

## Research Article

# Polycyclic Aromatic Hydrocarbons (PAHs) Concentrations in Roasted Plantain and Fish from Port Harcourt City, Rivers State, Nigeria

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**Abstract**

The consumption of roasted plantain and fish popularly known as Bole has been on the increase especially during lunch hours in recent times within Port Harcourt city. The manner of consumption and environment of preparation of this food sample have presented a situation where consumers suspect that this food may have been exposed to contamination by polycyclic aromatic hydrocarbons (PAHs). This study was carefully designed to investigate the levels of polycyclic aromatic hydrocarbons in roasted plantain and fish within Port Harcourt city. The food samples were collected from three locations within the city and then prepared. After preparation, the samples were subjected to PAHs analysis using Gas chromatography equips with flame ionization detector. Results of the analysis showed that a total ten EPA priority PAHs were quantified in the roasted plantain with concentrations ranging between 0.86 and 3.596 mg/kg while in the fish sample, a total of nine were quantified with concentrations ranging between 1.342 and 5.562 mg/kg.

The obtained concentrations of PAHs in the study were quite high and may be attributed to petrogenic source and also the use of charcoal in the roasting. These high concentrations of PAHs in the food sample could be of detrimental effect to human health on high consumption; hence reduction in consuming roasted plantain and fish from the city can help to reduce possibility of PAHs absorption in the human system.

**Keywords:** carcinogenic, mutagenic, roasted, plantain, fish, grill, ubiquitous, hydrocarbon, Port Harcourt, environment, location

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**Introduction**

The consumption of roasted foods such as plantain, yam, potato and fish have of recent been on the increase in tertiary institutions campuses, strategic points, on busy streets, along high ways, motor parks, business environment, concentrated areas, busy junctions etc. Majority of the consumers of this food may not know the health hazards associated with such food as the preparation is carried out in the open with exposure to polluted environment. [1] stated that, food items and products could be contaminated by soils, polluted air, and water. According to [2], polycyclic aromatic hydrocarbons are a class of ubiquitous environmental pollutants consisting of two or more fused aromatic rings which can be generated during the preparation of food. In their view, [3] posited that poly aromatic hydrocarbons are found in foods as a result of certain industrial food processing methods such as smoking, curing, broiling, roasting and grilling over open fires or charcoal which permits the direct contact between food and combustion products.

Among the lots of hydrocarbons, the occurrence of polycyclic aromatic hydrocarbons in food has attracted so much attention, due to the potential risk or health hazards of poly aromatic hydrocarbons. According to [4], grilled or roasted fish and plantain in Nigerian are available throughout the year and people are patronizing their consumption these days on the high scale. A number of hydrocarbons found in foods such as roasted fish, roasted beef, and roasted plantain are carcinogenic and/or mutagenic, which may have a significant contribution to human cancer. The direct exposure of fishes and plantains to heat from wood charcoal during their roasting or preparation gave motivation to absorption of heat. [5] depicted that direct exposure of fishes and plantains, potatoes, beef, and other food items through an incomplete combustion of charcoal have been linked with generation of poly aromatic hydrocarbons. Plantain and other food crops contain carbohydrate with different compositions which is the major source of energy to man. The presence of carcinogenic hydrocarbons 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 [6]. Processes such as drying, boiling, cooking, frying, grilling, roasting and smoking are noted sources of deleterious hydrocarbons like poly aromatic hydrocarbons in foods [5].

