

**THE EFFECT OF ORGANOCHLORINE ON THE NUTRITIONAL VALUE OF BEANS**



**BY**

**THOMAS IMADE**

**PHA1908519**

**UNIVERSITY OF BENIN**

**BENIN CITY.**

**NOVEMBER 2025**

**THE EFFECT OF ORGANOCHLORINE ON THE NUTRITIONAL VALUE OF BEANS**

**BY**

**THOMAS IMADE**

**PHA1908519**

**SUPERVISED BY**

**PROF. PATRICK IGBINADUWA**

**DEPARTMENT OF PHARMACEUTICAL CHEMISTRY**

**FACULTY OF PHARMACY**

**UNIVERSITY OF BENIN,**

**BENIN CITY.**

**NOVEMBER 2025**

## CERTIFICATION

This is to certify that this project work was carried out by Thomas Imade of the Department of Pharmaceutical chemistry, Faculty of Pharmacy, University of Benin, Benin city. Edo state Nigeria in partial fulfillment of the requirement for the award of the Doctor of Pharmacy degree (PHARM. D).

---

**PROF. PATRICK IGBINADUWA**

(Supervisor)

---

Date

---

**DR. VINCENT IMIJIE**

(Head of Department)

---

Date

---

**THOMAS IMADE**

(Project student)

---

Date

## **DEDICATION**

This work is dedicated first to God almighty my greatest helper in life, my awesome Supervisor Prof. Patrick Igbinaduwa, my loving parents, Mr. Osabueki Iyengumwena & Mrs.Eunice Osabueki Iyengumwena and Siblings (Blessing Osabueki,Eseosa Osabueki and Iyobosa Osabueki.To my spiritual father's and mentors, Pst.Ransom Ogar,Pst.Michael Osazuwa and Pst.Ezekiel Okunkonye

## ACKNOWLEDGEMENT

First and foremost, I give all praise and thanks to God for granting me the strength, wisdom, and perseverance to complete this research. Without divine guidance and blessings, this journey would not have been possible.

My profound appreciation goes to my mother whose unwavering support and guidance have been a constant source of strength and motivation throughout my sojourn in pharmacy school. To my beloved father, Mr. Osabueki Iyengumwena whose values and teachings have been a guiding light, I am eternally grateful.

Let me also extend my heartfelt gratitude to my ever loving and supportive siblings for their love and readiness to support my journey.

I am sincerely grateful to my esteemed Professor and supervisor, Mr. Patrick Igbinaduwa, for his patience, mentorship, and invaluable insights that have played a pivotal role in shaping this work. Your unwavering commitment to excellence has been truly inspiring.

My sincerest thanks goes to my vibrant project group members, Mrs. Janeth and Master Victor. Your Cooperation and commitment have contributed greatly to the success of this project.

Special appreciation goes to my dear friends, Courage Aighobahi, Favour Obayangbona, Efosa Izevbizua, Lydia Osadolor, Imagbenikaro Osasenega, Bernice Imoobe am indeed grateful for all your immense support through all Pharmacy school, along with all the remarkable individuals who have crossed my path. Your presence has enriched my life in profound ways. I express my profound gratitude to everyone who has been a part of this journey, contributing to its success in ways big and small. Your support, encouragement, and friendship will always be of immense value to me.

## TABLE OF CONTENT

COVER PAGE	i
TITLE PAGE	ii
CERTIFICATION	iii
DEDICATION	iv
ACKNOWLEDGEMENT	v
ABSTRACT	viii
INTRODUCTION	1
1.1 BACKGROUND STORY	1
1.2 OBJECTIVE OF THE STUDY	3
1.3 LITERATURE REVIEW	3
1.3.1 OVERVIEW OF ORGANOCHLORINE PESTICIDES	8
1.3.2 PERSISTENCE AND BIOACCUMULATION OF ORGANOCHLORINE	10
1.3.3 NUTRITIONAL COMPOSITION OF BEANS	17
1.3.4. PROXIMATE COMPOSITION OF BEANS	20
Mineral Compositions	20
1.3.5 IMPACT OF ORGANOCHLORINE ON SOIL AND PLANT HEALTH	21
1.3.6 MECHNAISM OF NUTRITIONAL DEGREACTION IN CROPS	25
1.3.7 HEALTH IMPLICATION OF ORGANOCHLORINE RESIDUE IN FOOD	29
CHAPTER TWO	35
MATERIALS AND METHOD	35
2.1 Materials used	35
2.2 Method of analysis	35
2.4 Process of beans digestion	36

2.5 Method of proximate determination	37
CHAPTER THREE	41
RESULTS	41
3.1 PROXIMATE COMPOSITION	41
3.2 HEAVY METALS ANALYSIS	42
3.4 METAL ANALYSIS	43
DISCUSSION	45
4.1 PROXIMATE ANALYSIS	45
4.2 HEAVY METALS ANALYSIS	50
4.3 MINERAL ANALYSIS	52
CHAPTER FIVE	56
CONCLUSION	56
5.1 Recommendations	56
5.2 Contribution to knowledge	57
REFERENCES	58
TABLE OF RESULTS	64
PROXIMATE COMPOSITION	64

## ABSTRACT

**Introduction:** The use of organochlorine pesticides (OCPs) in the preservation of food substances most especially beans from pest has raised concerns about the potential impact on the nutritional value of food crops, including beans. This study aimed to determine the levels of OCP residues in beans, assess their impact on the nutritional value, (proximate composition) Such as %Protein content, %Ash content, %moisture content, %crude fibre, ethyl extract and nitrogen free extract. The presence of heavy metals such as lead (Pb) and copper (Cu), minerals and some vital elements.

**Objective:** To assess the impact of organochlorine pesticides on the nutritional values of beans.

**Method:** Beans sample was collected from the market and was divided into four portions T0 (control), T1, T2 and T3 each portion weighing 200g respectively. Three concentration of sniper were prepared 10%, 20% and 50%. And was used mixed the beans sample labeled (T1,T2 and T3) except the control T0,each sample were air dried and milled into fine powder, Protein content was determined using Kjeldahl digestion and the ammonia obtain was titrated again sulphuric acid. The heavy metals (Pb) and (Cu) as well as minerals were determined using atomic absorption spectrophotometry AAS.

**Result:** The results for % protein was significant lesser in control (T0) 16.7, the value increased slightly as concentration of sniper used for treated sample increased from 10 %( 18.74) to 20% however, decreased when 50 %( 18.88) sniper was used but still higher as opposed to control. Lead content was 0.00 for control and value became 0.01 for 10%,,0.02 for 20% and 0.03 for 50%.The content of copper was 0.09 for control and the content increased as the concentration of copper increased.

**Conclusion:** Organochlorine pesticides significant affect the nutritional value of beans, and contaminate the bean samples with lead which is not safe health and can pose a diverse health risk to human such as cognitive impairment, kidney and liver toxicity as well as reproductive issues like infertility due to lead contents.

**Keywords:** Organochlorine pesticides, beans, Kjeldahl digestion, safety, nutritional value, health risk, heavy metals, proximate composition, atomic absorption spectrophotometry AAS.

## CHAPTER ONE

### INTRODUCTION

#### 1.1 BACKGROUND STORY

Organochlorine pesticides (OCPs) are long lasting chemicals such as DDT, lindane, aldrin, and endosulfan. Despite many being banned or restricted, they remain a significant challenge for agriculture and food safety. These substances persist in soil, water, and crops, where they can disrupt ecosystems, build up through food chains, and threaten human health. For instance, research on legumes has shown that OCPs can change the nutritional makeup of beans, including reductions in protein, carbohydrate, and mineral content (Adeyemi & Adesiyun, 2015).

OCPs affect crops mostly by disrupting the soil microbiome and nutrient cycling. Exposure to these chemicals can lower soil microbial diversity, change which bacteria and fungi are present, and reduce important soil enzyme activities (Liu *et al.*, 2020; Iqbal & Feng, 2019). These changes can make nutrients like nitrogen, phosphorus, and other micronutrients less available to crops, which in turn affects plant growth and the nutritional content of harvested seeds. Research shows that soils contaminated by OCPs have fewer microbes involved in vital processes like nitrification, mineralization, and forming beneficial partnerships with plants (Sun *et al.*, 2022). There's also evidence that pesticide stress reduces the activity of nitrogen-fixing bacteria in legumes, leading to lower nitrogen fixation and less protein in the seeds.

In addition to effects on nutrient status, OCPs can influence the uptake and accumulation of heavy metals in crops. Several recent investigations have found that OCP contamination of soils can increase the bioavailability of metals such as lead (Pb), cadmium (Cd), and mercury (Hg) to plants. This may be due to altered soil pH, chelation processes, microbial shifts, or competitive

interactions at the root interface. For example, a systematic review of Nigerian food crops found that heavy metals and OCPs often occur, and the combined hazard quotients (HQ) for OCPs were often  $>1$ , signaling potential non-carcinogenic risk to consumers. Other studies have directly linked OCP residue levels in staple legumes to elevated heavy metal concentrations in the edible seed. The presence of heavy metals and pesticide residues in food staples, therefore, increases the potential for additive or synergistic health risks via bioaccumulation and bio magnification (Kumar & Singh, 2019; Nduka & Orisakwe, 2019; Alengebawy *et al.*, 2021).

Moreover, OCPs themselves are known to bio accumulate in lipophilic tissues and bio magnify through food chains, meaning that consumption of crops grown on contaminated soils may pose significant human health risks. Documented adverse effects of OCP exposure include endocrine disruption, carcinogenesis, neurotoxicity, and immunotoxicity (Karami Mohajeri & Abdollahi, 2011; Mnif *et al.*, 2011). More recent systematic reviews indicate that OCPs, such as aldrin, dieldrin, HCB, and lindane, are among the pesticide residues most often associated with carcinogenic risk in foodstuffs (Systematic review of carcinogenic pesticides, 2023).

Studies analyzing beans and other legumes often detect OCP residues, highlighting the risk of human exposure through consumption of these food staples (Bempah & Asomaning, 2017; Hassan & El Saeid, 2018). Importantly, the magnitude of compositional change in beans – reductions in protein, carbohydrate, ash, minerals (e.g., Ca, Mg, Fe, Zn) – appears to depend upon pesticide type, application rate, soil type, environmental conditions, and interactions with other agrochemicals or heavy metals (Iwegbue & Nwajei, 2017). The interactive effects of OCPs with soil biota, nutrient cycling, heavy metal mobilization, and crop physiology thus present a complex chain of influence from the applied pesticide to the human consumer.

In light of these findings, the present study investigates the effects of OCP contamination on the proximate composition, mineral, and heavy metal content of beans grown in contaminated soils. By analyzing these multiple endpoints, the study aims to elucidate not only the direct uptake and residue burden in the bean seed but also the indirect effects mediated via soil microbiome disruption and nutrient cycling impairment.

## **1.2 OBJECTIVE OF THE STUDY**

### **General Objective**

- To examine the impact of organochlorine pesticide residues on the nutritional value and safety of beans.

### **Specific Objectives**

- To quantify the effect of organochlorine pesticide residues on the protein content in beans.
- To assess the influence of contamination on proximate composition and mineral profiles.
- To evaluate the presence of heavy metals in beans treated with organochlorine pesticides.
- To examine the effects of organochlorine pesticides on the mineral composition of beans.
- To suggest practical strategies to reduce residue levels while maintaining nutritional quality.

## **1.3 LITERATURE REVIEW**

### **OVERVIEW OF PESTICIDES**

Pesticides is a general name for chemical substances used to prevent, destroy, repel, or mitigate undesirable organisms like weeds, insects, and rodents (Gupta, 2017). They are commonly used in agriculture, households, and public health programs to control pests and diseases. There are different types of pesticides which includes Insecticides used to kill insects (Karunamoorthi and Sabesan, 2013), herbicides used kill weeds and unwanted plants, fungicides used to control fungal diseases (Qin *et al.*, 2021), rodenticides used to kill rodents, bactericides used to control bacterial disease, larvicides used to kill larvae.

Pesticides can contaminate soil, water, and air, and have been linked to various health problems, including cancer, neurological damage, and reproductive issues (Beyuo *et al.*, 2024; Abolhassani *et al.*, 2019). Some pesticides, like DDT and neonicotinoids, have been banned or restricted due to their environmental persistence and toxicity (Vale and Lotti, 2015).

### **TYPE OF INSECTICIDES.**

Insecticides are chemical agents developed to control or eliminate insect pests that pose risks to agricultural productivity, animal health, and human welfare. Classification of insecticides is based on chemical composition, mode of action, and origin. Modern insecticides are categorized into classes, including pyrethroids, neonicotinoids, organophosphates, carbamates, diamides, insect growth regulators, avermectins, formamidines, spinosyns, and oxadiazines. Each class exhibits distinct structural features and mechanisms that disrupt insect physiology, resulting in mortality or developmental inhibition.

Pyrethroids are among the most widely used insecticide classes and are synthetic analogues of natural pyrethrins found in chrysanthemum flowers. Their primary mode of action involves altering voltage-gated sodium channel function in insect neurons, leading to prolonged

depolarization, hyperexcitation, paralysis, and death (Hodoşan *et al.*, 2023). Pyrethroids such as permethrin, deltamethrin, and cypermethrin are favored in agricultural and domestic pest control due to their efficacy at low concentrations and relatively low mammalian toxicity. Nevertheless, widespread use has raised environmental concerns, particularly regarding toxicity to aquatic organisms and the development of resistance in target insect populations.

