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Determination of Heavy Metals in Locally Produced Rice (*Oryza Sativa*) Species in Ogwashi-Uku, Delta State, Nigeria

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Abstract:

This study was based on the analysis of heavy metals in three selected brands of locally produced rice (Oryza sativa) that circulates in Ogwashi-Uku, Delta State of Nigeria. Some heavy metals namely, Copper (Cu), Manganese (Mn), Zinc (Zn), Lead (Pb), and Cadmium (Cd) were analyzed using Atomic Absorption Spectroscopy (AAS). Rice samples were digested using nitric acid (conc.). The mean concentrations of Cu, Mn, Zn, Pb and Cd were <0.001-0.180±0.001mg/kg, <0.001-0.021±0.001mg/kg, 0.023±0.002mg/kg - 0.037±0.002mg/kg, 0.477±0.011mg/kg - 0.760±0.001 mg/kg and 0.002±0.012 - 0.018±0.001mg/kg respectively. The result shows that Cu, Mn, Zn, and Cd where within the permissible limit stipulated by WHO/FAO (2010). The mean value of Pb (0.477±0.011mg/kg - 0.760±0.001) was high than the allowable limit of 0n.2mg/kg in all the rice samples. This high value obtained could have resulted from the excessive use of fertilizers and pesticides in the cultivation process and frequent consumption of these rice samples may lead to bioaccumulation of Lead (Pb) in human which may cause serious health implications.

Keywords:

Contamination, Consumption, Food, Heavy Metals, Health, Human, Pollution, Rice

1. Introduction

Rice is the seed of the grass species Oryza Sativa [Asian rice] or Oryza glaberrima [Africa rice] [1]. As a cereal grain, it is the most widely consumed staple food for a large part of the world with Nigeria ranked the highest producer and consumer of rice in the West Africa region.

Rice is relatively easy to produce and is grown for sales and for home consumption. In some areas, there is long tradition of rice growing, but for many, rice has been considered a luxury food for special occasion only. With the increased availability of rice, it has become part of the everyday diet of many in Nigeria [2].

The cultivation of rice in Nigeria has tremendously increases since ban was placed on imported rice. The high demand for the locally produced rice requires that safety measures should be put in place to ensure good health of the public. Food safety

awareness is gaining prevalence in recent years among most developing countries. Safety and quality are of major concern to most individuals and countries [2]. Lack of food safety is a major problem in most developing nations in Africa. Many of our food items are loaded with lots of heavy metals contamination. Consumption of the contaminated foods has serious implication on both human health and economic status of populace [3,4,5].

Heavy metal is any metallic chemical element that has high density and can be toxic at low concentration. Examples include Zinc, Arsenic, Lead, Cadmium, Nickel and Mercury etc. They occur as natural constituents of the earth crust and are also distributed by human activities such as the use of agrochemical, deposition of urban and industrial waste on the soil and the water used to irrigate the plants [6].

Rice pollution with heavy metals also depends on other reasons such as Industry Status area, traffic and distance of the rice grown from the road. Therefore, the plants grown in industrial areas have higher concentrations of heavy metals.

Heavy metals, such as lead, cadmium, nickel and mercury are toxic to human even in small amounts and cause various health problems, such as kidney damage, lung problems, cancer and bone injuries [7]. On the other hand, farmers that cultivate rice, fertilize their crops using chemical fertilizers causing the accumulation of these metals in rice [8].

Earlier studies have confirmed the presence of significant levels of some of these metals in rice grains. [2] reported that Lead content in locally produce rice in Nigeria were high and the values ranged from 0.311 mg/kg to 0.525mg/kg. It was also reported that Lead (Pb) toxicity claimed 28 lives with 44 others hospitalized in Niger Delta. Another report in 2010 recorded the death of more than 500 individuals in a community located in Zamfara state on account of same Pb poisoning [9]. In both cases the heavy metal concentration in the blood was above the recommended dosage.

In effort to ensure that rice consumers are not at risk of metal poisoning, the research aim to investigate the level of heavy metals in rice sold in Ogwashi-Uku Main Market, Delta State and to ascertain if they are within the permissible level stipulated by FAO/WHO and will assist in putting in place measures to ensure safety of the rice consumed in Ogwashi-Uku community.

2. Materials and Methods

2.1. Study Area

The study area was Ogwashi-Uku in Delta State which is located west of the state capital, Asaba.

