



DETERMINATION OF PESTICIDE RESIDUES AND THEIR RISK ASSESSMENT IN BEANS (*Phaseolus Vulgaris*) PURCHASED AT PORTHARCOURT, USING GAS CHROMATOGRAPHY

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ABSTRACT

This study assessed pesticide residue levels in seven bean samples collected via grab sampling from various bean sellers at the Boricamp market in Rumuokoro, Rivers State, Nigeria. The bean samples collected are Navy, Honey, Aloka, Brown, Patasco, Groundnut, and Iron. The samples were prepared using n-hexane and analyzed using gas chromatography. Fifteen different pesticides were identified in the samples. They include Isopropylamine, 2,4-Dichlorophenoxyacetic acid (2,4-DCP), Dichloro-biphenyl, Hexachlorobenzene (HCB), Aldrin, Lindane, P, P'-Dichlorodiphenyldichloroethane (p,p'-DDD), Chlordane, Profenofos, Glyphosate, Carbofuran, Dichlorvos, Heptachlor, Biphenyl, and trans-Nonachlor (t-nonachlor). Groundnut beans had the highest number of pesticide residues, with a high Aldrin concentration of 21.09ppm and a low Isopropylamine concentration of 0.02 ppm. On the other hand, Brown beans had the lowest pesticide residue levels, with a high Biphenyl concentration of 23.08 ppm and a low Isopropylamine concentration of 0.14 ppm. The concentration of pesticides in the bean samples was compared with the Codex standard for the maximum residue limit in food grains, set at 2 ppm. Some of the pesticides were within the standard limit, while others were above it, posing significant health risks to humans when consumed. The health risk index was calculated for both adults and children, based on the Estimated Daily Intake and Acceptable Daily Intake. The results showed potential health risks to all consumers, especially children. Highly toxic pesticides should be replaced with less harmful alternatives. There should be regular monitoring of pesticide residues in crops to mitigate food safety risks and reduce overall exposure to pesticides.

Keywords: Beans; Pest; Pesticides; Risk assessment; Toxicity.

1.0. Introduction

Insect pests are major causes of crop yield losses worldwide, and pest management plays a critical role in ensuring food security and farm incomes (Ofuya et al., 2023). Crop quantity and quality depend on crop protection practices, such as pesticide use (Erhunmwuse et al.,

2014). Since before 20 BC, humans have used pesticides to protect their crops (Miller et al., 2002). Pests are controlled with various pesticides, including insecticides, rodenticides, fungicides, molluscicides, and herbicides. Estimates of global crop losses from pests in some regions indicated that pest-induced losses exceeded 50% of attainable crop output

(Cooper & Dobson, 2007). Insects destroyed 15% of crops; disease pathogens and weeds, 13% each; and postharvest pest infestations, another 10%. These losses could double easily if appropriate crop protection practices are not implemented. Without pesticides, food production would drop, and food prices would soar, thereby increasing global food scarcity (Cooper & Dobson, 2007). With lower production and higher prices, farmers would be less competitive in global markets for major commodities (Donald, 2001). Preventing or reducing agricultural losses from pests with pesticides improves yields, ensuring reliable supplies of affordable consumer-priced agricultural produce and enhancing its quality (Erhunmwuse et al., 2014).

Synthetic chemicals are hazardous to humans, consumers, and handlers alike, and this is particularly critical in Nigeria, where pesticide education is low, and the tendency of misuse is very high (Ofuya et al., 2023). In light of this, however, pesticides, whether natural or synthetic, have varying degrees of toxicity and adverse effects on living organisms in the environment (both aquatic and terrestrial) (Relyea & Hoverman, 2008). According to the World Health Organization, 20% of global pesticide use occurs in developing countries, and this share is increasing. Previous studies have indicated that the unsafe use of pesticides is common in developing countries (Donald, 2001). For instance, developed countries banned most organochlorine pesticides, such as aldrin/dieldrin, early on, so most reported toxicity incidents involving aldrin now occur in developing countries (Pang et al., 2022). It has been estimated that about 125,000–130,000 metric tons of pesticides are applied annually in Nigeria (Saheed et al., 2020). These studies portray the increasing risks to human and animal health associated with continued exposure to these pesticides (Singh et al., 2017).

Otitoju and Lewis (2021) conducted a study on the risk assessment of pesticide residues in beans stored and sold in Wukari Town, Nigeria. The pesticide residue analysis was performed by GC/MS after sample extraction, filtration, and concentration. Aldrin was detected in all samples analyzed, and p,p'-DDT occurred the least with a calculated HRI above 1. Nwajideobi and Onye (2025) conducted a comparative analysis of pesticide residue concentrations in three common grains (beans, maize, and rice) sourced from markets in the Port Harcourt Metropolis and from farms in nearby rural areas. Using Gas Chromatography-Mass Spectrometry (GC-MS), a total of 22 pesticide residues were detected, with significantly higher pesticide residue levels in market-sourced grains compared to farm-fresh samples. Comparing the detected residue levels with the maximum residue limit (MRL) for the standard given by WHO/FAO. The mean levels of most pesticides exceeded the FAO/WHO permissible limits. The elevated residue levels in markets were attributed to post-harvest pesticide treatment and improper storage practices.