Neonicotinoids form another major group of insecticides, notable for their systemic properties that enable absorption and distribution throughout plant tissues. They act on the insect nervous system by binding irreversibly to nicotinic acetylcholine receptors (nAChRs), leading to overstimulation, paralysis, and death (Martínez Ávila *et al.*, 2024). Examples include imidacloprid, thiamethoxam, clothianidin, and acetamiprid. Although highly effective against sap sucking pests such as aphids and whiteflies, neonicotinoids have been linked to significant declines in pollinator populations, particularly bees, due to their persistence and sublethal effects on foraging and reproduction.

Organophosphates are among the earliest classes of synthetic insecticides and remain widely used in many developing regions. Their mode of action involves irreversible inhibition of the acetylcholinesterase enzyme, resulting in the accumulation of acetylcholine in nerve synapses and continuous stimulation of the nervous system (Ali and Kumar, 2018). Common examples include chlorpyrifos, malathion, and diazinon. Despite their effectiveness against a broad range of insect pests, organophosphates are associated with severe neurotoxic and endocrine-disrupting effects in humans and wildlife, prompting regulatory restrictions in several countries.

Closely related to organophosphates are the carbamates, which also act as acetylcholinesterase inhibitors but differ by producing reversible enzyme inhibition (Khan and Akram, 2021).

Compounds such as carbaryl, carbofuran, and propoxur are effective against both chewing and sucking insects. They are less persistent in the environment than organophosphates but remain toxic to aquatic life and pollinators. Carbamate insecticides are often used in integrated pest management systems due to their relatively short environmental half-lives.

Diamide insecticides, including chlorantraniliprole, flubendiamide, and cyantraniliprole, represent a newer generation of selective insecticides. They act on the ryanodine receptors in insect muscle cells, leading to uncontrolled calcium release, muscle paralysis, and death (Lahm *et al.*, 2020). These compounds exhibit high specificity toward target pests such as lepidopteran larvae while showing low toxicity to mammals and beneficial insects. Their unique mode of action also makes them valuable in resistance management programs.

Another important class is the insect growth regulators (IGRs), which disrupt the normal growth and development of insects rather than causing immediate death. These compounds function by mimicking or inhibiting juvenile hormones or interfering with chitin synthesis, thereby preventing successful moulting and metamorphosis (Zhang *et al.*, 2019). Examples include methoprene, pyriproxyfen, and diflubenzuron. IGRs are considered environmentally friendly due to their selectivity for insects and minimal impact on non-target organisms, though their slower mode of action can limit their use in situations requiring rapid pest suppression.

Avermectins, such as abamectin, ivermectin, and emamectin benzoate, belong to the macrocyclic lactone group derived from *Streptomyces* species. They act by activating glutamate-gated chloride channels in the nervous system, causing hyperpolarization and paralysis (Burg and Miller, 2020). Avermectins are particularly effective against mites, nematodes, and certain insect

larvae. However, they are highly toxic to aquatic organisms, necessitating careful application and management.

Formamidines, including amitraz and chlordimeform, act through modulation of octopamine receptors in the insect nervous system, leading to behavioral disorientation, feeding inhibition, and death (Sparks and Nauen, 2017). Although effective against mites and ticks, the potential toxicity of formamidines to mammals and bees has led to their restricted use in many regions.

Spinosyns constitute a group of naturally derived insecticides produced by the actinomycete *Saccharopolyspora spinosa*. They target nicotinic acetylcholine receptors and cause continuous excitation of the nervous system, leading to insect mortality (Crouse *et al.*, 2018). Spinosad and spinetoram are among the most widely used compounds in this class due to their effectiveness against a variety of insect pests and relatively low toxicity to beneficial species. Nevertheless, resistance development has been reported in some pest populations following repeated exposure.

Finally, oxadiazine insecticides such as indoxacarb represent a relatively recent addition to pest management tools. They function by blocking voltage-dependent sodium channels in insect neurons, resulting in paralysis and death (Wing and Sparks, 2020). Oxadiazines are effective at low doses and demonstrate a favorable mammalian safety profile. However, their environmental persistence necessitates careful regulation to minimize potential accumulation in soil and water systems.

The continuous development and classification of insecticides are driven by the need for compounds that combine efficacy, selectivity, and environmental safety. Although chemical insecticides remain indispensable for global pest control, their use must be balanced with

integrated pest management practices and ongoing monitoring to prevent ecological disruption and resistance emergence.

### **1.3.1 OVERVIEW OF ORGANOCHLORINE PESTICIDES**

Organochlorine pesticides (OCPs) are a class of synthetic organic compounds that were widely used in agriculture and public health for pest and vector control. They are characterized by the presence of multiple chlorine atoms attached to hydrocarbon structures, giving them remarkable chemical stability, lipophilicity, and resistance to environmental degradation (Liu *et al.*, 2020). These properties, while initially advantageous for long-lasting pest control, have resulted in their persistence and bioaccumulation in the environment, leading to widespread contamination of soil, water, air, and biota. OCPs such as dichlorodiphenyltrichloroethane (DDT), lindane ( $\gamma$ -HCH), aldrin, dieldrin, endrin, heptachlor, and chlordane became some of the most commonly used pesticides globally during the mid-20th century (Adeyemi and Adesiyun, 2015; Alengebawy *et al.*, 2021).

Although many OCPs have been banned or severely restricted in most developed countries due to their adverse environmental and health effects, they continue to be used in some developing nations where regulatory frameworks are weak, enforcement is limited, and cheaper pest-control alternatives are sought (Bempah and Asomaning, 2017). Their persistence, long-range atmospheric transport, and semi-volatility enable OCPs to move far from application sites, contaminating regions where they were never used. This global distribution has resulted in their classification as persistent organic pollutants (POPs) under the Stockholm Convention on Persistent Organic Pollutants, an international treaty aimed at eliminating or restricting their production and use (Alengebawy *et al.*, 2021).

From an environmental perspective, OCPs are highly recalcitrant to degradation, allowing them to remain in soil and sediment for decades. They can alter soil physicochemical properties and disturb microbial communities responsible for essential ecosystem functions such as nitrogen fixation, carbon cycling, and organic matter decomposition (Iqbal and Feng, 2019). These disruptions in the soil microbiome can impair nutrient availability and uptake by plants, leading to changes in the proximate composition and nutritional quality of crops such as beans. Studies have demonstrated that beans grown in OCP-contaminated soils exhibit reduced protein, carbohydrate, and mineral content, thereby diminishing their nutritional and economic value (Liu *et al.*, 2020).

OCPs also exhibit a strong tendency for bioaccumulation in living tissues and biomagnification through food chains, leading to elevated concentrations in higher trophic levels, including humans (Alengebawy *et al.*, 2021). Chronic exposure to OCPs has been associated with numerous health problems, such as endocrine disruption, reproductive dysfunction, immunotoxicity, neurotoxicity, and carcinogenesis (Karami Mohajeri and Abdollahi, 2011; Mnif *et al.*, 2011). Their lipophilic nature allows them to accumulate in fatty tissues, breast milk, and blood plasma, resulting in prolonged biological half-lives and potential transgenerational effects. The human health risks associated with OCP exposure are of particular concern in agricultural communities where farmers, consumers, and surrounding populations are routinely exposed through dermal contact, inhalation, and ingestion of contaminated food and water (Kumar and Singh, 2019).

In addition to direct health impacts, OCP residues in food crops pose significant food safety challenges. Research has revealed the presence of DDT, lindane, and endosulfan residues in beans, cereals, and vegetables across Africa and Asia at concentrations exceeding World Health

Organization (WHO) and Food and Agriculture Organization (FAO) maximum residue limits (Bempah and Asomaning, 2017; Nduka and Orisakwe, 2019). These residues threaten not only local consumers but also export markets, where compliance with international food safety standards is required. Furthermore, the co-occurrence of OCPs and heavy metals in soil may intensify the toxicological burden of food crops. OCPs can increase the mobilization and uptake of heavy metals such as lead, cadmium, and mercury in plants by altering soil pH, redox potential, and microbial enzyme activity (Kumar and Singh, 2019). This combined contamination raises further public health concerns, as both classes of pollutants exert synergistic toxic effects.

Despite their environmental persistence and toxicity, OCPs remain attractive in certain agricultural settings because of their low cost, broad-spectrum activity, and long-lasting effectiveness against pests. However, their continued use highlights a pressing need for improved regulation, monitoring, and public education in developing regions. Modern pest management approaches, including integrated pest management (IPM) and biopesticide use, are increasingly promoted as sustainable alternatives to mitigate the adverse effects of OCPs on environmental and human health (Alengebawy *et al.*, 2021). Strengthening analytical monitoring of pesticide residues in soil and crops, enhancing farmer awareness, and enforcing international pesticide control measures are essential steps toward reducing OCP-related risks and safeguarding food quality.

### **1.3.2 PERSISTENCE AND BIOACCUMULATION OF ORGANOCHLORINE**

#### **Persistence**

Organochlorine pesticides (OCPs) are characterized by their exceptional chemical stability and resistance to degradation, making them among the most persistent pollutants in the environment. Their persistence is one of the major environmental concerns because it allows them to remain active for many years after application, leading to long-term contamination of soil, water, and biota (Liu *et al.*, 2020). The molecular structure of OCPs comprising multiple chlorine atoms bound to aromatic or aliphatic hydrocarbon rings confers strong carbon-chlorine bonds that are resistant to breakdown by physical, chemical, or biological processes (Iqbal and Feng, 2019). This resistance to degradation means that OCPs do not readily undergo hydrolysis, photolysis, or microbial metabolism, enabling them to persist in the environment for decades.

The persistence of OCPs varies depending on environmental factors such as soil texture, pH, organic matter content, and temperature, as well as the specific physicochemical properties of each compound. For instance, compounds like DDT and dieldrin have half-lives that can range from 10 to over 30 years in soil, while others such as lindane and endosulfan may persist for up to 10 years (Alengebawy *et al.*, 2021; Liu *et al.*, 2020). The low water solubility and high lipid solubility of OCPs also contribute to their strong sorption onto soil organic matter and sediments, limiting their mobility but increasing their long-term retention. This means that even decades after their use has been banned or restricted, residues of OCPs are still detected in agricultural soils, river sediments, and atmospheric deposits across various regions (Bempah and Asomaning, 2017).

The persistence of OCPs in the environment facilitates their long-range atmospheric transport, allowing them to travel thousands of kilometers from their original application sites through processes such as volatilization and condensation. This global dispersal phenomenon, known as the “grasshopper effect,” results in the detection of OCP residues even in remote ecosystems

such as the Arctic and Antarctic, far removed from agricultural or industrial activities (Alengebawy *et al.*, 2021). The re-volatilization of OCPs from soil and water surfaces further prolongs their environmental lifetime, as they can repeatedly cycle between different environmental compartments. Consequently, these pollutants remain in circulation for extended periods, contributing to chronic exposure among wildlife and human populations.

From an ecological and health standpoint, the persistence of OCPs presents serious risks because continuous low-level exposure can occur even years after application has ceased. Persistent residues in soil can be taken up by crops, contaminating food supplies and contributing to cumulative human exposure through ingestion. Moreover, persistent OCPs in aquatic systems can accumulate in sediments, posing a long-term hazard to aquatic organisms that feed or reproduce in contaminated environments. Such prolonged persistence and stability in the environment make OCPs prototypical persistent organic pollutants (POPs), regulated under the Stockholm Convention due to their persistence, bioaccumulative nature, and potential for long-range transport (Alengebawy *et al.*, 2021).

### **Bioaccumulation**

Bioaccumulation refers to the process by which chemical substances such as OCPs are absorbed by organisms from their environment or diet and stored in their tissues at concentrations higher than those in the surrounding medium. The lipophilic (fat-loving) nature of OCPs enables them to readily penetrate biological membranes and accumulate in fatty tissues, where they are stored over long periods due to their slow metabolic degradation and elimination rates (Karami Mohajeri and Abdollahi, 2011). Repeated or chronic exposure leads to progressive buildup in the body, resulting in long-term biological persistence and potential toxic effects.

OCPs can bioaccumulate through various routes of exposure, including ingestion of contaminated food and water, inhalation of contaminated dust or air, and dermal absorption during pesticide handling or application (Liu *et al.*, 2020). In plants, bioaccumulation occurs through root uptake from contaminated soils or irrigation water, with subsequent translocation to edible parts such as seeds and pods. This process is particularly concerning for leguminous crops such as beans, which are capable of absorbing and concentrating OCP residues due to their close interaction with soil microbiota and organic matter (Bempah and Asomaning, 2017).

Once absorbed by primary producers or lower trophic organisms, OCPs can enter the food chain and undergo biomagnification, a process by which concentrations increase progressively at higher trophic levels (Iqbal and Feng, 2019). This means that top predators, including humans, fish-eating birds, and marine mammals, often exhibit the highest levels of OCP accumulation. The bioaccumulation and biomagnification of OCPs pose significant ecological and health risks. In wildlife, they have been linked to reproductive failure, eggshell thinning in birds, immune suppression, and behavioral abnormalities in aquatic species. In humans, OCP residues have been detected in blood, adipose tissue, breast milk, and even the placenta, indicating their ability to cross biological barriers and affect multiple generations (Alengebawy *et al.*, 2021).

