PREDICTORS OF ADVERSE HEALTH CONDITIONS IN TYRE COMBUSTION FOR MEAT PROCESSING IN ABA SOUTH LGA., ABIA STATE, NIGERIA.

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ABSTRACT

Background: The potential risks associated with tyre combustion for meat processing is of great concern to human health. Human exposure to heavy metals can occur through ingestion of contaminated meat. Practice of tyre combustion for meat processing is a serious public health issue in Nigeria due to the adverse health conditions associated with the practice. This study aims to determine the predictors of adverse health conditions in tyre combustion for meat processing in Aba South Local Government Area, Abia State, Nigeria.

Methods: This observational study used laboratory analytical study design and was conducted in randomly and systemic selected slaughter houses in Aba South. A total of thirty (30) samples were collected between the months of May and June, 2018 from Aba Riverside and Nsulu Road slaughter slabs in Aba South Local Government Area and were analysed for the identification of heavy metal contents in tyre-combusted cow head, cow skin and cow feet. The heavy metal concentrations were determined with the application of Atomic Absorption Spectroscopy (AAS) technique. The Poly Aromatic Hydrocarbons (PAH) profile of the kerosene used to aid fire wood combustion was analysed by the use of Gas Chromatograph technique.

Results: The result of the study that the mean concentration of Cr (0.30 mg/kg), Fe (0.14 mg/kg), Zn (0.45 mg/kg and Cd (0.59mg/kg) were by 0.25 mg/kg; 0.13mg/kg; 0.15 mg/kg; 0.09 mg/kg respectively higher than the FAO/WHO (2011) recommended Maximum Permissible Limits [Cr (0.05 mg/kg), Fe (0.01 mg/kg), Zn (0.3 mg/kg) and Cd (0.5 mg/kg)]. The concentration of Cu (0.10 mg/ kg), As (0.05 mg/kg) and Pb (0.10 mg/kg) were stable. The concentration of Mercury was below detection levels. PAHs concentration of Benzo (a) pyrene of washed combusted cow head, cow skin and cow feet analysed from slaughter houses in Aba South Local Government Area were lower than the European Union Limit of 2 µg/kg.

Conclusions: From the findings of the study we conclude that Cr, Fe, Zn and Cd predict adverse health conditions like liver, lung, kidney damage, cancer, gastrointestinal irritation etc. due to the hazardous and toxic characteristics of these heavy metals. The practice of tyre combustion for meat processing in Aba South LGA., Abia State, Nigeria should be banned by Government and the use of Hot-Water Method for meat processing should be encouraged.

Keywords: Predictors, Adverse Health Conditions, Tyre Combustion, Heavy Metals, Liver damage, Cancers, Gastrointestinal irritation.

Introduction

The potential risks associated with tyre combustion for meat processing is of great concern to human health. Human exposure to heavy metals can occur through ingestion of contaminated meat or water (Hill, 2015); it can occur through inhalation of air polluted with tyre – fire smoke.

These exposures can likely cause acute (short term) and chronic (long term) health risks to the communities and pose occupational hazards to butchers and other meat processing operators. Practice of tyre combustion for meat processing is a serious public health issue in Nigeria due to the adverse health conditions associated with the practice. Meat is a vital food ingredient and is made up of mainly proteins, fat and some important essential nutrients which are essential for growth and maintenance of good health. The consumption pattern of cow skin (*kanda*), is rising in Aba South because of non-availability of non – polluted rivers and streams for fishing activities in Aba South Local Government Area which significantly changes the pattern of animal protein consumption from fish – dependence to meat – dependence.

The benefits of consuming cow skin (*kanda*) are enormous because it contains proteins of high biological value which are described as complete protein due to high gelatin content. Consumption of cow skin is of great benefit to man because it also contains essential amino acids needed for growth and maintenance of the body. Cow skin (*kanda*) is high in collagen, a type of protein quite important for holding bones and skin tissues in place. 100 gram portion of raw ground beef contains vitamins B12, B3 (Niacin), B6, iron, zinc, selenium and various other vitamins and minerals. Consumption of meat also provides humans with creatin, carionsine, which are found in animal foods. It also helps blood circulation according to Patty, Qi – Sum, HU, Krass, and R.M. (2010). Consumption of animal protein is associated with increased muscle mass. Protein is important for bone health.