The common bean (*Phaseolus vulgaris*) is one of the most important legume crops grown because of its high protein, fiber, and carbohydrate content (Gepts et al., 2008). In Nigeria, they are used to prepare a wide variety of dishes. As with most staple crops, farmers rely on pesticides to protect their crops from pest infestations and ensure they reach consumers in good condition. However, the indiscriminate use of pesticides can cause more harm than good. Hence, the aim of this study is to determine the concentration of pesticide residues in different bean samples from Bori camp market, Rumuokoro, Obio-Akpor local government area of Rivers state

2.0. Materials and Method

2.1. Sampling

2.1.1. Study area

This area is in Rumuokoro, a town in Obio-Akpor local government area of Rivers State, Nigeria. It consists of five communities: Rukpakwulusi, Eliogbolo, Awalama, Rumuagholu, and Elieke. It lies at latitudes

4°52'01.8" N and 6°59'52.0" E (Oridikitorusinyaa et al., 2024). The map showing the study area is shown below in Figures 1 and 2

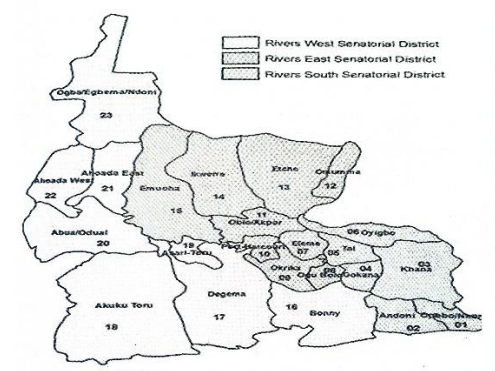


Fig. 1: Map of Rivers state showing Obio-Akpor

2.1.2. Sample collection

Seven types of beans were collected from various bean sellers at the Bori camp market in Rumuokoro town, Obio-Akpor Local Government Area, Rivers State. The common bean samples, which included Aloka beans (*Vigna unguiculata* [L] Walp.), Patasco beans, Navy beans, Brown beans, Honey beans (*Vigna unguiculata* [Linn]), Iron beans (*Phaseolus vulgaris* L.), and Groundnut beans (*Arachis hypogaea*), were identified by the laboratory technologist of the Department of Plant Science and Biotechnology, University of Port Harcourt, Nigeria. The beans were sorted to remove debris, sun-dried for 3 days, and stored in cellophane bags for future use.

2.1.3. Sample Preparation

The stored bean samples were ground with a grinding machine, sieved, and stored in sample bottles, awaiting extraction. The extraction was done using the method of Yusuf and Bolaji (2019), with slight modifications. Ten (10) g of each ground bean sample was weighed and transferred into a 500 mL beaker. 6 g of sodium sulphate was added, and the mixture was extracted with 300 mL of n-hexane. The filtrate was concentrated. 1 mL of filtered residue was

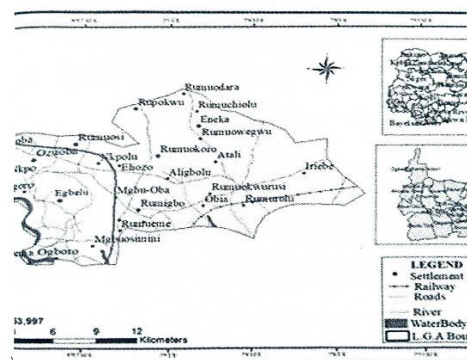


Fig. 2: Map of Obio-Akpor showing Rumuokoro town

dissolved in 50 mL of chloroform at room temperature. 1 mL of each of the reagents (20 vol% toluene and 55% (v/v) methanol) was added. It was heated in a 40 °C water bath for 10 minutes. After heating, 1 mL of hexane and 1 mL of water were added to the mixture. The mixture was centrifuged for 2 minutes. Half of the top hexane phase was transferred to a small test tube for injection.

2.2. Gas Chromatography (GC) Analysis

The final extract was analyzed using a gas chromatograph (Buck M910 scientific gas chromatography) equipped with an electron capture detector, which enabled detection of the contaminant even at trace concentrations (in the lower µg/g and µg/kg range) in the matrix, where other detectors do not respond. The GC instrument used for the analysis was an HP-88 capillary column (100 m × 0.25 µm film thickness), CA, USA. The injector and detector temperatures were set at 250 °C and 290 °C, respectively. The oven temperature was programmed as follows: 110 °C held for 5 minutes, and finally ramped at 10 °C/min to 320 °C. Helium was used as the carrier gas at a flow rate of 1.0 mL/min and as the detector make-up gas at 29 mL/min. The GC injector volume was

8.0 µL. The total run time for each sample was 48 minutes.

