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Heavy Metal Contents of Meats from Auchi, Edo State, Nigeria

[1]A. Inobeme, [2]P.A. Obigwa, [1]E. Olori, [1]C. Eziukwu and [3]O. Bamigboye
[1]Department of Chemistry, Edo University Iyamho, Edo State, Nigeria
[2]Sheda Science and Technology Complex, Abuja, Nigeria
[3]Department of Chemisty, Kings University, Odeomu Osun State, Nigeria

Abstract: The present study examined the effect of smoking on heavy metal content of beef, chicken and goat meat from selected areas in Edo State, Nigeria. Fresh and smoked meat samples were collected together and analyzed for the concentration of some metals using Atomic Absorption Spectrometer (GBC scientific equipment Sens AAs 1175). There was a decrease in the content of Mn, Cu, Cd and Zn on grilling. Cd was not detected in all the samples except chicken. The content of Fe increase with smoking. With the exception of Pb with a maximum concentration of 2.73 in smoked beef, the content of the metals in the smoked meats were within safe limits based on WHO standard. The concentrations of the metals were in the general order: Fe>Zn>Cu>Mn>Pb>Mn>Cr. Fe showed a very strong association with Cr , likewise Cd with Pb. There is need to educated meat sellers on the need to avoid open smoking of public food for consumer safety.

Key words: Smoking, meat, heavy metals, fresh, grilling, smoked meat

INTRODUCTION

Meats play a vital role in human diet due to their high protein content alongside mineral compositions, hence their wide consumption. They have also been reported to contain metals such as Cu, Fe, Co , Mn, Pb, Cd amongst others, collectively known as heavy metals. Heavy metals are metals with density usually above 5 g/cm^3. These metals have become issue of concern in recent times due to their deleterious effect and presence in most environmental matrices including food. They also have a unique tendency to bioaccumulate along the food chain and are not biodegradable (Akan *et al.,* 2010). At their geochemical state, the metals are less available to humans; however, anthropogenic effects such as mining, combustion of fossil fuel, industrial activities and agriculture have contributed greatly to environmental contamination by these metals (Abduljaleel, 2012). The major routes through which man gets in contact with these metals include food, air, water and soil. Various heavy metals show varying level of toxicity to life. Metals such as cadmium, lead and mercury have been reported to have no known physiological functions in organisms and yet are highly toxic even at trace amount (Hassanin *et al*., 2014). Others such as Copper are vital to health at a low concentration but very toxic at high level. Toxicity due to exposure to chromium at high concentration includes lung cancer, inflammation of skin amongst others. Lead is associated with severe damages of vital body organs such as brain and kidney (Imran *et al*., 2015).

In recent times attention has been shifted to the content of these metals in food due to concern for human safety. Various kinds of roasted and barbecued foods such as chicken, beef, cat fish and sardine are commonly available and consumed in various localities in Edo State, Nigeria. Contamination of roasted meats and fishes occur through feeds, water, methods of processing and environment (Iwegbue *et al*., 2008). Also, the general handling of street roasted and vended meats also contribute to their safety threat because they are prepared and sold in open and dusty environment with high levels of contamination from various sources (Bamuwamye *et al.,* 2015). There are different methods available for processing fish, beef and chickens. These methods tend to expose them to metals in different extent hence varying level of contamination. There is dearth in data on effect of smoking on heavy metal content of these foods. The present study examines the effect of smoking on heavy metal content of meat from Auchi in Edo State.

MATERIALS AND METHODS

Sampling: Ten samples of different types of roasted meat (chicken, beef, goat) were collected from various selling points in three Auchi, Edo State. Equal numbers of unprocessed meats were also collected from same areas.

Corresponding Author: A. Inobeme, Department of Chemistry, Edo University Iyamho, Edo State, Nigeria

These samples were placed in polythene bags which were washed with de-ionised water prior to the sampling. The samples were taken to the laboratory for pre-treatment and subsequent analyses.

Sample pretreatment: The collected samples were washed with de-ionized water, deboned and then oven dried at 40°C for three days. The dried samples were impoverished using mortar and pestle.

Sample digestion: The digestion of the sample was done using conc. HNO_3 in line with the method reported by Ahmad (2016) with slight modifications. The 0.5 g of the ground sample was placed in a digestion tube and 5.0 mL of conc. HNO_3 added. Digestion was done at 150°C, another 5 mL was added and heated until the solution became clear. It was then cooled and filtered into a 100 mL flask. It was made up to the volume with distilled water. Blanks were also run as quality control measures. The heavy metal content was determined using Atomic Absorption Spectrometer (GBC scientific equipment Sens AAs 1175).

Calculation of metal content: The metal content was calculated using the formula:

$$\text{Metal content (mg/kg)} = C \times V/W$$

Where:

C = The Concentration of the metal from the AAS result (mg/L)

V = The final volume of the solution

W = The mass of the sample weighed (g)

Statistical significance difference among parameters was checked using ANOVA while inter-elemental correlation coefficient was determined using spearman correlation analysis.

