Short Research Article

Determination of Arsenic Content in Different Brands of Rice Sold in Port Harcourt, Nigeria.

ABSTRACT

Arsenic, a naturally occurring element seen in the environment and cycled by water has been seen to be a pollutant in soil and water. The inorganic form of arsenic is associated with major health problems and cancer mainly arising from its anthropogenic activities. The content of arsenic was assayed in six rice brands sold in Port Harcourt, Rivers State, Nigeria. The rice samples were ground to powdered forms and subjected to acid digestion before analysis. The Agilent Micro Plasma Atomic Emission Spectrophotometer (MP-AES) was used to analyze the digested samples. Results showed arsenic mean concentration in Vico Rice, the highest as 1.0073 ± 0.0064. This was followed by Local Rice 0.9420 ± 0.0020,Marori Benz 0.9140 ± 0.0122, Golden Stallion Rice 0.861 ± 0.0029 and the Cap Rice 0.8077 ± 0.0068 while the least mean concentration of arsenic was recorded in African Princess Rice 0.6417 ± 0.0021. The mean concentration was significantly different in the six brands of rice ($P<0.05$). The arsenic content in the different rice brand was within the tolerable concentration not above the Maximum Allowable Concentration of 1.4mg/kg in cereals and vegetables. This concentration did not exceed the Maximum Permissible Limit of 1mg/kg hence considered safe for consumption except Vico rice with a higher concentration above 1mg/kg. This shows that rice brands sold in Port Harcourt pose no health risk for consumers.

Key Words: Rice Brand, Arsenic Concentration, Port Harcourt

1. INTRODUCTION

Rice (*Oryza sativa*), the second most prevalent cereal in the world is a staple food that is mainly the people's diet. It is the source of about 72% calorie and 66% of the protein in its entire nutritive content [1]. Its global importance cannot be overemphasized especially in the Asian, Caribbean, and Sub –Sahara Africa [2] where there is a higher need for its consumption as a staple food and serves as a major source of their economy.

Despite the fact that Nigeria accounts for about 44% of rice production in West Africa [3], the demand for rice still outweighs the local production, hence, need for importation from countries like India, Thailand, China, etc [4].

Rice is often grown around flooded areas covered with water of irrigation or in paddies that are mostly contaminated with arsenic thus raising a serious environmental and health concern to humans [5,6,7]. Arsenic is naturally present in the environment. A mineral seen in the earth crust found in soil, water, plants, and animals. However, humans complicated the issue of pollution by adding more arsenic to the soil through the application of pesticides and fertilizers, discharge of industrial waste into water, mining and smelting activities, coal burning, etc.[8,9]. Consumption of staple food such as rice is grown in some contaminated soil which is now recognized as a tangible route of human exposure to arsenic. Arsenic (As) occurs in food because it is present in the soil and water environment and it is taken up by crop plants. Arsenic can exist in the inorganic, organic and gaseous forms. The inorganic form of arsenic has been implicated to be the major cause of both cancerous and non-cancerous health related problems due to its toxicity. Examples of such disease include Blackfoot disease [10], hyperkeratosis, conjunctivitis, cardiovascular [11], and cancer of the bladder, skin, lung, liver, and kidney which can result from continuous consumption of elevated levels of arsenic from drinking water however, consumption of even low levels of arsenic over a long period can cause a multitude of diseases [12].

In recent decades, millions of people have suffered from arsenic poisoning as a result of drinking arsenic contaminated water extracted from shallow tube wells in South and South East Asia. Moreover, the presence of arsenic in drinking water has reached calamitous proportion in many parts of the world[13]. The presence of such water on agricultural soils can be a major source of arsenic uptake by crop plants. Moreover, excess uptake of arsenic by crops may present food safety problems. The organic species (monomethylarsonic acid, MMA, and dimethylarsenic acid, DMR) are common metabolites found in the human body which are less harmful and readily eliminated by the body. They are mostly found in kinds of seafood. However, the inorganic form is highly toxic compared to the organic arsenic. Moreover, arsenic pollution is of environmental concern because the metalloid form is not easily biodegradable, hence may affect the biological systems in humans, and animals [14] even when they may be present in very low concentration in food and drinking water.

The inorganic forms of arsenic is generally considered more toxic and of public health concern while the organic form though non-toxic is believed to be a promoter for cancer [15] especially in rice. Studies have reviewed alarming levels of arsenic in rice and human exposure to these heavy metals through food needs to be checked and averted to reduce serious health complications and challenges. [16,17] highlighted arsenic toxicity and poisoning, coupled with the global issue that rice can be poisonous [18] because rice has been found to absorb more arsenic than other food crops [19].Therefore, it is of importance in this study to evaluate the content of arsenic in some rice brands sold and consumed within Port Harcourt Metropolis, Rivers State, Nigeria.

