# ANALYSIS OF HEAVY METALS IN HAWKED CHARCOAL ROASTED BEEF (SUYA) WITHIN PORT HARCOURT METROPOLIS

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## ABSTRACT

Analysis of raw and roasted beef (suya), sold and consumed in Iwofe, Trans Amadi and Port Harcourt city were screened for the presence of iron, lead, cadmium, chromium and nickel. They were determined after digesting with aqua regia and analyzed using atomic absorption spectrophotometer. Various concentrations of these metals obtained were subjected to statistical analysis using SPSS statistical software. Appreciable mean amounts of Fe (19.35mg/kg) and (15.91mg/kg) in the roasted and raw meat samples respectively were recorded in Iwofe. Port Harcourt City recorded the highest value for Ni (5.54mg/kg) in the roasted beef sample. Lead, cadmium, and chromium were all assayed for and appreciable amounts were found to be present in the roasted and raw beef samples respectively. FAO/WHO (2001) permissive level for Fe (48mg/kg) and USDA (2006) permissive levels for Cr and Cd (1.0mg/kg and 0.5mg/kg) were higher than those in the samples. However, Pb and Ni far exceeded the permissive levels of FAO/WHO (2001) permissive level of 0.2mg/kg respectively. The nature of the food chain and certain environmental activities can impact negatively on the nutritional content of foods. This therefore places consumers at potential health risk.

**Keywords:** Heavy metals, pollution, roasted beef, DNA, toxicity.

## INTRODUCTION

Humans all over the world have suffered from different dangerous health challenges because of environmental degradation. This degradation is as a result of pollution which has caused mortality in man, plant and animal. Heavy Metals are some of the released pollutants due to various anthropogenic activities and these metals accumulate in the food chain affecting man through consumption. Heavy metals are defined as metallic elements that have a relatively high density compared to water (Fergusson, 1990). Metals are naturally found in the earth's crust and their compositions vary among different localities, resulting in spatial variations of surrounding concentrations. They are also substances with high electrical conductivity, malleability, and luster, which voluntarily lose their electrons to form cations .With the assumption that heaviness and toxicity is inter-related, heavy metals also include metalloids, such as arsenic, which are able to induce toxicity at low levels of exposure (Duffus, 2002).

When heavy metals are released into the environment, they find their way into different compartment of the environment including plants, animals and human systems. Such metals find their way into parts of the body such as liver, lung, gizzards, kidney, and brain tissue, thereby compromising human health (Michael and Ayebaemi, 2013). Contamination of food by metals such as cadmium, lead, nickel, chromium and iron in areas with high anthropogenic activities is widespread (Ejaz-ul, *et al*., 2007).

Human health can be affected seriously because of excessive consumption of dietary heavy metals from food. The excess heavy metals can deplete some essential nutrients in the body causing a decrease in immunological defenses, intrauterine growth retardation, impaired psycho- social behaviours, disabilities associated with malnutrition and a high prevalence of upper gastrointestinal cancer (Arora *et al*. 2008). Metal ions have also been found to interact with cell components such as DNA and nuclear proteins, causing DNA damage and conformational changes that may lead to cell cycle modulation, carcinogenesis or apoptosis (Beyersmann & Hartwig 2008).

Different anthropogenic activities such as power transmission, sludge and industrial effluent dumping, mining, intensive agricultural practices military operations and energy/fuel production lead to the distribution of heavy metals in the environment (Orcutt and Nilsen, 2000, Cseh, 2002).

This study focuses on the assessment of the level of selected heavy metals in roasted and raw beef sold in Port Harcourt metropolis.

## MATERIALS AND METHODS

### Sample collection

Nine (9) samples of roasted beef (suya) and raw beef were respectively collected from three locations; Iwofe, Trans Amadi and Port Harcourt city in Rivers State Nigeria.
All collected samples were stored in polyethylene bags and taken to the laboratory for preparation and treatment

### Sample treatment and preparation

The collected samples were washed with distilled water to remove any contaminant particles, cut to small pieces and dried in an oven at $100^0$C for 3 hours. After drying 2g of each beef sample was weighed into 100ml conical flask and aqua regia ($HNO_3$: HCl) was added and heated for few minutes. After cooling to room temperature, the volume was made to mark with distilled water, shaken and filtered into polyethylene (PET) bottle respectively for atomic absorption spectrophotometer analysis.

### Procedure for Atomic Absorption Spectrophotometry (AAS)

Standard solution of metal of interest (Fe, Pb, Cr, Cd & Ni) was prepared respectively. Out of the stock solution, serial dilutions were made and standard peaks developed using the AAS. Determination of heavy metals (Fe, Ni, Pb, Cr, Cd) was achieved by obtaining peaks that corresponded to the standard peaks. The atomic absorption spectrophotometer Perkin Elmer Analyst 200 model was used in this research.

