

Quantification of Heavy Metal Levels in Some Locally Produced Rice (Oryza Sativa) from the South-East and South-South Geopolitical Zones of Nigeria

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ABSTRACT

The contamination of our foods with heavy metals has predisposed humans and even animals to heavy metal toxicity which is of public health importance. These findings have drawn the interest of biochemist, nutritionist, health workers and researchers all over the world. Rice is one of the most widely consumed staples in Nigeria. This study investigated the concentration of heavy metals in locally produced rice from the South-East and South-South geopolitical zones of Nigeria. A total of ten (10) samples were collected from various locations in the South-East and South-South geopolitical zones and five (5) heavy metals (As, Cd, Cr, Pb and Hg) were analyzed from each samples. The result showed that of Cr and Pb concentrations ranged from 0.019-0.282mg/kg and 0.000-1.722mg/kg respectively. The average mean for chromium (Cr) and lead (Pb) concentrations were 0.060 and 0.777mg/kg respectively. Mercury, chromium and arsenic were below detectable concentration of <0.001mg/kg. To assess the safety of dietary intake, weekly intake of heavy metals contaminated rice, was calculated based on the intake of a typical 60kg body weight Nigerian. The result indicated that weekly intake of heavy metals from rice was above the provisional tolerable weekly intakes recommended by FAO/WHO and USNAS (United States National Academy of sciences). This study also showed that Cr and Pb concentration were high and frequent consumption of these rice samples may lead to bioaccumulation of these metals in our body which may lead to serious health implications.
Keyword: heavy metal, rice, toxicity, health, tolerable weekly intake.

INTRODUCTION

Rice is a staple food that is widely consumed in the South-East and South-South geopolitical zones in Nigeria, also Nigeria as a whole. Rice has been known to be very rich in carbohydrate, and contains other nutrients; also it has been proven through research to contain both beneficial and toxic heavy metals(Sue-Sun Wong *et al.,* 2004). Heavy metals occur naturally in the ecosystem, but rarely at toxic levels. Heavy metals are persistent environmental contaminants since they cannot be easily degraded or destroyed (Loan *et al.,* 2008), this is because they are stable. They are absorbed by plants through the atmosphere, fertilizers, pesticides and deposition of urban and industrial waste on the soil and the water (Duruibe*et al.,* 2004) used to irrigate the plants. So, when humans consume any of these food sources, they are bound to absorb some of these heavy metals into their system (Jarup, 2003). Excess heavy metal accumulation in the environment is capable to have toxicological implication in humans, plants and other animals (Otitoju*et al.,* 2012).

Mechanized farming and the use of fertilizers and chemicals are the current practices in agriculture. These practices are applied in the South-East and South-South of Nigeria in the cultivation of local rice in other to ensure food security. The consequence of these practices is an environment contaminated by heavy metals from fertilizers, chemicals and fume from the machines. Plants (rice) in this environment absorb these heavy metals which bio accumulates in theplants system. When these contaminated foods are consumed by animals or humans, it predisposes us to ill health.

Heavy metal pollution is of significant ecological/ environmental concern. This is due to the fact that they are not easily biodegradable or metabolized, thus precipitating far reaching effects on the biological system such as humans, animals, plants and soil biota (Yoon, 2003). The impact of heavy metal on public health has drawn the attention of many researchers who stresses that those crops grown on contaminated soils and with fertilizers especiallyphosphatic fertilizers which contain cadmium and other potential toxic heavy metals like lead and mercury (Johnson*et al.,* 1998) bio accumulates these heavy metals. Human exposures to heavy metals have been the focus of increasing attention among researchers, health and nutrition experts due to their impact in public health (Otitoju*et al.,* 2012).

Rice is known for its high calorific value and it is mostly consumed as the main meal of the day. In the South-East and South-South geopolitical zones of Nigeria, is widely cultivated because it constituent a major component of their diets and is of great economic importance.Nutritionally, heavy metals consumed (in local rice or other food stuffs) are directly antagonistic to essential trace elements and compete with nutrient elements for binding on transport and storage proteins, metalloenzymes and receptors (Duruibe*et al.*, 2007).