Figure 1. *Map of Ogwashi-Uku, Delta State (Source: Google map data, 2020).*

Its geographical coordinates are latitude 6° 10' 0" North of the equator and longitude 6° 31' 0" East of Greenwich Meridian. The population of Ogwashi-Ukwu is about 50,234 which have vastly increased.

2.2. Sample Collection

Rice samples were collected from different retail stores in Ogwashi-Uku Main Market, Delta State using a plastic container, each with proper identification parameters (name and locations). Three different brands namely illah rice (from Illah in Delta State), Umza rice (from Anambra State) and Ogoja rice (from Cross River State) were randomly selected. The samples were carried to Springboard Laboratory in Awka, Anambra State for preparation and analysis.

2.3. Sample Preparation

$2g$ of rice sample was weighed out and poured into a digestion flask. $20ml$ acetic acid mixture ($600ml$ Conc. HNO_3, $80ml$ perchloric acid and Conc. H_2SO_4) was then measured using measuring cylinder and added to the sample. The digestion flask was heated with the aid of a heating mantle until a clear digest was observed. After which the digest was diluted with distilled water to bring the digest up to 50ml mark. Appropriate dilution was made for each element. The filtrate was then analyzed using FS240AA Agilent Model.

2.4. Preparation of Reference Solution

A series of standard metal solution in the optimum concentration range was prepared, the reference solution were prepared by diluting the single stock element solutions with water containing *1.5ml* concentrated nitric acid/litre. A calibrate ion blank was prepared using all the reagents except for the metal stock solution.

Calibration curve for each metal was prepared by plotting the absorbance of standards versus their concentration.

2.5. Sample Analysis

Heavy metal analysis of the rice samples were conducted using Varian AA240 Atomic Absorption Spectrophotometer according to the method of [10]. Atomic Absorption Spectrometer's working principle is based on the sample being aspirated into the flame and atomized when AAS's light beam is directed through the flame into the monochromator and on to the detector that measure the amount of light absorbed by the atomized element in the flame. Since metals have their own characteristic absorption wave length, a source lamp composed of that element is used, making the method relatively free. The characteristic wave length absorbed in the flame is proportional to the concentration of the element in the sample.

2.6. Statistical analysis

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

3. Results

The result of heavy metal analysis for locally produced rice common in Ogwashi-Uku, Delta State is presented in Table 1.

Table 1. *Concentration of heavy metals in the different rice samples.*

Samples Identity	Cu (mg/kg)	Mn (mg/kg)	Zn (mg/kg)	Pb (mg/kg)	Cd (mg/kg)
Illah Rice	0.019±0.003	N.D	0.037±0.002	0.760±0.001	0.018±0.001
Umza Rice	0.180±0.001	0.002±0.001	0.026±0.002	0.681±0.017	0.005±0.001
Ogoja Rice	N.D	0.021±0.001	0.023±0.002	0.477±0.011	0.002±0.012
FAO/WHO (2010)	**0.5mg/kg**	**0.5mg/kg**	**0.3-1.0mg/kg**	**0.2mg/kg**	**0.4mg/kg**

Mean ±Standard deviation N.D: Not Detected

The result shows that Copper (Cu) concentrations ranges from N.D to 0.180±0.001mg/kg with Ogoja rice having the lowest value which was not detected at <0.001mg/kg. The mean value for Mn ranged from N.D to 0.021±0.001, Zinc (Zn) ranged from 0.023±0.002mg/kg to 0.037±0.002mg/kg with Illah rice having the highest value of 0.023±0.002mg/kg. The mean concentration value for Lead (Pb) ranged from 0.477±0.011mg/kg (Ogoja rice) to 0.760±0.001mg/kg (Illah rice) while that of Cd ranged from 0.002±0.012 to 0.018±0.001mg/kg.