### Statistical Analysis

The achieved data were processed statistically and presented as mean ± Standard deviation and statistical significance of the treatment effect were analyzed using one way analysis of variance (ANOVA). Statistical package for social science (SPSS) version 21 windows software and significance level at p values $\leq 0.05$ were considered significant, while p values $\geq 0.05$ were considered to be statistically non-significant.

## RESULTS AND DISCUSSION

**TABLE 1:** Mean concentrations (mg/Kg) of heavy metals contained in roasted beef (Suya)

| METAL | SAMPLE LOCATION | | |
|---|---|---|---|
| | IWOFE | TRANS-AMADI | PORT HARCOURT CITY |
| Fe | 19.35±9.20 | 12.98±4.93 | 7.18±3.18 |
| Pb | 0.14±0.00 | 0.14±0.00 | 0.14±0.00 |
| Cr | 1.11±0.00 | 1.11±0.00 | 1.11±0.00 |
| Cd | 3.00±1.10 | 5.34±1.59 | 5.46±0.64 |
| Ni | 4.09±2.00 | 5.03±2.40 | 5.54±0.87 |

M±SD: Mean ± Standard deviation, n=3

**TABLE 2: ANOVA for Roasted Beef (Suya)**

| Metal | | Sum of Squares | Df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| Fe | Between Groups | 222.446 | 2 | 111.223 | 2.805 | .138 |
| | Within Groups | 237.887 | 6 | 39.648 | | |
| | Total | 460.332 | 8 | | | |
| Pb | Between Groups | .000 | 2 | .000 | . | . |
| | Within Groups | .000 | 6 | .000 | | |
| | Total | .000 | 8 | | | |
| Cr | Between Groups | .000 | 2 | .000 | . | . |
| | Within Groups | .000 | 6 | .000 | | |
| | Total | .000 | 8 | | | |
| Cd | Between Groups | 11.576 | 2 | 5.788 | 3.899 | .082 |
| | Within Groups | 8.907 | 6 | 1.485 | | |
| | Total | 20.483 | 8 | | | |
| Ni | Between Groups | 3.252 | 2 | 1.626 | .465 | .649 |
| | Within Groups | 20.971 | 6 | 3.495 | | |
| | Total | 24.223 | 8 | | | |

In Nigeria there has been several reported cases of heavy metals pollution such as iron, lead, nickel, chromium, copper, arsenic etc. (Ibeto and Okoye 2010). This study presents in Table 1, the result of summary and comparative analysis of the mean values of heavy metals in roasted beef around Iwofe, Trans Amadi and Port Harcourt city. According to the result, the highest mean concentration of Iron was found in Iwofe (19.35mg/kg) while the lowest mean value was found in Port Harcourt city (7.18mg/kg). The mean concentration in this work is higher compared to report by Makan-Juola and Olakunle (2016) (4.81mg/kg) but lower than the recommended daily intake of (48mg/kg) by Food and Agriculture Organization/World Health Organization (2001). Lead showed the same value of (0.14mg/kg) for all locations, this value is higher than Iweala, *et al.*, (2014) (0.02mg/kg) but slightly low compared to that recommended by FAO/WHO, (2001) (0.2mg/kg). Chromium gave the same value of (1.11mg/kg) for all locations. This value is far higher than that reported by Makan-Juola and Olakunle (2016), who reported below detectable limits and is higher than WHO, (1993)

permissible limit of (0.5mg/kg). The mean values for Cadmium showed highest mean concentration in Port Harcourt city (5.46mg/kg) and lowest mean concentration in Iwofe (3.00mg/kg). This mean result is far higher than WHO (2001) permissible limit of (0.005mg/kg) and report on fresh processed beef 0.6mg/kg, long processed beef (2.3mg/kg) given by Ujowundu, *et al.*, (2013). The result for Nickel shows a very high concentration in the three locations. Port Harcourt city has highest mean value of (5.54mg/kg) while Iwofe has lowest mean value of (4.09mg/kg). This value for Nickel is higher than Iweala, *et al.*, (2014) of (0.83mg/kg) and also above FAO/WHO (2001) tolerable limit of (0.05mg/kg).

Table 3.2 shows a statistical report which describes the level of significance. Iron showed 0.138 level of significance, Lead showed not detected, Chromium showed not detected, Cadmium showed 0.082 while Nickel showed 0.649. This result stipulates that there is no significant difference in the source of pollution between the different locations because the values are higher than $p \leq 0.05$ which is a standard for level of significance.