2.3. Health Risk Analysis

2.3.1. Health risk estimates for adults

Probable daily pesticide exposure or estimated daily intake for each pesticide and individual (adult) consumers was calculated using the following equation:

$$EDI = \frac{\text{Beans consumption} \left(\frac{\text{kg}}{\text{day}} \right) \times \text{pesticide concentration in beans} \left(\frac{\text{mg}}{\text{kg}} \right)}{\text{Body weight}}$$

Equation 1

2.3.2. Estimation of health risk from pesticides

The risk of an individual's exposure to a pesticide (adults with an average body weight of 60 kg) was estimated on the basis of the potential health risk index (HRI) or hazard quotient (HQ) for non-carcinogenic chemicals, according to Akoto et al. (2015), using the following formula:

$$HRI = \frac{EDI}{ADI} \quad \text{Equation 2}$$

Where HRI stands for health risk index, EDI stands for estimated daily intake, and ADI stands for acceptable daily intake.

3.0. Results and Discussion

3.1. Pesticide Concentrations in the various beans samples

Table 1.0: Results of the analysis of the different beans samples

S/N	Parameters (Pesticides)	Codex Standard (Mg/Kg) ppm	Concentration in Bean Samples (Mg/Kg)						
			Navy Beans	Honey Beans	Aloka Beans	Brown Beans	Patasco Beans	Ground nut Beans	Iron Beans
1.	Isopropylamine	2.0	-	-	-	0.14	-	0.02	-
2.	2,4-Dichlorophenoxy acetic acid (2,4-DCP)	2.0	0.16	51.36	4.31	-	4.92	0.04	3.54
3.	Dichloro-biphenyl	2.0	2.43	-	-	1.04	4.15	2.43	-
4.	Hexachlorobenzene (HCB)	2.0	4.40	-	-	-	-	4.40	-
5.	Lindane	2.0	5.52	0.10	0.12	-	12.71	5.52	-
6.	P,p'-Dichlorodiphenyl dichloroethane (p,p'-DDD)	2.0	6.70	19.64	9.69	23.08	12.0	6.70	9.43
7.	Chlordane	2.0	40.88	--	-	-	-	3.94	-
8.	Biphenyl	2.0	-	27.84	27.84	-	-	-	27.84
9.	Profenofos	2.0	5.44	-	-	-	-	5.44	-
10.	Glyphosate	2.0	0.56	0.72	0.07	5.56	2.30	1.51	0.06
11.	Carbofuran	2.0	1.72	1.16	2.96	6.24	1.85	1.72	1.16
12.	Dichlorvos	2.0	4.56	14.27	14.28	-	9.96	4.56	14.25
13.	Heptachlor	2.0	8.29	17.19	12.40	-	-	12.98	12.39
14.	Aldrin	2.0	13.8	14.32	11.08	16.12	32.16	21.09	11.06

15.	<i>trans</i> -nonaChlor (t-nonaChlor)	2.0	-	-	-	-	0.008	-	-
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As shown in Table 1.0 above, the concentration of the pesticide in Navy beans showed that 2,4-DCP, Glyphosate and Carbofuran were within standard limits, Isopropylamine, t-nonaChlor and Biphenyl were absent while Hexachlorobenzene (HCB), Lindane, Dichloro Biphenyl, p'p-DDD, Chlordane, Dichlorvos,

Heptachlor and Aldrin were found to be above standard limits with Chlordane having the highest concentration of 40.88mg/kg, thus making them very toxic and harmful when consumed. The GC analysis of Navy beans is shown in Figure 3 below.

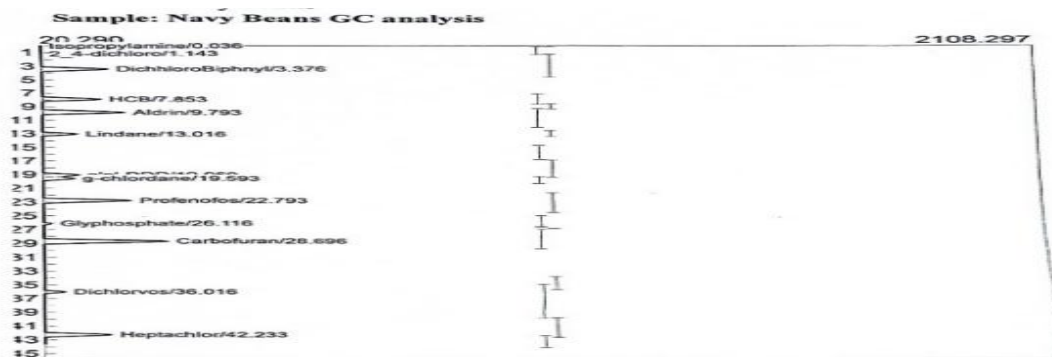


Figure 3: GC analysis of Navy beans

The Honey Beans result showed that Lindane, Glyphosate, and Carbofuran were within standard limits. Isopropylamine, Dichloro biphenyl, HCB, Chlordane, Profenofos, and t-nonaChlor were absent, while 2,4-DCP, Aldrin, p'p-DDD, Dichlorvos, and Heptachlor