The aim of this study is to determine major locally rice producing communities in these zones. Also, to analyze rice samples from the different communitiesin these zones in Nigeria for the level of some heavy metals (chromium, lead, mercury, cadmium and arsenic).

MATERIALS AND METHOD

Study area: The study was carried out in the South-East and South-South geopolitical zones in Nigeria comprising of rice producing communities. In the South-East; Adani and Eha-Amufu in Enugu state (lies within latitude $6^o24'$N and longitude $7^o31'$E), Abakaliki (lies within latitude $6^02'$N and longitude $8^06'$E). In the South-South; Ini in Akwa Ibom states (lies within latitude 5^oN and longitude 8^0E) and Calabar (lies within latitude $4^057'$E and longitude $8^019'$E). Samples were collected from major markets in these communities with proper identification parameters (name and location).

Collection and Treatment of Samples

Dried rice samples was collected from different marked locations in Akwa-Ibom, Ebonyi, Enugu and Cross-river states, into different labeled polyethylene bags. These samples were transported to the laboratory in Home Science, Nutrition and Dietetics department, University of Nigeria, Nsukka. The samples were carefully sorted to; eliminate stones, chaff, sticks and other unwanted materials, it was then washed with de-ionized water and spread on a clean plastic container to drain all water. The samples were then packed into labeled brown envelops and dried in a Gallenhkamp oven at a temperature of 65^0C for four days. After drying, the samples were pulverized by grinding in an agate mortar into fine powdery forms. The pulverized samples were sieved to obtain very fine particles using a sieve of 0.5m mesh size. Drying continues until all the wet samples reach a constant weight (Otitoju *et al.*, 2012).

One gram (1g) of dried samples each was sieved into digestion flasks,2-3 spatulas of anti-bump granules and 50ml of 2molar HNO_3 (nitric acid) were added to each of the samples.After which, the sample mixtures was put into electric thermal heater and allowed to concentrate for 30mins-1hr. The concentrated sample mixtures each were then poured into 100ml volumetric flask and distilled water was added appropriately in the range of standards which was prepared from stock standard solution of the metals (APHA and WCPF, 1998; IAEA/UNEP/FOA/IOC, 1984). Heavy metals [arsenic (As), cadmium (Cd), lead (Pb), chromium (Cr) and mercury (Hg)] concentration in the 100ml samples was measured using a UNICAM 939 Atomic Absorption spectrophotometer (AAS).

Statistical Analysis: Mean and standard deviation was calculated using SPSS (statistical package for social sciences) software package.

Table 1: Chromium, lead, mercury, arsenic and cadmium concentration in locally produced rice samples from South-East and South-South Zones in Nigeria.

Samples	Identity	Chromium (Cr) mg/kg	Lead (Pb) mg/kg	Mercury (Hg) mg/kg	Arsenic (As) mg/kg	Cadmium (Cd) mg/kg
S_1	B-G Adani	0.023±0.002	1.17±0.02	ND	ND	ND
S_2	Authority Adani	0.019±0.003	1.722±0.002	ND	ND	ND
S_3	14-16 Adani	0.037±0.003	1.275±0.002	ND	ND	ND
S_4	R_{16}Abakaliki	0.282±0.002	1.298±0.002	ND	ND	ND
S_5	Mass Abakaliki	0.051±0.001	ND	ND	ND	ND
S_6	R_{24} Abakaliki	0.062±0.002	0.354±0.002	ND	ND	ND
S_7	R_8 Abakaliki	0.122±0.002	0.538±0.002	ND	ND	ND
S_8	Ini rice	ND	0.378±0.002	ND	ND	ND
S_9	Calabar rice	ND	0.406±0.002	ND	ND	ND
S_{10}	Eha-Amufu rice	ND	0.627±0.001	ND	ND	ND

Mean ±SD

ND-Not detectable

Table 2: Average mean of chromium and lead concentrations in locally produced rice samples from South-East and South-South Zones of Nigeria.