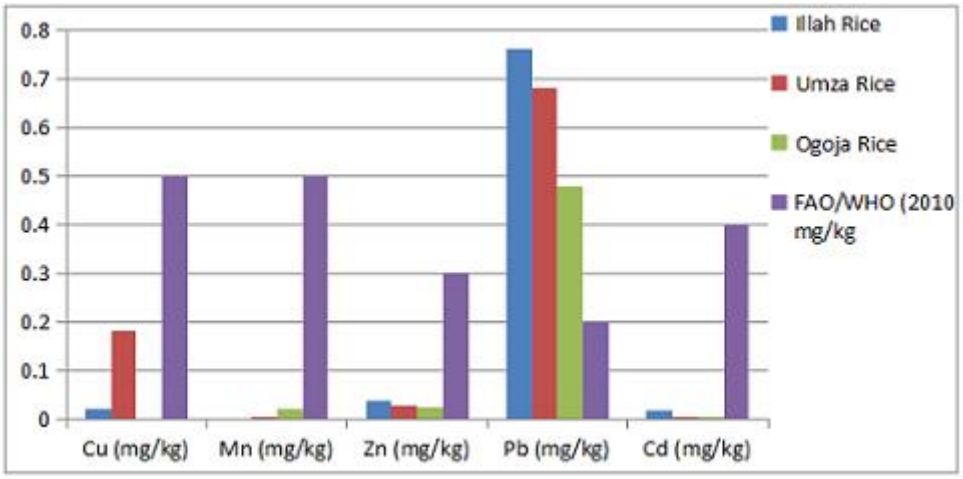

Figure 2. *Mean Concentrations of heavy metals in locally produced rice according to location.*

4. Discussions

Rice is seen as a staple food widely consumed by Nigerians but the consumption of rice contaminated with heavy metals, poses adverse health challenges in the health of the consumers.

The results from this study shows that heavy metals (Copper (Cu) and Manganese (Mn) analyzed were all within the permissible limit stipulated by [10]. Cu in Ogoja rice sample and Mn in Illah rice samples were below detectable limit of <0.001mg/kg.

The concentration of zinc in the rice samples as shown in Table 1 were within the recommended value permissible by [11] and was far lower than the value (19.050mg/kg) obtained by [12] when Some Heavy Metals in Aerial Parts of Wild Rice Plant in Kaduna State, Nigeria was evaluated. Zn is present in biochemical system as a trace metal and it is indispensable for the growth and development of plants and animals. Zinc is very necessary in the synthesis of nucleic acid and the manufacture of their components also as a component of enzymes [13]. This might have contributed to the amount in the plant and grain in this study.

Also, result obtained in this study shows that lead (Pb) is the major contaminant of locally produced rice consumed in Ogwashi-Uku, ranging from

0.4770.023±0.0020.011mg/kg (Ogoja rice) to 0.760±0.001mg/kg (Illah rice) as it has the highest value in the samples analyzed. This lead (Pb) contamination poses a threat to food safety and health of consumers. Other studies have also reported higher concentration of lead (Pb) in rice. In the work of [2] on the determined of levels of some heavy metals (Cd, Cr, As, Pb and Hg) in locally produced rice samples from the northern region of Nigeria, the results showed that lead (Pb) ranged from 0.311 – 0.525mg/kg in the samples. Average lead (Pb) concentration was 0.260 mg/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 [14,15] provisional tolerable weekly intake of lead (Pb). In humans, Lead (Pb) can result in a wide range of biological effects depending upon the level and duration of exposure. Health effects include hematological effects, neurological and behavioral effects, renal effects, cardiovascular effects and effects on the reproductive system. Children are more vulnerable to the effects of the lead than adults. Long term low-level lead exposure in children may lead to diminished intellectual capacity [16]. The high level of lead (Pb) in the locally produced rice could be attributed to soil contamination by industrial activities, and the overuse of fertilizers and pesticides.

Cadmium exposure in humans has been linked with several adverse effects leading to illnesses notably amongst them being cancer [17]. Foods such as cereals, vegetables and starchy root tubers are known to contain lower cadmium concentrations. Rice is known to accumulate high concentration of cadmium if grown on cadmium polluted soils, thus considered as one of the major sources of cadmium in humans [18]. In this study, the cadmium content of the rice samples were below the maximum limit of 0.4 mg/kg permitted by [11].

5. Conclusions

The ban in imported price in Nigeria has increase the dependent on locally produced rice especially the low income populace not minding if it is safe. The study investigated the heavy metals (Cu, Mn, Zn, Pb and Cd) content of locally produced rice brands commonly consumed within Ogwashi-Uku, Delta State, Nigeria. The findings indicate that the rice brands have heavy metals at tolerable concentrations that do not exceed the Maximum Allowable Concentration set by [19] except for lead (Pb). Concluding from the results obtained, it is necessary for locally produced rice in Nigeria to be properly screened to ascertain how safe it is for human consumption. This study will help the government, organizations, and the entire populace to identify locally produced rice with high levels of heavy metal and to take necessary measures in monitoring and controlling heavy metal pollution that affects rice plant while still in the field which in turn poses some health hazards to human when consumed.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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