were found to be above standard limits, with 2,4-DCP having the highest concentration of 51.36 mg/kg, thus making them very toxic and harmful when consumed. The GC analysis of Honey beans is shown in Figure 4 below

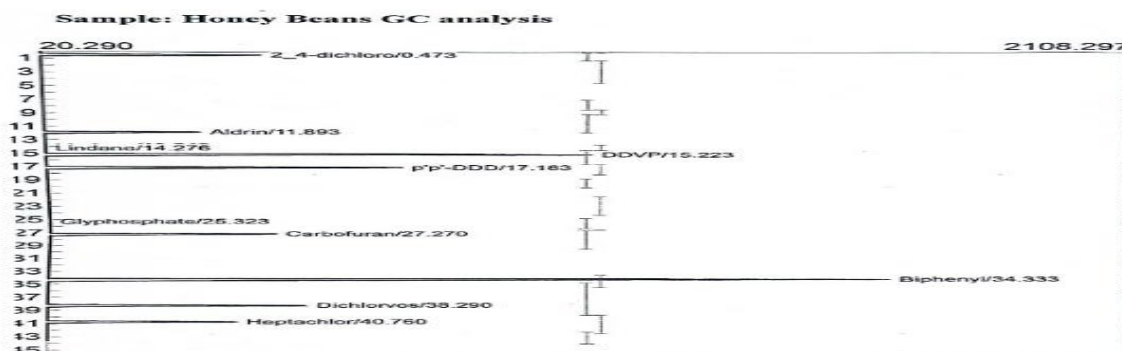


Figure 4: GC analysis of Honey beans

The Aloka Beans result showed that Lindane and Glyphosate were within standard limits, Isopropylamine, Dichloro biphenyl, HCB, Chlordane, Profenofos, and t-nonaChlor were absent, while 2,4-DCP, Aldrin, p'p-DDD, Carbofuran, Biphenyl, Dichlorvos, and

Heptachlor were found to be above standard limits, with Biphenyl having the highest concentration of 27.84 mg/kg, thus making them very harmful and toxic when consumed. The GC analysis of Aloka beans is shown in Figure 5 below.

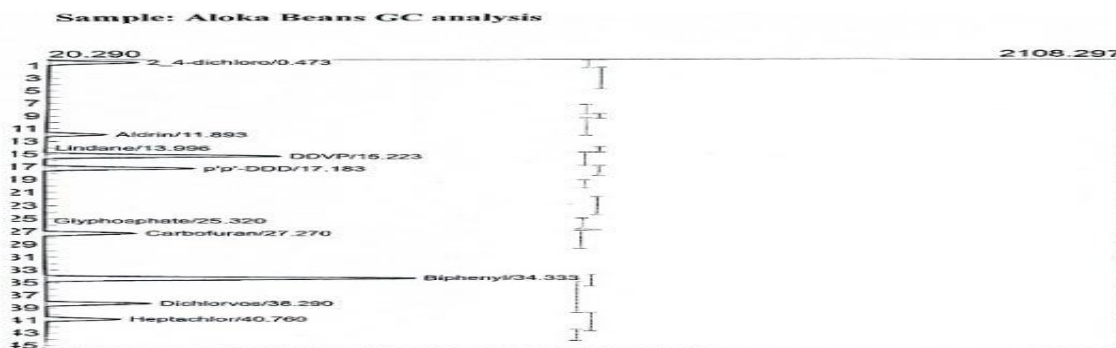


Figure 5: GC analysis of Aloka beans

The Brown Beans result showed that Isopropylamine and Dichloro-biphenyl were within standard limits, 2,4-DCP, HCB, Lindane, Chlordane, Biphenyl, Profenofos, Dichlorvos, Heptachlor, and t-nonaChlor were absent, while Aldrin, p'p-DDD, Glyphosate,

and Carbofuran were found to be above standard limits, with p'p-DDD having the highest concentration of 23.08mg/kg, thus making them very harmful and toxic when consumed. The GC analysis of Brown beans is shown in Figure 6 below.