Bioaccumulated OCPs have been associated with endocrine disruption, reproductive impairment, immunotoxicity, carcinogenesis, and neurotoxicity (Mnif *et al.*, 2011). Chronic exposure to low doses can also interfere with metabolic processes, leading to hormonal imbalances, altered enzyme activity, and oxidative stress. In regions where OCPs are still used, populations may experience continuous dietary exposure, especially through consumption of contaminated staple foods such as beans, cereals, and vegetables. For example, studies conducted by Nduka and Orisakwe (2019) detected elevated levels of DDT and lindane in locally produced beans,

exceeding permissible limits set by the World Health Organization and Food and Agriculture Organization. These findings underscore the ongoing threat posed by OCP bioaccumulation to food safety and public health, particularly in developing countries where monitoring and regulation are limited.

The bioaccumulative nature of OCPs is compounded by their ability to interact with other environmental contaminants such as heavy metals. Co-exposure to OCPs and metals can produce synergistic toxic effects, intensifying oxidative stress, disrupting endocrine function, and enhancing carcinogenic potential (Kumar and Singh, 2019). Such combined exposure scenarios are particularly relevant in agricultural systems where both classes of pollutants are present, as they may compromise crop quality and increase the health risks to consumers.

Overall, the persistence and bioaccumulation of OCPs create a cycle of environmental contamination and exposure that can span multiple decades. Despite global efforts to phase them out, their residues continue to pose a serious threat to environmental sustainability and human well-being. Effective mitigation strategies such as soil remediation, residue monitoring, and public education are therefore essential to minimize their long-term impacts and ensure food safety.

## **DESCRIPTION OF BEANS**

Beans are a group of leguminous plants belonging to the family *Fabaceae* (also known as *Leguminosae*), one of the largest and most diverse families of flowering plants. They are cultivated extensively across tropical, subtropical, and temperate regions of the world for both human consumption and animal feed. Beans are among the most important food crops globally due to their high nutritional value, adaptability to different climatic conditions, and ability to

improve soil fertility through biological nitrogen fixation (Kang *et al.*, 2021). They form a vital component of traditional diets in Africa, Asia, and Latin America, serving as an affordable source of protein, dietary fiber, and essential micronutrients for millions of people, especially in developing countries where animal protein is less accessible (Boukid and Rosell, 2021).

Botanically, beans are annual or perennial herbaceous plants characterized by trifoliolate leaves, self-pollinating flowers, and pods that contain multiple seeds. The seeds, commonly referred to as “beans,” vary in color, size, and shape depending on the species and variety. They are rich in macronutrients such as protein, carbohydrates, and dietary fiber, and provide essential vitamins including folate (vitamin B9), thiamine (vitamin B1), and minerals such as iron, magnesium, potassium, and zinc (Akibode and Maredia, 2021). The high protein content, ranging between 20–35%, makes beans a critical component of vegetarian and low-meat diets. Additionally, beans contain bioactive compounds such as polyphenols, flavonoids, and tannins, which contribute to their antioxidant and anti-inflammatory properties, supporting their role in preventing chronic diseases such as diabetes, cardiovascular disorders, and certain cancers (Nascimento *et al.*, 2022).

There are various types of beans cultivated globally, each with unique agronomic, nutritional, and economic characteristics. The common bean (*Phaseolus vulgaris*) is the most widely consumed and cultivated species worldwide, encompassing varieties such as black beans, kidney beans, pinto beans, and navy beans. It is particularly important in Latin America and Africa, where it serves as a staple source of plant protein and energy (Assefa *et al.*, 2019). The soybean (*Glycine max*) is considered the most economically important member of the legume family due to its versatile uses in food, animal feed, and industry. It is a major source of vegetable oil and protein meal, with global significance in both human nutrition and livestock production (Zhou *et*

*al.*, 2020). The broad bean (*Vicia faba*), also known as fava bean, is an ancient crop extensively grown in the Mediterranean, North Africa, and the Middle East. It is valued for its high protein and fiber content and is commonly used in traditional dishes such as falafel and ful medames.

The chickpea (*Cicer arietinum*), also known as garbanzo bean, is another widely consumed legume, particularly in South Asia, the Middle East, and Mediterranean regions. It is rich in protein, complex carbohydrates, and micronutrients such as iron and zinc, and is a key ingredient in foods like hummus and curry (Yadav *et al.*, 2020). The cowpea (*Vigna unguiculata*), also called black-eyed pea, is primarily cultivated in sub-Saharan Africa, Asia, and parts of the Americas. It is drought-tolerant and well-adapted to marginal soils, making it a crucial crop for food security in arid and semi-arid regions. Cowpeas play a major role in traditional dishes such as akara (bean cakes) and moin-moin (bean pudding) in West Africa (Egbadzor *et al.*, 2021). Other notable species include mung beans (*Vigna radiata*), adzuki beans (*Vigna angularis*), and lima beans (*Phaseolus lunatus*), each contributing to dietary diversity and nutritional enrichment in different parts of the world.

Beyond their nutritional significance, beans play a vital role in sustainable agriculture. They are leguminous plants capable of symbiotic nitrogen fixation through their association with *Rhizobium* bacteria in root nodules. This biological process enriches the soil with nitrogen, reducing the need for synthetic fertilizers and improving soil fertility for subsequent crops (Saxena *et al.*, 2023). Consequently, bean cultivation supports environmentally friendly agricultural systems, enhances crop rotation efficiency, and contributes to climate change mitigation by reducing greenhouse gas emissions from fertilizer use.

In addition to their agronomic and nutritional benefits, beans also have considerable socioeconomic importance. They provide income for millions of smallholder farmers, particularly women, who are involved in their cultivation, processing, and marketing. The global demand for beans continues to rise due to growing consumer awareness of plant-based diets and sustainable food systems. However, bean production faces challenges such as pest infestations, poor postharvest handling, and contamination from agrochemicals, including organochlorine pesticides, which can affect their safety and nutritional quality (Nduka and Orisakwe, 2019). Thus, ensuring safe cultivation and residue management practices is essential for maintaining the health and economic value of this important crop.

### **1.3.3 NUTRITIONAL COMPOSITION OF BEANS**

Beans (*Phaseolus vulgaris* and related species) are among the most nutritionally valuable leguminous crops, forming a key component of diets in many parts of the world due to their rich nutrient profile and affordability. They are a nutrient-dense food, providing a balanced combination of macronutrients and micronutrients essential for human health and development (Liu *et al.*, 2020; Kumar and Singh, 2019; Iwegbue and Nwajei, 2017). Beans are an excellent source of plant-based protein, typically containing between 20–30%, which makes them an ideal substitute for animal protein, especially in vegetarian and low-meat diets. The proteins found in beans are rich in lysine, an essential amino acid often limited in cereal-based diets, making beans an important complement to grains and a cornerstone of food security in many developing nations.

In addition to their high protein content, beans are a significant source of dietary fiber, contributing between 10–20% of their composition. The fiber content in beans promotes satiety,

supports digestive health, and helps regulate blood sugar and cholesterol levels. The soluble fibers present in beans can lower low-density lipoprotein (LDL) cholesterol, thereby reducing the risk of cardiovascular diseases, while the insoluble fibers aid in maintaining healthy bowel function. Regular consumption of beans has been associated with a reduction in constipation and improved gut microbiota balance, fostering overall digestive well-being.

Beans are also rich in essential vitamins such as thiamine (vitamin B1), riboflavin (vitamin B2), niacin (vitamin B3), and folate (vitamin B9), which play vital roles in energy metabolism, red blood cell formation, and nervous system health. Folate, in particular, is crucial for DNA synthesis and cell growth, making beans an important food source for pregnant women to prevent neural tube defects in developing infants. Alongside these vitamins, beans contain valuable minerals such as iron, zinc, calcium, magnesium, and potassium, all of which are critical for various physiological functions. Iron and zinc support immune function and oxygen transport in the blood, calcium strengthens bones and teeth, while potassium helps in maintaining proper fluid balance and heart function.

Beyond their macronutrient and micronutrient content, beans contain a variety of bioactive compounds such as polyphenols, flavonoids, and tannins, which contribute to their antioxidant and anti-inflammatory properties. These compounds help protect the body's cells from oxidative stress caused by free radicals, reducing the risk of chronic diseases. Regular consumption of beans has been linked to several health benefits, including lowering the risk of heart disease, diabetes, obesity, and certain cancers (Adeyemi and Adesiyun, 2015; Bempah and Asomaning, 2017). Their low glycemic index makes them suitable for individuals managing diabetes, as they help regulate blood glucose levels and improve insulin sensitivity.

Beans also play an important role in maintaining a healthy body weight. Due to their high protein and fiber content, they promote satiety, which helps reduce overall calorie intake. This makes them beneficial for weight management and obesity prevention. The combination of nutrients in beans supports a balanced diet, providing sustained energy release and contributing to long-term health and vitality.

Furthermore, the nutritional composition of beans can vary depending on the species, variety, and growing conditions. Environmental factors such as soil fertility, temperature, and exposure to agrochemicals, including organochlorine pesticides, can influence the concentration of proteins, carbohydrates, and minerals. However, regardless of these variations, beans consistently remain a highly nutritious and versatile food that supports human health and nutrition across all age groups.

In summary, beans are a nutrient-rich, health-promoting food source that provides an excellent balance of protein, fiber, vitamins, and minerals. Their regular inclusion in the diet not only supports optimal nutrition but also contributes to disease prevention and overall well-being.

## **OVERVIEW OF PROXIMATE**

Proximate composition analysis is a fundamental method in food science for determining the major nutritional components of food samples. This analysis typically includes measurements of moisture, ash, crude protein, crude fat, crude fiber, and carbohydrates (AOAC, 2016). Recent studies have applied this method to various food products to assess their nutritional value and quality.

### **1.3.4. PROXIMATE COMPOSITION OF BEANS**

Beans are excellent source of nutrients, and their proximate composition varies depending on the type and variety. Generally, beans are rich in protein, fiber, and minerals.

**Moisture Content:** Beans typically contain 9-11% moisture, which affects their storage stability

**Protein Content:** Beans are a good source of protein, with a content range of 20.69-28.56% depending on the variety. For example, white beans have been found to contain 28.56% protein, while brown beans contain 23.62%

**Fat Content:** The fat content of beans is relatively low, ranging from 0.59-2.03%.

**Fibre Content:** Beans are high in fibre, with a content range of 3.60-6.86%. This fiber content can help lower blood cholesterol levels and prevent diseases like diabetes and hypertension

**Ash Content:** The ash content of beans ranges from 3.10-5.61%, indicating a significant mineral content

**Carbohydrate Content:** Beans are rich in carbohydrates, with a content range of 54.31-69.23%

#### **Mineral Compositions**

**Potassium (K):** Beans are a good source of potassium, with a content range of 25.0-248.53 mg/kg. Potassium helps maintain cellular water balance and supports healthy blood pressure

**Phosphorus (P):** Beans contain significant amounts of phosphorus, ranging from 154.98-850.00 mg/100g. Phosphorus is essential for bone health and energy production

**Calcium (Ca):** The calcium content of beans ranges from 188.35-653.33 mg/kg, supporting bone health.

**Iron (Fe):** Beans contain iron, with a content range of 2.45-9.80 µg/100g, essential for healthy red blood cells.

These values demonstrate the nutritional significance of beans, making them an excellent addition to a balanced diet

### **1.3.5 IMPACT OF ORGANOCHLORINE ON SOIL AND PLANT HEALTH**

Organochlorine pesticides (OCPs) have been shown to exert profound and long-lasting effects on both soil and plant health. Their persistent and lipophilic nature allows them to remain in the environment for extended periods, influencing the physical, chemical, and biological properties of soil and altering the overall growth and nutritional quality of crops such as beans. These effects extend beyond immediate toxicity, often disrupting the delicate balance of soil ecosystems, nutrient cycling, and plant physiological processes (Adeyemi and Adesiyani, 2015; Bempah and Asomaning, 2017).

#### **Effects on Nutritional Composition**

OCPs can significantly alter the nutritional composition of beans by disrupting the plant's metabolism and nutrient assimilation processes. Exposure to these pesticides has been shown to reduce the levels of essential macronutrients such as proteins, carbohydrates, and lipids, which are critical for both plant growth and human nutrition (Iwegbue and Nwajei, 2017; Kumar and Singh, 2019). The reduction in protein content is often attributed to the inhibition of nitrogen fixation and assimilation, as OCPs negatively affect the symbiotic relationship between beans

and *Rhizobium* bacteria responsible for atmospheric nitrogen conversion. This interference leads to reduced amino acid synthesis and, consequently, lower protein accumulation in bean seeds.