Studies have shown that the consumption of protein is associated with increased bone density in old age and a lower risk of fractures (Kerslelther, Kenny & Insoya, 2011). The processing method can affect nutritional content of such meat which may result to adverse health conditions. Meat processing is described as the preparation of meat for human consumption (Russel, 2016); processed meat is considered to be any meat which has been modified in order to either improve its taste or extend its shelf life. Traditionally, cow head, cow skin and cow feet were processed by removing the skin with sharp 'butcher knife'. The de–furred cow skin is dried. The use of raffia palm fire wood for burning of cow skin likely posed insignificant health problems to consumers of such meat in those days in Aba South Local Government Area. However, presently, the de – furring of cow skin (kanda) is being done by the practice of tyre combustion. The change from the method of using raffia palm fire wood and use of butcher's knife to de- fur cow skin to the burning of tyre for de – furring cow is likely to pose significant adverse health conditions. Slaughtered ruminants such as goats, sheep and cattle for meat are roasted to get rid of the fur (Naomi, 2013). The scarcity of raffia palm fire woods and the increasing generation of waste tyre in Aba South Local Government Area have led to the practice of tyre combustion for meat processing. It is unfortunate that the used tyres are being used in slaughter houses in Nigeria to de–fur Kanda – a popular cow skin delicacy. This

practice exposes the butchers and consumers of such meat to Polycyclic Aromatic Hydrocarbons (PAHs) (Okonkwo, Ejike, Berger, Schmaling, Shierl, and Radon, 2014).

Chemical analysis of tyre material has also revealed that heavy metals such as Zinc (Zn), Iron (Fe) and Cadmium (Cd) can be present in different concentrations. Tyre contains many potential harmful substances, the practice of combustion of cow skin with waste tyre imposes enormous risk of deposition of toxic elements and compounds into animal hides, which could significantly compromise meat quality, thereby potentially posing great source of health risks (Naomi, 2013; Amfo – Otu, Agyenin, and Adzaka, 2014; Ekenma, Andon, and Ottah, 2015). Heavy metals such as Arsenic, Cadmium, Mercury, Chromium, lead etc., are emitted from open combustion which are associated with carcinogenicity in human (Hill, 2015). Tyre contains chlorine as an aromatic extender oils which is being identified as a toxic waste product of oil refining. This chlorine content has been linked to cause cancer in laboratory animals. Thus, it is likely a potential human carcinogen (Green, 2010). Polycyclic Aromatic Hydrocarbons have been linked to increased incidence of breast, lung, skin, bladder and colon cancers in humans (International Agency for Research on Cancer, 2014b). The variables of interest in this study is to predict whether the adverse health conditions being experienced by people in Aba South is dependent on the consumption of meat de-furred by tyre combustion. The dependent variable (adverse health conditions) will likely be associated with the independent variable (consumption of tyre–combusted meat).

General Objective

The general objective of this study is to determine the predictors of adverse health conditions in tyre combustion for meat processing in Aba South Local Government Area of Abia State, Nigeria.

Specific Objectives

In order to achieve the overall objectives of the study, the following are the specific objectives of the study:

I. To identify heavy metals (Chromium, Iron, Copper, Zinc, Cadmium, Arsenic, Mercury and Lead) in tyre-combusted meat in Aba South Local Government Area of Abia State, Nigeria.

II. To determine the contents of hydrocarbons in fuel used for tyre combustion for meat processing in Aba South Local Government Area of Abia State, Nigeria.

III. To compare the contents of heavy metals and hydrocarbons in un-burnt cow head, cow skin, cow feet and fire wood processed meat with the Maximum Permissible Limit.

IV. To compare the levels of heavy metals in Un–burnt cow skin with tyre-combusted cow head, cow skin and cow feet with the maximum permissible limit of heavy metals in meat.

Materials and Methods

Study Design

This study used an observational and laboratory analysis study design which was conducted in randomly and systematically selected slaughter houses in Aba South Local Government Area of Abia State, Nigeria.

Sample Size

To determine the sample size, 50 % of 60 slaughter slabs were chosen because all the slabs had homogenous characteristics and it was calculated to obtain a sample size of 30.

Sampling Methods

Simple random sampling method was used in selecting the first slaughter slab sample to be used in this study; while the subsequent slabs were selected by systematic random sampling method. Each cow hide sample was collected per day. Three (3) samples were collected from each cow, which include the following parts: head, trunk (cow skin) and feet.

A total of thirty (30) freshly un–washed and washed samples of cow head, cow skin and cow feet was collected from the two (2) slaughter houses (River Side and Nsulu Road) which was 50% of sixty (60) slabs in the two slaughter houses. Appropriately 35 g portions of cow head, and cow skin and cow feet were carefully cut from each animal at the slaughter slabs. In each case, the 35g portions of meat were cut before combusting; after combusting and when the combusted carcass was washed. In all, there were ten treated groups, with ten samples in each group as follows:

Control Sample Group

I. Non combusted Cow - head
II. Non combusted Cow - skin (Trunk)
III. Non combusted Cow - feet

Main Study Group

IV. Combusted un–washed Cow - head

V. Combusted un–washed Cow - skin

VI. Combusted un–washed Cow - feet

VII. Combusted and washed Cow– head

VIII. Combusted and washed Cow – skin

IX. Combusted and washed Cow – feet

X. Kerosene and fire wood.

Instrument for Data Collection

The instrument for data collection was the Atomic Absorption Spectrometer and Gas Chromatography/ Flame Ionization Detector (GCFID) which analysed the samples in sections which consist of section A – D; that embedded the four study objectives.

