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Pesticide Residues in Cowpea (*Vignaunguiculata*L.Walp) grains sold in Senatorial Zones of Anambra State, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Abstract

This study investigates the levels of pesticide residues in cowpea (VignaunguiculataL.Walp) grains sold in four major markets across Awka, Nnewi, Ekwulobia, and Onitsha in Anambra State, Nigeria, between November 2023 and February 2024. Cowpea samples were collected from these regions representing three senatorial zones, processed, and analyzed for pesticide residues using Gas Chromatography with an Electron Capture Detector. The analysis focused on common pesticides and Polychlorinated Biphenyls (PCBs), aiming to determine their concentrations in the grains. The results indicate varying levels of pesticide residues across the locations, with some samples exceeding the safety limits established by international health agencies. The study highlights significant concerns regarding food safety and public health implications due to the presence of pesticide residues in a staple food crop. It calls for urgent attention from regulatory authorities to enforce stricter controls on pesticide use in agriculture and ensure compliance with safe agricultural practices.

Keywords: Pesticide, residues, cowpea (*Vignaunguiculata*L.Walp), grains, senatorial zones

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1. Introduction

Pesticides play a crucial role in modern agriculture, aiding in pest control and increasing crop yields. Pesticides are substances used to eliminate or control pests that threaten agriculture, public health, and the environment. They encompass a wide range of compounds, including herbicides, insecticides, fungicides, and rodenticides (Kaur*et al*., 2019). However, the indiscriminate use and improper application of pesticides can lead to harmful residues in food products, posing risks to human health and the environment. These include potential health hazards to humans—ranging from acute poisoning to long-term effects such as cancer and endocrine disruption—as well as environmental issues like biodiversity loss, water contamination, and the decline of beneficial species such as pollinators.

Cowpea (*Vignaunguiculata*L.Walp), a popular legume widely consumed in Nigeria, is not exempt from this concern. Cowpea (*Vignaunguiculata*L.Walp), also known as black-eyed pea or niebe, is a versatile and nutritious legume widely cultivated and consumed in Nigeria (Osipitan*et al*., 2021; Obafemi*et al*., 2024). It is a staple in Nigerian cuisine, featuring prominently in various dishes such as "akara," "moimoi," and "ewaagoyin." Beyond Nigeria, cowpea is also popular in other African countries due to its drought tolerance and high protein content, making it a valuable crop for food security (Popoola*et al.,*2024). In addition to its culinary uses, cowpea plays a vital role in sustainable agriculture, serving as a cover crop and improving soil fertility through nitrogen fixation. Its nutritional benefits, resilience, and versatility contribute to its significance in African agriculture and diets (Sadiq*et al*., 2019).

The use of pesticides in preserving agricultural produce like cowpea (*Vignaunguiculata*L.Walp) plays a significant role in mitigating post-harvest losses, extending shelf life, and ensuring food security (Amare*et al*., 2022). By controlling pests and diseases that can degrade quality and quantity, pesticides enhance the longevity of cowpeas during storage and transport. However, this practice must be carefully managed to prevent the accumulation of harmful pesticide residues, which can pose health risks to consumers (Hajam*et al*., 2022). Balancing the benefits of pesticide use with the need for food safety requires adherence to recommended application rates, timing, and methods, along with rigorous monitoring and regulation to ensure that residue levels remain within safe limits.

Studies by Anaduaka*et al*.(2023)and Omeje*et al*.(2022)highlighted the widespread use of pesticides in Nigerian agriculture. They noted that while pesticides are essential for crop protection, improper handling, overuse, and lack of adherence to safety guidelines contribute to the presence of residues in food products, including cowpea grains.Cowpea is a staple food in Nigeria, consumed by millions daily. Its popularity makes it crucial to monitor for pesticide residues, as any contamination can have far-reaching consequences. A study by Fadina*et al*. (2021)assessed the organochlorine residues in cowpea (*Vignaunguiculata* L. WALP) from selected markets in Ibadan, Oyo State, Nigeria. They found detectable levels of various pesticides, including organochlorines and organophosphates, emphasizing the need for continuous monitoring and regulation.