**TABLE 3:** Mean concentrations (mg/Kg) of heavy metals contained in raw beef.

| METAL | SAMPLE LOCATION | | |
|---|---|---|---|
| | IWOFE | TRANS-AMADI | PORT HARCOURT CITY |
| Fe | 15.91±1.33 | 20.95±7.59 | 22.60±3.25 |
| Pb | 4.18±1.22 | 4.84±0.72 | 4.71±0.26 |
| Cr | 0.44±0.13 | 0.42±0.06 | 0.72±0.28 |
| Cd | 0.02±0.00 | 0.02±0.00 | 0.02±0.00 |
| Ni | 4.42±0.44 | 11.86±12.67 | 3.80±0.22 |

M±SD: Mean±Standard deviation, n=3

**TABLE 3.4:** ANOVA for Raw Beef

| Metal | | Sum of Squares | Df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| Fe | Between Groups | 72.880 | 2 | 36.440 | 1.562 | .284 |
| | Within Groups | 139.962 | 6 | 23.327 | | |
| | Total | 212.842 | 8 | | | |
| Pb | Between Groups | .731 | 2 | .365 | .529 | .614 |
| | Within Groups | 4.141 | 6 | .690 | | |
| | Total | 4.871 | 8 | | | |
| Cr | Between Groups | .177 | 2 | .088 | 2.665 | .148 |
| | Within Groups | .199 | 6 | .033 | | |
| | Total | .375 | 8 | | | |
| Cd | Between Groups | .000 | 2 | .000 | . | . |
| | Within Groups | .000 | 6 | .000 | | |
| | Total | .000 | 8 | | | |
| Ni | Between Groups | 120.644 | 2 | 60.322 | 1.125 | .385 |
| | Within Groups | 321.793 | 6 | 53.632 | | |
| | Total | 442.437 | 8 | | | |

Level of significance: $p \leq 0.05$

Table 3.3 presents the summary and comparative analysis of the mean values of heavy metals in raw beef around Iwofe, Trans Amadi and PH city.

According to the result, Iron in Iwofe gave a value of (15.91mg/kg), Trans Amadi gave a value of (20.95mg/kg) while Port Harcourt city gave a value (22.60mg/kg) respectively. From the result Port Harcourt city gave the highest mean value while Iwofe gave the lowest mean concentration. The mean concentration in this work is higher compared to report by Makan-Juola and Olakunle (2016) (4.81mg/kg) but lower than the recommended daily intake of (48mg/kg) by FAO/WHO, (2001). Lead revealed the values in the locations Iwofe (4.18mg/kg), Trans Amadi (4.84mg/kg) and Port Harcourt city (4.71mg/kg). The highest concentration was detected in Trans Amadi while the lowest concentration was detected in Iwofe. This result is higher than report stated by Mirian, *et al.*, (2014) (1.2mg/kg), EC, (2001) (0.4mg/kg) and FAO/WHO, (2001) recommended daily intake of (0.2mg/kg). Chromium was detected with a mean concentration of (0.44mg/kg) in Iwofe, (0.42mg/kg) in Trans Amadi and (0.72 mg/kg) in Port Harcourt city. The highest mean value was found in Port Harcourt city while the lowest mean value was found in Trans Amadi. The highest mean value is higher than the World Health permissible limit of 0.5ppm (Brain and Allen 1993) but was found to be lower than the tolerable level by USDA, (2006) (1.0mg/kg). The report from this work on chromium is far above studies by Amos-Tautua, *et al.*, (2013) (0.09mg/kg). The amount of Cadmium observed in the different locations showed the same mean values of (0.02mg/kg) respectively. This result is far below the permissible limit of 0.5 mg/kg, as recorded by USDA, (2006) and slightly below report stated by Mirian, *et al.*, (2014) (0.08mg/kg). Nickel gave a value of (4.42mg/kg) in Iwofe, (11.86mg/kg) in Trans Amadi and (3.80mg/kg) in Port Harcourt city. The highest value was found in Trans Amadi while the lowest value was found in Port Harcourt city. This report is far above work done by Makan-Juola and Olakunle, (2016) (0.56mg/kg) and (0.2mg/kg) by FAO/WHO (2001) permissible limit.

Table 3.4: shows a statistical report which describes the level of significance. Iron gave 0.284 level of significance; lead gave 0.614 level of significance; chromium gave 0.148 level of significance; Cadmium was not detected while nickel gave 0.385 level of significance. This study reports that there is no significant difference in the source of pollution between the different locations because the values are higher than $p \leq 0.05$ which is a standard for level of significance.

The mean concentration of pollutants for both roasted beef (Suya) and raw beef is very high. Iron in raw beef is higher in concentration than Iron in roasted suya beef. Lead is higher in raw beef and very low in roasted suya beef. Chromium is very low in both roasted and raw beef but is higher than the permissible limit set by FAO/WHO (2001). Cadmium is very low in raw beef and higher in roasted beef while Nickel is slightly higher in raw beef than in roasted beef. The reasons for the level of contamination in roasted beef could be as a result of the activities carried out during its preparation. It can also be that as the roasted beef is hawked uncovered from one point to another, pollutants from vehicle emissions, industrial activities and dust particles from dump sites could have accumulated on the roasted beef. Level of contamination for raw beef could be that the cattle have been exposed to water or food contaminated with these metals before being slaughtered. Considering the fact that raw and roasted beef are exposed to the atmosphere, there is every tendency for contamination to occur.