Section A identified heavy metals (lead, cadmium, Chromium, Arsenic, Mercury, Copper and zinc) in tyre-combusted meat in Aba south LGA., Abia State, Nigeria.

Section B determined contents of hydrocarbons in fuel for tyre combustion for meat processing in Aba South LGA., Abia State, Nigeria.

Section C compared the contents of heavy metals and hydrocarbons in Un–burnt cow head, cow skin and cow feet and fire wood.

Section D compared the levels of heavy metals in tyre-combusted cow head, cow skin and cow feet with the Maximum Permissible Limit of heavy metals in meat.

The determination of heavy metals was directly on each of the final solute on using the Atomic Absorption Spectroscopy (A.A.S). The following heavy metals; Lead (Pb); Chromium (Cr); Arsenic (As) Mercury (Hg), Cadmium (Cd); Iron (Fe) and Zinc (Zn) were analyzed at the United Nations Industrial Development Organization (UNIDO) Laboratory, Owerri, Imo State. The PAHS analysis was also analysed at UNIDO laboratory.

Method of Data Collection

Non–tyre combusted meat and tyre-combusted meat were collected as Control-Group and Main–Study Group; respectively.

A total of 30 samples were collected from two (2) slaughter houses (River Side and Nsulu Road) in Aba South Local Government Area in different days.

35gm of each meat sample was collected as shown in control and main study group above.

Samples were collected every Saturday morning (7am) and were collected between the months of May and June 2018. Ermmenyeri flask (Sample bottle) was used to collect the samples and was coded as: CH (Cow Head); CS (Cow Skin) and CF (Cow Feet); Blending Method was used to prevent any error of bias in the study that may occur during analysis. The hides were scraped to remove ash. The researcher preserved the samples by dry salting with 30% non–iodized salt which was evenly sprinkled on the samples and taken to the laboratory for digestion and elemental analysis.

Digestion of Samples

The combusted hides were scraped to remove ash. Flasks of 5mm thick of the processed hides were weighed and oven-dried at 50 ^{0}C for 2 hours and were reweighed. 35g of the cow head, cow skin and cow feet were ashed to 500^{0}C and were decomposed by wet digestion with 5cm^2 concentrated HNO_3 for determination of Lead (Pb); Chromium (Cr); Arsenic (As, Mercury (Hg)) Cadmium (Cd); Iron (Fe) and Zinc (Zn). The digestion flask was heated for 15 minutes using electric heater and heating mantle inside the flume chamber. After digestion, the contents

were filtered in 25ml digestion tube and were made up to the mark with distilled water and transferred into the laboratory sample bottle for Atomic Absorption Spectroscopy on a Perkin Elemer Atomic Absorption Spectrophotometer, model AA 200. The digestion analysis was performed by the researcher and the environmental health laboratory officer at UNIDO laboratory, Owerri, Imo State.

Elemental Analysis of Sample

Sample of the same cow hides was boiled for 1 hour and processed for Atomic Absorption Spectroscopy analysis. The control group (Non – tyre combusted meat samples) was processed by Atomic Absorption Spectroscopy. The determination was carried out in triplicates. 30 samples of the cow hides were processed. For each heavy metal (Pb, Cr, As, Cd, Cu, Hg, Fe and Zn.) there was a specific "Hollow Cathode lamp" and the machine was set at a particular wave length for the heavy metal to be analyzed. The absorbances of the heavy metals was measured at 15 mA of lamp and the peak mode of the following wave lengths were used: Pb - 283, 3 mm, Cr - 356,9 mm; Cd - 228, 8 mm; Hg - 253,7mm; As – 193,9 mm; Cu – 324,9 mm; Fe – 248,3 mm and Zn– 213,9 mm. The analysis of metals present in petrol used as fuel for the processing to aid combustion was also carried out.

Gas Chromatography/Flame Ionization Detector (GC-FID) Analysis

The target analytes included fifteen(15) non-alkylated PAHs, achieved through isolation, identification and quantification of the 15 priority pollutants, which follows a standard procedure of ultrasonic extraction, sample clean up and analysis based on GC-FID capabilities. The PAHs contents in the sample were determined using USEPA 8270D test method and the quantification of the PAH analytes using an Agilent 6890N GC. PAH extraction employed USEPA 3550c test method (Sewage – waste, SW-846 methods) with some modifications.

Hot – Water Method

Ten (10) liters of cold water were poured into a big pot and were boiled on a stove at 120^{o}c. A thermometer was used to determine the temperature of the water. The hot water was poured into a plastic container and covered, after which 35g of non-combusted cow hides were soaked inside the hot water for 3 hours so as to soften cow hides in order to enhance the fast de–furring of the hides. After 3 hours of soaking, the hides were removed and placed on clean chopping board. The soaked hides were scrapped with a sharp knife. The knife was moved up and down on hide so as to de–fur the cow hides.