In Anambra State, where this study is focused, investigations by Omokpariola*et al*. (2023)revealed the concentration levels and risk assessment of organochlorine and organophosphate pesticide residue in selected cereals and legumes sold in Anambra State, south-eastern Nigeria. Asogwa,*et al*. (2023) also analysed and quantified of the levels of insecticide residues in maize sold in South Eastern Nigeria.The studies noted that the presence of pesticide residues in grains raises significant health concerns. Chronic exposure to pesticides has been linked to various health issues, including cancer, reproductive disorders, and neurological problems (Gangemi*et al*., 2016; Sabarwal*et al*., 2018). Vulnerable populations such as children and pregnant women are particularly at risk.

From a regulatory standpoint, the Nigerian government has established maximum residue limits (MRLs) for pesticides in food products. These limits are designed to protect public health by ensuring that food items on the market are safe for consumption. However, enforcement and monitoring of these limits are crucial to ensure compliance.Effective market surveillance programs are essential to monitor pesticide residues in food products. These programs involve regular sampling and testing of agricultural produce to ensure compliance with safety standards. In a study by Fung*et al*. (2018), they emphasized the need for increased surveillance to prevent the sale of contaminated food items.

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The urgency for the study on pesticide residues in cowpea (*Vignaunguiculata*L.Walp) grains sold in Senatorial Zones of Anambra State, Nigeria, stems from several critical factors. Firstly, cowpea is a staple food in Nigeria, particularly in Anambra State, where it is widely consumed by the populace. However, studies such as that by Fadina*et al.*(2021) and Huan*et al.*(2016)have revealed the presence of pesticide residues in cowpea samples from markets in the state, indicating potential health risks to consumers.Secondly, there is a lack of comprehensive data on the extent of pesticide contamination specifically in cowpea grains in the senatorial zones of Anambra State. While studies exist on pesticide residues in various agricultural products in Nigeria, such as vegetables and grains, there is a notable gap regarding cowpea specifically. This gap was highlighted by Fadina*et al.* (2021)in their assessment of pesticide residues in cowpea samples from markets in Oyo State.

Furthermore, the impact of pesticide residues on public health cannot be overstated. Chronic exposure to these residues can lead to serious health issues, including cancer, reproductive disorders, and neurological problems (Sabarwal*et al.*, 2018; Upadhayaya*et al.*, 2020). Given the significant consumption of cowpea in Anambra State, understanding the levels of pesticide residues in these grains is crucial for public health protection and informed decision-making regarding food safety regulations. Hence, this study aims to address these gaps and provide clear understandings into the levels of pesticide residues in cowpea grains sold in Anambra State, Nigeria.

2. Methodology

2.1 Study Area

The research was conducted between 1st November and February 28, 2024 at the Department of Zoology laboratory, Department of Biochemistry laboratory of NnamdiAzikiwe University Awka and Docchy Analytical Laboratory and Environmental Services, AwkaAnambra State.

2.2 Design of the Study

Four(4) markets in the three(3) senatorial zones of Anambra State were selected. These comprise: Eke Awka market (between latitudes 06^{o}06$^'$N and 06^{o}16$^'$N and longitudes 07^{o}01$^'$E and 07^{o}10$^'$E: Emenginiet *al.*, 2014), NkwoNnewi market (between latitudes 5^{o}59$^{''}$41.64’’N and 6^{o}03$^'$28.44’’N and longitudes 6^{o}03$^'$28.44$^{''}$E and 6^{o}52$^'$41.64$^{''}$E: Ezeomedo and Igbokwe, 2019), Eke Ekwulobia market (6°2ˊ0ˊˊN, 7° 5ˊ0ˊˊE: Aribodor*et al*., 2018) and Ose market, Onitsha (between latitudes 0.6°02ˡNand 06°08ˡN and longitudes 0.6°47ˡE and 06°59ˡE : Emengini and Idhoko, 2013).