The production of carcinogenic hydrocarbon in food by roasting over charcoal is a function of both the fat content of the food, duration of roasting, temperature used [6]. According to [6,7], the hydrocarbons found in roasted fish and roasted plantain are mainly the poly aromatic hydrocarbons and these compounds are generated by incomplete combustion of organic matter arising in part, from natural combustion (forest fires, volcanic eruption) and mostly from human activities such as engine exhaust industrial, coal derived products, distillates and waste incineration among others. In a study conducted by the United State Environmental Protection Agency (USEPA); 16 poly aromatic hydrocarbons were identified with different concentrations in roasted fish and roasted plantain, were considered to be carcinogenic and they include; Benzo(a)anthracene, Benzo(a)Pyrene, Dibenzo(b)fluoranthene, benzo(K)fluoranthene, chrysene, chrysene, dibenzo(a)anthracene and indeno (1,2,3-cd) perylene. In another study conducted by Osai (2007), on an investigations of PAHs densities in roasted plantain and smoked fish in Ondo State, the following range of the individual PAHs were obtained in the roasted plantain acenphthene (1.9-3.7ng/kg), flourene (0.5-4.8ng/kg), pyrene (0.1-3.8ng/kg), Benzo(a) anthracene (0.3-2.8ng/kg) and chrysene (1.0- 4.5ng/kg) [8] conducted a study on the PAHs concentrations in roasted plantain, roasted meat and smoked fish in Ondo State, the concentration of individual PAHs obtained were in plantain, dibenzo (a,h) anthracene (0.00991ng/kg) and flourance (0.1047ng/kg) and in fish the concentration obtained were dibenzo (a,h) anthracene (0.009923ng/kg) and chrysene (0.7215ng/kg). [9] carried out another study on the human health risk assessment of polycyclic aromatic hydrocarbons in smoked fish species from market in southern Nigeria, the following PAHs concentrations were obtained in clariaias gariepinus specie: pyrene (0.015mg/kg), flourene (0.013mg/kg), anthracene (0.029mg/kg), chrysene (0.135mg/kg), naphthalene (0.056mg/kg).

Ziegler, R.G. (2012) [10] reported that eating a charcoal – broiled food may expose one to the some quantity of poly aromatic hydrocarbons as one would receive from smoking 600cigarettes. Similarly, epidemiological studies carried out by [11-13] indicated a statistical correlation between the increased occurrence of cancer of the intestinal tract and frequent intake of roasted food.

## Materials and Methods

### *Sample Collection/Preparation*

The roasted plantain and fish were collected from three locations namely Aker Junction, Rumuokwuta Junction and Rumuokoro Junction all in the Port Harcourt city Local Government Area of Rivers State. These locations are densely populated with high traffic. Roasted fish, mostly Atlantic Mackerel (*Scomber*, *Scombus*) were prepared by thaw, scaled and cut into pieces, washed in water, steeped into palm oil mixed with dried pepper, salt and flavour (such as monosodium glutamate). These were then arranged on wire gauze placed over an open charcoal fire. Also roasted plantain were prepared by washing ripe or unripe plantain in water and peeled. The raw pulps were placed on wire gauze that was placed over an open charcoal fire to roast until they were slightly brown. The roasted plantain and fish were taken to the laboratory and separately mashed first with ceramics mortar and pestle immediately after collection, air dried for 3-days to remove the remaining water particles and crushed into fine powdered form.

### *Sample Extraction/analysis*

Polycyclic aromatic hydrocarbons were extracted from the sample through digestion with an alcoholic solution of potassium hydroxide and extraction with 1, 1, 2-trichlorotrifluoroethane (TCTFE). Extracts were further purified to reduce interferences. The empirical purification entailed the use of alumina (neutral activity 1) as an adsorbent. This was introduced in a slurry form with hexane into 1-cm glass columns to a depth of about 10cm. Concentrated extracts were dissolved in hexane and subsequently introduced to the wet adsorbent and eluted with this solvent to remove aliphatic hydrocarbons. The second eluant was benzene, which removed the aromatic materials with sufficient purity for capillary GC analysis. The purified aromatics were analyzed by capillary GC using an HP 6890 Series GC system equipped with FID. The column used was a HP-5, 30 m X 0.25 mm X 0.25 $\mu$ m (HP Part No. 19091S-433). Hydrogen (10.2psi) was used as carrier gas at 1.5ml/min. The column was kept at 80 $^{\circ}$ C (1 min), 20 $^{\circ}$ C/min 280 $^{\circ}$ C, 2.5 $^{\circ}$ C/min, 300 $^{\circ}$ C (4 min). Temperature of the FID  $T_{ij}$  was kept at 325 $^{\circ}$ C.

## Results and Discussion

The results of the analysis of polycyclic aromatic hydrocarbons in roasted plantain and fish from Port Harcourt city are presented in **Tables 1-6**. A total of six EPA priority PAHs were quantified in the roasted plantain from the Aker location. The lowest individual concentration of 0.864mg/kg was obtained for phenanthrene while the highest

concentration of 2.239mg/kg was obtained for benzo (g,h,i) perylene. Other PAHs obtained from this location with their concentrations were pyrene (1.664mg/kg), chrysene (1.235mg/kg), dibenzo (a) anthracene (1.264mg/kg) and flourene (1.100mg/kg). [14] in a study on an investigations of PAHs densities in roasted plantain and smoked fish in Ondo State, obtained the following range of individual PAHs in roasted plantain acenphthene (1.9-3.7ng/kg), flourene (0.5-4.8ng/kg), pyrene (0.1-3.8ng/kg), Benzo(a) anthracene (0.3-2.8ng/kg) and chrysene (1.0- 4.5ng/kg). The concentrations of PAHs in roasted plantain from Aker junction were high compared to those obtained from other works. The high concentrations of PAHs in roasted plantain from this location may be attributed to the use of charcoal in the roasting which is in good agreement with the works of [5] who stated that processes such as drying, boiling, cooking, frying, grilling, roasting and smoking are noted sources of deleterious hydrocarbons like poly aromatic hydrocarbons in food.

