RESEARCH ARTICLE

THE EFFECT OF ALUMINIUM AND STEEL COOKING UTENSILS ON TRACE METAL LEVELS IN BOILED RICE

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ABSTRACT

Levels of trace metals: iron (Fe), aluminum (Al), copper (Cu), chromium (Cr) and nickel (Ni) were analyzed spectrophotometrically in rice cooked in aluminum and stainless steel pots. These metals were also determined in uncooked rice which served as the control. Results obtained indicated that, the lowest concentrations of all the metals analyzed for were recorded in the uncooked rice (the control). It was also noticed from results recorded that Al recorded its highest mean level (0.44±0.04mg/kg) in rice cooked in aluminum pot while Chromium recorded the highest mean concentration (0.98 ± 0.04mg/kg) in rice boiled in stainless steel pot. Results obtained in this study further revealed that, cooking utensils can leach some quantities of trace metals into food during processing, hence resulting in slight increase in the concentration of these metals in processed foods. The general results showed that levels of Fe and Al obtained were within their recommended safe limits whereas, concentrations of Cu, Cr and Ni were above their maximum acceptable levels. The study has also shown that rice has a high potential of leaching these metals from cook wares examined. Based on results obtained, cooking of rice in aluminum pot should be discouraged since this metal present a risk for the consumers especially in the prolonged exposure even at low concentrations. These results are discussed based on their environmental and health implications.

KEYWORDS: rice, heavy metals, spectrophotometer environmental and health implications

INTRODUCTION

Environmental pollution is a major cause of the elevated levels of micro and macro elements in food chain (Nnorom *et al.*, 2007). When soil environment is polluted by trace metals, plants grown on them absorb these toxic metals and transferred same directly to human and grazing animals when these plants are taken up by them (Raphael *et al.*, 2010). The soil–plant transfer of trace metals is a part of chemical element cycling in nature but a very complex process governed by several factors, both natural and artificial

(Kabata-Pendias, 2004). Trace metals are potential environmental contaminants /pollutants with the capabilities of causing human health problems if present in foods at high concentrations (Fair-weather Tait, 1988; Ebong, Obot and Etuk, 2010). However, trace metals are significant in nutrition especially if its concentration is within the safe limit. Food can be contaminated during different stages of agricultural production particularly in the soil where these metals are naturally, present (Zhuang *et al.,* 2009). Trace metals due to their persistence, non-biodegradability and toxicity even at low concentrations, are given special attention by researchers throughout the world. Studies have shown that the nature of cooking wares, cooking process, storage and processing methods can increase trace metal levels in foods (Ebong *et al.*, 2010). Cabrera *et al.* (2003) reported that, the type of cooking utensil used might contribute some considerable amounts of trace metals into our foods by way of leaching in addition to the ingredients used. In Akwa Ibom State and Nigeria in general, the most commonly used cooking pots are those made of aluminum and stainless steel. The choice of these pots is because, they are the most popular and economical cookware commonly found in most Nigerian markets in addition to the fact that they are easy to clean, have unique surfaces that cannot crack easily, difficult to rust and high life expectancy. This research therefore seeks to study the levels of trace metals in cooked and uncooked rice using aluminum and steel cooking wares.

RESEARCH METHODOLOGY

The uncooked rice utilized for this research work was bought from Watt market in Calabar South, Cross River State of Nigeria. In the laboratory,1kg of rice was washed with distilled water to remove dust particles and divided into three (3) equal parts each, two (2) of which were cooked differently in aluminum pot and stainless steel pot 30mins for rice using electric stove. The soft samples were then sieved to remove water, dried in oven at 105^0C for 12 hrs then ground into fine powdery form. The uncooked samples were oven dried at 100^oC for 24hrs and grinded using mixer grinder (model 33750). These ground samples were preserved for digestion and trace metal analysis (Adeniji et al., 2007).

Samples digestion and trace metal determination

Sample Digestion and trace metals Determination: 1g of each of the ground samples was weighed into a $125cm^3$ Erlenmeyer flask, $4cm^3$ of perchloric acid ($HClO_4$) was added followed by $25cm^3$ conc. HNO_3 and $2cm^3$ concentrated H_2SO_4 in a conical flask under perchloric acid fume hood to almost dryness. The content was continuously heated at 180- 220^0C for about 35mins until dense white fumes appeared on the topmost part of the flask. The solution was heated again for about 10mins until a clear yellow solution was obtained. The resulting solution was allowed to cool, after which $40cm^3$ of distilled water was added, re-boiled for 30seconds on the same plate at medium heat. The solution was cooled and then filtered with Whatman filter paper No. 42 into a $100cm^3$ Pyrex volumetric flasks and made up the volume with distilled water. The trace metal determination was done using Atomic Absorption Spectrophotometer (AAS) model GBC Aranta Pm according to the methods of Sobukola *et al*. (2009).