Method of Data Analysis

Statistical Analysis

The descriptive statistical analysis tool was used to determine the Mean concentration which was calculated for each parameter and was done using SPSS (version 22.0) windows software package. The individual characteristics of heavy metal concentration of cow head, cow skin and cow feet were compared with FAO recommended Maximum Permissible Limit (MPL). Data obtained from variable was summarized as means. A 5% level of significance was used to conduct the test.

RESULTS

Identification of Heavy Metal Contents in Tyre–Combusted Hide in Aba South LGA., Abia State, Nigeria.

In table I and figure I, the average heavy metal contents of Zn (0.60 mg/kg) and Cd (0,75mg/kg) were higher in combusted un–washed cow feet. The concentration of heavy metals decreased from combusted un–washed cow hides to combusted washed cow hides. The concentration of combusted washed cow hide were lower than the concentration of combusted un–washed cow hides. Concentration of Zn and Cd decreased in washed tyre – combusted cow meat as shown in table II and figure II.

Table I: Average Heavy metal content in Tyre–combusted meat in Aba South LGA, Abia State, Nigeria.

Sample Identity	Heavy Metals(Mg/kg)							
	Cr	Fe	Cu	Zn	Cd	As	Hg	Pb
Combusted Un–washed Cow Head	0.30	0.14	0.07	0.50	0.62	0.04	<0.00	0.12
Combusted Un–washed Cow skin	0.31	0.15	0/07	0.57	0.73	0.06	<0.00	0.14
Combusted Un–washed Cow Feet	0.33	0/16	0.08	0.60	0.75	0.07	<0.00	0.16
Combusted Washed Cow Head	0.28	0.13	0.16	0.39	0.52	0.03	<0.00	0.10
Combusted Washed Cow Skin	0.30	0.14	0.06	0.47	0.62	0.05	<0.00	0.10
Combusted Washed Cow Feet	0.32	0.15	0.07	0.48	0.63	0.06	<0.00	0.10

Source: Research Laboratory Analysis Data 2018

Table II: Summary of Heavy Metal Contents In Tyre-Combusted Cow Hide In Aba South LGA., Abia State, Nigeria.

Sample Identity	Heavy Metals (Mg/kg)							
	Cr	Fe	Cu	Zn	Cd	As	Hg	Pb
Un–washed Tyre–combusted Cow meat	0.31	0.15	0.07	0.56	0.70	0.06	0.00	0.14
Washed Tyre–combusted Cow meat	0.30	0.14	0.10	0.45	0.59	0.05	0.00	0.10

Source: Research Data 2018

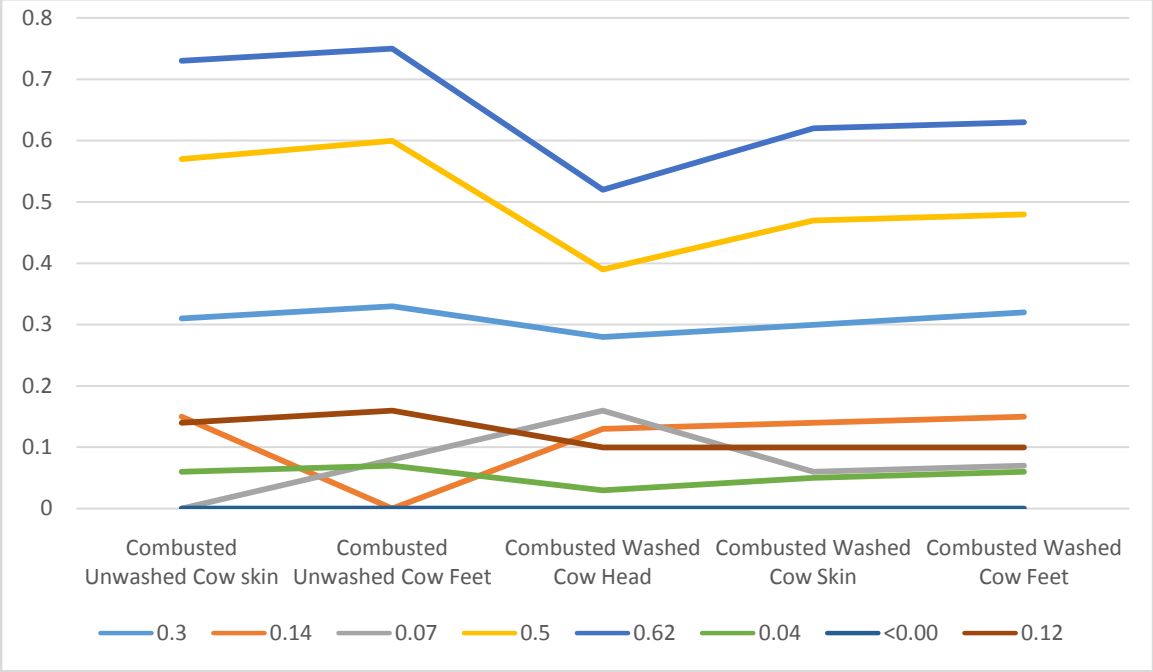

Figure I: Line Graph Representation of Average Heavy metal content in Tyre–combusted meat in Aba South LGA., Abia State, Nigeria.

