, 2011). If an adult with an average weight of 70kg can consume 500g of rice per day, he/she is bound to consume about 5folds lead concentration higher than the Tolerable Daily Intake (TDI). Some individuals may consume more than twice of the average amount of rice and their dietary intakes of these heavy metals would further exceed the PTWI. Chronic poisoning of rice contaminated with heavy metals (Pb) may lead to blood anemia and brain damage. Research has shown that long term low-level lead exposure in children may lead to diminished intellectual capacity (WHO, 1995). Again, Huo et al., (2007) reported elevated lead levels in blood samples from children in Guiyu, an E-waste recycling center in China. Though lead concentration in USA rice was the lowest compared to other countries in used in this study, attention still needs to be paid to the amount and frequency of imported rice being consumed in Nigeria.

Heavy metal concentration (As, Hg, Cd, Cu, Cr) in some imported rice samples were below detectable limit of 0.001. It is therefore obvious that consumers of imported rice grown in polluted environment are at a greater risk of heavy metal toxicity. This polluted environment could be attributed to soil contamination by heavy metals and human activities such as mining, overuse of fertilizers and pesticides. Studies have demonstrated that high concentration of toxic heavy metals such as Pb, Cd, Hg, reduce soil fertility and agricultural output (Lokhande and Kall, 1999). It has also been reported that metals such as Iron, Copper, Cadmium, Chromium, Lead, Mercury, Nickel have the ability produce reactive oxygen species. The result of this is lipid peroxidation, DNA damage, and altered calcium homeostasis (Stohs and Bagchi, 1994; Otitoju and Onwurah, 2005). Therefore, consumption of rice imported into the country may require another level of screening in order to save the exposed or vulnerable population (Pregnant women and children). This result will therefore help the government, individuals and the entire populace to identify imported rice with high levels of heavy metal and to take necessary measures in controlling heavy metal pollution that affects rice plant while still in the field which in turn poses some health hazards to human when consumed.

Acknowledgment

The authors acknowledge the assistance of Divine Concept Laboratory Port-Harcourt, Nigeria for helping in the analysis of this study. We also appreciate the efforts of friends for helping in sample collection.

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