**Table 1** The Concentrations of Polycyclic Aromatic Hydrocarbons (PAHs) in mg/kg in roasted plantain from Aker Junction

Name	Type	Rest Time (MIN)	Amount/Area	Area (PAS)	Amount (mg/kg)
Acenaphthene		6.332	-	-	-
Acenaphthylene		9.140	-	-	-
Anthracene		9.517	-	-	-
1,2-Benzanthracene		10.604	-	-	-
Benzo (a) pyrene		12.867	-	-	-
Benzo(b)flouranthene		13.076	-	-	-
Benzo (g,h,i.) Perylene	HH	15.939	4.18032e-1	3.03592	2.23902
Benzo (k)flouranthene	-	16.876	-	-	-
Pyrene	W	17.722	6.80722e-1	97.12453	1.64496
Chrysene	VP	19.787	8.13252e-1	50.56721	1.23561
Dibenzo (a)anthracene	BB	20.122	4.45938e-1	62.90854	1.26462
Napthelene		20.923	-	-	-
Benzo (a) flouranthene		21.233	-	-	-
Phenanthrene	HH	22.156	8.13252e-2	50.56721	0.86431
Flouranthene	-	23.143	-	-	-
Flourene	W	23.234	3.8995e-1	24.45938	1.10094
Indeno (1,2,3-cd) Pyrene		24.234	-	-	-
Total					8.34946

**Table 2** Concentrations of Polycyclic Aromatic Hydrocarbons (PAHs) in Mg/kg in roasted fish from Aker Junction

Name	Type	Rest time (MIN)	Amount/Area	Area (PAS)	Amount (mg/kg)
Acenaphthene		6.332	-	-	-
Acenaphthylene		9.140	-	-	-
Anthracene		9.517	-	-	-
1,2. Bezanthracene	BB	10.604	5.81659 e-I	6.31012	2.37889
Benzo (a) Pyrene		12.867	-	-	-
Benzo (b)flouranthene		13.076	-	-	-
Benzo (g,h,i) Perylene		15.939	-	-	-
Benzo (K)flouranthene		16.876	-	-	-
Pyrene		17.722	-	-	-
Chrysene		19.787	-	-	-
Dibenzo(a)anthracene	VB	20.122	5.93865e-I	34.1.4288	3.76597
Napthelene		20.923	-	-	-
Benzo(a) flouranthene		21.233	-	-	-
Phenanthrene	VB	22.156	6.10272e-I	91.86072	1.96967
Flouranthene		25.143	-	-	-
Flourene	VP	30.234	2.09645	11.33144	2.09645
Indeno (1,2,3,-cd)Pyrene	W	40.234	6.09765e-1	934.14265	2.32533
Total					12.53631

Table 2 shows the concentrations of PAHs in roasted fish from Aker junction. It was observed that a total of five EPA priority PAHs were quantified in fish from this location. The lowest individual concentration of 1.6969mg/kg of phenanthrene was obtained from this location while the highest concentration of 3.765mg/kg was for dibenzo(a) anthracene. Other individual PAHs and their concentrations obtained in the study were 1,2-bezanthracene (2.378mg/kg), indeno (1,2,3-cd) pyrene (2.325mg/kg) and flourene (2.096mg/kg). [9] in their study on the concentrations of PAHs in clarias gariepinus specie of fish from Southern Nigeria obtained a range of 0.012-0.095mg/kg. The concentrations of PAHs obtained in roasted fish from Aker junction were quite high when compared with others. The high concentrations of PAHs in the roasted fish may be attributed to high vehicular traffic and the use of charcoal in the roasting.

