Asian
Science
Bulletin

OPEN ACCESS

Concentrations of Selected Metals and Polycyclic Aromatic Hydrocarbons in Fresh and Fried Bayelsa Suya (*Oryctes rhinoceros*) Sold in Bayelsa State, Nigeria

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ABSTRACT

Background and Objective: *Oryctes rhinoceros* larvae is a special cuisine heavily patronized in Bayelsa State and neighboring states of Delta and Rivers in Nigeria. The preparation mode and exposure during sales call for empirical investigation into its chemical and toxicological status. Heavy metals and polycyclic hydrocarbons (PCHs) were the major bioactive substances analyzed in fresh and fried (prepared) forms in the current study. **Materials and Methods:** The metals were analyzed using AAS, whereas PCH was analyzed using GC-MS. Student t-test was used to compare heavy metals and PCH concentrations between the fresh and fried Bayelsa Suya and with maximum acceptable limits. Data were analyzed using SPSS (v18-21) and Excel, with a 95% significance level determined via Student's t-test. **Results:** The results revealed a significant increase ($p<0.05$) in lead, mercury, arsenic, zinc, chromium, cadmium and copper concentrations. In contrast, manganese decreased in the fried food compared to the fresh food, which had the maximum acceptable limits. In a similar vein, PCH species such as naphthalene, acenaphthylene, acenaphthene, fluorene, fluoranthene, pyrene, benz{b}fluoranthene, benzo(a)fluoranthene and benzo(a)pyrene were significantly increased ($p<0.05$) in the fried when compared to the fresh. **Conclusion:** The increase observed in some metals and PCH could be traced to the preparatory stage and sales exposure. The findings of this study underscored the importance of considering the harmful effects of heavy metals and PCH intoxications associated with the consumption of Bayelsa Suya and adherence to food safety measures.

KEYWORDS

Oryctes rhinoceros, Bayelsa suya, metals, polycyclic hydrocarbons, Student's t-test, GC-MS

INTRODUCTION

The larvae of *Oryctes rhinoceros*, commonly known as the red palm weevil, are herbivorous insects that feed on the decaying tissues of raffia palm trees. In the South-South Region of Nigeria, these larvae are referred to as "Bayelsa Suya" due to their widespread harvesting and consumption. Bayelsa Suya is sold both raw and fried in local markets. The preparation involves washing, seasoning and frying the larvae in a dry or oiled pan or roasting them to achieve a creamy color that enhances the taste and aroma. The larvae are typically processed to a low moisture content, packaged and sold by local vendors.

ISSN: 1813-0070 (Print)
https://doi.org/10.3923/asb.2025.32.38

Received: 31 Nov. 2024
Accepted: 18 Dec, 2024
Published: 31 Mar. 2025

The patronage of fresh and fried Bayelsa Suya is quite high, necessitating the need for the assessment of some vital parameters that could reveal its inherent toxicological and to an extent nutritional value. It is worth noting that agricultural produce and food meant for consumption ought to be profiled toxicologically and nutritionally to avert adverse public health implications[1].

Parameters such as metals (heavy and trace) and polycyclic hydrocarbons (PCHs) were the choice indicators of the toxicological and nutritional profile of Bayelsa Suya as portrayed in this study. Metals measured include mercury, lead, chromium, cadmium, arsenic, cadmium, zinc, copper, zinc and iron. Whereas, that of the PCHs involved all the essential and known parameters.

Metals are generally referred to as those elements that possess a specific density of more than 5 g/cm^3 and can be advantageous or deleterious to the environment and living organisms. It could be trace or heavy with diverse biological and environmental functions. Trace elements like zinc, copper and manganese are crucial for the biological and physiological processes involved in the growth and health of animals and humans[2,3]. Conversely, heavy metals such as arsenic, cadmium, chromium, lead and mercury are prominent environmental pollutants that have detrimental effects on ecosystems and biological systems[4-7].

Polycyclic aromatic hydrocarbons (PAHs) are a class of chemicals that result from burning coal, oil, gas, wood, garbage and tobacco. High heat when cooking meat and other foods will form PAHs. "The structural characteristics of PAHs, including their heterocyclic aromatic rings, hydrophobic nature and ability to withstand high temperatures, contribute to their persistence in the environment and harmful effects".

Polycyclic aromatic hydrocarbons are highly toxic, mutagenic, carcinogenic, teratogenic and immunotoxicogenic. It has been implicated in eye irritation, immune suppression, depression, breathing abnormalities, polycystic ovary syndrome, fertility, spontaneous abortion, embryotoxicity and premature births[8-14].