In addition, OCP exposure can disrupt carbohydrate metabolism by affecting the activity of key enzymes involved in photosynthesis and respiration. When these processes are impaired, plants produce less energy, leading to reduced growth and lower carbohydrate reserves. The fat content of beans can also be affected, as lipid metabolism is highly sensitive to chemical stress. OCPs may interfere with lipid biosynthesis and degradation pathways, altering the fatty acid composition of bean seeds. As a result, beans grown in contaminated soils may have diminished nutritional value and reduced energy content, ultimately impacting food quality and consumer health (Liu *et al.*, 2020).

Moreover, the presence of OCPs in the soil can indirectly influence plant nutrient uptake by damaging root membranes and reducing root permeability. This limits the plant's ability to absorb water and nutrients effectively. Over time, such stress conditions can cause stunted growth, poor yield, and visible physiological symptoms such as chlorosis (yellowing of leaves) and reduced pod development. In essence, OCP contamination not only lowers the nutritional value of beans but also compromises their agronomic performance and economic worth.

### **Effects on Mineral Content**

OCPs have been found to alter the mineral composition of beans, particularly by reducing the availability and absorption of essential minerals such as iron, zinc, and calcium (Akinyosoye *et al.*, 2020; Ogunfowokan and Oyekunle, 2018). These minerals are vital for various metabolic processes, including enzyme activation, photosynthesis, and cellular structure maintenance. However, OCP residues in the soil can bind to mineral particles and organic matter, making them

less available for plant uptake. The reduction in essential mineral content affects both plant vitality and the nutritional quality of harvested beans, as deficiencies in iron and zinc are linked to anemia and weakened immune function in humans.

In contrast, OCP-contaminated soils have been associated with an increase in the concentration of toxic elements such as lead, cadmium, and mercury. This happens because OCPs can modify soil chemistry by changing pH and redox conditions, which in turn affect the solubility and mobility of heavy metals. As a result, toxic metals become more bioavailable and are absorbed by plants, accumulating in edible parts such as seeds. The consumption of such contaminated beans poses serious health risks, including neurotoxicity, kidney damage, and developmental disorders. Therefore, the alteration of mineral balance by OCPs presents a dual problem: deficiency of essential elements and excess of toxic metals, which threatens both agricultural productivity and food safety (Kumar and Singh, 2019).

### **Effects on Heavy Metal Levels**

The interaction between OCPs and heavy metals in soil further compounds their detrimental impact on plant health. OCPs can increase the levels of heavy metals in the soil and plant system by enhancing their mobility and uptake. This occurs because OCP molecules can form complexes with metal ions, facilitating their transport into plant tissues (Liu *et al.*, 2020). Once absorbed, these heavy metals accumulate in the roots, stems, and seeds of beans, disrupting cellular metabolism and causing oxidative stress. The accumulation of heavy metals interferes with enzyme activity, damages cellular membranes, and hinders the synthesis of vital biomolecules.

Furthermore, the combined presence of OCPs and heavy metals can create synergistic toxic effects that are more severe than either contaminant alone. This combined toxicity can result in higher oxidative stress levels, DNA damage, and impairment of photosynthetic pigments, leading to reduced chlorophyll production and lower photosynthetic efficiency. Over time, this reduces crop yield and affects the overall physiological health of the plant.

At the soil level, OCP contamination can impair the biological activity of microorganisms that are crucial for maintaining soil fertility. Beneficial microbes such as nitrogen-fixing bacteria and decomposers become less active or die off, leading to nutrient imbalance and slower organic matter breakdown. This degradation of soil microbiota reduces nutrient recycling and weakens the natural resilience of the soil ecosystem. Consequently, beans and other crops grown in such soils experience nutrient deficiencies, lower productivity, and increased vulnerability to diseases and environmental stress.

In summary, the impact of organochlorine pesticides on soil and plant health is profound and multifaceted. These compounds not only persist in the environment but also disrupt the intricate biological and chemical processes that sustain soil fertility and crop nutrition. In beans, their influence manifests through reduced protein, fiber, and mineral content, increased heavy metal accumulation, and overall decline in plant vigor and productivity. The long-term effects of OCP contamination pose a serious threat to sustainable agriculture, food safety, and human health, underscoring the need for careful management, soil remediation, and the promotion of safer pest control alternatives.

### **1.3.6 MECHNAISM OF NUTRITIONAL DEGREATION IN CROPS**

Nutritional degradation in crops is a multifaceted process influenced by several biochemical, physiological, and environmental factors. Among these, the use of pesticides, particularly organochlorine pesticides (OCPs), has been identified as a major contributor to the decline in the nutritional quality of food crops such as beans. These chemicals can interfere with normal plant metabolism, soil microbial activity, and nutrient assimilation processes, ultimately reducing the concentration of essential nutrients and increasing the accumulation of toxic substances in plant tissues (Liu *et al.*, 2020; Kumar and Singh, 2019; Iwegbue and Nwajei, 2017).

The mechanisms through which pesticides cause nutritional degradation are complex and interrelated, involving oxidative stress, enzyme inhibition, microbial disruption, impaired nutrient uptake, and heavy metal interactions. These processes not only affect the plant's growth and productivity but also compromise the nutritional quality and safety of the harvested produce.

#### **Pesticide-Induced Oxidative Stress**

One of the primary mechanisms by which pesticides induce nutritional degradation in crops is through oxidative stress. When plants are exposed to OCPs, they generate an excess of reactive oxygen species (ROS), such as superoxide anions, hydrogen peroxide, and hydroxyl radicals. These highly reactive molecules can damage vital cellular components, including lipids, proteins, and nucleic acids. Oxidative stress disrupts chloroplast and mitochondrial functions, leading to reduced photosynthesis and impaired energy metabolism.

As a result, plants under pesticide stress often experience reduced synthesis of essential biomolecules such as carbohydrates, proteins, and lipids. The breakdown of cell membranes due to lipid peroxidation further compromises nutrient storage and transport within plant tissues.

Prolonged exposure to pesticides can weaken the plant's natural antioxidant defense systems, such as superoxide dismutase and catalase, exacerbating nutrient loss and reducing the overall nutritional quality of crops.

### **Alteration of Enzyme Activity in Nutrient Metabolism**

Pesticides can significantly alter the activity of enzymes responsible for nutrient metabolism. Enzymes such as nitrate reductase and glutamine synthetase, which play crucial roles in nitrogen assimilation, can be inhibited or inactivated by OCP residues. This leads to reduced conversion of nitrate into amino acids, ultimately resulting in decreased protein synthesis.

Similarly, pesticides can interfere with carbohydrate metabolism by affecting enzymes involved in starch and sugar synthesis, such as sucrose synthase and amylase. Lipid metabolism is also affected as pesticide residues disrupt the activity of enzymes like acetyl-CoA carboxylase and lipoygenase, which are vital for fatty acid biosynthesis and degradation. These biochemical disruptions reduce the concentration of essential macronutrients and alter the overall composition of the crop, making it less nutritious and of lower quality for human consumption.

### **Disruption of Soil Microflora**

Another critical mechanism contributing to nutritional degradation is the disruption of soil microflora. Pesticides can drastically reduce the diversity and activity of beneficial soil microorganisms, including nitrogen-fixing bacteria, phosphate-solubilizing microbes, and mycorrhizal fungi. These organisms are essential for nutrient cycling and availability in the rhizosphere, the zone of soil surrounding plant roots.

When OCPs disrupt microbial populations, the natural processes of nitrogen fixation, mineralization, and organic matter decomposition are slowed down. This leads to a reduction in soil fertility and nutrient bioavailability. Plants growing in such disturbed soils struggle to absorb sufficient nutrients, particularly nitrogen, phosphorus, and potassium, leading to poor growth and nutrient deficiencies. Moreover, the absence of beneficial microbes can increase plant susceptibility to diseases and environmental stresses, further reducing their nutritional value and productivity.

### **Increased Oxidative Degradation of Nutrients**

Pesticides can enhance the oxidative degradation of essential nutrients such as lipids, proteins, and vitamins. Under pesticide-induced stress, the elevated levels of ROS attack unsaturated fatty acids, leading to lipid peroxidation and the destruction of cell membranes. Proteins may also undergo oxidative modification, which affects their structure and function, leading to denaturation or fragmentation.

Vitamins, particularly those with antioxidant properties such as vitamin C and E, are also susceptible to oxidative degradation. The reduction of these vital compounds diminishes the plant's nutritional quality and its capacity to defend against oxidative damage. Over time, the cumulative effect of oxidative degradation results in a measurable decline in the nutritional density of crops, rendering them less beneficial for human health.

### **Reduced Nutrient Uptake**

Pesticide exposure can impair the ability of plants to absorb and translocate nutrients from the soil. This may occur due to alterations in root morphology, such as reduced root length, surface

area, and branching. The damage to root cell membranes and nutrient transport proteins can restrict the uptake of essential minerals like iron, calcium, and magnesium.

Furthermore, OCPs can disrupt the electrochemical balance of root cells, reducing the efficiency of ion exchange mechanisms that facilitate nutrient absorption. In some cases, pesticides form insoluble complexes with soil nutrients, making them unavailable for plant uptake. These combined effects result in nutrient deficiencies that manifest as stunted growth, chlorosis, and lower yields, ultimately diminishing the nutritional quality of harvested crops.

### **Increased Heavy Metal Accumulation**

A particularly concerning mechanism of nutritional degradation is the increased accumulation of heavy metals facilitated by pesticide residues. OCPs can alter soil chemistry by changing pH, cation exchange capacity, and redox potential, which affects the solubility and mobility of heavy metals such as lead, cadmium, and mercury. These metals become more bioavailable and are readily absorbed by plant roots.

Once inside the plant, heavy metals accumulate in tissues and interfere with metabolic processes, including enzyme function, nutrient assimilation, and photosynthesis. The presence of heavy metals not only displaces essential elements like zinc and iron but also increases the plant's oxidative stress levels. This dual effect nutrient displacement and toxicity leads to a decrease in nutritional quality and an increase in potential health risks for consumers.

### **Mechanisms of Nutritional Degradation in Beans**

Beans are particularly susceptible to nutritional degradation due to their high protein and mineral content. Mechanisms of nutritional degradation in beans include (Adeyemi and Adesiyani, 2015;

Bempah and Asomaning, 2017), Pesticides can degrade proteins in beans, leading to a loss of nutritional value, pesticides can induce mineral deficiencies in beans, particularly iron, zinc, and calcium, pesticides can alter the carbohydrate composition of beans, leading to a loss or decrease in the nutritional value, it can also degrade vitamins in beans, particularly thiamine and riboflavin.

### **1.3.7 HEALTH IMPLICATION OF ORGANOCHLORINE RESIDUE IN FOOD**

Organochlorine pesticide (OCP) residues in food represent a major public health concern due to their persistence, bioaccumulative nature, and toxic effects on multiple organ systems. Once introduced into the food chain, OCPs such as DDT, aldrin, dieldrin, and lindane tend to accumulate in fatty tissues of both humans and animals, where they can remain for extended periods. Continuous exposure, even at low concentrations, can lead to chronic toxicity with long-term health consequences. Vulnerable groups such as infants, children, pregnant women, and the elderly are particularly at risk due to their higher sensitivity and lower detoxification capacity. The health impacts of OCPs arise from their ability to interfere with normal physiological functions through mechanisms such as endocrine disruption, neurotoxicity, immunosuppression, and carcinogenesis.

#### **Neurotoxicity**

One of the well-documented effects of organochlorine residues in food is neurotoxicity. These compounds disrupt normal nerve signal transmission by interfering with ion channel function and neurotransmitter regulation in the nervous system. Specifically, OCPs such as lindane and dieldrin act on the gamma-aminobutyric acid (GABA) receptor, inhibiting chloride ion flow and

leading to neuronal hyperexcitability. This can result in symptoms such as headaches, dizziness, tremors, seizures, and, in severe cases, convulsions or loss of consciousness.

Chronic exposure to low levels of OCPs has also been linked to neurodegenerative disorders, including Parkinson's disease and Alzheimer's disease. These effects stem from the accumulation of oxidative stress and neuronal damage over time. Children and infants are particularly susceptible because their nervous systems are still developing, and their detoxification mechanisms are not fully mature. Prenatal exposure through maternal consumption of contaminated food can affect fetal brain development, leading to long-term cognitive and behavioral deficits later in life.

### **Endocrine Disruption**

OCPs are potent endocrine-disrupting chemicals (EDCs) that interfere with the body's hormonal systems. Their molecular structure allows them to mimic, block, or alter the activity of natural hormones such as estrogen, testosterone, and thyroid hormones. By binding to hormone receptors, OCPs can disrupt normal signaling pathways involved in growth, reproduction, and metabolism.

For instance, DDT and its metabolites, particularly DDE, exhibit estrogenic properties, leading to hormonal imbalance and reproductive dysfunction in both males and females. Such disruptions may cause menstrual irregularities, early puberty, and altered sperm production. In severe cases, endocrine disruption can contribute to developmental abnormalities in fetuses and infants, such as low birth weight, impaired thyroid function, and metabolic disorders. The persistence of OCPs

in adipose tissue further exacerbates their hormonal effects, as they can be slowly released into the bloodstream over time, prolonging exposure even after initial contact has ceased.