**Table 3** The Concentrations of Polycyclic Aromatic Hydrocarbons (PAHs) in Mg/kg in roasted plantain from Rumuokwuta junction

Name	Type	Rest time (MIN)	Amount/Area	Area (PAS)	Amount (mg/kg)
Acenaphthene	VB	6.332	5.10976e-1	6.66639	3.40546
Acenaphthylene		9.140	-	-	-
Anthracene		9.517	-	-	-
1,2. Bezanthracene		10.604	-	-	-
Benzo (a) Pyrene		12.867	5.60346e-1	10.75511	2.02659
Benzo (b)flouranthene		15.939	-	-	-
Benzo (K) flouranthene		16.876	-	-	-
Pyrene		17.722	-	-	-
Chrysene		19.787	-	-	-
Dibenzo(a)anthracene	VB	20.122	6.93865e-1	47.21531	1.81249
Napthalene	VP	20.923	5.93865e-1	23.51694	2.16527
Benzo (a)flouranthene		21.233	-	-	-
Phenanthrene		22.156	-	-	-
Flouranthene		25.143	-	-	-
Flourene	VB	30.234	5.51828e-1	35.41972	2.24357
Indeno (1,2,3,-cd) Pyrene		40.234	-	-	-
Benzo (g,h,i) Perylene		15.939	-	-	-
Total					11.65338

**Table 4** The Concentrations of Polycyclic Aromatic Hydrocarbons (PAHs) in Mg/kg in Roasted Fish from Rumuokwuta Junction

Name	Type	Rest time (MIN)	Amount/Area	Area (PAS)	Amount (mg/kg)
Acenaphthene		6.332	-	-	-
Acenaphthylene		9.140	-	-	-
Anthracene		9.517	-	-	-
1,2. Bezanthracene		10.604	-	-	-
Benzo (a) Pyrene		12.867	-	-	-
Benzo (b)flouranthene		13.076	-	-	-
Benzo (g,h,i) Perylene		15.939	-	-	-
Benzo (K) flouranthene		16.876	-	-	-
Pyrene		17.722	-	-	-
Chrysene	VP	19.787	5.24138e-1	27.36522	4.34316
Dibenzo(a)anthracene	BV	20.122	5.25972e-1	28.24940	3.23439
Napthelene		20.923	-	-	-
Benzo (a)flouranthene		21.233	-	-	-
Phenanthrene	HH	25.156	5.53456e-1	32.06921	3.96986
Flouranthene	BB	30.143	5.93865e-1	18.77077	2.63017
Flourene	VV	35.234	5.58123e-1	13.11010	1.34213
Indeno (1,2,3,-cd) Pyrene	VB	40.234	5.86532e-1	4.42871	3.58527
Total					19.10498

The concentrations of PAHs in roasted plantain from the Rumuokwuta junction are presented in Table 3. A total of five EPA priority PAHs were quantified in the roasted plantain from this location. The lowest individual concentration of 1.81224 mg/kg of dibenzo (a) anthracene was obtained and the highest concentration of 3.405 mg/kg of acenaphthene. Other individual PAHs obtained with their concentrations were benzo(b) flouranthene (2.026mg/kg), naphthalene (2.165mg/kg) and flourene (2.243mg/kg). In a study conducted by [14] on an investigations of PAHs densities in roasted plantain and smoked fish in Ondo State, the following range of the individual PAHs were obtained in the roasted plantain: acenphthene (1.9-3.7ng/kg), flourene (0.5-4.8ng/kg), pyrene (0.1-3.8ng/kg), Benzo(a) anthracene (0.3-2.8ng/kg) and chrysene (1.0- 4.5ng/kg). The levels of PAHs obtained in this study did not agree with other works.

**Table 5** The Concentrations of Polycyclic Aromatic Hydrocarbons (PAHs) in Mg/kg in roasted plantain from Rumuokoro Round About

Name	Type	Rest time (MIN)	Amount/Area	Area (PAS)	Amount (Mg/kg)
Acenaphthene		6.332	-	-	-
Acenaphthylene		9.140	-	-	-
Anthracene		9.517	-	-	-
1,2- Bezanthracene		10.604	-	-	-
Benzo (a) Pyrene	BB	12.867	3.16340e-3	185.85942	3.59667
Benzo (b)flouranthene	VB	13.076	4.81032e-1	115.17342	2.29889
Benzo (g.h.i) Perylene	W	15.939	2.35571e-1	234.53121	2.43218
Benzo (K)flouranthene		16.876	-	-	-
Pyrene	BP	17.	3.45872e-1	353.30573	3.34091
Chrysene	W	19.787	2.46345e-1	474.74133	2.65317
Dibenzo(a)anthracene		20.122	-	-	-
Naphthelene		20.923	-	-	-
Benzo (a)flouranthene		25.233	-	-	-
Phenanthrene		30.156	-	-	-
Flouranthene		35.143	-	-	-
Flourene		40.234	-	-	-
Indeno (1,2,3,-cd) Pyrene		44.234	-	-	-
Total					14.32182