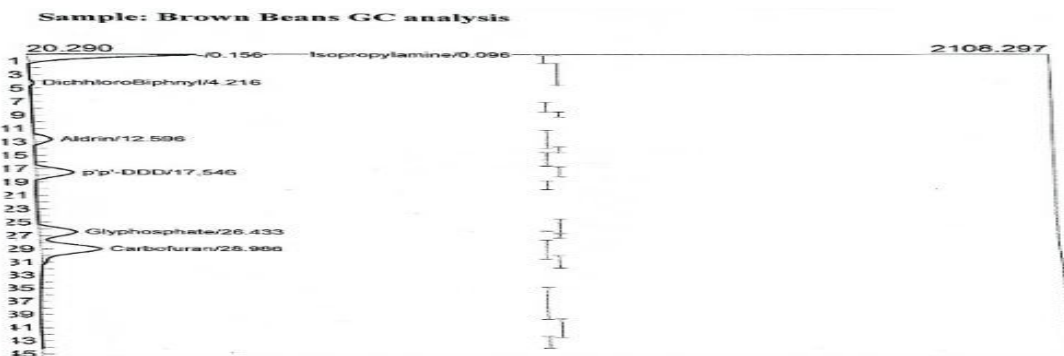


Figure 6: GC analysis of Brown beans

The Patasco Beans result showed that Glyphosate, Carbofuran, and t-nonaChlor were within standard limits, Isopropylamine, HCB, Chlordane, Biphenyl, Profenofos and Heptachlor were absent, while 2,4-DCP, Aldrin, Dichloro biphenyl, Lindane, p'p-DDD,

and Diclorvos were found to be above the standard limits, with Aldrin having the highest concentration of 32.16mg/kg, thus making them very harmful and toxic to human health when consumed. The GC analysis of Patasco beans is shown in Figure 7 below.

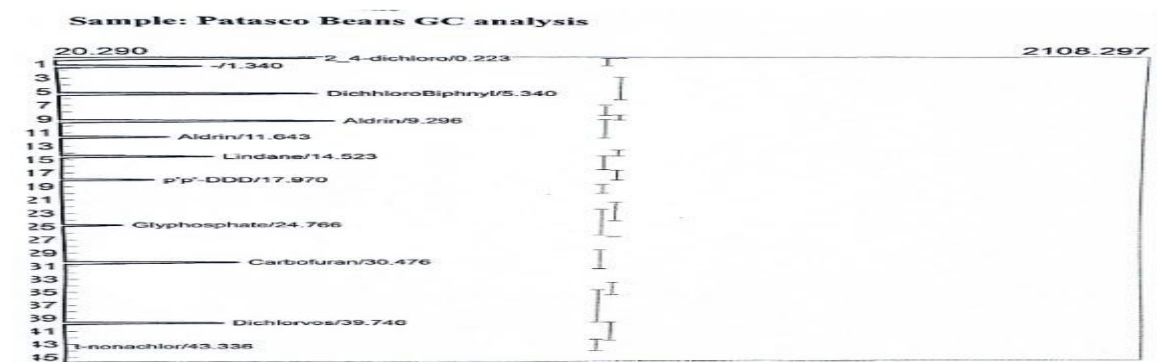


Figure 7: GC analysis of Patasco beans

The Groundnut Beans (*Arachis hypogaea*) result showed that Isopropylamine, 2,4-DCP, Dichloro biphenyl, Glyphosate and Carbofuran were within standard limits, Biphenyl and t-nonaChlor were absent while HCB, Aldrin, Lindane, p'p-DDD, Chlordane,

Profenofos, Dichlorvos and Heptachlor were found to be above standard limits with Aldrin having the highest concentration of 21.09mg/kg, thus making them very toxic and harmful when consumed. The GC analysis of Groundnut beans is shown in Figure 8 below.

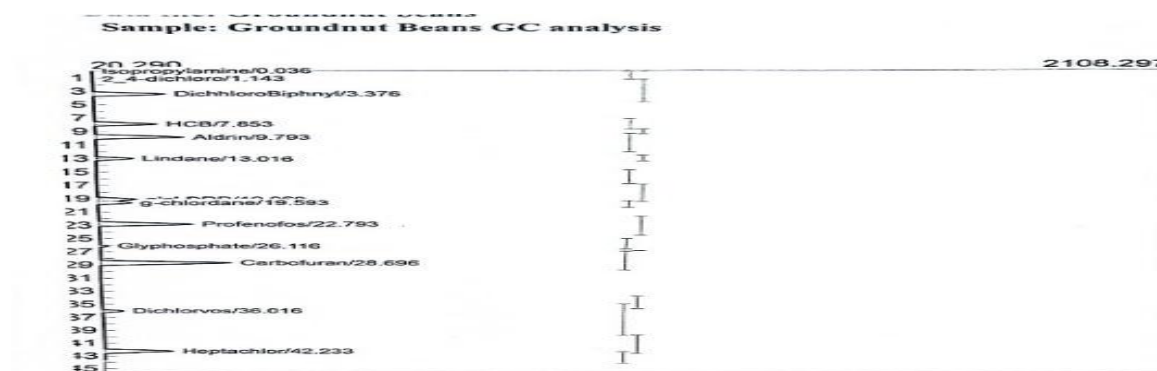


Figure 8: GC analysis for Groundnut beans

The Iron Beans result showed that Glyphosate and Carbofuran were within standard limits, Isopropylamine, Dichloro biphenyl, HCB, Lindane, Chlordane, Profenofos, and t-nonaChlor were absent, while 2,4-DCP, Aldrin, p'p-DDD, Biphenyl, Dichlorvos, and