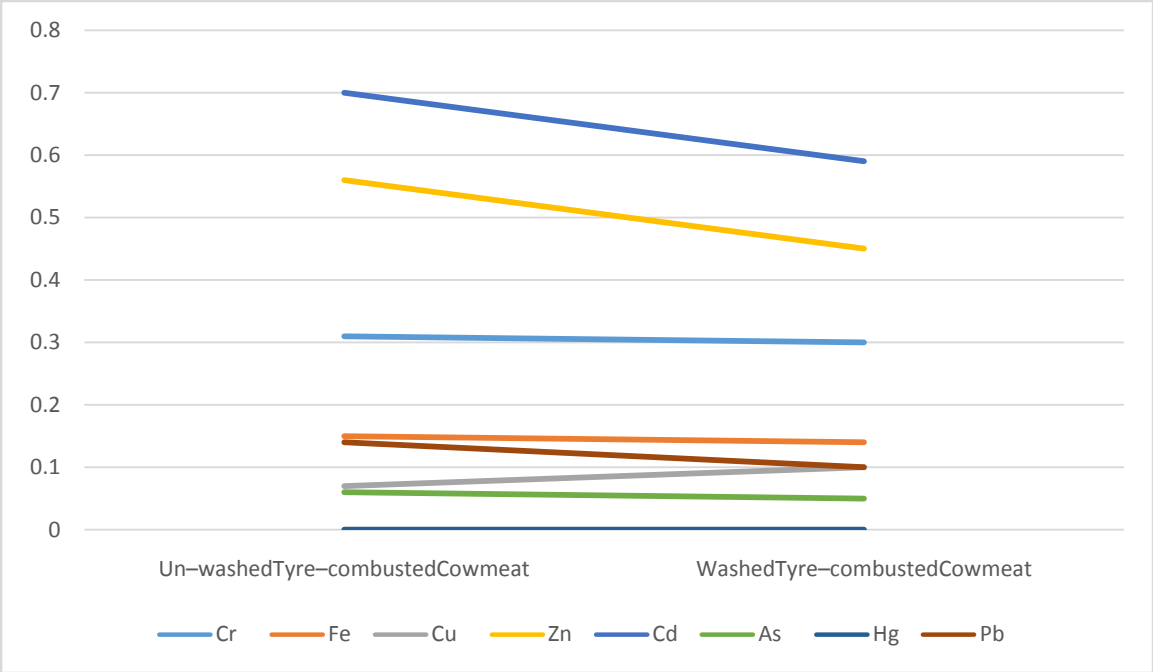

Figure II. Line Graph Showing Summary of Heavy Metal Contents In Tyre-Combusted Cow Hide In Aba South LGA., Abia State, Nigeria.

Determination of Contents of Hydrocarbons in Fuel Used For Combustion for Meat Processing In Aba South Local Government Area of Abia State, Nigeria.

In table III and Figure III, the mean concentration of Napthalene (20.80 µg/kg) was higher than other PAHs detected in the meat samples in Aba South LGA.

Table III: Concentration of Poly Aromatic Hydrocarbons (PAHs) in Tyre Combusted Cow Meat in Aba South LGA., Abia State, Nigeria.

	Sample and PAH Concentration µg/kg					
PAH Profile	CUWCH	CUWCS	CUWCF	CWCH	CWCS	CWCF
Napthalene	2.30	0.20	20.80	8.71	9.59	3.19
Accnaphtlene	0.99	0.59	8.10	4.99	3.69	0.29
Accnaphthylene	ND	ND	ND	ND	ND	ND
Fluorene	1.99	ND	7.19	2.49	3.19	0.29
Phenanthrene	ND	ND	4.39	1.35	1.89	0.00
Anthracene	ND	ND	2.00	ND	0.90	ND
Pyrene	ND	ND	2.79	0.99	0.69	0.79
1,2,Dibenzethracene	ND	ND	ND	ND	ND	ND
Chrysene	ND	ND	ND	ND	ND	ND
Benz(6)fluranthene	ND	ND	ND	ND	ND	ND
Benzo(k)fluranthene	ND	ND	ND	ND	ND	ND
Benzo(a)pyrene	0.09	ND	4.79	1.19	1.89	0.69
Indeno[1,2,3cd]–pyrene	0.19	0.09	7.49	3.29	2.09	2.09
1,2,5,6–1–Di benzoanthraccene	ND	ND	2.69	1.19	0.39	0.19
1, 2, Benzoperylene	ND	ND	0.80	ND	0.49	ND