## **Reproductive Issues**

The reproductive system is highly sensitive to OCP exposure. Studies have shown that organochlorine residues can impair fertility in both men and women by disrupting the normal function of reproductive hormones and gametogenesis. In females, OCP exposure has been associated with irregular menstrual cycles, decreased ovarian reserve, and increased risk of miscarriages. In males, it can result in reduced sperm count, decreased motility, and altered morphology, all of which contribute to subfertility or infertility.

OCPs can also cross the placental barrier and accumulate in fetal tissues, leading to pregnancy complications such as preterm birth, intrauterine growth restriction, and spontaneous abortion. Prolonged time-to-pregnancy, stillbirth, and early pregnancy loss have also been linked to high levels of OCP residues in maternal blood. These reproductive effects highlight the multigenerational risks associated with pesticide contamination in food, emphasizing the need for strict monitoring and regulation to protect maternal and child health.

## **Cancer Risk**

Organochlorine pesticides, including DDT, lindane, and chlordane, have been classified as probable human carcinogens due to their ability to induce oxidative stress, DNA damage, and hormonal imbalances that contribute to tumor development. These compounds can promote carcinogenesis by generating reactive oxygen species that damage genetic material, impairing cellular repair mechanisms, and altering gene expression involved in cell growth and apoptosis.

Epidemiological studies have linked chronic dietary exposure to OCPs with increased risks of several types of cancer, including breast, colorectal, liver, and thyroid cancers. For example, DDT and its metabolites have been implicated in estrogen-related cancers such as breast cancer due to their hormone-mimicking effects. Lindane, in particular, has been associated with non-Hodgkin lymphoma and liver cancer. The lipophilic nature of OCPs allows them to accumulate in body fat, where they can exert continuous toxic pressure on surrounding tissues, promoting tumor growth over time.

### **Immune System Disruption**

The immune system can also be adversely affected by the presence of organochlorine residues in food. These compounds can alter immune cell activity, impair antibody production, and suppress the body's ability to respond to infections. OCPs such as DDT and aldrin have been shown to reduce the activity of macrophages and lymphocytes, which are essential for pathogen defense.

Prolonged exposure can lead to immunosuppression, making individuals more susceptible to bacterial, viral, and fungal infections. In some cases, OCPs may also trigger autoimmune reactions, where the immune system mistakenly attacks the body's own tissues. These immunotoxic effects are particularly concerning for children and individuals with preexisting health conditions, as their immune systems may already be compromised.

### **Developmental Problems**

Exposure to organochlorine pesticides during pregnancy or early childhood can have severe developmental consequences. Because these chemicals can cross the placenta and accumulate in

breast milk, fetuses and infants may be exposed during critical stages of development. Prenatal exposure has been linked to neurodevelopmental disorders such as attention deficit hyperactivity disorder (ADHD), learning disabilities, and reduced IQ in children.

OCPs can interfere with the normal signaling of thyroid hormones, which are essential for brain development, resulting in structural and functional abnormalities in the nervous system. In addition to neurological effects, developmental exposure may also affect growth patterns, immune competence, and metabolic regulation later in life. These findings underscore the long-term and transgenerational effects of organochlorine contamination in food systems.

## CHAPTER TWO

### MATERIALS AND METHOD

#### 2.1 Materials used

Beans 800g (*Phaseolus vulgaris*) obtained from Urhehue Orhiomwon Local government area Edo State Benin City, samples (control and treated)

Organochlorine pesticide solution Salvage Arm Inc. (USA) (Sniper at concentrations of 10%, 20% and 50%), Distilled water Idaho Ice (USA) ,50ml beakers Sun Platec (Japan) ,500ml flasks, 10ml pipettes Normax (Portugal) ,Analytical balance Kern and Sohn GmbH(Germany) ,Soxhlet extractor M.M. Scientific & Surgical Co.(India) used for fat analysis ,Kjeldahl apparatus Heduyingtu China (used for protein determination),Furnace (used to determine ash content),Atomic Absorption Spectrophotometry( AAS) PerkinElmer( USA) (For heavy metal analysis: Pb, Cu). (Ademulegun *et al.*, 2024).

#### 2.2 Method of analysis

Proximate analysis was carried out using standard methods, to determine, Moisture content, Ash content, Crude protein (Kjeldahl method), Crude fat (Soxhlet extraction), Crude fibre, Nitrogen-free extract (by calculation),. Heavy metal and minerals were analysis using Atomic Absorption Spectrophotometry (AAS) PerkinElmer (USA) (Edet *et al.*, 2023; Oke *et al.*, 2023).

### 2.3 Method of sample preparation

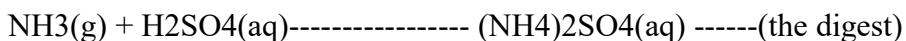
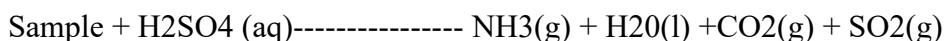
The Beans was sorted, cleaned and divided into four groups, T0 (control, untreated), T1 (treated with 10% organochlorine solution), T2 (treated with 20% organochlorine solution), T3 (treated with 50% organochlorine solution)

Each group was air-dried and milled into fine powder to ensure uniformness before analysis.

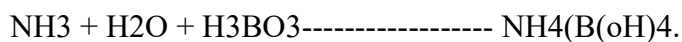
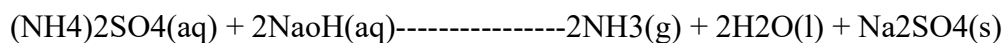
### 2.4 Process of beans digestion

**Protein:** Protein was determined by using Kjeldahl digestion to convert nitrogen into ammonium sulfate, followed by distillation and titration. Digestion Process begins by placing the untreated amount of sample T0 (control) in a Kjeldahl flask. 10ml of Concentrated sulfuric acid was added using a bent funnel (to prevent explosion), along with a copper catalyst and potassium sulfate salt to raise the acid's boiling point. The mixture was heated to high temperature of about 350 °C (Ademulegun *et al.*, 2024).

Equation of reactions,



Equation of distillation process,



The sulfuric acid acts as an oxidizing agent, breaking down the organic material. During this process, all organically bound nitrogen in the sample is chemically converted into ammonium sulfate, a stable, non-volatile form. The digestion is complete when the solution becomes clear and colorless, with the disappearance of carbon residues. The digested sample is then cooled, and water was added to dilute the solution and convert the ammonium sulfate into ammonium. The procedure was repeated for T1 (treated with 10% organochlorine solution), T2 (treated with 20% organochlorine solution) and T2 (treated with 20% organochlorine solution) respectively. For the determination of ash content, samples were incinerated in a furnace at 550°C until white ash was obtained. For heavy metal analysis, dried samples were digested using a mixture of concentrated nitric acid and perchloric acid before being analyzed on AAS. (Methods for the Extraction of Organic Compounds, 2024).

## 2.5 Method of proximate determination

**Moisture content:** Oven-drying method at 105°C until constant weight was achieved, about 15g of the control beans powder T0 was weighed into two separate containers labelled W1 and W2 respectively, the container label W2 was heated at a temperature of 105°C until a constant weight of the sample label W3 was obtained after which the moisture content was determined. The same procedure was repeated for T1 (treated with 10% organochlorine solution), T2 (treated with 20% organochlorine solution) and T3 treated with 50% organochlorine solution, (Edet *et al.*, 2023; Oke *et al.*, 2023). respectively and the moisture content(%) was determined using the formula:

$$\text{Moisture content}(\%) = \frac{W1 - W3}{W3} \times 100$$

Where;

W1 = initial weight of the powdered beans

W3 = dry weight (weight after all the moisture have been removed

**Ash content:** muffle furnace at 550°C About 5g of the sample T0 was weighed into a crucible and the total weight of the crucible with the sample was recorded ,the crucibles was placed in a muffle furnace and incinerated at a high temperature 550°C for several hours until light gray or constant weight is achieved). This process burns off organic matter, leaving only inorganic residue, (Edet *et al.*, 2023; Oke *et al.*, 2023). After the incineration was completed, the crucibles was carefully removed from the furnace using tongs and was placed in a desiccator to cool down to room temperature. Once cooled, the crucible with the ash weighed to determine the weight of the ash residue. The recorded weights was used to calculate the percentage of ash content using the formula:

$$\text{Ash content}(\%) = \frac{\text{Weight of ash}}{\text{Weight of sample}} \times 100$$

**Protein:** Kjeldahl method (nitrogen determination  $\times 6.25$ ) from the ammonium obtained from the digestion process of beans sample, an alkali (potassium hydroxide) was added to the mixture to liberate ammonia, which was then distilled into a vessel or trap containing a standard acid solution. The amount of ammonia was then determined by titration with a standard sulphuric acid in the burette, and the nitrogen content was then multiplied by a specific conversion factor (6.25) to estimate protein content. (Ademulegun *et al.*, 2024).

**Crude Fat:** The already dried powdered beans extract, both the control and the others containing different concentration of sniper were weighed(2g each) and was placed in a flask about 100ml volume of ethyl acetate was added to the flask containing the powdered beans the mixture were allowed to soak for 1 hours at room temperature, with frequent shaking. The mixture were filtered to separate the liquid (filtrate) from the solid bean residue so as to collect the ethyl acetate filtrate. The ethyl acetate were removed from the filtrate using a rotary evaporator to obtain a crude extract. The crude extract was placed in a shallow, flat-bottomed cup that has been pre-weighed and dried in an oven at 105°C until the weight became constant. The remaining solvent was evaporated by heating the cup at 105°C in the oven. The cup with the residue were weighed accurately and the value obtained was subtracted from the initial weight of the empty cup to determine the final weight of the ethyl extract.(Borges *et al.*, 2024; Khan *et al.*, 2021), The percentage weight of ethyl extract were calculated using the formula:

$$\%weight\ of\ ethyl\ extract = \frac{weight\ of\ extract}{weight\ of\ sample} \times 100$$

**Crude fibre:** A well-ground sample of beans both from control and others mixed with sniper at different concentration that is neither too coarse nor too fine and was passed through a 1.0 mm sieve. The fat content of the crude beans fibre was removed first using petroleum ether extraction in a Soxhlet extractor to form a defatted sample. The defatted sample was boiled with a dilute sulfuric acid solution for 30 minutes under reflux. The same boiling process was repeated with a dilute sodium hydroxide solution for the same duration. After each digestion, filter the contents to separate the solid residue. The residue were

washed with boiling water until the washings were acid-free, then washed with hot water, ethanol, and finally with petroleum ether. The washed residue was dried in a crucible at 105°C until it reaches a constant weight of 20g. (Borges *et al.*, 2024; Khan *et al.*, 2021).

The crucible and its contents were incinerated in a muffle furnace at 550°C to burn off all the carbonaceous matter. The % crude fibre was determined using the formula:

$$\text{Crude fibre} = \frac{W3 - W2}{w1} \times 100$$

Where;

W1=initial weight of crucible

W2=Weight of crucible and sample

W3=weight of crucible and extract

**Nitrogen Free Extract:** NFE was done for both the control and the other samples mixed with various concentration of sniper: The Percentage free nitrogen extract was determined by the summation of the percentage value of moisture content, ash, protein, crude fibre and ethyl extract from the results and subtracting the results value from 100%

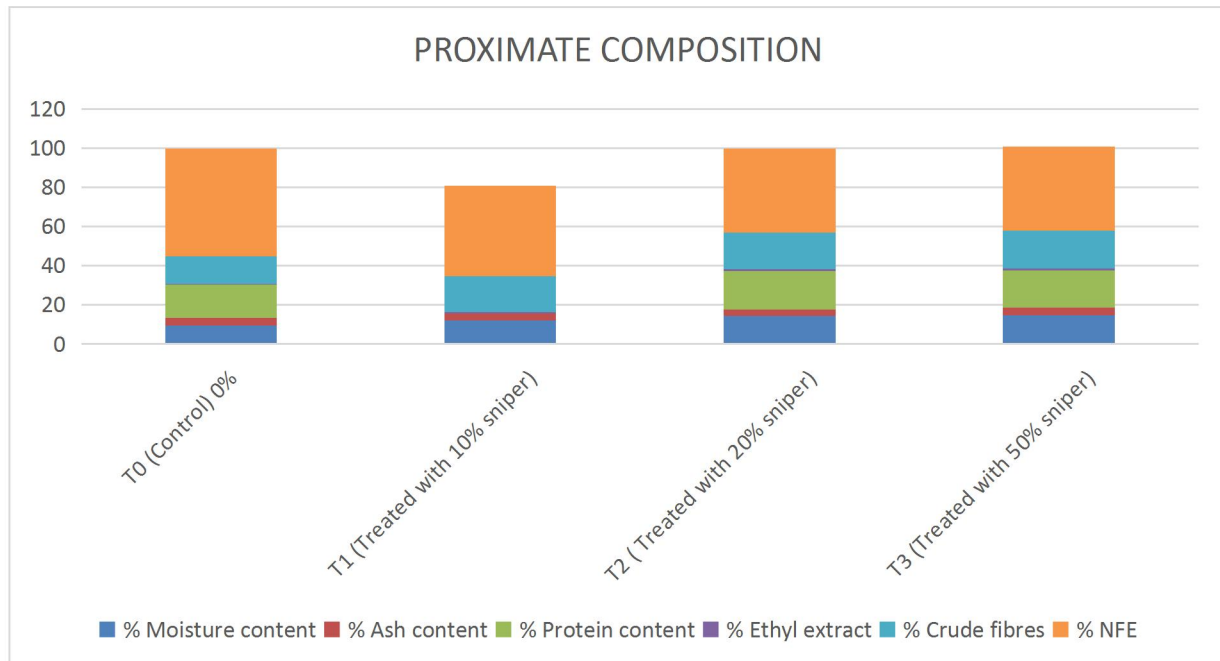
## CHAPTER THREE

### RESULTS

#### 3.1 PROXIMATE COMPOSITION

The chart below shows the proximate composition of beans treated with different concentrations of Sniper. After being analyzed, it can be seen clearly as shown on the chart that, Moisture, protein, and crude fibre contents increase slightly with higher Sniper levels, while nitrogen-free extract (NFE) decreases. And this may pose a significant effect on the nutritional value of beans.