2. MATERIALS AND METHODS

Rice Collection: A total of six brands of rice were bought within Port Harcourt metropolis. Three different samples were collected from each of the brands of rice as representative samples. The rice grain samples were ground using an electric blender to fine powdered form which was placed in airtight plastic containers until analysis. Each sample was properly labeled accordingly. The Mass Plasma -Atomic Emission Spectroscopy (MP-AES) was used for the quantitative determination of arsenic concentration using the API-RP45 method.

Digestion: Accurately weighed 1gm of well-pulverized rice grain was placed in a small beaker followed by the addition of 10mL of concentrated HNO_3 and allowed to stand overnight. The mixture was then heated on a hot plate until the production of red NO_2 fumes has stopped. The beaker was then allowed to cool, followed by the addition of 2-4mL of 70% $HClO_4$ and heated to evaporation of small volume of the mixture. The remaining quantity was then transferred to a 50mL flask and diluted to volume with distilled water to the 50mL mark. The prepared solution was then analyzed for arsenic concentrations using the standard method of API-RP45 in MP-AES Agilent machine.

Statistical Analysis: The results were expressed as Mean ± Standard Deviation (SD).Data were computed to check for statistical significant of arsenic concentrations in the different brands using the Analysis of Variance (ANOVA) and the Turkey Multiple Comparison tests were used to check differences in means between the different brands of rice. Values were considered significant at P<0.05. The SPSS Version 22 software was used for the computation of data.

3. RESULTS

Table 1. Arsenic Concentrations(triplicate) in Brands of Rice Studied

GS	CR	APR	VR	MB	LR
0.864	0.813	0.640	1.012	0.920	0.940
0.860	0.810	0.641	1.010	0.900	0.942
0.859	0.800	0.644	1.000	0.922	0.944

Source: Authors' Field Survey, 2019.

Table 2: Statistical Evaluation of As Concentration in Rice (n=3).

Brands of Rice	Mean ± SD	SE
Golden Stallion (GS)	0.8610± 0.0029	0.0015
CAP Rice (CR)	0.8077 ± 0.0068	0.0039
Africa Princess Rice (APR)	0.6417 ± 0.0021	0.0012
Vico Rice (VR)	1.0073 ± 0.0064	0.0037
Marori Benz (MR)	0.9140 ± 0.0122	0.007
Local Rice (LR)	0.9420 ± 0.0020	0.0015

Source: Authors' Field Survey, 2019.

The result reported in triplicates (Table 1) revealed that variation exists in the arsenic concentrations of the different brands of rice studied. On subjecting the result to descriptive statistic, it was confirmed that the aforementioned variation existed as shown by their respective means and standard deviations (Table 2). The arsenic (As) content varies between 0.647 ± 0.0021 As mg/kg DW – 1.0073 As mg/kg DW. The result further revealed that Vico rice had the highest arsenic (As) content (1.0073 ± 0.0064 As mg/kg DW), followed by Local rice (0.9420 ± 0.0020 As mg/kg DW), Marrori Benz rice (0.9140 ± 0.0122 As mg/kg DW), Golden Stallion rice (0.8610 ± 0.0027 As mg/kg DW), and Caprice (0.8077 ± 0.0068 As mg/kg DW), while the least concentration was recorded in African Princess rice (0.6417 ± 0.0021 AS mg/kg DW). This ranking agrees with the bar chart shown in as the brands of rice were arranged according to ascending order of their respective arsenic (As) content (Figure 1).

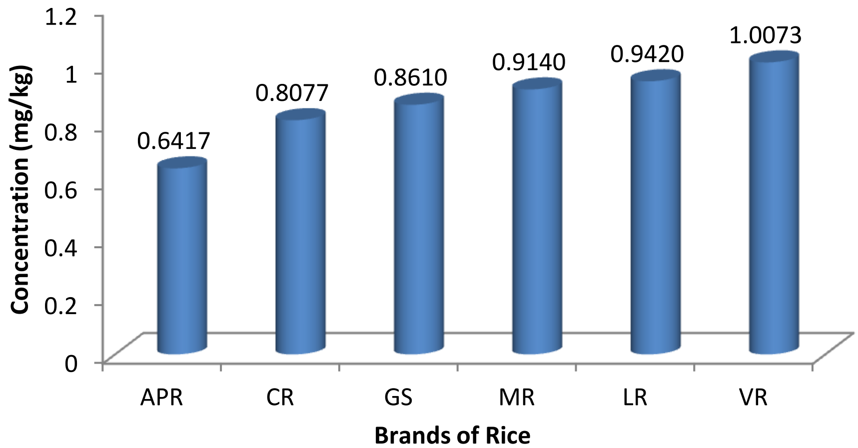

Figure 1: Bar Chart showing Variation of As Concentration in Rice

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Table 3: Single Factor ANOVA for As concentration in Brands of Rice Studied.

Source of variation	SS	df	MS	F	Sig.
Between groups	0.245	5	0.049	1172.154	0.000
Within Groups	0.001	12	0.000		
Total	0.245	17			

Source: Authors' Field Survey, 2019.

The result was subjected to a single factor ANOVA to ascertain if there is any statistically significant difference in arsenic (As) content of the rice studied and presented in Table3.