Source: Research Laboratory Analysis Data 2018

CUWCH = Combusted Un–washed Cow Head

CUWCS = Combusted Un–washed Cow skin

CUWCF= Combusted Un–washed Cow Feet

CWCH = Combusted Washed Cow Head

CWCS Combusted Washed Cow skin

CWCF = Combusted Washed Cow Feet

ND = Not Detected

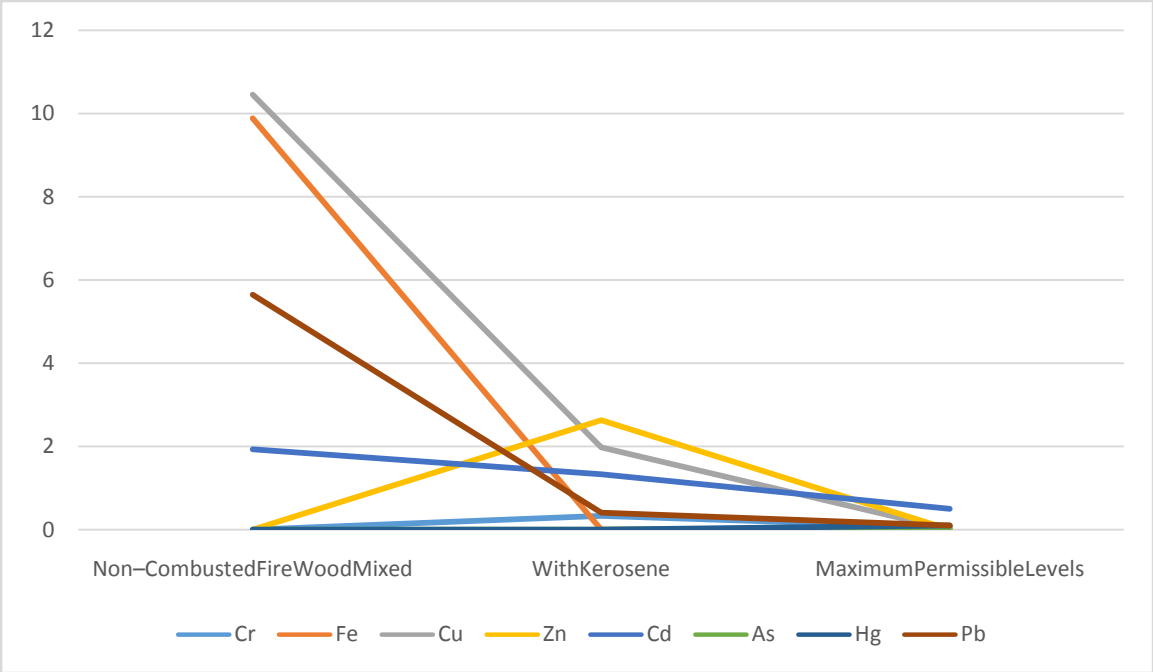

Figure III: Line Graph Showing the Comparison of Heavy Metal Concentration in Non–Combusted

Comparison of Heavy Metal Contents and Hydrocarbons in Un–burnt Cow Head, Cow Skin, Cow Feet and Fire Wood Processing Method With Maximum Permissible Limit

In table IV and figure III the concentrations of heavy metals in non – tyre combusted cow hides were higher than the concentrations of heavy metals in fire wood mixed with kerosene. Also the concentrations of heavy metals in non - combusted meat were higher than the FAO/ WHO 2011 Maximum Permissible Limit as shown in tables IV and V.

Table IV: Comparison of Heavy Metal Concentration In Non – Combusted Cow Hides Wide And Fire Wood Processing Method With Maximum Permissible Limit.

Method of Processing	Heavy Metals (Mg/kg^{-1}) Cr	Fe	Cu	Zn	Cd	As	Hg	Pb
Non–Combusted Fire Wood Mixed	NA	9.88	10.45	NA	1.93	NA	NA	5.65
With Kerosene	0.33	NA	1.98	2.63	1.33	NA	NA	0.41
Maximum Permissible Levels	0.05	0.01	0.05-0.5	0.3–1.0	0.5	0.05	0.1	0.1

Source: Research Data 2018

Table V: Comparison of Heavy Metal Concentration in Un–burnt Cow Hide and With Tyre – Combusted With Maximum Permissible Limits of Heavy Metals in meat

Method of Processing	Heavy Metals (Mg/kg)							
	Cr	**Fe**	**Cu**	**Zn**	**Cd**	**As**	**Hg**	**Pb**
Un–burnt Cow Hide	NA	9.88	10.45	NA	1.93	NA	NA	5.65
Fire Wood	0.33	NA	1.98	2.63	1.33	NA	NA	0.41
Un-washed	0.31	0.15	0.07	0.56	0.70	0.06	0.00	0.14
Tyre–Combusted Cow Meat Washed	0.30	0.14	0.10	0.45	0.59	0.05	0.00	0.10
Tyre–Combusted Cow Meat Maximum Permissible Levels	0.05	0.01	0.05 - 0.5	0.3 – 1.0	0.5	0.05	0.1	0.1

Source Research Data 2018

Comparison of Heavy Metal Concentration in Un–burnt Cow Hides and Tyre Combusted with Maximum Permissible Limits Of Heavy Metals In Meat

Mean Concentrations of Un–burnt cow hides were higher than the mean concentration of heavy metals in tyre combusted meat and the FAO/WHO 2011 Maximum Permissible Limit. The concentration of Cu (10, 45 mg/kg) and Fe (9.88 mg/kg) were higher in Un–burnt meat. While the concentration of heavy metals decreased in washed tyre combusted meat as shown in table I.