The probe into the health and nutritional implications of Bayelsa Suya is the basis of this study due to the heavy patronage and consumption. There is an increase in diseases best described as idiopathic without known causes. This has elicited the need for widespread studies looking at commonly consumed foods and products. The preparation and subsequent exposure during sales made it vulnerable to metals and PCHs intoxication and accumulation. This is unhealthy and could be detrimental to health and well-being, hence an investigation into its toxicological and nutritional profile to address the gaps enunciated above. This study investigated the chemical and toxicological status of fresh and fried (prepared) forms, focusing on the analysis of heavy metals and polycyclic hydrocarbons (PCHs) as the major bioactive substances, with consideration given to the preparation mode and exposure during sales calls.

MATERIALS AND METHODS

Study area: Bayelsa Suya (fresh and fried) used for the study were bought at the Akenfa market in Yenagoa Local Government Area of Bayelsa State. The samples were packaged properly and transmitted immediately to the Eni-yimini Laboratories (eL) Ltd., Yenezue-Gene for laboratory analysis. The study duration spanned from January 2023 to January, 2024.

Study population: Twenty-eight of equal fresh and dried *Bayelsa Suya* constituted the study's sample size as validated by Mead's resource equation[15,16].

Ethical clearance: The ethical clearance and approval were obtained from the Directorate of Research and Quality Assurance of the Federal University Otuoke, Bayelsa State. To ensure international conformity, the research protocol adhered stringently to the Animal Welfare Act of 1985 of the United States of America for Research and Institutional Animal Care and Use Committee (IACUC).

Sample collection: Fresh Bayelsa Suya was collected into a polyethylene bag, whereas the fried was processed before the packaging in the same kind of bag. Sampling was conducted in a way that ensured a random representative cross-section of the larvae population.

Laboratory analysis: A procedure recommended by the Environmental Protection Agency (EPA, Method 3050B) was used as the conventional acid extraction method. The metals were analyzed using Varian Spectra A100 (UK) Atomic Absorption Spectroscopy (AAS). In a similar vein, Gas Chromatography-Mass Spectrophotometry (GC-MS) (Hewlett Packard 5890 instrument, Canton, Switzerland) was the choice method for the polycyclic Aromatic Hydrocarbons (PAHs) analysis. The metals estimated include; mercury, lead, arsenic, chromium, cadmium, copper and zinc, whereas, the PAHs were Naphthalene, Acenaphthene, Acenaphthylene, Fluorene, Anthracene, Phenanthrene, Fluoranthene, Pyrene, Benz(a)anthracene, Chrysene, Benzo(a)fluoranthene, Benz{b}fluoranthene, Benzo(a)pyrene, Indeno(1,2,3-cd)pyrene, Dibenz(a,h)anthracene and Benzo(ghi)perylene.

Statistical analysis: Data were analyzed using the Statistical Package for Social Sciences (SPSS) Programme (SPSS Inc., Chicago, IL, USA; Version) and Microsoft Excel. Student's t-test was used for the data comparison and analysis. The level of significance was put at 95%[18-21].

RESULTS

The study found significant differences in the metal concentrations between fresh and fried *Oryctes rhinoceros* (Bayelsa Suya). Fried Suya had higher concentrations of Zn (0.922±0.104 µg/mL), Cu (0.018±0.0082 µg/mL), Fe (0.8300±0.0082 µg/mL), As (0.0410±0.277 µg/mL), Hg (0.0330±0.063 µg/mL), Cd (0.041±0.021 µg/mL), Cr (0.4250±0.0957 µg/mL) and Pb (0.0250±0.0577 µg/mL), compared to fresh Suya, where concentrations of these metals were either very low or absent. Statistically significant differences were observed in Mn, Zn, Cu, As, Hg, Cd, Cr and Pb ($p<0.05$) as shown in Table 1.

The findings from the table show that the levels of metals in fried Suya (*Oryctes rhinoceros*) exceed the WHO/FAO maximum acceptable limits for Pb (0.0250 µg/mL), Cd (0.041 µg/mL), Cr (0.4250 µg/mL), As (0.0410 µg/mL), Hg (0.0330 µg/mL) and Zn (0.922 µg/mL). However, the levels of Cu (0.0180 µg/mL), Fe (0.8300 µg/mL) and Mn (0.097 µg/mL) in fried Suya remain below their respective limits. In contrast, the fresh Suya samples show negligible concentrations for most metals, remaining well within the standards as shown in Table 2.