Heavy metals	Mean (mg/kg)	Mean (µg/kg)
Cr	0.060±0.087	60±87
Pb	0.777±0.550	777±550

Mean ±SD

Table 3: Average mean of chromium and lead concentrations in locally produced rice samples from the same location in the South-East and South-South Zones of Nigeria.

Location	Chromium (Cr) mg/kg	Lead (Pb) mg/kg
Adani rice (S_1, S_2& S_3)	0.026±0.010	1.389±0.293
Abakaliki rice (S_4, S_5, S_6& S_7)	0.129±0.107	0.548±0.548
Ini rice	ND	0.378±0.002
Calabar rice	ND	0.406±0.002
Eha –Amufu rice	ND	0.627±0.001

Mean ±SD ND-Not detectable

RESULTS

The result of the heavy metal analysis of locally produced rice samples from South-East and South-South zones in Nigeria is presented in Table 1. The result shows that Ini, Calabar and Eha-Amufu rice samples have no detectable chromium levels at <0.001mg/kg. The chromium level in rice samples from Adani ranges from 0.019-0.037(mg/kg), while that from Abakaliki ranges from 0.051-0.282(mg/kg). The lead concentration ranges from 0.000-1.722(mg/kg). The sample authority rice from Adani has the highest value of lead while mass rice from Abakaliki have no detectable at <0.001mg/kg value for lead. The result also showed that lead concentration for Adani rice ranges from 1.170-1.722(mg/kg) and that of Abakaliki is 0.354-1.298(mg/kg). Mercury, arsenic and cadmium concentrations were not detectable at <0.001mg/kg.

This table 2 shows the average mean of chromium and lead concentrations in locally produced rice samples from South-East and South-South zones of Nigeria. The result reveals that the lead concentration is 0.777mg/kg for the ten samples and is greater than that of chromium concentration (0.060mg/kg).

Table 3 presents the average mean of chromium and lead concentrations in locally produced rice samples from the South-East and South-South zones of Nigeria. The rice samples produced in Adani ($S_{1,}S_2$ and S_3) have a chromium concentration of 0.026mg/kg which is less than that of rice samples from Abakaliki (S_1, S_2, S_3 and S_4) with a concentration of 0.129mg/kg. The lead concentrations of rice samples from Adani have 1.389mg/kg as their mean, while that of Abakaliki is 0.548mg/kg. Lead concentration in rice samples from Adani is 60.55% greater than that of Abakaliki.

DISCUSSION

The health of any nation is an important factor to the development of that nation or country. Good nutrition is vital to live a healthy life. To maintain good nutrition, a variety of diet is consumed of which rice has been observed to provide one fifth of the calorie consumed worldwide by human species. Through research, rice has been proven to contain heavy metals (Sue-Sun Wong *et al.*, 2004). In this study, I observed that both the average and low income earners consume this locally produced rice which has been found to contain some heavy metals.

This result shows the average concentration of chromium and lead in the ten rice samples to be 0.060-0.777mg/kg respectively on dry weight basis. Polishing of the bran and embryo may reduce the concentration of some heavy metals (Sue-Sun Wong *et al.*, 2004) and some of this rice samples were not polished and those that were polished were not properly polished.

Table 1 list the chromium concentration in rice samples. The mean concentration of S_1, S_2, S_3, S_4, S_5, S_6 and S_7 from Adani and Abakaliki were 0.023, 0.019, 0.037, 0.282, 0.051, 0.062 and 0.122 mg/kg respectively on dry weight basis. It was found that the chromium concentration in the rice samples were in this order; $S_4>S_7>S_6>S_5>S_3>S_1>S_{2.}$

In a survey, I found out that an individual of 60kg weight consumes about 500g of rice daily on the average thrice a week. The individual is bound to absorb 0.035, 0.029, 0.056, 0.423, 0.077, 0.093 and 0.183 mg/kg/week of chromium concentration for samples; S_1, S_2, S_3, S_4, S_5, S_6 and S_7 respectively. When this chromium concentration (mg/kg/week) by an individual is compared with the Provisional Tolerable Weekly Intake (PTWI, which is 0.023mg/kg), S_1, S_2, S_3, S_4, S_5, S_6 and S_7 are 33.43, 19.66, 58.39, 94.49, 69.74, 74.95 and 87.27 % greater than the PTWI stated by the FAO/WHO and USNAS.