Heptachlor were found to be above standard limits, with Biphenyl having the highest concentration of 27.84mg/kg, thus making them very toxic and harmful when consumed. The GC analysis of Iron beans is shown in Figure 9 below.

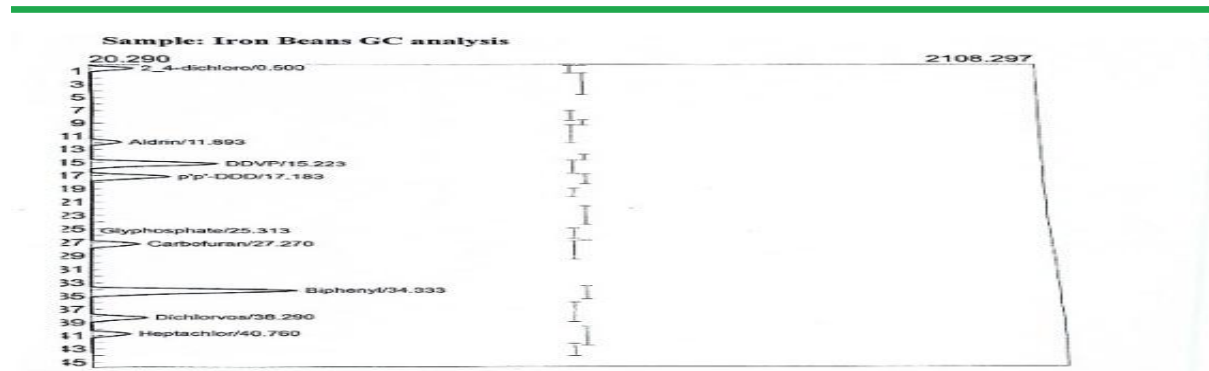


Figure 9: GC analysis of Iron beans

In general, the average pesticide concentrations in the bean samples, including Isopropylamine, trans-nonachlor, Glyphosate, and dichlorobiphenyl, were within or slightly above the CODEX standard limits. However, other pesticides were present at very high concentrations in the bean samples. 2,4-DCP had the highest concentration of 51.36 mg/kg in Honey beans, which is more than 25 times the standard limit. This thereby makes the bean sample highly toxic and unfit for consumption. Chlordane had a concentration of 40.88 mg/kg in the Navy bean sample, which is about 20 times the standard limit, rendering it very toxic and unfit for consumption. Aldrin had a very high concentration of 32.16 mg/kg, as against the 2.0 mg/kg standard limit in the Patasco bean sample. Biphenyl had a high concentration of 27.84 mg/kg in Honey, Aloka, and Iron beans, respectively. P'P-DDD had high concentrations of 23.08 mg/kg and 19.64 mg/kg in Brown and Honey beans, respectively. Heptachlor showed a high concentration of 17.19 mg/kg in Honey beans, while Dichlorvos showed high concentrations of 14.28 mg/kg and 14.27 mg/kg in Aloka and Honey beans, respectively.

Previous work by Otitoju and Lewis (2021) detected 29 pesticide residues in bean samples from Wukari, Taraba State. The pesticide residues belonged to three major classes: Organochlorines (such as Aldrin, p,p'-DDD, Heptachlor, etc.), Organophosphates, and Pyrethroids; some exceeded the standard limits

(Otitoju & Lewis, 2021). Ezeani et al. (2022) detected HCB in bean samples, and its concentration exceeded the standard limits (Abare-Jen et al., 2024). In their work, they detected 11 pesticide residues in their bean samples. Most pesticide residues, especially organochlorines, were detected at levels exceeding standard limits (Abare-Jen et al., 2024). The results of Kalu et al. (2023) showed the presence of 17 pesticide residues in all bean samples. 2,4-Dichlorophenoxyacetic acid (2,4-D) and 2,2-dichlorovinyl dimethyl phosphate (DDVP) were detected in all samples of beans and at levels above the European Union's (EU's) MRL, except in iron bean samples. Glyphosate was detected in all the samples at concentrations above the EU's MRL. The remaining pesticide residues were detected below the standard limits (Kalu et al., 2023).