**Table 6** The Concentrations of Poly Aromatic Hydrocarbons (PAHs) in mg/kg in roasted fish from Rumuokoro Round About

Name	Type	Rest time (MIN)	Amount/Area	Area (PAS)	Amount (mg/kg)
Acenaphthene		6.332	-	-	-
Acenaphthylene		9.140	-	-	-
Anthracene		9.517	-	-	-
1,2- Bezanthracene	BV	10.604	5.04309e-1	36.339981	3.83265
Benzo (a) Pyrene		12.867	-	-	-
Benzo (b)flouranthene	VB	13.076	5.81452e-1	15.10342	4.38543
Benzo (g.h.i) Perylene	W	15.939	5.19886e-1	65.92880	5.56421
Benzo (K) flouranthene		16.876	-	-	-
Pyrene		17.722	-	-	-
Chrysene	W	19.787	5.88663e-1	82.99121	3.56721
Dibenzo(a)anthracene	VB	20.122	6.10597e-1	90.67210	2.21487
Naphthelene		22.923	-	-	-
Benzo (a)flouranthene		25.233	5.21093e-1	96.56432	1.80280
Phenanthrene		30.156	-	-	-
Flouranthene		35.143	-	-	-
Flourene		40.234	-	-	-
Indeno (1,2,3,-cd) Pyrene		44.234	-	-	-
Total					21.36717

It was observed from the study on the concentration of PAHs in roasted fish from Rumuokwuta location that six EPA priority PAHs were quantified. The lowest individual concentration of 1.342mg/kg of flourene was obtained and the highest concentration of 4.343mg/kg of chrysene. Other PAHs obtained at this location with their concentrations were phenanthrene (3.9698mg/kg), dibenzo (a) anthracene (3.324mg/kg), indeno (1,2,3-cd) pyrene(3.585mg/kg) and flouranthene (2.6301mg/kg). The concentrations of PAHs obtained in this study were quite high when compared with that of [9].

The total number of EPA priority PAHs quantified in roasted plantain from the Rumuokoro location was five. The lowest individual concentration of 2.298mg/kg was recorded for benzo (b) flouranthene while the highest concentration of 3.596mg/kg was for benzo (a) pyrene. Other PAHs and their concentrations quantified from this location were benzo (g,h,i) perylene (2.432mg/kg), pyrene (3.340mg/kg) and chrysene (2.653mg/kg). The concentrations of PAHs recorded in roasted plantain from this location were quite high.

Six EPA priority PAHs were quantified in roasted fish from Rumuokoro location. The highest concentration of 5.563mg/kg of benzo (g,h,i) perylene was obtained from this location and 1.802mg/kg of benzo (a) flouranthene was obtained as the lowest concentration. The other PAHs obtained from this location were chrysene (3.567mg/kg), dibenzo (a) anthracene (2.2148mg/kg), benzo (b) flouranthene (4.385mg/kg) and 1,2 benzanthracene (3.382mg/kg). From the investigation, it was discovered that the concentrations of PAHs in roasted fish from the Rumuokoro location were high when compared with others in literature. The high concentrations of PAHs in roasted fish may be attributed to the use of charcoal in roasting as posited by [3] that poly aromatic hydrocarbons are found in foods as a result of certain industrial food processing methods such as smoking, curing, broiling, roasting and grilling over open fires or charcoal which permits the direct contact between food and combustion products.

## Conclusion

The concentrations of polycyclic aromatic hydrocarbons in roasted plantain and fish from the three locations investigated were quite high when compared with those from other works. Presently, the consumption of roasted plantain and fish commonly known as Bole during lunch hours within Port Harcourt metropolis is on the increase. It is known that high level of PAHS in human system is dangerous since it is carcinogenic, mutagenic and teratogenic in nature. With these high concentrations in the food sample, the consumption is seen to be dangerous and it is our view that the consumption should be curtailed at the moment pending when a proper mode of preparation and safe environment are made available. The high level of PAHs in the roasted plantain and fish may be attributed to the use of charcoal in the roasting and high vehicular traffic experienced around these locations where the food samples were collected.

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