Results and Discussion

The mean levels of trace metals analyzed for in cooked and uncooked rice obtained from watt market Calabar South, Cross River State using Aluminum and stainless steel pots are presented in Table 1.

Results obtained revealed that the food item studied recorded variable levels of trace metals with aluminum recording the lowest metal level. Results obtained also indicated that, iron recorded the highest mean metal concentration with a range of 1.83 – 4.45mg/kg, the lowest Fe level was recorded in uncooked rice (1.83mg/kg) and the highest in plantain cooked with stainless steel pot (4.45mg/kg).

Table 1: Level of trace metals (mgkg^{-1}) in cooked and uncooked rice, beans, yam and plantain.

Cooking Utensils	Mean conc. In mg/kg dry weight ± S.D				
	Fe	Al	Cu	Cr	Ni
Uncooked	1.83 ± 0.03	0.20±0.01	1.05±0.35	0.37 ±0.13	1.86 ±0.05
Aluminum pot	2.67±0.02	0.44±0.04	1.47±0.12	0.48± 0.01	3.37±0.11
Stainless steel	3.46±0.12	0.10±0.01	1.14±1.03	0.98 ±0.04	4.32±0.21
Traditional (clay) pot	87.5±02a	28.9±03b	<0.1c	<0.1c	<0.1c

Values are mean ±SD of samples analyzed in triplicate

The high level of Fe recorded in this study may be attributed to the availability of the metal in the earth's crust and its importance for both plant growth and human (Ebong *et al*., 2006). The result also revealed that food cooked with stainless steel pot recorded more of the Fe than those cooked with aluminum pot or their uncooked counterparts. This may be attributed to the fact that stainless steel is a metal alloy that contain more than fifty percent (50%) Fe be it ferritics or martensitic which are the most common constituent in almost all stainless steel cooking utensils found in homes and industries among other factors. However, the range of Fe obtained in this study is within the recommended safe limit for the metal in food (0.8mg/kg) by JECFA (1983).

This is in agreement with the findings reported by Accominotti *et al*. (1998) who reported in his study that the amount of metals released into food during cooking or processing were still less than the tolerable daily intake (TDI) recommended. The low concentrations of Fe recorded in the control samples have shown that, some amounts of Fe have been leached from the cooking utensil into the food items cooked. Thus, a periodic assessment of the level of this metal in human body is recommended to avoid bioaccumulation and its attendant's effects in future. A range of 0.04 - 0.44mg/kg was obtained for Al in this study. The Results recorded for Al indicated that, the metal was leached from the cooking utensil into the food items cooked since high levels were obtained in samples cooked in aluminum pot. This is in agreement with reports by Dobonne *et al*. (2010) that, the level of aluminum increased from 1.60 mg/g in uncooked rice to 18.1mg/g in rice cooked with traditional cooking pot made of aluminum during their research work. However, the range of Al recorded in cooked and uncooked food items are within the safe limit in food (7.00mg/kg) by JECFA (1989). This is in agreement with reports that, cooking in aluminum vessels increases the content in the foodstuffs less than 1 mg/kg for about half the foodstuffs examined, and less than 10 mg/kg for 85% of the foodstuffs examined (Pennington and Jones, 1989). Studies have also shown that, acidic foodstuffs and soft fruits most frequently take up more Al from the containers than their basic counterparts (Hughes, 1992). Greger *et al*. (1985) reported that, the longer the cooking time, the greater the accumulation of aluminum and about 3.5 mg/day quantity of Al is added to the daily diet through the use of aluminum for food processing. Based on results obtained, cooking of rice in aluminum pot should be discouraged since this metal present a risk for the consumers especially in the prolonged exposure even at low concentrations. Several complications have been reported on toxicity of aluminum in human like Alzheimer's disease (Harrigton, 1994), Neurons alteration diseases (Crapper *et al.*, 1976; Bharathi *et al*., 2008) among others. Copper according to Codex (1995) is naturally present in most foodstuffs in the form of copper ions or copper salts. It is among the most effective of metal biochemical oxidizing agents. Copper though needed in our body can be harmful if present in excess amount as it acts as a hemolytic agent (Aaseth and Norseth, 1986). Copper recorded a range of 1.05 – 7.26mg/kg in this study with the highest level in beans cooked with aluminum pot while uncooked rice showed the lowest Cu concentration. The obtained results also indicated that, levels of Cu in all the food items cooked with aluminum pot were higher than their corresponding levels in food items cooked in stainless steel pot and uncooked ones. This confirmed that, aluminum cook wares may contain alloying elements such as magnesium, silicone, iron, manganese, copper and zinc (European Standard EN 601; European Standard EN 602).