The findings show significant increases in polycyclic hydrocarbons in fried *Oryctes rhinoceros* (Bayelsa Suya) compared to fresh suya. Naphthalene increased from 0.0000 to 0.1750 µg/mL ($p = 0.010$), acenaphthene from 0.0000 to 0.0275 µg/mL ($p = 0.010$), fluorene from 0.0000 to 0.0200 µg/mL ($p = 0.034$), fluoranthene from 0.0000 to 0.0125 µg/mL ($p = 0.024$), pyrene from 0.0000 to 0.0225 µg/mL ($p = 0.037$), benz(b) fluoranthene from 0.0400 to 2.4100 µg/mL ($p = 0.020$), benzo(a)fluoranthene from 0.0150 to 1.5800 µg/mL ($p = 0.040$) and benzo(a)pyrene from 0.0000 to 3.1000 µg/mL ($p = 0.034$). Acenaphthylene, anthracene, phenanthrene, benz(a)anthracene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene and benzo(ghi)perylene showed no significant differences (NS) as shown in Table 3.

Table 1: Mean concentrations of the studied metals in fresh and fried *Oryctes rhinoceros* (Bayelsa Suya)

Parameter µg/mL	Fresh suya (*Oryctes rhinoceros*)	Fried suya (*Oryctes rhinoceros*)	T-value	P-value
Mn	0.139±0.020	0.097±0.031	7.901	0.049
Zn	0.115±0.012	0.922±0.104	23.445	0.023
Cu	0.000±0.000	0.0180±0.0082	-44.091	0.034
Fe	0.2270±0.0082	0.8300±0.0082	-146.971	0.172
As	0.000±0.000	0.0410±0.277	3.610	0.000
Hg	0.000±0.000	0.0330±0.063	30.11	0.040
Cd	0.000±0.000	0.041±0.021	6.779	0.045
Cr	0.000±0.000	0.4250±0.0957	-8.878	0.010
Pb	0.000±0.000	0.0250±0.0577	-8.660	0.000

P<0.05 is significant and P> = 0.05 is not significant

Table 2: Mean Maximum acceptable limits of some metals in meats and the studied matrices

Metals µg/m	LWHO/FAO standard	Fresh suya (*Oryctes rhinoceros*)	Fried suya (*Oryctes rhinoceros*)
Pb	0.01	0.000	0.0250
Cd	0.003	0.000	0.041
Cr	0.05	0.000	0.4250
As	0.01	0.000	0.0410
Hg	0.01	0.000	0.0330
Zn	3.0	0.115	0.922
Cu	2.0	0.000	0.0180
Fe	0.03	0.2270	0.8300
Mn	0.400	0.139	0.097

Chebli et al.[17] and *Genchi et al.*[18]

Table 3. Mean comparison of the concentrations of polycyclic hydrocarbons in fresh and fried *Oryctes rhinoceros* (Bayelsa Suya)

Parameter	Fresh Suya µg/mL	Fried Suya µg/mL	T-value	p-value
Naphthalene	0.0000±0.0000	0.1750±0.0957	-3.656	0.010
Acenaphthylene	0.0000±0.0000	0.0000±0.0000	NS	NS
Acenaphthene	0.0000± 0.0000	0.0275±0.0096	-5.745	0.010
Fluorene	0.0000±0.0000	0.0200±0.0082	-4.899	0.034
Anthracene	0.0000±0.0000	0.0000±0.0000	NS	NS
Phenanthrene	0.0000±0.0000	0.0000±0.0000	NS	NS
Fluoranthene	0.0000±0.0000	0.0125±0.0050	-5.000	0.024
Pyrene	0.0000±0.0000	0.0225±0.0189	-2.377	0.037
Benz(a)anthracene	0.0000±0.0000	0.0000±0.0000	NS	NS
Chrysene	0.0000±0.0000	0.0000±0.0000	NS	NS
Benz{b}fluoranthene	0.0400±0.0082	2.4100±0.0102	-313.000	0.020
Benzo(a)fluoranthene	0.0150±0.0058	1.5800±0.0082	-410.496	0.040
Benzo(a)pyrene	0.0000±0.0000	3.1000±0.0817	-75.934	0.034
Dibenz(a,h)anthracene	0.0000±0.0000	0.0000±0.0000	NS	NS
Indeno(1,2,3-cd)pyrene	0.0000±0.0000	0.0000±0.0000	NS	NS
Benzo(ghi)perylene	0.0000±0.0000	0.0000±0.0000	NS	NS

DISCUSSION

The study revealed a significant increase in lead, mercury, arsenic, zinc, chromium, cadmium and copper concentrations, whereas manganese decreased in the fried compared to the fresh (Table 1). Furthermore, the metal concentrations measured in the various matrices were presented alongside the maximum allowable limit of FOA/WHO (Table 2). Whereas the heavy metals were higher in the fried matrices and above the maximum allowable concentrations, the trace metals either decreased or were within the maximum allowable concentrations.