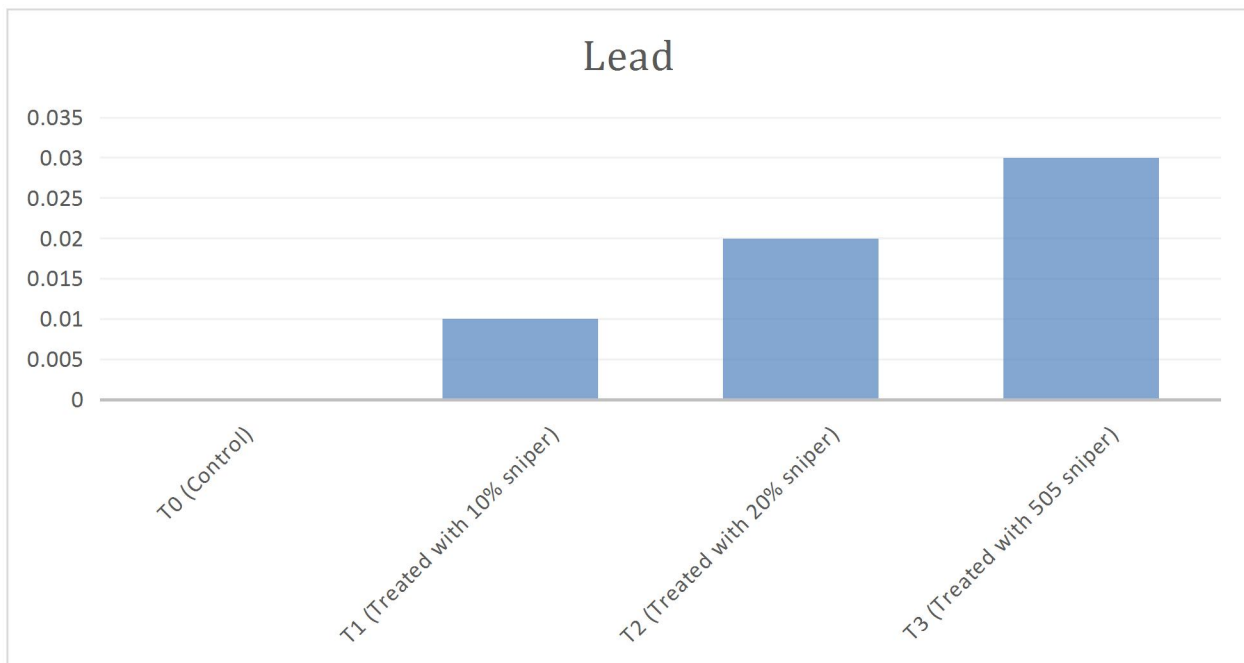
**Fig 3.1**, below explain how different Concentrations of sniper can alter the proximate compositions such as moisture content, Protein, Ethyl extract, nitrogen free extract, ash content and crude fibres etc.



**Figure 3.1.** Proximate compositions of both treated and control Beans samples.

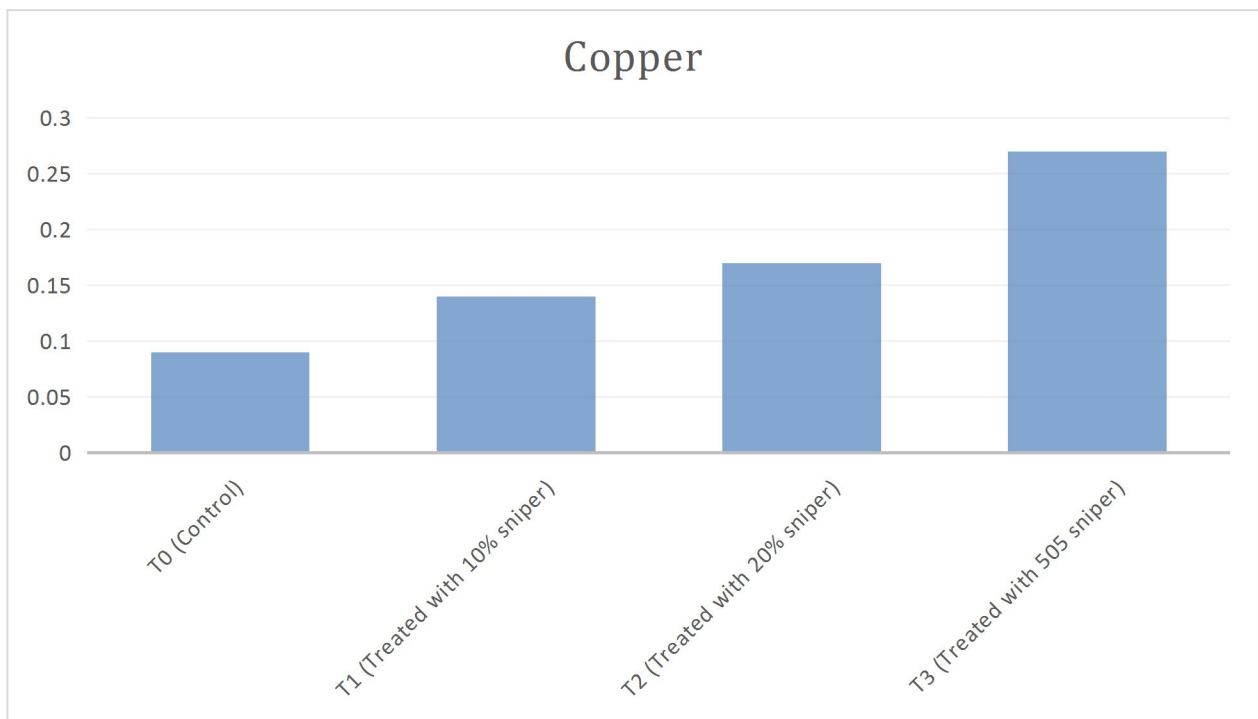
### 3.2 HEAVY METALS ANALYSIS

The chart below shows the results of Lead metal using atomic absorption spectrophotometer to determine for both control and treated Beans samples, from **Fig 3.2**, lead components was absent in the control sample T0 and contaminated the treated sample s which significantly increased as the Concentrations of sniper increases. The appearance of lead in the portion of beans treated with sniper may be due to the lead content in the sniper which initially shows 0.00% of lead in the control. The value of lead in mg/L on Y-axis were plotted against the beans samples treated with varying Concentrations of sniper and control.



**Figure 3.2.**Lead composition of both treated and untreated Beans samples.

**Fig 3.3** below is a chart showing the presence of copper in both untreated and treated Beans sample with varying Concentrations of sniper, from the graph it can be deduce that copper is present in both treated and control, however the value of copper increased as the concentration of sniper increases. The present of copper in the control sample maybe due to the presence of copper in the land in which the beans was cultivated. The value of copper on the Y-axis was plotted against the beans samples both treated and untreated.

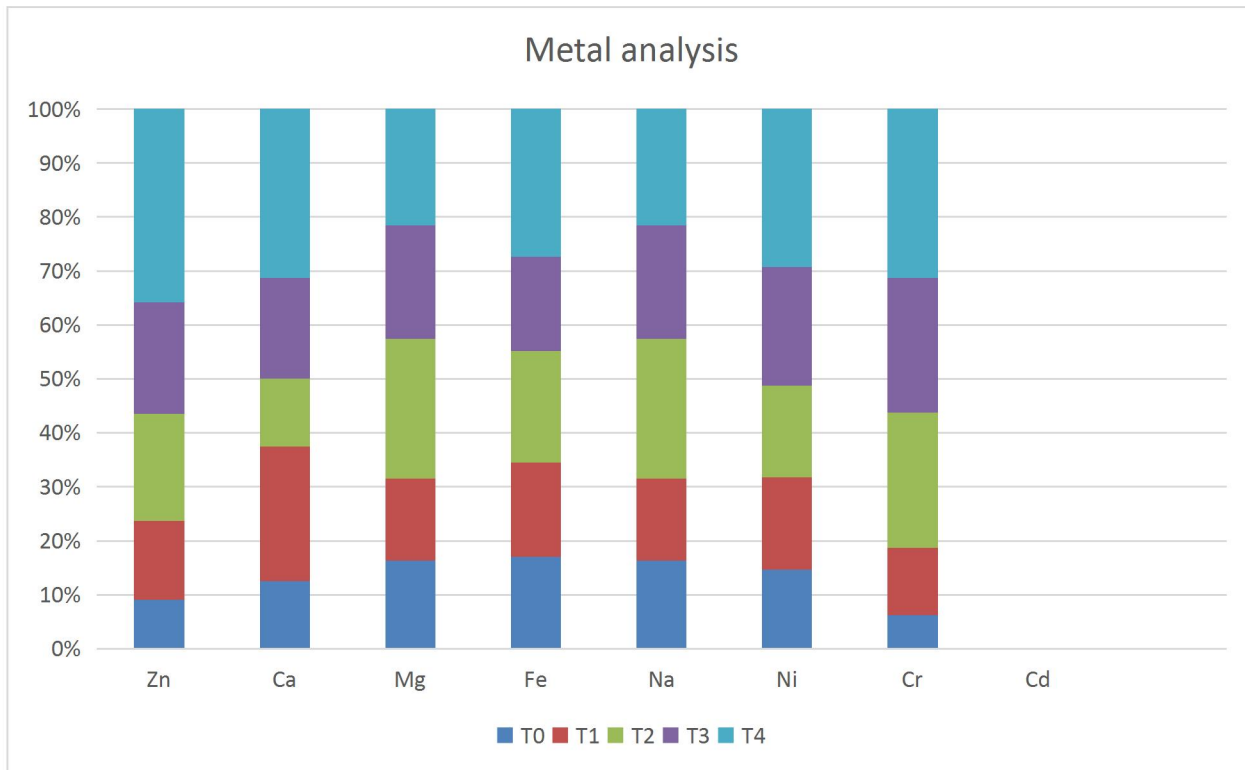


**Figure 3.3.** Copper composition of both untreated and treated Beans samples

### 3.4 METAL ANALYSIS

The chart below shows the mineral content of beans treated with various Sniper concentrations, including essential elements (Zn, Ca, Mg, Fe, Na) and trace metals (Ni, Cr, Cd), from fig 3.4 the

percentage of the minerals were seen to increase as the Concentrations of sniper increases when compared with the control.



**Figure 3.4 Metal Analysis**

## CHAPTER FOUR

### DISCUSSION

#### 4.1 PROXIMATE ANALYSIS

##### Overview

This study aimed at evaluating the effects of organochlorine pesticides on the nutritional value of beans, The major focus of this study is to determine the effects of organochlorine pesticides on the mineral constituents and proximate composition of beans such as % Moisture content,% Ash content,% Crude fibre, %ethyl extract and %nitrogen free extract as well as heavy metals lead and copper using atomic absorption spectrophotometry (AAS) by comparing the nutritional composition of a control sample (T0) with three treated samples (T1, T2, and T3) with varying concentrations of sniper (10%, 20%, and 50%)

##### Interpretation of findings

From the results of study, moisture Content increases with increasing sniper concentration, suggesting that sniper treatment may enhance water retention capacity of beans. Ash Content remains relatively stable across treatments, indicating minimal impact on mineral content. Protein content increases in T1 and T2, but decreases slightly in T3, suggesting optimal protein retention at moderate sniper concentrations. Ethyl extract Increases with sniper treatment, potentially indicating enhanced extraction of bioactive compounds. Crude fibres increases with sniper treatment, suggesting improved fibre content. NFE (Nitrogen-Free Extract) Decreases with sniper treatment, potentially indicating reduced starch or sugar content.

Sniper treatment appears to impact nutritional composition, particularly moisture, protein, and fibre content and optimal sniper concentration for protein retention seems to be between 10-20%. Increased fibre content could be beneficial for digestive health. The proximate analysis suggests that sniper treatment can alter the nutritional composition of the samples, with varying effects depending on concentration. These findings could have implications for food processing, animal feed formulation, or other applications where nutritional content is critical.

### **Protein and Proximate Composition**

In this study, Sniper treatment caused mixed effects on bean nutrition: low-to-moderate Sniper doses (10 to 20%) slightly increased protein content and fiber, while high doses (50%) saw a small decline in protein (though still above the untreated control). In contrast, most prior studies report consistent declines in nutrients with such pesticides. For example, Tizhe *et al.* (2021) treated cowpea with increasing Sniper concentrations and reported monotonic decreases in protein, fat, and fiber content, as well as reduced moisture over time.