Long-term exposure to these toxic chemicals by ingestion can affect the respiratory and nervous systems, causing symptoms such as headache, dizziness, nausea, vomiting, weakness, and even coma (Abhijit, 2018; Otitoju & Lewis, 2021). Aldrin and dieldrin (a metabolite of aldrin) pose a risk to human health worldwide because they accumulate in the food chain, and the human body cannot metabolize them (Bonzena et al., 2012). Aldrin acts as a ligand for androgens and alters epigenetic inheritance, which may contribute to prostate cancer development and growth (Asogwa & Dango, 2009; Maia et al., 2020).

3.2. Health Risk Assessment Results for Adults

Pesticide use has several environmental effects, raising concerns about potentially toxic or carcinogenic residues in the food chain (Ikpesu & Ariyo, 2013). Indiscriminate application of pesticides and gross misuse of bean crops result in residues that accumulate in human tissues. There is thus a continuing exposure of the general population to low doses of these chemicals through food, water, and soil. These may lead to chronic toxicity due to accumulation in the human body over time (Borell & Aguilar, 2006). Also, some

pesticides, especially organochlorine compounds, are persistent in the environment due to their high chemical stability and lipid solubility (Ogah et al., 2012). Thus, they may remain in soil, water, food, and the tissues of various organisms long after their use (Borell & Aguilar, 2006).

According to Akoto et al. (2015), when HRI is greater than 1, lifetime consumption of beans containing the measured pesticide level could pose health risks (Otitoju & Lewis, 2021). Table 2 below shows the calculated HRI for adults of all the bean samples in this study.

Table 2.0: HRI/HQ results of the pesticide assessment for adults.

Pesticide	Navy beans		Honey beans		Aloka beans		Brown beans		Patasco beans		Groundnut beans		Iron beans	
	EDI	HRI	EDI	HRI	EDI	HRI	EDI	HRI	EDI	HRI	EDI	HRI	EDI	HRI
Aldrin	0.03	0.3	0.03	0.3	0.02	0.2	0.04	0.4	0.07	0.8	0.05	0.5	0.02	0.2
Biphenyl	-	-	0.063	0.6	0.06	0.7	-	-	-	-	-	-	0.06	0.6
Carbofuran	0.004	0.04	0.003	0.03	0.01	0.1	0.01	0.1	0.004	0.04	0.004	0.04	0.002	0.02
Chlordane	0.092	1.02	-	-	-	-	-	-	-	-	0.008	0.1	-	-
Dichloro-biphenyl	0.005	0.05	-	-	-	-	0.002	0.02	0.01	0.1	0.005	0.05	-	-
Dichlorvos	0.01	0.1	0.03	0.3	0.03	0.3	-	-	0.02	0.2	0.01	0.1	0.03	0.3
Heptachlor	0.02	0.2	0.04	0.4	0.03	0.3	-	-	-	-	0.03	0.3	0.03	0.3
2,4-DCP	0.0004	0.04	0.115	1.3	0.01	0.1	-	-	0.01	0.1	0.0001	0.001	0.007	0.1
t-nonachlor	-	-	-	-	-	-	-	-	0.0002	≈ 0	-	-	-	-
p'-p-DDD	0.015	0.2	0.04	0.4	0.02	0.2	0.05	0.5	0.03	0.3	0.015	0.16	0.02	0.2
Glyphosate	0.001	0.01	0.002	0.02	0.0001	0.001	0.012	0.13	0.005	0.05	0.003	0.03	0.0001	0.001
HCB	0.01	0.1	-	-	-	-	-	-	-	-	0.01	0.1	-	-
Isopropylamine	-	-	-	-	-	-	0.0003	0.003	-	-	0.0005	0.005	-	-
Lindane	0.012	0.13	0.0002	0.002	0.0003	0.003	-	-	0.03	0.3	0.01	0.1	-	-
Profenofos	0.012	0.13	-	-	-	-	-	-	-	-	0.01	0.1	-	-

As shown in Table 2.0 above, the calculated Health Risk Index for the organochlorines g-Chlordane and 2,4-DCP in Navy and Honey beans, respectively, was greater than 1. Most of the pesticide residues were below the critical HRI. The report by Otitoju and Lewis (2021) showed that 50% of the organochlorine

pesticides, such as Aldrin, Aramite, Dieldrin, DDT, and Heptachlor, exceeded 1. The result is also consistent with a report by Oyeyiola et al. (2017). The report by Ezeani et al. (2022) showed that the HCB detected in the beans (white and brown beans) samples was below the critical HRI of 1. The detection of pesticide

residues in this study, with HRI > 1, indicates health risks associated with long-term bean consumption among adults at the study site.

3.3. Health Risk Estimates for Children

Probable daily pesticide exposure or estimated daily intake of each pesticide for children within the age bracket of 4 – 11 years was calculated using the same parameters as those of adults. The average body weight (bw) of children within the given age bracket was 20

kg, as calculated from the data provided by the US Environmental Protection Agency (EPA).