The results also revealed a high contamination of cooked rice in traditional utensil made of aluminum. In fact, after cooking the aluminum content of rice increased from 1.6 to 18.1 mg/g, more than 11 times (ATT = 11.31). The traditional pot is therefore directly responsible for this contamination. The analysis of the clay forming the utensil made of this material reveals a strong presence of aluminum (87.5 mg/g) and iron (28.9 mg/g). Other metals, like copper, zinc, lead, chromium and nickel are present at contents below 0.1 mg/g. This traditional utensil is very commonly used in some villages. It is used both for cooking and consumption of food. Its metals content shows that it is also a potential source of food contamination by aluminum. Its high content (87.5 mg/g) is due to the chemical composition of the site that provided the clay used for the manufacture of the utensil.

In fact, aluminum is one of the most abundant elements in the earth' crust. It is present in soil and water (Keith *et al*., 2002; Liang *et al*., 2009). The analysis also revealed the presence of several other metals among which there are elements such as lead, chromium and nickel, which are potentially toxic to humans. Whatever with low concentrations, these metals like aluminum present a risk for the consumer especially in the prolonged exposure materialized by the daily use of kitchen utensils.

CONCLUSION

Results obtained in this study has revealed that different food crops have different potential of accumulating trace metals in addition to supplying valuable information about the trace metal levels in food crop commonly eaten in Cross River State, Southern Nigeria.

REFERENCES

Accominotti, M., Bost, M.; Haudrechy, P.; Mantout, B.; Cunat, P. J.; Comet, F.; Mouterde, C.; Plantard, F.; Chambon, P. and Vallon, J. J. 1998. Contribution to chromium and nickel enrichment during cooking of foods in stainless steel utensils. *Contact Dermatitis,* 38 (6): 305-310.

Nnorom, I. C. (2007). Trace of heavy metal level of some bouillon cubes and food condiments readily consumed in Nigeria. *Pakistan Journal of Nutrition*, 6 (2):122 - 127.

Raphael, E. C., Eunice, O. E. and Frank, E. O. (2010). Trace metals distribution in some common tuber crops and leafy vegetables grown in the Niger Delta Region of Nigeria.

Pakistan Journal of Nutrition, 9 (10): 957-961.

Kabata-Pendias, A. (2004). Soil-plant transfer of trace elements-an environmental issue. *Geoderma* 122: 143- 149.

Fairweather-Tait, S. (1998). Zinc in human nutrition. *Nutrition Research Review* 1: 23-27.

Ebong, G., Obot, I. and Etuk, H. (2010). Copper Impacting Potential of Boiling Ring during Water Heating, *International Journal of Chemical, Environmental and Pharmaceutical Research,* 1(3):16-22.

Zhuang, P., H. Zou and W. Shu (2009). Biotransfer of heavy metals along a soil-plant-insect- chicken food chain: Field Study. *Journal of Environmental Science*, 21 (6): 849-853.

Cabrera, C., Lloris, F., Gimenze, R., Olalla, M., Lopez, C., (2003). Mineral content in legumes and nuts: Contribution to the Spanish dietary intake. *Science Total Environment,* 308:1-14.

Sobukola, O. P., Adeniran, O. M., Odedaira, A. A., Kajihausa, O. E. (2009). Heavy metal levels of some fruits and leafy vegetables from selected markets in Lagos, Nigeria. *African Journal of Food Science*, 4 (2): 389-393.

JECFA (1983). Evaluation of certain food additives and contaminants. Twenty-seventh report of the Joint FAO/WHO Expert Committee on Food Additives. World Health Organization, Technical Report Series 696.