In their study, cowpea protein fell from 26.2% to 22.8% as Sniper dose increased, and all proximate parameters (protein, fat, fiber) decreased significantly with higher pesticide (also ash and carbohydrates increased)

Similarly, an independent review notes Sniper reduced cowpea fat, protein, and fiber while raising ash and carbohydrates. By comparison, this study showed protein increases at low doses and only a minor drop at the highest dose, a pattern opposite to Tizhe's. Likewise, this study observed an increase in crude fiber with Sniper, whereas Tizhe saw a decrease in fiber. In short,

this study's results disagree with the cowpea study and general reports that pesticides tend to degrade legume nutrition. This discrepancy may reflect differences in species (Phaseolus beans vs. Vigna cowpea), exposure conditions (immediate mixing vs. 30 to 60 day storage), or analytical methods. It suggests that Sniper's impact on bean protein and proximate nutrients can vary.

### **Heavy Metal (Pb, Cu) Accumulation**

In this study we detected a rising trend of heavy metals: lead went from 0 (undetectable) in controls to 0.03 mg/L in beans treated with 50% Sniper, and copper rose above the control's 0.09 mg/L level. Direct literature on pesticide-driven Pb/Cu uptake in beans is scarce. However, it is known that pesticide formulations can introduce metal contaminants. Rashid *et al.* (2023) review that many insecticides/fungicides (especially older formulations) contain heavy metals as active ingredients or impurities

For instance, historical insecticides included lead arsenate and copper acetoarsenite, and modern analyses have found Pb, Cu, Zn, Cr etc. as contaminants in pesticide products. Thus, Sniper itself might carry trace metals or could mobilize soil metals during treatment. In practice, however, beans typically accumulate lead from environmental sources. In a study from Marković *et al.* (2010) found that vegetables from polluted areas had Pb levels exceeding safety limits, often due to industrial emissions. In this experiment the absolute Pb was very low (0–0.03 mg/L). Notably, the FAO/WHO limit for Pb in grains is 1.0 mg/kg, so the treated beans Pb is below that threshold, though any increase is concerning given that no lead exposure is entirely safe.

## **Mineral Content (Zn, Ca, Mg, Fe)**

The this study, we found that zinc, magnesium, iron, and sodium in beans tended to increase with higher Sniper doses, while calcium showed a fluctuating pattern (peaking at moderate dose). These trends partially align with other reports. In Tizhe *et al.* (2021), cowpea minerals (P, Ca, Mg, K) rose with higher Sniper concentration and storage time. Their data showed Ca and Mg significantly higher at 60 days with more Sniper, mirroring this study Zn and Mg increases. In general, several studies note that mineral levels can concentrate when pesticides dehydrate or stress seeds.

The agreement with Tizhe (increased minerals) suggests Sniper may tend to concentrate certain nutrients in legumes over time. The disagreement on calcium (this study saw non-monotonic Ca changes) highlights variability. Overall, the literature on mineral effects is mixed: some studies (including Tizhe's cowpea) found increases in mineral content with Sniper

## **Clinical Implications**

The results of this study have several clinical implications for human health, particularly in relation to nutrition and food safety. The changes in protein content and potentially altered amino acid profiles may impact the nutritional quality of beans as a protein source. This could be particularly significant for individuals relying heavily on beans as a protein source, the increase in crude fibre content could have beneficial effects on digestive health, satiety, and blood sugar control. However, high fibre intake can also lead to gastrointestinal discomfort or interact with certain medications, any changes in nutrient composition may impact the overall nutritional balance of beans. This could be particularly significant for individuals with specific dietary requirements or restrictions.

## **Implications for Food Safety**

The use of sniper (an insecticide) may lead to toxic residues on beans, potentially posing health risks to consumers. This highlights the importance of proper pesticide use and regulation. The increased moisture content in treated beans may enhance the growth of microorganisms, potentially leading to foodborne illnesses, changes in protein composition or structure may lead to increased allergenicity or altered immune responses. Exposure to sniper residues or other contaminants may pose health risks, particularly with long-term consumption.

## **Implications on Vulnerable Populations**

Vulnerable populations, such as pregnant women, children, older adults, and individuals with compromised immune systems or chronic diseases, may be disproportionately affected by changes in the nutritional composition or potential contamination of beans treated with sniper. Changes in nutrient composition may lead to deficiencies in essential nutrients, potentially impacting fetal development. Prolong exposure to sniper residues may pose risks to fetal development, including birth defects or developmental delays

Children and adolescents have high nutrient requirements for growth and development, any changes in nutrient composition may impact their nutritional status required for growth and development. Children and adolescents may be more vulnerable to the effects of toxins, including sniper residues, due to their developing bodies

The population of older adults may be more susceptible to nutrient deficiencies due to age-related changes in nutrient absorption and utilization. Older adults with chronic diseases may be more vulnerable to the effects of changes in nutrient composition or potential contamination. Individuals with compromised immune systems, such as those with HIV/AIDS or undergoing

chemotherapy, may be more susceptible to foodborne illnesses, any changes in nutrient composition may exacerbate existing nutrient deficiencies, potentially compromising immune function.

Individuals with chronic diseases, such as diabetes or kidney disease, may need to manage their nutrient intake carefully. Changes in nutrient composition may impact their disease management, exposure to sniper residues may exacerbate existing health conditions or interact with medications.

## **4.2 HEAVY METALS ANALYSIS**

The results show the levels of lead and copper in beans treated with varying concentrations of sniper, using atomic absorption spectrophotometry (AAS)

### **Interpretation of findings**

The results suggest that sniper treatment leads to an increase in both lead and copper content in beans. This could be due to the fact that sniper may contain heavy metals, which are then absorbed by the beans or may lead to increased heavy metal uptake from the soil. This implies that, the presence of heavy metals in food crops can pose health risks to consumers. The levels of lead and copper in treated beans should be evaluated against regulatory limits to ensure food safety.

### **Clinical Implications of Lead and Copper**

Lead and copper are essential and non-essential heavy metals, respectively, that can have significant clinical implications for human health.

#### **Lead (Pb)**

Lead is a toxic metal that can cause a range of health problems, including: Neurological damage (e.g., cognitive impairment, developmental delays), cardiovascular disease (hypertension, cardiac failure, Coronary heart disease etc. kidney damage reproductive issues such as infertility, liver cirrhosis. Vulnerable populations Children, pregnant women, and individuals with pre-existing medical conditions are particularly susceptible to lead toxicity. Lead poisoning can cause non-specific symptoms, such headaches, abdominal pain fatigue and constipation Lead is classified as a probable human carcinogen by the International Agency for Research on Cancer (IARC), meaning it likely plays a role in causing cancer. Research suggests that prolonged lead exposure is associated with an increased risk of developing various types of cancer, including Gastrointestinal tract cancers( Stomach cancer, Colon cancer, urinary system cancers, kidney cancer, bladder cancer).Other potential cancer risks are lung cancer (evidence is restricted and may be influenced by confounding factors like arsenic exposure).

The exact mechanisms by which lead induces cancer are not fully understood but may involve, oxidative damage to cell's DNA, directly or indirectly damage DNA, leading to mutations and cancerous cell growth, interfere with normal cell function and DNA repair processes. The population that are mostly vulnerable to lead toxicity are the pregnant women, infant and children the older population, population with liver or kidney impairment.

### **Copper (Cu)**

Copper is an essential nutrient that plays a crucial role in various bodily functions, including, connective tissue health, immune function, neurotransmitter synthesis despite its health benefits, excessive copper intake can cause, gastrointestinal symptoms (e.g., nausea, vomiting, diarrhea), liver damage, kidney damage, neurological symptoms (e.g., tremors, seizures), Copper toxicity

can cause a range of symptoms, including, abdominal pain, jaundice, hemolysis (red blood cell destruction)

The presence of lead and copper in beans can pose health risks to consumers, particularly if consumed in excess, it is essential to conduct thorough risk assessments to determine the potential health risks associated with consumption of beans contaminated with lead and copper. Beans are an important source of protein and fiber in many diets. However, individuals with concerns about lead or copper intake may need to consider alternative sources or cooking methods to minimize exposure.

#### **4.3 MINERAL ANALYSIS**

The mineral analysis results presented in Table 3 show the effects of different concentrations of Sniper on the mineral composition

##### **Interpretation of findings**

From the results of Minerals analysis, it can be deduce Zinc (Zn) Concentration increases with increasing Sniper concentration with the highest value (2.29 mg/L) at 50% Sniper treatment (T4) and the lowest value (0.58 mg/L) in the control sample (T0), Calcium (Ca) values fluctuate, with the highest concentration (28.80 mg/L) at 20% Sniper treatment (T2) and the lowest (17.00 mg/L) at 10% Sniper treatment (T1), Magnesium (Mg) Concentrations vary with the highest value (6.60 mg/L) at 50% Sniper treatment (T4) and the lowest (4.10 mg/L) in the control sample (T0). Iron (Fe) values increase with Sniper concentration, with the highest concentration (28.80 mg/L) at 20% Sniper treatment (T2) and the lowest (18.10 mg/L) in the control sample (T0), Sodium (Na) concentration increases with Sniper concentration, with the highest value (0.12 mg/L) at 50%

Sniper treatment (T4) and the lowest (0.06 mg/L) in the control sample (T0). Ni (Nickel) and Cr (Chromium) concentrations are relatively low, with slight increases at higher Sniper concentrations and Cd (Cadmium) was Not detected in any sample.

Sniper treatment affects mineral composition, with varying effects on different minerals. Increasing Sniper concentration generally increases Zn, Mg, Fe, and Na concentrations, calcium and Chromium concentrations show fluctuating trends. Nickel concentrations remain relatively low across treatment. The mineral analysis results indicate that Sniper treatment alters mineral composition, with varying effects on different minerals. Further research is necessary to understand the implications of these findings and the underlying mechanisms.

### **Possible mechanism**

Several mechanisms could contribute to the observed changes in mineral composition, the effects of on the mineral composition of beans may be, sniper may contain minerals or compounds that introduces Zn, Mg, Fe, and Na into the system, these minerals could be inherent to the formulation or result from manufacturing processes. Sniper might alter the pH of the environment, affecting mineral solubility and availability, changes in pH could increase the mobility of certain minerals, leading to increased concentrations. Sniper or its degradation products might form complexes or chelates with minerals, influencing their solubility and bioavailability and this could enhance or reduce mineral mobility, depending on the specific interaction, Sniper or its degradation products might interact with surfaces or particles, exchanging ions or adsorbing mineral, and this could affect mineral availability and distribution.

### **Clinical implications**

Despite that, zinc and iron may be required for the normal function of the body system for example, Zinc is required for the activation of many enzyme in the system, required by the immune system, needed for maintenance of the skin where it can act as an anti-inflammatory and can be used to prevent diarrhea, while iron is the major elements required for the formation of hemoglobin. However, exposure to the toxic level of these Minerals could detrimental to health or subject the system to serious adverse reaction for example, zinc can cause gastrointestinal issues like nausea, vomiting, stomachache, and diarrhea, may lead to copper deficiency, impairing iron absorption and metabolism, it can also reduce HDL (good) cholesterol levels and weaken immune function, may cause neurological problems and anemia in severe cases. While iron toxicity, can lead to gastrointestinal symptoms like nausea, vomiting, and abdominal pain, may cause organ damage and failure in severe cases, can lead to hemochromatosis, a condition characterized by excessive iron accumulation in the body.

Sodium was also seen to have increased in concentration due to the increase in sniper concentration, and this may have health implications, Sodium is an essential nutrient, but excessive intake can have negative health effects. Sodium helps regulate fluid balance in the body, sodium plays a role in nerve function and transmission of impulse, and it is also helps regulate muscle contraction and relaxation. High sodium intake can increase blood pressure, leading to cardiovascular disease, excessive sodium consumption is linked to increased risk of heart disease, stroke, and cardiac failure. High sodium intake can strain kidney function and worsen kidney disease, fluid buildup in the body, swelling and discomfort, may also be the result of high intake of sodium. Risk populations are individuals with hypertension, those with kidney disease or kidney failure, heart failure patients and older adults.

## **Limitations of study**

Sample size, which could impact the generalizability of the finding. The experimental design of the study might not account for all potential variables or confounding factors. The study may only have a few data points, which could limit the ability to detect significant differences or trends. There might be potential measurement errors or variability.

Laboratory or greenhouse studies might not accurately represent real-world conditions, limited sample size could impact statistical power and generalizability, potential biases in experimental design or sampling methods. Weather, soil type, and other environmental factors could influence Sniper's effects. Studies might focus on specific regions or climates, limiting applicability to other areas, different bean varieties might respond differently to Sniper and studies might only examine a single or few varieties of beans.

## CHAPTER FIVE

### CONCLUSION

The study on the effects of organochlorine pesticides on mineral composition, heavy metals, and proximate composition reveals concerning findings include, alteration of the mineral profiles in beans, potentially affecting nutritional value, changes in mineral composition might impact human health and soil fertility. Presence of heavy metals in beans, posing potential health risks to consumers, bioaccumulation of heavy metals in beans could have long-term environmental and health implications. Changes in proximate composition (e.g., protein, carbohydrate, fat content) might affect bean quality and nutritional value.