RESULTS AND DISCUSSION

Fe: The concentration of Fe was observed to be generally, higher in the smoked samples. The value ranged from 16.81-27.30 mg/kg. The highest amount was in the smoke goat meat while the least was in fresh chicken meat Table 1. Mitic *et al.* (2012) reported the content of Fe in chicken as 7.3-9.2 mg/kg in a study on smoked meat. This is lower than the values obtained in this study. reported a concentration of Fe in sausages which ranged from 82.9-270 mg/kg with mean 135.00±10.48 mg/kg which is however higher. Fe content in the meat is higher than the safe limit of 15.0 mg/kg reported by Joyce *et al.* (2016). The observed increase

Table 1: Heavy metal content in smoked and fresh goat meat (mg/kg)

Goat	Smoked	Fresh	Permissible limit
Fe	27.30±1.01^b	23.40±0.37^a	15.0 (Kobia *et al.* in 2016)
Mn	0.28±0.13^a	0.31±0.62^b	-
Cd	ND	ND	0.1 (ECin 2006)
Cu	1.99±0.18^a	2.12±0.12^b	5.0 (EC in 2006)
Cr	1.01±0.09^b	0.89±0.01^a	1.0 (EC in 2006)
Pb	0.68±0.11^a	ND	1 (EC in 2006)
Zn	9.31±0.71^a	11.05±0.16^b	50 (FAO in 1980)

Table 2: Heavy metal content in smoked and fresh chicken meat (mg/kg)

Chicken	Smoked	Fresh	Permissible limit
Fe	21.11±0.72^b	16.81±0.23^a	15.0 (Kobia *et al.* in 2016)
Mn	0.34±0.31^a	0.61±0.15^b	-
Cd	0.01±0.01^a	0.02±0.01^a	0.1 (EC in 2006)
Cu	0.92±0.01^a	1.38±0.09^b	5.0 (EC in 2006)
Cr	0.01±0.02^a	ND	1.0 (EC in 2006)
Pb	0.40±0.01^a	0.63±0.10^b	1 (EC in 2006)
Zn	10.03±0.21^a	14.21±0.60^b	50 (FAO in 1980)

Table 3: Heavy metal content in smoked and fresh beef (mg/kg)

Beef	Smoked	Fresh	Permissible limit
Fe	20.20±1.10^b	19.87±0.19^a	15.0 (Kobia *et al.* in 2016)
Mn	0.86±0.10^b	0.98±0.23^a	-
Cd	ND	ND	0.1 (EC in 2006)
Cu	1.99±0.12^a	2.37±0.10^a	5.0 (EC in 2006)
Cr	ND	ND	1.0 (EC in 2006)
Pb	1.73±0.16^b	ND	1 (EC in 2006)
Zn	10.30±0.10^b	11.01±0.17^a	50 (FAO in 1980)

Results are expressed as mean±SD; Values with the same superscript on same row do not differ; ^{a,b}Significantly vlues at $p>0.05$

in the concentration of Fe could be attributed to the interactions between the meat and the metal grid which is often made of iron. During smoking, some of the Fe particles can get into the meat. This could have accounted for the higher Fe concentration in the smoked meat. There was a strong positive correlation of Fe with Cu, Cr, Pb and Zn Table 2 which shows the close association of these elements with Fe.

Mn: Mn showed the least concentration after Cd among the metals investigated. The results showed a decrease in the content of Mn in the smoked goat meat and beef (Table 1-3). There was however no significant difference in the concentration in smoked chicken at $p> 0.05$. There was a decrease in the concentration of Mn on grilling. Joyce *et al.* (2016) reported that cooking methods can change the levels of toxic metals through various means, including the evaporation of water and volatile constitutes, solubilization of the element and also due to metals binding to other macronutrients present in the food item. The concentration of Mn is higher than 0.19-0.80 mg/kg reported by Federick *et al.*, (2015) in smoked meat and 0.22 mg/kg reported by Akan *et al.* (2010) in a related study. Federick *et al.* (2015) in his study also reported that the heavy metals concentration in the fresh and smoked beef samples did not differ significantly ($p>0.05$) from each other. The content from

this study was however lower than 3.06 mg/kg and maximum 6.141 mg/kg reported by Mitic *et al.* (2012) in a related study. A close association was observed between Mn and Cd from the correlation coefficient obtained (0.92). Mn however showed a negative correlation with Cu and Zn.