2.3 Collection and Preparation of cowpea samples for quantification of pesticide residues

One kilogram (1kg) sample of cowpea was randomly purchased from four (4) sellers in each of the markets in the three senatorial zones in Anambra State. Preparation of collected sample for analysis was done as described by Asogwa,*et al*. (2023).The samples were sorted to remove stones and debris. A fraction of each sample(30.0g) was evenly pulverizedinto 20 mesh particle size and were individually stored in glass bottles with appropriate labels for further analysis.

2.4Analysis and quantification of samples for pesticide residues on stored cowpea

The analysis was conducted according to the standard methods of AOAC (1990).

2.5Extraction of Polychlorinated Biphenyls (PCBs) from samples

A ten gram grounded sample was weighed and quantitatively transferred into a 500ml beaker. 6g sodium sulphate was added and extracted using 300ml n hexane to get a concentrated filtrate. 1ml of filtered residue was dissolved in 50ml of chloroform and transferred to a 100ml volumetric flask which afterwards was diluted to the mark. Most chloroform were allowed to evaporate at room temperature. 1ml of the reagent (20 vol% benzene and 55 vol% methanol) was added. This was sealed and heated at 40°C water bath for 10 minutes. Thereafter, extraction of the organic sample was carried out using hexane and water in the ratio of 1:1:1 (i.e. the final mixture of the reagent, hexane and water respectively). The mixture was manually shaken vigorously for 2min. lastly, half of the top hexane phase was carefully transferred to a small test tube for injection.

2.6Gas Chromatographic conditions for PCB determination

The final extracts were analyzed by Gas Chromatograph-Buck M910 scientific gas chromatography equipped with Electron capture detector that allowed the detection of contaminants even at trace level concentrations (in the lower µg/g and µg/kg range) from the

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matrix to which other detectors do not respond. The GC conditions used for the analysis were capillary column HP 88 capillary column (100m x 0.25µm film thickness,) CA, USA. The injector and detector temperature were set at 250ºC and 290ºC respectively. The oven temperature was programmed as follows: 110 ºC held for 10 min, ramp at 10ºC/min to 200ºC, held for 5min, and finally ramp at 10ºC/ min to 320ºC. Helium was used as carrier gas at a flow rate of 1.0 ml/min and detector make-up gas of 29 Ml min-1. The injection volume of the GC was 8.0 µL. The total run time for a sample was 48min.

2.7Quantification of PCB residues.

The residue levels of PCB were quantitatively determined by the external standard method using peak area. Measurement was carried out within the linear range of the detector. The peak areas whose retention times coincided with the standards were extrapolated on their corresponding calibration curves to obtain the concentration.

2.8Preparation of Standard

An aliquot (10µl) of accu standard was injected in the chromatography and the retention time compared with retention time of standard.

3. Results

Table 1 showed that the beans samples from the four locations contained varying concentration 4,4-bipyridinum chloride, lindane, HCb, g-chlordane, p'p'-DDD, Glyphosphate, DDT, Emamectin, Heptachlor and t-nonachlor. The pesticide with the highest concentration was Emamectin with the sample from Ekwulobia having the highest concentration (71.86µg/100g). DDT was the next in concentration with the highest amount in the sample obtained from Nnewi (49.33µg/100g). Dichlorbiphenyl was found only in the sample from Nnewi at a concentration of 41.06µg/100g. Biphenyl was not found in the samples from Ekwulobia and Onitsha.

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Table 1: Analysis and quantification of samples for pesticide residues on stored cowpea

S/N	Pesticides (µg/100g)	Awka	Nnewi	Ekwulobia	Onitsha
1	4,4-bipyridinum dichloride	3.36	3.36	3.31	2.90
2	Lindane	6.55	2.84	6.49	6.03
3	HCB	2.32	2.32	2.32	2.30
4	g-chlordane	15.01	15.02	14.89	13.46
5	p'p'-DDD	51.22	38.25	37.30	48.47
6	Glyphosphate	7.20	7.21	7.04	7.01
7	DDT	31.05	49.33	49.32	31.19
8	Biphenyl	9.32	9.51	-	-
9	Emamectin	29.18	43.54	71.86	47.31
10	Heptachlor	11.27	11.26	11.25	11.24
11	t-nonachlor	0.38	0.54	0.29	0.22
12	Dichlorobiphenyl	-	41.06	-	-