There is no single acceptable daily intake (ADI) for beans in children. According to The Beans Institute and Healthline, serving sizes are recommended based on age. The average daily serving for the above-listed age bracket is about half a cup of cooked beans, which is calculated to be 0.09 kg. The daily average beans consumption (0.1 kg/day) was calculated based on the data obtained from a survey within the study area.

Table 3.0: HRI/HQ results of the pesticide assessment for children.

Pesticide	Navy beans		Honey beans		Aloka beans		Brown beans		Patasco beans		Groundnut beans		Iron beans	
	EDI	HRI	EDI	HRI	EDI	HRI	EDI	HRI	EDI	HRI	EDI	HRI	EDI	HRI
Aldrin	0.07	0.8	0.07	0.8	0.06	0.6	0.08	0.9	0.16	1.8	0.1	1.2	0.05	0.6
Biphenyl	-	-	0.14	1.55	0.14	1.55	-	-	-	-	-	-	0.14	1.5
Carbofuran	0.009	0.1	0.006	0.07	0.01	0.2	0.03	0.3	0.01	0.1	0.009	0.1	0.006	0.06
Chlordane	0.2	2.3	-	-	-	-	-	-	-	-	0.02	0.2	-	-
Dichloro-biphenyl	0.01	0.1	-	-	-	-	0.005	0.06	0.02	0.2	0.01	0.1	-	-
Dichlorvos	0.02	0.2	0.07	0.8	0.07	0.8	-	-	0.05	0.6	0.02	0.2	0.07	0.8
Heptachlor	0.04	0.5	0.09	1.0	0.06	0.7	-	-	-	-	0.06	0.7	0.06	0.7
2,4-DCP	0.0008	0.01	0.26	2.9	0.02	0.2	-	-	0.02	0.3	0.0002	0.002	0.02	0.2
t-nonachlor	-	-	-	-	-	-	-	-	0.00004	≈ 0	-	-	-	-
p'p-DDD	0.03	0.3	0.1	1.1	0.05	0.5	0.12	1.3	0.06	0.7	0.03	0.4	0.05	0.5
Glyphosate	0.003	0.03	0.004	0.04	0.0004	0.004	0.03	0.3	0.01	0.1	0.007	0.08	0.0003	0.003
HCB	0.02	0.2	-	-	-	-	-	-	-	-	0.02	0.2	-	-
Isopropylamine	-	-	-	-	-	-	0.0007	0.008	-	-	0.0001	0.001	-	-
Lindane	0.03	0.3	0.0005	0.005	0.0006	0.007	-	-	0.06	0.7	0.03	0.3	-	-
Profenofos	0.03	0.3	-	-	-	-	-	-	-	-	0.03	0.3	-	-

As shown in Table 3.0 above, the calculated HRI for Aldrin was greater than 1 in Patasco and Groundnut beans, but remained below 1 in the other samples. Biphenyl was detected at HRI levels greater than 1 in Honey, Aloka, and Iron beans, but less than 1 in the remaining bean samples. P'P-DDD occurred at HRI levels greater than 1 in Honey and Brown beans, but less than 1 in the rest of the bean samples. Chlordane showed a high HRI value

of 2.3 in Navy beans but less than 1 in the other bean samples. 2,4-DCP also showed a high HRI value of 2.9 in Honey beans, but values below 1 in the other bean samples. Carbofuran, Dichlorobiphenyl, Dichlorvos, Heptachlor, t-nonachlor, Glyphosate, HCB, Isopropylamine, Lindane, and Profenofos occurred at levels below 1 in all bean samples. These results suggest that the pesticide residues in the bean

samples pose a high potential health risk to everyone, especially children.

These results indicate that children exhibit more sensitivity and vulnerability to the detected pesticides. Their sensitivity or vulnerability to these pesticides or other forms of pollutants is due to their high food intake to body weight ratio, and immaturity of their defence systems against toxic chemicals (Nougadère *et al.*, 2020; Maia *et al.*, 2020)

4.0. Conclusions

The results of this study revealed that pesticides are still used without adhering to maximum residue limits. Using these pesticides indiscriminately poses significant threats to humans, plants, and animals alike (Gezer *et al.*, 2020). The residues investigated in the study could pose a risk of liver and kidney toxicity for adult consumers of beans (Integrated Risk Information System, 2019). Consumption of beans contaminated with DDT and other organochlorine pesticides could cause liver lesions and may also disrupt reproductive functions and pose carcinogenic risks (Adeoluwa *et al.*, 2019; Mosudi *et al.*, 2020). Urgent measures should be taken to enact laws and regulations governing the sale and purchase of pesticides, with use prescribed by a specialist. There should also be regular monitoring of pesticide residues in foods to assess food safety risks and the population's exposure to pesticides.

Conflict of Interest

The authors declare no conflicts of interest regarding this article.

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