Cd: Cd was not detected in most of the fresh samples analysed. The highest value (0.02 mg/kg) was in fresh chicken and this did not differ significantly from the smoked at ($p>0.05$). The observed increase in the content of Cd may be connected to addictives for the processing of meats. Aljaff *et al.* (2014) reported the content of Cd in unprocessed beef as 0.0060-0.00509 μ/g for chicken. Cadmium is a toxic heavy metal which causes high blood pressure, mutations and prostate cancer. Studies have also shown than Cd can affect Ca, P and bone metabolism in both industrial and people exposed to Cd in general environment (Jarup *et al.*, 1998). Cd could also be from atmospheric deposition on the food substance during processing as well as contaminations from feeds (Aljaff *et al.*, 2014). The maximum limit of Cd is 0.1 mg/kg according to EC in 2006. There was a strong positive association of Cd with Pb as reflected in the correlation coefficient.

Cu: The content of Cu in the meat was observed to decrease on smoking. Parekhan *et al.*, 2014 in a related study gave the concentration of Cu in raw meats as 0.42, 0.16 and 0.40 for beef, chicken and sheep, respectively. The highest concentration of Cu was in fresh goat meat (2.37 mg/kg). At high temperature some metals tend to undergo certain reactions with other components of the meat such as carbohydrates and proteins which make them to be converted to other compounds. Smoked goat meat had the highest content of Cu. Mitic *et al.* (2012) reported the concentration of Cu as 6.3-8.7 mg/kg in smoked chicken which is higher than the value from this study. In a study on trace metal in beef, Akan *et al.* (2010) reported the value of Cu in chicken as 1.44 μ/g. Copper constitutes public health hazards in high concentrations (Brito *et al.*, 1990). The permissible Cu concentration for pork and beef samples has been proposed by the World Health Organization (WHO) (1993) as 7.0 and 1.6 mg/100g wet wt. Thus the smoked meat from this study are safe in terms of Cu. Joyce *et al.* (2016) in a related study reported that the concentration of Cu in smoked meat increased from 0.96-1.99 ppm which is different from the findings from this study. Cu showed a strong positive association with Cr and Zn.

Cr: The content of Cr showed variation among the various smoked meat. The concentration of Cr ranged from ND to 1.01 mg/kg with the highest value was in smoked goat meat. Cr was not detected in beef and chicken. The observed content of Cr may therefore be due to the smoking process. Smoking of meats in these areas is usually done in open atmosphere thereby making the meats exposed to all sort of contaminants. Akan *et al.* (2010) in a study reported the content of Cr in chicken as 0.65 μ/g which is lower than the reported value from this study. The maximum allowed concentration of Cr according to EC (2006) is 1.0 mg/kg wet wt. Aljaff *et al.* (2014) in their study reported the concentration of Cr in fresh cow, chicken and sheep meats as 0.042, 0.08 and 0.04 μ/g, respectively.

Pb: The highest value of Pb was obtained in the smoked beef (1.73 mg/kg). The fresh meat generally had the least amount. Activities in the smoking areas may be accountable for this observation. Pb is a vital component of automobile exhaust discharge. Mitic *et al.* (2012) in his study on smoked beef reported the content of Pb in smoked beef as 8.8-14 mg/kg which is higher when compared to the value from this study. It is however higher than 0.63-1.63 mg/kg reported by Federick *et al.*, 2015. The values for Pb obtained in this study are also lower than 2.18 mg kg for beef reported by Mariam *et al.* (2004) in a related study. The values obtained for Pb is above the permissible limit of 1.0 mg/kg given by European Regulations. In a related study, Garba *et al.* (2017) reported a rise in the concentration of Pb from 0.07 in fresh beef to 2.24 mg/kg on smoking. The observed rise may be due to other factors such as car batteries deposited, panel beating as well as other activities around the areas. Lead is a very toxic metal and has the potential of binding with enzymes and other vital cellular components there by causing damage to vital body organs like brain and kidney (Cunningham and Saigo, 1997).

Zn: The concentration of Zn differed significantly among the various meat samples. The concentrations ranged from 1.01-3.01 mg/kg. The detection of metals in the fresh meat could be due to prior contamination from the environment and metal based animal feeds. There was an increase in the mean content of Zn on smoking in the beef and chicken sample while for goat meat there was no significant change in concentration of the metal on smoking. Federick *et al.* (2015) in his study reported the Zn content in beef sample as 1.45-2.24 mg/kg which is comparable to the value from this study. The value of Zn obtained from the present study is within the permissible limit of 60 mg/kg set by WHO (Bamuwamye *et al.*, 2015).

The effect of smoking on the concentration of Zn differs from the findings reported by Joyc *et al*., (2016) which documented a decrease in the content of Zn from 7.40-6.97 on smoking.

CONCLUSION

The research has examined the heavy metal contents of smoked and fresh meats (chicken, beef and goat. With the exception of Pb with concentration of 1.73 in smoked beef, and Fe in all samples, the content of the metals in the smoked meats were within safe limits based on WHO standard. The concentrations of the metals were in the general order: Fe>Zn>Cu>Mn>Pb>Mn>Cr>Cd. Fe showed a very strong association with Cr, likewise Cd with Pb. It is therefore paramount to continually check the contents of metals in smoked food, especially in areas that are more prone to environmental contamination.

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