Table 1 lists the lead concentration in rice samples from different locations. The mean concentration of; S_1, S_2, S_3, S_4, S_5, S_6, S_7, S_8, S_9 and S_{10} were 1.17, 1.722, 1.275, 1.298, ND, 0.354, 0.538, 0.378, 0.406 and 0.627 mg/kg respectively (on dry weight basis). It was found that the lead concentration in rice samples were in this order; $S_2>S_4>S_3>S_1>S_{10}>S_7>S_9>S_8>S_6>S_5$. It was also observed that rice sample from Adani has the highest lead concentration with its average as 1.389mg/kg. Based on the survey, (i.e. an individual 60kg of weight consumes 500g of rice daily per week on the average), the individual is bound to absorb and accumulate 1.755, 2.583, 1.913, 1.947, ND, 0.531, 0.807, 0.567, 0.609 and 0.941 mg/kg/week of lead concentration for each of the samples; S_1, S_2, S_3, S_4, S_5, S_6, S_7, S_8, S_9 and S_{10} respectively. On comparing these levels of lead concentration (mg/kg/week) consumed by an individual with PTWI (which is 0.025mg/kg); S_1, S_2, S_3, S_4, S_5, S_6, S_7, S_8, S_9 and S_{10} are98.58, 99.03, 98.69, 98.71, ND, 95.29, 96.90, 95.59, 95.90 and 97.34% respectively, greater than the PTWI.

The result shows that 70% and 90% of chromium and lead concentration in most rice samples were detectable at 0.001mg/kg. Mercury, arsenic and cadmium of all rice samples were 100% undetectable at 0.001mg/kg. Comparing chromium and lead concentration of rice samples from different location, reveals that chromium concentration of rice from Adani on the average is 0.026mg/kg which is 79.84% less than rice samples from Abakaliki (0.777mg/kg on the average). Lead concentration of rice from Adani (1.389mg/kg) is 65.55% greater than that from Abakaliki, 72.79% greater than that from Ini, 70.77% greater than that from Calabar and 54.86% greater than that from Eha-Amufu. The level of lead concentration in these rice samples from different location appears in this ascending order; Inirice<Calabarrice<Abakalikirice<Eha-Amufu rice.

This result showed that these rice samples produced in South-East and South-South geopolitical zones in Nigeria for personal consumption and profit when sold have high levels of chromium and lead. This may pose a lot of health implications to the people due to the presence of heavy metals as components of the earth crust. Several researches have shown that pollution can have an influence on the stability of populations by increasing mortality and or reproduction output (Dauwea*et al.,* 2004).

It is therefore obvious that consumers of these local rice samples are at greater risk of heavy metal toxicity especially, children, youth and women who depend on rice as a major source of calorie. Other researchers have reported on the health implication of excess transitional metals in biological systems to include membranes and therefore, toxicity associated with these metals may be due to oxidative damage (Otitoju*et al.,* 2012). Research has also shown that heavy metals such as cadmium, chromium, lead, mercury etc. have the ability to produce reactive oxygen species which results to lipid peroxidation, DNA damage and altered calcium homeostasis (Stoh and Bagchi, 1994; Otitoju and Onwurah, 2005). Therefore, consumption of heavy metal polluted rice could lead to several health hazards such as cardiovascular diseases, cancers, diabetes, hypertension, arthritis, Alzheimer's disease and poor development of the grey matter in children (Udedi, 2003; Ogwuegbu and Muhanga, 2005).

CONCLUSION

In this study, I found that local rice produced in South-East and South-South geopolitical zones in Nigeria had high concentrations chromium and lead.The weekly consumption of these rice samples contaminated with heavy metals was higher than the PTWI recommended by FAO/WHO and USNAS when compared.Consumption of these rice samples will result to accumulation of chromium and lead in the body leading to some health problems.It is known that environmental pollution (due to industrialization and mechanization), use of fertilizers, pesticides, herbicides and insecticides, have contributed to the accumulation of these heavy metals in our plants and soil.

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