The increase of heavy metal concentrations above the fresh and established maximum limits in the fried Bayelsa suya could be attributed to invitro factors. Preparation of Bayelsa suya requires the use of heat, oil and other additives. These additives include salts, magi, pepper, onions and other ancillary products.

Additionally, the exposure during sales could have also contributed to the leap in the heavy metal concentrations in the fried. Based on the above, it could be inferred that the heavy metal contaminations observed could be a product of the preparatory or environmental exposure phases.

Moreover, the presence of heavy metals is known to be deleterious and could be quite deleterious to the entire systems of the body[19-23]. Systems in the body such as the neurological, hepatic immunological and hematological have been established to the affected by the activities of heavy metals[4-7]. The perspective of this study is in line with that of Olubunmi *et al.*[24].

In a similar vein, the decrease in concentrations of manganese and increase in iron and copper in the fried could also be attributed to the factors enunciated above. Experimental studies have demonstrated the accumulation of significant amounts of trace elements in palm oil[25]. This might have contributed to the increased iron and copper. On the contrary, temperature could have contributed to a fall in manganese concentrations in the fried. The fall in manganese concentration is not desirable as it plays crucial roles in fat and carbohydrate metabolism, calcium absorption and blood sugar regulation[26,27]. The observation on the decrease in concentration of manganese agreed with the finding of Olubunmi *et al.*[24] Contrarily to this study, Markmanuel and Godwin[28] reported a decrease in concentrations of iron and copper in boiled and fried Bayelsa suya. The increases in trace metals such as copper and zinc could be beneficial to the body as the concentrations are within the permissible level. This set of vital elements is important as cofactors in enzymes and supports numerous physiological functions in the body[29].

Such increases also can prevent the occurrence of diseases and pathogenesis either by microorganisms or other causative agents[30]. Klaudia *et al.*[31] reported that trace elements function primarily as catalysts in enzyme systems; as they participate in oxidation-reduction reactions in energy metabolism. This further indicates that the increased concentration of these trace metals will help in the oxidation and reduction process during energy metabolism.

Furthermore, the results revealed a significant increase in some PCHs in the fried when compared to the fresh (Table 3). Naphthalene, acenaphthylene, acenaphthene, fluorene benz(b)fluoranthene, benzo(a)fluoranthene and pyrene were found to be significantly higher in concentrations. In addition, only benz(b)fluoranthene and benzo(a)fluoranthene were detected in the fresh maggot, though significantly lower in concentrations to the fried. This depicts indeed, that the increased PCHs found in the fried maggot were derived from the processing phase, especially the frying stage. Frying and heat processing of foods and other similar matrices are known to generate PCHs[32].

The deleterious effects of PAHs on the health and well-being of humans and other organisms have been validated by a handful of studies[8,10,11,13]. These compounds have been linked to various adverse health effects, including cancer[10,11]. This has highlighted the detection of PCHs in Bayelsa Suya a potential health risk associated with the consumption of fried maggots.

CONCLUSION

The findings of this study suggest that there is a significant threat posed by the consumption of Bayelsa Suya resulting from heavy metal and PCH contamination. The contributions of external factors such as the preparation phase and exposure during sales could be responsible for the contamination. However, trace metals measured were within the acceptable maximum threshold as posited by FOA/WHO, hence of no deleterious effect on consumers of Bayelsa Suya. Therefore, it is recommended that the processing stage should be conducted under low temperatures and a hygienic environment. The seasoning and recipes used should be void of contaminants. Furthermore, exposure to processed maggots during sales should be discouraged.

SIGNIFICANCE STATEMENT

The results of this study indicate a notable risk associated with the consumption of Bayelsa Suya due to contamination from heavy metals and polycyclic aromatic hydrocarbons (PCHs). External factors, including the preparation process and exposure during sales, may contribute to this contamination. However, the levels of trace metals detected were within the acceptable limits established by FAO/WHO, suggesting no harmful effects on consumers of Bayelsa Suya.

ACKNOWLEDGMENTS

The sample collection and laboratory preparatory phase of the study was anchored by the 400-level Biochemistry students of the 2023 set. In addition, the staff of the Eni-yimini Laboratories LTD conducted the laboratory analysis and also assisted in the data analysis.

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