DISCUSSION

The heavy metal concentration of tyre-combusted meat of un–washed tyre–combusted cow meat detected were Cr (0.31 mg/kg), Fe (0.15 mg/kg). Cu (0.07 mg/kg), Zn (0.56 mg /kg), Cd (0.7 mg/kg), As (0.06 mg/ kg), and Pb (0.14 mg/kg) as shown in table II. The concentrations of Zn (0.56 mg /kg), Cd (0.7 mg/kg) were respectively higher than the concentration of other heavy metals in the un–washed tyre – combusted cow hides. While in the washed tyre – combusted cow hide the concentration of heavy metals decreased. The concentrations of heavy metals in the washed tyre – combusted cow hide were Cr (0.30 mg/kg), Fe (0.14 mg/kg), Cu (0.10 mg/kg, Zn (0.45 mg/kg), Cd (0.59 mg/kg), As (0.05 mg/kg and Pb (0.10 mg/kg). The concentrations of heavy metals in the washed tyre combusted cow hide were lower than the concentration of heavy metals in un–washed tyre–combusted cow hide (un–washed tyre–combusted cow hide> washed tyre – combusted cow hide) as shown in table II. The slight decrease in the concentration of washed tyre- combusted cow hide may be attributed to the use of uncontaminated source of water (bore hole) in the processing method. The mean concentration of Cr (0.30 mg/kg), and Fe (0.14 mg/kg), were slightly higher than FAO/WHO (2011) Maximum Permissible Limit recommended for meat for human consumption. This

study is in line with the studies by Amfo –otu, Agyemim and Adzraku and Friday and Nwite which reported that heavy metal concentration higher than the Maximum Permissible Limit (MPL) found in meat are toxic and may eventually lead to impairment of health or premature death (Amfo – Otu *et al.*, 2014; Friday and Nwite, 2016). The concentration of Zn (0.45 mg/kg) and Cd (0.59 mg/kg) in the washed tyre combusted cow hides were higher than the Maximum Permissible Limit recommended by the FAO/ WHO (2011) confirms the study by Amfo–otu, Agyemim and Adzraku which reported that Cadmium mostly competes and displaces Zinc in human bodies and disrupts some activities of enzymes (Amfo – Out, *et al.*, 2014). Also, cadmium accumulates in animal hide and fatty tissues, hence, consumers are exposed to Zinc and Cadmium when they consume such contaminated meat. The high concentration of Zinc may cause acute effects such as vomiting and gastrointestinal irritation such as cramps and diarrhea while Cadmium in human body may negatively manifest in adverse health condition such liver, kidney, lung, placenta and brain damage. This study is also similar to the study of Oladipo and Okareh (2015) which reported that a number of serious health problems can develop as a result of uptake of food contaminated with heavy metals (Oladipo and Okareh, 2015).

The concentration of Cu (0.10 mg/ kg), As (0.05 mg/kg) and Pb (0.10 mg/kg) were stable, which may not pose adverse health conditions when consumed in cow hides. The concentration of Mercury in tyre combusted cow hide was below detection levels which may imply that Mercury in waste tyre is of low concentration which may not contribute as such to the contamination of cow hides.

As shown in table III above, the profile of 15 Poly Aromatic Hydrocarbons (PAHs) analysed in samples collected from the two slaughter houses in Aba South LGA., the mean concentration of Napthalene (20.80 mg/kg) was significantly higher ($P < 0.05$) than the mean concentrations of other PAHs in the six combusted samples (CUWCH, CUCWCS, CUWCF, CWCH, CWCS and CWCF).

Accnaphthylene, 1, 2 Dibenzethracene, Chrysene, Benz (6) fluranthene and Benzo (k) fluranthene were not detected in any of the samples, while Phenanthrene, Anthracene, Pyrene, 1,2,3,6 – 1- Dibenzoanthraccene were not detected in combusted un–washed cow head (CUWCH) and combusted un – washed cow skin (CUWCS), but were detected in combusted washed cow head (CWCH), combusted washed cow skin (CWCS) and combusted washed cow feet (CWCF). Indeno [1, 2, 3 cd] pyrene were detected in all the samples. This shows that rubber tyre adds unwanted PAHs in the meat samples.