Table 4: Multiple Comparison of Arsenic (As) Concentration in Brands of Rice by Post Hoc Test.

Brand of Rice	Arsenic Concentration (mg/kg)
Golden Stallion (GS)	0.8610 ± 0.0027[a]
Cap Rice (CR)	0.8077 ± 0.0068[b]
African Princess Rice (APR)	0.6417 ± 0.0021[c]
Vico Rice (VR)	1.0073 ± 0.0064[d]
Marori Benz (MR)	0.9140 ± 0.0122[e]
Local Rice (LR)	0.9420 ± 0.0020[f]
F Value	1172.154
P-Value	0.000

Source: Authors' Field Survey, 2019.

The ANOVA result was further subjected to post hoc multiple tests to know where the significance occurred, and presented in Table 4.

4. DISCUSSION

From Table 2, the result revealed that the arsenic (As) contents of the brands of rice marketed and consumed in the city of Port Harcourt and it's environ varied between 0.6417 (Least) – 1.0073(highest). The result is in agreement with results obtained by [20,21,22] who reported arsenic (As) content of 0.156 – 0.19 mg/kg in rice produced and consumed in most European countries like Italy and Spain, and US respectively. Moreover, the arsenic (As) content in the rice consumed and marketed in Nigeria had a very low content of arsenic (As) when compared to these foreign rice.

Again, the result obtained from a similar survey in Awka, Nigeria, was at variance with the result obtained from this study. The arsenic content (1.373 As mg/kg DW) in the rice from Awka, Nigeria, was found to be very much higher in arsenic content than the one obtained in Port Harcourt [23]. However, this arsenic (As) content in the different brands of rice marketed and consumed in Port Harcourt city and its environs, were smaller or lower than the maximum allowable concentration (MAC) of 1.4mg As kg^{-1} as recommended by JECFA [24 and15] who recommended a maximum permissible limit of 1mg As kg^{-1}.

Furthermore, Vico rice (VR) is the only rice that has arsenic content (1.0073 mg As kg-1) closer to the recommended limit prescribed by [24] but was at par with the maximum permissible limit prescribed by [15]. This implies that consumption of this brand of rice can be a possible means of exposure to arsenic poisoning, if not properly monitored to know the reasons for the presence of arsenic at that high level. In addition, this may be a major source of dietary arsenic exposure to humans and animals that may consume it [25, 26].

The arsenic (As) content in the studied brands of rice confirmed the presence of arsenic in the soils from which these brands of rice were grown [25]. Thus, suggesting that the arsenic present in this rice is geogenic. Thus, indicating that arsenic contents found in rice could be traced to the source from which the particular rice was gotten from. This idea was corroborated by [26] who reported documented evidence of arsenic uptake by rice grown in some soils in Asian countries like Bangladesh, Bengal, etc., where geogenic arsenic (As) has been implicated to be a major contributor to the presence of this element in rice. This idea was further corroborated by [27], who unanimously reported the bioaccumulation of arsenic (As) by rice grown in arsenic (As) contaminated soils. It could, therefore, be inferred that Vico rice (VR), local rice (LR), Marori Benz (MB), Golden Stallion (GSR), and Caprice (CR) may have been grown in soils that naturally contained higher levels of geogenic arsenic.

Again, in order to increase agricultural output, farmers sometimes apply arsenic (As) containing pesticides (Sodium, calcium and lead arsenate) and fertilizers exclusively which in their mobile state in the soil, can be absorbed (taken up) by plants. Thus, application of such pesticides and fertilizers on the soil from which these rice brands were grown could be implicated.

Irrigation water containing arsenic (As) bearing effluents used in rice paddy could be another contributor. In most Asian countries this practice is common, and this has led to the uptake of heavy metals into crops irrigated with arsenic (As) bearing water. Moreover, if the source of water used in planting, is contaminated with arsenic, there is a likely hood that the plant will take up arsenic from the soil [28, 6].

Hence, arsenic contamination from different routes must be monitored in rice production and procession [29, 30, and 31]. This can also be applied to local rice produced in Nigeria which was reported to having arsenic (As) content close to Vico rice, in order to prevent food poisoning from this source. Moreover, this may even reduce arsenic content to a very low level comparable to rice grown and consumed in Thailand [32].

The result when subjected to single factor analysis of variance and a post hoc test revealed and confirmed that the brands of rice statistically differed in their arsenic (As) content at $P < 0.05$. (Table 3 and Table 4).

5. CONCLUSION

Arsenic content in the brands of rice studied varied between 0.6417 ± 0.0021(least) and 1.0073± 0.0064 mg As kg^{-1}DW(Highest), which could be attributed to soil geogenicity, application of pesticide and fertilizer containing arsenic, and use of arsenic contaminated irrigation water for rice paddy. Moreover, the method used was able to achieve its purpose and is environmentally friendly. Rice consumption is one of the methods of human and animal exposure to environmental arsenic, which can be reduced by avoiding over usage of the aforementioned contributors.

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