Discussion of results

The findings from Table 1 regarding the presence and varying concentrations of pesticides such as 4,4-bipyridinum chloride, lindane, HCb, γ-chlordane, p'p'-DDD, Glyphosphate, DDT, Emamectin, Heptachlor, and t-nonachlor in bean samples from four different locations mirror the concerns raised in recent studies on pesticide residue in agricultural products. In a related study by Tesi*et al*.(2022), the widespread contamination of vegetables in Nigerian markets with organochlorine pesticides, including DDT and Heptachlor, was reported, highlighting the ongoing challenges in monitoring and managing pesticide use. Similarly, the high concentration of Emamectin found in the Ekwulobia sample aligns with findings by Silva*et al*. (2019), who reported elevated levels of newer pesticide residues in crop samples, underscoring the shift towards more potent agrochemicals in response to pest resistance.In contrast, the detection of Dichlorbiphenyl exclusively in Nnewi samples contrasts with findings by Oyebamiji*et al*., (2018), suggesting a localized source of contamination or specific agricultural practices. Furthermore, this finding agrees with research by Oshatunberu (2023), which emphasized the geographical variance in pesticide residue profiles across different farming communities in Nigeria, indicating the influence of local farming practices and pesticide usage patterns.

This finding aligns with recent research on pesticide residues in agricultural products. In a study by Omeje*et al*.(2022), similar variability in pesticide residue levels was observed in vegetables from different regions in Nigeria. The study emphasized the need for comprehensive monitoring due to health implications.In contrast, the slightly positively skewed distribution of residue levels in Awka, Nnewi, and Ekwulobia suggests potential exposure risks. This finding is consistent with Omokpariola*et al*.(2023), who reported skewed distributions of pesticide residues in grains from Nigerian markets. The high mean and deviation in Ekwulobia resonate with a related study by Nicholson and Williams (2021), which highlighted agricultural intensity and pesticide usage.Furthermore, the variability across locations echoes findings by Nipers*et al*.(2024), indicating diverse pesticide application practices in Nigeria. These studies collectively emphasize the importance of continuous monitoring and regulation to mitigate pesticide exposure risks in food products.

The correlation matrix suggests a significant interrelationship between pesticide levels across different locations, aligning and contrasting with existing literature. For instance, this finding agreed with the study by Rahman andChima (2018), which found strong positive correlations in pesticide levels across agricultural zones in Nigeria, indicating regional similarities in pesticide use and exposure risks.In contrast, the lack of significant correlation between local pesticide levels and overall levels contrasts with findings by Ogwo(2021), who reported a significant nationwide trend in pesticide distribution, suggesting a more uniform application of pesticides across Nigeria. This discrepancy highlights the complexity of pesticide dynamics and the influence of local practices.In a related study, Ogbeide*et al*.(2018)also highlighted strong correlations between pesticide residues in neighboring communities, underscoring the role of geographic and environmental factors in residue

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dispersion.Furthermore, the research by Nibbering (2023)on improving pesticide exposure estimates using wind direction interpolation methodscould explain the strong correlations observed in certain areas, offering an environmental perspective to the distribution of pesticide residues.

5. Conclusion

The investigation into pesticide residues in cowpea (*Vignaunguiculata*L.Walp) grains sold across the senatorial zones of Anambra State, Nigeria, has provided critical understandings into the current state of agricultural chemical usage and its implications for food safety and public health. The study revealed that cowpea grains from all surveyed markets—Awka, Nnewi, Ekwulobia, and Onitsha—contained varying levels of pesticide residues, with some samples exceeding internationally recognized safe limits. These findings underscore the urgent need for regulatory authorities to enhance surveillance and enforcement of pesticide use regulations in agricultural practices.

Furthermore, the study emphasizes the importance of educating farmers about alternative pest control methods that minimize environmental and health risks. Implementing stricter controls and ensuring adherence to safe agricultural practices will not only protect consumer health but also contribute to the sustainability of the agricultural ecosystem. The research calls for a collaborative effort among stakeholders to address these challenges, aiming for a future where food security is not compromised by the very practices intended to ensure it.

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