The locations where these samples were collected are highly polluted areas because of the activities carried out in such environment. Trans Amadi is highly industrialized with companies like Total, Air Liquid company, companies that carry out metal works , breweries etc. Port Harcourt city is very populated with small companies, lots of vehicular emissions, commercial and domestic activities etc. Iwofe is populated, with oil and gas industries, bunkery and ship navigation activities. Iwofe also has a massive dumpsite where numerous materials are deposited as such leachate from these sites could easily get to source of water and be drunk by cattle. Unhygienic practices in abattoirs and during post-process handling are associated with potential health risk to consumers due to the presence of pathogens in meat and environmental contamination (Abdullahi, *et al*., 2006). Abattoir operations generate large quantities of waste which constitute a major source of environmental pollution.
All these anthropogenic activities contribute to the pollutions of these environments which has the capacity to accumulate in food and affect human health adversely.

**Pollution/Contamination Index (C/P):**
**C/P** was developed by Lacutusu (2002) to assess the extent of contamination or pollution of a sample in relation to a reference or target value It is given as:

$$C/P = \frac{\text{Concentration of Metal in Sample}}{\text{Concentration of Reference Value}}$$

The reference values used in this work are those of FAO/WHO (2001) and USDA (2006) permissive values.

**Table 3.5: Significance of Intervals of Contamination/Pollution Index**

| C/P | Significance |
|---|---|
| <0.1 | Very Slight Contaminated |
| 0.1 – 0.25 | Slight Contamination |
| 0.26 – 0.50 | Moderate Contamination |
| 0.51 – 0.75 | Severe Contamination |
| 0.76 – 1.00 | Very Severe Contamination |
| 1.10 – 2.00 | Slight Pollution |
| 2.10 – 4.00 | Moderate Pollution |
| 4.10 – 8.00 | Severe |
| 8.10 – 16.00 | Very Severe Pollution |
| < 16.0 | Excessive Pollution |

Table 3.6: Computation of Contamination/Pollution Index in Roasted Beef

| METAL | SAMPLE LOCATION | | |
|---|---|---|---|
| | WOJI | IWOFE | TRANS-AMADI |
| Fe | 0.40 | 0.27 | 0.15 |
| Pb | 0.70 | 0.70 | 0.70 |
| Cr | 1.11 | 1.11 | 1.11 |
| Cd | 6.00 | 10.68 | 10.92 |
| Ni | 20.45 | 25.15 | 27.7 |

Table 3.7: Computation of Contamination/Pollution Index in Fresh Beef

| METAL | SAMPLE LOCATION | | |
|---|---|---|---|
| | WOJI | IWOFE | TRANS-AMADI |
| Fe | 0.33 | 0.43 | 0.47 |
| Pb | 20.9 | 24.2 | 23.5 |
| Cr | 0.44 | 0.42 | 0.72 |
| Cd | 0.04 | 0.04 | 0.04 |
| Ni | 22.1 | 24.3 | 19.0 |

From Tables 3.6 and 3.7, whereas the pollution index is very high with respect to lead in the fresh beef, cadmium on the other hand is high in the roasted beef. However, the fresh and roasted beef samples were excessively polluted with nickel. Cr is slightly polluted but severely contaminated at Trans Amadi location while in the roasted beef the pollution index recorded slight pollution in the three locations. Diet and poor handling procedures are responsible for these different levels of contamination and pollution of beef consumed in the city of Port Harcourt.

## CONCLUSION AND RECOMMENDATION

The result from this study has revealed the presence of heavy metals in raw beef and roasted beef (Suya) sample. It is obvious that the ambient air within Port Harcourt is highly polluted which could be as a result of different industrial activities such as petrochemical, metallurgical, petroleum, oil and gas companies as well as illegal refining of crude oil (bunkery) carried out in the environment. Seeing that raw beef and roasted beef (Suya) are not covered there is every possibility for contamination/ pollution to occur. If nothing is done to reduce this phenomenon, bioaccumulation of the metals may be highly detrimental to human health. It is therefore recommended that animals to be slaughtered for consumption be put in a lairage where recent exposure will be reduced and screenings of the animal for heavy metals are done before slaughter. Hawked roasted beef (Suya) at the point of sale should be covered. Cattles should be raised away from environment that is known for heavy metals discharge or emission, so as to reduce their bioaccumulation. Also, release of these pollutants into the environment should be discouraged through proper advocacy program.

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