Science Journal of Chemistry
2017; 5(3): 31-35
http://www.sciencepublishinggroup.com/j/sjc
doi: 10.11648/j.sjc.20170503.11
ISSN: 2330-0981 (Print); ISSN: 2330-099X (Online)

Review Article

Polycyclic Aromatic Hydrocarbons (PAHs) in Some Smoked Foodstuffs in Lagos State, Southwest, Nigeria

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To cite this article:

Tajudeen Adejare Aderibigbe, Chijioke Olisah, Olasupo Sabitu Babatunde. Polycyclic Aromatic Hydrocarbons (PAHs) in Some Smoked Foodstuffs in Lagos State, Southwest, Nigeria. *Science Journal of Chemistry.* Vol. 5, No. 3, 2017, pp. 31-35. doi: 10.11648/j.sjc.20170503.11

Received: April 26, 2017; **Accepted**: May 15, 2017; **Published**: July 18, 2017

Abstract: The smoked food samples (Smoked fish, roasted yam, sharwama, suya, roasted plantain and roasted corn) were sampled from retail outlets in Lagos State, Nigeria. The analysis was carried out with a Gas Chromatography (GC) – Flame Ionization Detector (FID) equipped with auto sampler. The results of sixteen PAHs in the studied smoked food shows that PAHs of low molecular weight such as acenaphthene and anthracene were detected in all the food samples. High molecular weight PAHs such as fluoranthene, pyrene and benzo (a) anthracene were also detected. Five and six membered ring PAHs benzo (k) fluoranthrene, benzo (a) pyrene, indenol (1, 2, 3) perylene, dibenzo (a, h) anthracene and benzo (g, h, i) perylene were not detected in all the food samples. Total PAHs concentrations determined in smoked food samples were: smoked fish 0.3303 Mg/Kg, roasted yam 0.2456 Mg/Kg, sharwama 0.4508 Mg/Kg, suya 0.4762 Mg/Kg, roasted plantain 0.1844 Mg/Kg and roasted corn 0.1719 Mg/Kg. The sum of the total fraction of PAHs in smoked food samples calculated according to their rings number and percentage. A two-ring PAHs (naphthalene) was not detected in all the samples except in roasted plantain with 20.6%. A three-ring PAHs recorded the highest percentage of the total PAHs constituting 87.2% in smoked fish, 43.8% in roasted yam, 81.9% in sharwama, 83.3% in suya, 37.5% in roasted plantain and 67.4% in roasted corn. While a four- ring PAHs constitute 12.8% in smoked fish, 56.2% in roasted yam, 18.1% in sharwama, 16.7% in suya, 41.9% in roasted plantain and 32.7% in roasted corn.

Keywords: Foods, PAHs, Percentage Concentrations, Sample

1. Introduction

The Polynuclear Aromatic Hydrocarbons (PAHs) are organic compounds that are mostly colourless, white or pale yellow solids. A larger group of organic chemicals containing two or more fused aromatic rings of carbon and hydrogen atoms, could be formed during processing of coal, crude oil and natural gas, incomplete combustion and other organic substances [1]. They could also be found in cigarette smoke, exhaust from automobile and machineries, asphalt, coal tar and creosote treated wood products [1-2] as well as from natural sources such as volcanoes.

They are lipophilic, chemically stable [3-4] and can be found practically everywhere in soil, water and food. Their presence in food is of major interest, as they could be found in cereals, grains, flour bread, vegetables, fruits, meats, processed or packed foods and even contaminated cow milk [5-6] observed that some coolant methods such as roasting, barbecuing and smoking increases the levels of PAHs in foods, while steaming and boiling barely introduces PAHs. The formation of PAHs on roasted foods has been observed to be dependent on the distance of food from the heat source [7] fat contents of the food [6] duration of roasting [8] temperature used [9] whether melted fat is allowed to drop onto the heat source and type of fuel used [10].