PAHs concentrations in combusted un–washed cow meat samples were significantly ($p<0.05$) higher than concentrations in combusted washed cow meat samples. This implies that thorough washing of the combusted samples with non-contaminated water reduces PAH concentration in combusted washed cow head, cow skin and cow feet. This study is in line with the study of Nnaji, Madu & Chukwuemeka–Okorie which reported that Benzo (a) pyrene is a well known carcinogen and formerly used as a standard for PAHs (Nnaji, Madu and Chukwuemeka-Okorie, 2017). The European Union (2014) Maximum Limits for Benzo (a) pyrene in smoked meat and smoked products is 2 µg/kg. Benzo (a) pyrene concentration was lower than the

European Union Limits in consumer ready combusted washed samples but were higher in combusted un–washed cow feet (4.79 µg/kg). But Benzo (a) PAH concentration in CWCS (1.89µg/kg) is considered higher because it is approximately close to the limit. This predicts that the detection of Benzo (a) pyrene (1.89 µg/kg) in combusted washed cow skin (CWCS) may be attributed to occurrence of cancers when such meat is consumed.

The results from the study showed that the hides of cattle (cow head, cow skin and cow feet) slaughtered in slaughter houses in Aba South local Government Area of Abia state, Nigeria accumulated different levels of heavy metals like chromium (Cr), Iron (Fe), Copper (Cu), Zinc (Zn), Cadmium (Cd), Arsenic (As), Mercury (Hg) and Lead (Pb). The mean concentration of heavy metals in Un – burnt (Non - combusted) hides were as follows: Fe (9.88mg/kg), Cu (10.45 mg/kg), Cd (1, 93 mg/kg), and Pb (5.65 mg/kg) as shown in table IV. Heavy metal such as chromium (Cr), Arsenic (As) and mercury (Hg) were not available in samples analysed, this may be due to non - exposure of the hides during hot water processing method.

The high concentration of heavy metals recorded in the un- burnt hides may be attributed to the presence of heavy metals in the local environment which the animal could easily have come in contact with through scavenging in open waste or refuse dumps, free range grazing, drinking water from polluted streams and drains and exposure to atmospheric depositions especially from automobile fumes and open burning of solid waste (Kalu**,** Nwanta and Anaga, 2015). These metals could also have come from various sources like vehicle emissions, tyre and engine wears, and agricultural chemicals, urban and industrial wastes (Okoye and Ugwu, 2010).

In table IV as shown above, the mean concentration of heavy metals in washed tyre – combusted cow meat were Cr (0.30 mg/kg), Fe (0.14 mg/kg), Cu (0.10 mg/ kg), Zn (0.45 mg/kg), Cd (0.59 mg/ kg), As (0.05 mg/kg), Hg (0.00 mg/kg) and Pb (0.10 mg/kg) while in table V the FAO/WHO (2011) recommended Maximum Permissible Limit (MPL) of heavy metals in meat are Cr (0.05 mg/kg), Fe (0.01 mg/kg), Cu (0.05 – 0.5 mg/kg), Zn (0.3 - 1.0 mg/kg), Cd (0.5 mg/kg), As (0.05 mg/kg), Mercury (0.1 mg/kg) and Pb (0.1 mg/kg). In this study, it was detected that concentration of Cr (0.30 mg/kg), Fe (0.14 mg/kg)and Cd (0.59 mg/ kg) were higher than FAO/WHO (2011) Maximum Permissible Limit of heavy metals in meat. This implies that Fe, Cr, Zn and Cd were identified as predictors of adverse health conditions in the practice of tyre combustion for meat processing in Aba South LGA because of their high concentrations which were above the Maximum Permissible Limit.

The findings from this study is similar to the study of Amfo –otu, Agyemim and Adzraku and Friday and Nwite (2016) which reported that heavy metal concentration higher than the maximum permissible limit are toxic to consumers.

CONCLUSION

This study is useful to public health by identifying that heavy metals such as Cr, Fe, Zn and Cd with concentrations higher than the maximum permissible limit are toxic and are predictors of adverse health conditions for consumers of tyre – combusted cow head, cow skin and cow feet.

The results from this study shows that un-burnt cow hide contained higher concentration of heavy metals, which may be attributed to local environment when the animal could come in easy contact with through scavenging in open waste dumps, free range grazing, drinking water from polluted streams and exposure to automobile fumes.

The PAHs detected in the combusted washed cow head, cow skin and cow feet are lower than the European Union Maximum Permissible Limit.

Also, based on the findings from the comparison of the Hot-Water Method with Tyre combustion method which showed non–availability of heavy metals like Chromium, Cadmium and Arsenic in the Hot – Water Method, it is necessary to contribute that a new knowledge on the use Hot – Water Method for de-furring cow hides in Aba South LGA., Abia State, Nigeria contributes to the body of knowledge used in de–furring cow hides because of the non – toxic nature of the Hot – Water Method.

The practice of Tyre – combustion for meat processing should be banned by government because it exposures consumers of tyre – combusted cow hides to toxic heavy metals such as Chromium, Iron, Zinc and Cadmium which are significant in prediction of adverse health conditions such as Cancer, kidney, liver and lung damages, and gastrointestinal irritation among others.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest between them.

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