In Nigeria, the consumption of roasted foods offers rapid

supply of protein, carbohydrates, fat, vitamins and minerals to several consumers especially of the middle and lower classes. Increasingly, these fast-food centres which are often sited at strategic locations, especially at road and junctions serve the growing interests of both city and suburb dwellers. The presence of PAHs in food stuffs occur as a consequence of environmental contamination, physiology and ecological features of the product and as well as the thermal processes to which the foods are subjected to during processing and manufacture of foods [11]. Processes such as drying, boiling, cooking, frying, grilling, roasting and smoking are noted sources of PAHs in foods [12-13]. The impact of PAHs on human health depends mainly on the length and route of exposure or concentration of PAHs as well as the relative toxicity of the PAHs. Other factors could be pre-existing health status and age. Occupational exposures to high levels of pollutants mixtures containing PAHs have resulted in symptoms such as eye irritation, nausea, vomiting, diarrhea and confusion. Nevertheless, it is not known which components of the mixtures were responsible for these effects and other compounds commonly found with PAHs may be the cause of these symptoms [14].

The primary purpose of this study was to determine the concentration of polynuclear aromatic hydrocarbons (PAHs) in food samples (smoked fish, roasted yam, sharwama, suya, roasted plantain and roasted corn) in Lagos State, Nigeria.

2. Method

2.1. Sampling

Sampling was done according to the European commission directives [15], 100 g each of smoked food samples (smoked fish, roasted yam, sharwama, suya, roasted plantain and roasted corn) were collected from retail outlets in Lagos State, Nigeria. The samples were packed in aluminium foil and placed in an ice chest prior to laboratory analysis.

Figure 1. *Shawarma.*

2.2. Sample Preparation

Edible part of smoked food samples where homogenized using mortar and pestle. Each sample was divided into two different part for extraction and reference purposes and stored in the freezer.

2.3. Reagents

All reagent used for sample preparation and extraction processes were of analytical grade quality. Acetone, dichloromethane, anhydrous sodium sulphate, silica gel and glass wool were all purchased from Sigma Aldrich. PAHs mix standard of 16 congeners was purchased from Cerilliant.

2.4. Extraction and Sample Clean-Up

All glassware was rinsed with acetone before usage. 10 g aliquot of well mixed samples was measured into a solvent rinsed beaker. Saponification was carried out by adding 50 mL of 3.5 M methanolic KOH solution (methanol/water 9 + 1), this was sealed and kept at 70°C in a drying cabinet for 2 hours. 50 mL of solvent mix (1:1 of acetone and dichloromethane) was added to the flask and sonicated for 25 mins at 70°C. This was followed by the addition of 10 g anhydrous sodium sulphate. The extraction process was repeated with addition 50 mL of solvent mix. The clear layer of both extraction solvent was decanted into a round bottom flask and concentrated to 2 mL using a Yomato rotary evaporator. Sample clean-up was carried out by passing the concentrated sample through a packed column (a cartridge packed with silica gel and glass wool, preconditioned at 150°C overnight) followed by eluting with 50 mL dichloromethane into a round bottom flask. This was further concentrated to 2 mL and placed into a Teflon screw vial, labelled and refrigerated ready for gas chromatography analysis.

Figure 2. *Smoked Fish.*

Figure 3. *Roasted plantain.*

Figure 4. *Roasted Yam.*

Figure 5. *Roasted Corn.*

Figure 6. *Roasted meat (Suya).*

2.5. Instrumental Analysis

Agilent 7820 A gas chromatograph – FID equipped with auto-sampler was used for the analysis. 1 mL of the sample solution was injected in the splitless mode onto a 30m x 0.25mm crossed linked PH ME siloxane -1909 1J-233 capillary column. Other operating conditions were: Initial temperature: 100°C; final temperature – 310°C; detection temperature – 300°C; Linear velocity – 30 cm/sec; rate – 1:4°C/min. Calibration curve of PAHs was obtained by running standards of 5, 10, 50 and 100 mg/L. The concentration of each PAH in the sample was calculated using the following equation:

1. Cf = Area (p) ×Rf×Vf×Df/Wi

Where:

Cf= Final sample concentration in mg/kg

Area (p) = Measured area of peak

Wi= Initial weight extracted (g dry weight)

Vf= Final extract volume (mL)

Df= Dilution factor of sample or extract

Rf= Response factor from calibration standard calculation

3. Results

Table 1. *Results of concentrations of Polyaromatic Hydrocarbon (PAHs) in smoked food.*

S/N	COMPONENT SMOKED	FISH	ROASTED YAM	SHARWAMA	SUYA	ROASTED PLANTAIN	ROASTED CORN
1	Naphthalene (mg/kg)	0.0000	0.0000	0.0000	0.0000	0.0381	0.0000
2	Acenaphthylene (mg/kg)	0.0895	0.0000	0.0000	0.0001	0.0000	0.0000
3	Acenaphthene (mg/kg)	0.1981	0.0730	0.0112	0.0001	0.0578	0.0846
4	Florene (mg/kg)	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
5	Phenathrene (mg/kg)	0.0001	0.0000	0.0000	0.0526	0.0000	0.0000
6	Anthracene (mg/kg)	0.0001	0.0346	0.3579	0.3438	0.0113	0.0312
7	Fluoranthene (mg/kg)	0.0001	0.0983	0.0001	0.0001	0.0641	0.0361
8	Pyrene (mg/kg)	0.0001	0.0002	0.0572	0.0395	0.0001	0.0001
9	Benzo(a)anthracene (mg/kg)	0.0142	0.0151	0.0244	0.0399	0.0130	0.0200
10	Chrysene (mg/kg)	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
11	Benzo(b)fluoranthrene (mg/kg)	0.0279	0.0244	0.0000	0.0000	0.0000	0.0000
12	Benzo(k)fluoranthrene (mg/kg)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
13	Benzo(a)pyrene (mg/kg)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
14	Indeno(1,2,3) perylene (mg/kg)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
15	Dibenzo(a,h)anthracene (mg/kg)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
16	Benzo(g,h,i) perylene (mg/kg)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Total (mg/kg)	0.3303	0.2456	0.4508	0.4762	0.1844	0.1719

Table 2. *The sum of total fractions of PAHs in smoked.*

Component		Smoked Fish	Roasted Yam	Sharwama	Suya	Roasted Plantain	Roasted Corn
2 rings	Concentration (mg/kg)	ND	ND	ND	ND	ND	ND
	% composition	<0.00	<0.00	<0.00	<0.00	20.6	<0.00
3 rings	Concentration (mg/kg)	0.2879	0.1076	0.3691	0.3966	0.0691	0.1158
	% composition	87.2	43.8	81.9	83.3	37.5	67.4
4 rings	Concentration (mg/kg)	0.0424	0.1380	0.1832	0.0795	0.0772	0.0562
	% composition	12.8	56.2	18.1	16.7	41.9	32.7
5 rings	Concentration (mg/kg)	ND	ND	ND	ND	ND	ND
	% composition	<0.00	<0.00	<0.00	<0.00	<0.00	<0.00
6 rings	Concentration (mg/kg)	ND	ND	ND	ND	ND	ND
	% composition	<0.00	<0.00	<0.00	<0.00	<0.00	<0.00

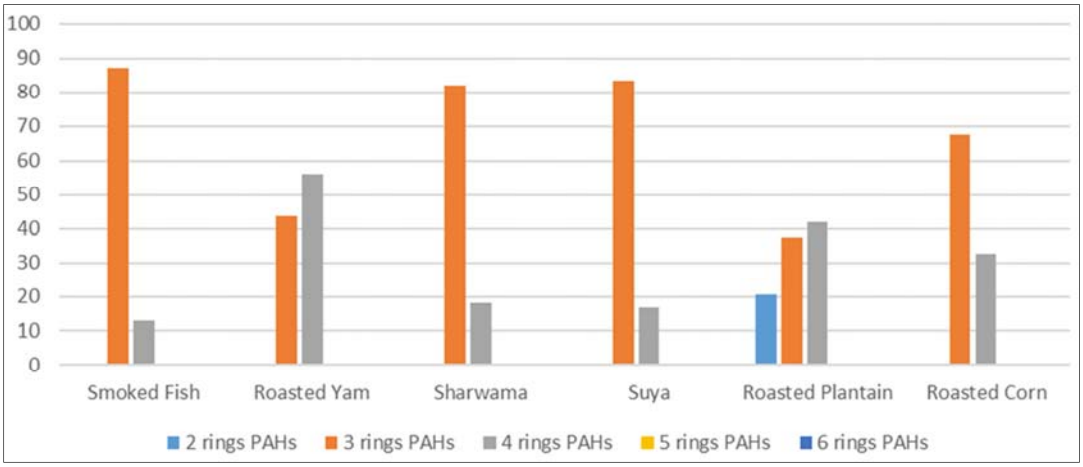

Figure 7. *Bar chart showing PAHs ring numbers in smoked food.*

4. Discussion

The results of analysis of sixteen PAHs in the studied smoked food are shown in Table 1. PAHs of low molecular weight such as acenaphthene and anthracene were detected in all the samples. This could be attributed to average wood temperature used in smoking process [16]. High molecular weight PAHs such as fluoranthene, pyrene and benzo (a) anthracene were also detected. The presence of benzo (a) anthracene in all the samples may be due to the condition of smoking process [17]. Five and six membered ring PAHs (benzo (k) fluoranthrene, benzo (a) pyrene, indeno(1, 2, 3) perylene, dibenzo (a, h) anthracene and benzo (g, h, i) perylene were not detected in all the samples. Total PAHs concentration determined in smoked food were: smoked fish - 0.3303 mg/kg; roasted yam – 0.2456 mg/kg; sharwama – 0.4508 mg/kg; suya – 0.4762 mg/kg; roasted plantain - 0.1844 mg/kg and roasted corn – 0.1719 mg/kg. PAHs present in the food samples are in the following order:

suya>sharwama>smoked fish>roasted yam>roasted corn>roasted plantain.

The sum of the total fraction of PAHs in smoked food, calculated according to their ring number and percentage are given in table 2. Two rings PAH (naphthalene) was not detected in all the samples except in roasted plantain which constitute a percentage of 20.6%. Three rings PAHs recorded the highest percentage of the total PAHs constituting 87.2% in smoked fish, 43.8% in roasted yam, 81.9% in sharwama, 83.3% in suya, 37.5% in roasted yam and 67.4% in roasted corn while four rings PAHs constitute 12.8%, 56.2%, 18.1%, 16.7%, 41.9% and 32.7% in smoked fish, roasted yam, sharwama, suya, roasted plantain and roasted corn respectively (Figure 1). High level of three and four rings PAHs may be due to the traditional process used in smoking these food samples, where smoke is generated at the bottom of the oven and the food is placed directly over the smoking wood. In modern industrial smoking process, the food sample is fed into a smoke generated chamber. This method promotes better control of the smoking process, thereby reducing the level of PAHs [18]. Benzo (a) pyrene which is used as a biomarker in monitoring carcinogenic PAHs was not detected in this study. The results obtained in this study may indicate that the smoked food may contribute no levels of cancer and cancer related cases in the study area. Smoked food vendors tends to re-smoke food product to increase this shelf life of the product, this contribute to increase levels of PAHs formation [19].

5. Conclusion

In this study, it is evident that high level of polyaromatic hydrocarbons was present in suya compared to the other smoked food samples under the investigation. Although benzo (a) pyrene was not present, but other mutagenic and carcinogenic PAHs that were present in these samples could result in cases of cancer and cancer related ailment in human being. Based on this study and our findings, there is need to

educate the public on the dangers associated with the consumption of smoked food product and also to device possible means of roasting these class of food samples under this investigation.

It is therefore recommended that more epidemiological studies should be carried out to assess the bioaccumulation of PAHs in human beings.

Acknowledgements

The authors appreciate the support from Mrs Aderibigbe Jemilat Olanike, Yunus Maryam, Yunus Aishat and Alhaji Abdulwahab Akeem.

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