#### 5.1 Recommendations

Various processes are required to minimize this gross degradation of the nutritional content of beans so as to ensure safety maximize the nutritional values in beans, first of all, implementation of integrated pest management strategies to reduce reliance on organochlorine pesticides. Promoting organic farming practices to minimize pesticide use ensures stability of the nutritional value of beans and rotating crops to break pest cycles and reduce pesticide use since pest is the major reason for the use of pesticides to ensure food safety.

Regularly monitor pesticide residues on beans to ensure safety, Washing of beans thoroughly and use of proper processing techniques to minimize pesticide residue minimize the exposure of beans to organochlorine pesticides by choosing organic or locally grown beans when possible, other important policy and research can also ensure safety in Beans consumption, such as strengthening regulatory frameworks to limit organochlorine pesticide use, supporting research on safer, more

sustainable pest control alternative, educating general public about the risks associated with organochlorine pesticides and promote safe food handling practices.

By implementing these recommendations, we can reduce the risks associated with organochlorine pesticide exposure and promote a healthier, more sustainable food system.

## **5.2 Contribution to knowledge**

This study contributes to the existing body of knowledge the study provides an insights into how organochlorine pesticides affect the nutritional composition of beans, highlighting potential risks to human health, by analyzing pesticide residues and their effects on bean quality, the study informs risk assessment and management strategies for food safety the findings can inform policy decisions on pesticide use, agricultural practices, and food safety standards, promoting safer and more sustainable practices, raising awareness among consumers, farmers, and policymakers about the potential health and environmental impacts of organochlorine pesticides, encouraging more informed choices. These study identifies the gaps in knowledge and areas for further research, guiding future studies on pesticide impacts on food safety and human health, contributing to the understanding of organochlorine pesticide effects on beans, this study supports efforts to ensure food safety, protect public health, and promote sustainable agricultural practices.

## REFERENCES

- Ademulegun, T. I., Akinrinmade, I., Alebiosu, I. A. & Adedayo, E. O. (2024) 'Effect of processing method on proximate, mineral and anti-nutrients composition of complementary foods produced from maize, soybean and pumpkin seed', *Asian Journal of Food Research and Nutrition*, 3(2), pp. 358-370. [journalajfrn.com](http://journalajfrn.com)
- Adeyemi, J. A., & Adesiyan, A. C. (2015). Occurrence and levels of potentially toxic metals and organochlorine pesticide residue in leguminous food crops from selected markets in Ibadan, Nigeria. *Journal of Environmental Science and Health, Part B*, 50(10), 703-713.
- Alengebawy, A., Abdelkhalek, S. T., Qureshi, S. R., & Wang, M. Q. (2021). Heavy metals and pesticides toxicity in agricultural soil and plants: Ecological risks and human health implications. *Toxics*, 9(3), 42.
- Bempah, C. K., & Asomaning, J. (2017). Organochlorine pesticide residues in beans from Ghana. *Journal of Environmental Science and Health, Part B*, 52(10), 721-729.
- Borges, R. de S., Soares, L. W. O. & Ventura, R. A. (2024) 'Development of a low cost alternative method for lipid extraction and quantification in food', *Research, Society and Development*, 9(10), article 8927. [rsdjournal.org](http://rsdjournal.org)
- Edet, I. V., Akpomie, T. M., Augustine, A. U., Samoh, T. F., Ekam, E. J. & Nzeqbuna, D. D. (2023) 'Comparative analysis on the proximate composition of processed cassava products obtained from January to March, 2023 in Lafia town, Nigeria', *Chemical Science International Journal*, 32(4), pp. 50-63. [journalcsij.com](http://journalcsij.com)
- Hassan, A. A., & El-Saeid, M. H. (2018). Organochlorine pesticide residues in beans from Saudi Arabia. *Journal of Environmental Science and Health, Part B*, 53(10), 670-678.
- AOAC (2016). *Official Methods of Analysis*. 20th ed. Association of Official Analytical Chemists, Washington DC

- Iqbal, M. F., & Feng, Y. (2019). Bioremediation of co-contaminated soil with heavy metals and pesticides: A review. *Environmental Science and Pollution Research*, 26(20), 20613-20626.
- Iwegbue, C. M., & Nwajei, G. E. (2017). Effects of organochlorine pesticides on the mineral composition of beans. *Journal of Food Science and Technology*, 54(10), 3411-3419.
- Karami-Mohajeri, S., & Abdollahi, M. (2011). Toxic influence of organophosphate, carbamate, and organochlorine pesticides on cellular metabolism of lipids, proteins, and carbohydrates: A systematic review. *Human & Experimental Toxicology*, 30(9), 1119-1140.
- Kumar, A., & Singh, S. (2019). Effects of organochlorine pesticides on the heavy metal composition of beans. *Journal of Environmental Science and Health, Part B*, 54(10), 531-538.
- Liu, X., Zhang, Q., Li, Y., & Wang, J. (2020). Organochlorine pesticides and heavy metals in food crops from agricultural fields in China: Occurrence, source, and risk assessment. *Environmental Science and Pollution Research*, 27(20), 25313-25324.
- Mnif, W., Hassine, A. I., Bouaziz, A., Bartegi, A., & Thomas, O. (2011). Effect of endocrine disruptor pesticides: A review. *International Journal of Environmental Research and Public Health*, 8(6), 2265-2303.
- Nduka, J. K., & Orisakwe, O. E. (2019). Effects of organochlorine pesticides on the proximate composition and mineral content of beans. *Journal of Food Science and Technology*, 56(10), 4523-4531.
- Abolhassani, M., Asadikaram, G., Paydar, P., Fallah, H., Aghaee-Afshar, M., Moazed, V., Akbari, H., Moghaddam, S. D., & Moradi, A. (2019). Organochlorine and organophosphorous pesticides may induce colorectal cancer; a case-control study. *Ecotoxicology and Environmental Safety*, 178, 168-177.
- Beyuo, J., Sackey, L. N. A., Yeboah, C., *et al.* (2024). The implications of pesticide residue in food crops on human health: a critical review. *Discovery Agriculture*, 2, 123. (link unavailable)
- Gupta, R. C. (2017). Toxicity of pesticides. In *Lu's Basic Toxicology* (pp. 453-485). CRC Press.

Karunamoorthi, K., & Sabesan, S. (2013). Insecticide resistance in insect vectors of disease with special reference to mosquitoes: a potential threat to global public health. *Health Scope*, 2(4), 157-165.

Qin, G., Chen, Y., He, F., Yang, B., Zou, K., Shen, N., Zuo, B., Liu, R., & Zhang, W. (2021). Risk assessment of fungicide pesticide residues in vegetables and fruits in the mid-western region of China. *Journal of Food Composition and Analysis*, 95, 103663.

Vale, A., & Lotti, M. (2015). Organophosphorus and carbamate insecticide poisoning. *Handbook of Clinical Neurology*, 131, 149-168.

World Health Organization (WHO). (2022). Pesticide residues in food.

WHO (2019). Dietary exposure to pesticides and human health: A review of the evidence. World Health Organization.

FAO/WHO (2019). Pesticide residues in food. Food and Agriculture Organization of the United Nations/World Health Organization.

Kumar, P. and Kumar, A. (2019). Pesticide-induced changes in the nutritional quality of food crops: A review. *Journal of Food Science and Technology*, 56(4), pp. 1824-1834.

Liu, X. and Zhang, Y. (2020). Heavy metal contamination in agricultural products: A review of the current status and future directions. *Environmental Science and Pollution Research*, 27(10), pp. 11551-11564.

Sharma, R.K. and Agrawal, M. (2019). Pesticide residues in food and their impact on human health: A review. *Journal of Environmental Science and Health, Part B*, 54, pp. 201-212. Singh, S. and Singh, N. (2019). Heavy metal toxicity in food crops: A review of the sources, effects, and mitigation strategies. *Environmental Science and Pollution Research*, 26(1), pp. 351-364.

Zhang, W. and Zhang, X. (2020). Pesticide-induced oxidative stress and antioxidant defense in plants: A review. *Environmental Science and Pollution Research*, 27(15), pp. 18031-18044.

Tizhe, T.D. *et al.* (2021) “Evaluation of the Effect of Using 2, 3-dichlorovinyl dimethylphosphate (Sniper) as Storage Insecticide on Quality of Cowpea Nutritional Content,” *European Journal of Biology and Biotechnology*, 2(4), pp.6–10

Rashid, A. *et al.* (2023) “Heavy Metal Contamination in Agricultural Soil: Environmental Pollutants Affecting Crop Health,” *Agronomy*, 13(6), 1521

Ali, D. and Kumar, S. (2018) ‘Toxicological impacts of organophosphate pesticides: A review’, *Environmental Science and Pollution Research*, 25(9), pp. 8180–8190.

Burg, R.W. and Miller, R.S. (2020) ‘Avermectins: Biological origins and mechanisms of insecticidal action’, *Applied Microbiology and Biotechnology*, 104(7), pp. 2933–2944.

Crouse, G.D., Sparks, T.C. and Garczynski, S.F. (2018) ‘Spinosyns: Chemistry, mode of action, and resistance management’, *Pesticide Biochemistry and Physiology*, 151, pp. 41–50.

Hodoşan, C., Ivascu, A. and Soran, M. (2023) ‘Pyrethrins and pyrethroids: A comprehensive review of naturally occurring compounds and their synthetic derivatives’, *Plants*, 12(23), p. 4022.

Khan, M.A. and Akram, W. (2021) ‘Toxicity and environmental implications of carbamate insecticides: An updated review’, *Chemosphere*, 268, p. 129273.

Khan, A., Naz Talpur, F., Bhangar, M. I., Musharraf, S. G. & Afridi, H. I. (2021) ‘Extraction of fat and fatty acid composition from slaughterhouse waste by evaluating conventional analytical methods’, *American Journal of Analytical Chemistry*, 12, pp. 202-225. SCIRP

Lahm, G.P., Cordova, D. and Barry, J.D. (2020) ‘New and selective ryanodine receptor activators for insect control’, *Pesticide Biochemistry and Physiology*, 170, p. 104679.

Martínez-Ávila, A.E., Rojas-Padilla, C. and Pineda, A. (2024) ‘A review of the adverse effects of neonicotinoids on the environment’, *Environments*, 11(9), p. 196.

Methods for the Extraction of Organic Compounds: 1. Solvent Extraction (2024) ‘Review of reviews’, *Journal of Analytical Chemistry*, 79, pp. 999-1010. SpringerLink

Oke, E. K. *et al.* (2023) ‘Proximate composition and sensory acceptability of cowpea-based pudding produced from cowpea cultivated using different weed control methods’, *Acta Universitatis Sapientiae, Alimentaria*, 16(1), pp. 49-62.

Sparks, T.C. and Nauen, R. (2017) ‘Mechanisms of insecticide resistance and prospects for resistance management’, *Pesticide Biochemistry and Physiology*, 151, pp. 61–77.

Wing, K.D. and Sparks, T.C. (2020) ‘Oxadiazine insecticides: Mode of action and toxicological profiles’, *Journal of Agricultural and Food Chemistry*, 68(3), pp. 521–530.

Zhang, L., Wang, Q. and Li, J. (2019) ‘Insect growth regulators: Modes of action and application prospects’, *Pesticide Biochemistry and Physiology*, 158, pp. 84–92

Akibode, S. and Maredia, M.K. (2021) ‘Global and regional trends in production, trade and consumption of food legume crops’, *FAO Research Working Paper Series*, Food and Agriculture Organization of the United Nations.

Assefa, T., Mahama, A.A., Brown, A.V., Cannon, E.K.S., Rubyogo, J.C., Rao, I.M., Blair, M.W., Cannon, S.B. and Beebe, S.E. (2019) ‘A review of breeding objectives, genomic resources, and molecular breeding approaches for common bean (*Phaseolus vulgaris*)’, *Frontiers in Plant Science*, 10, p. 1506.

Boukid, F. and Rosell, C.M. (2021) ‘Impact of legumes on nutritional quality and health benefits of bakery products: A review’, *Critical Reviews in Food Science and Nutrition*, 61(6), pp. 1152–1168.

Egbadzor, K.F., Osei, M.K., Ofori, K., Danquah, E.Y. and Tetteh, J.P. (2021) ‘Cowpea production constraints and breeding strategies for improved varieties in sub-Saharan Africa’, *Agronomy*, 11(5), p. 980.

Kang, Y., Dempewolf, H., Hill, L. and Ellis, D. (2021) 'Global conservation and use of plant genetic resources of legumes for sustainable agriculture', *Plants*, 10(3), p. 488.

Nascimento, A.C., Mota, C., Coelho, I., Gueifão, S., Santos, M., Matos, A.S., Gimenez, A., Lobo, M. and Samman, N. (2022) 'Nutritional composition and protein quality of dry beans from different origins', *Food Chemistry*, 366, p. 130685.

Nduka, J.K. and Orisakwe, O.E. (2019) 'Assessment of organochlorine pesticides and heavy metals in Nigerian beans and associated health risks', *Environmental Science and Pollution Research*, 26(24), pp. 24769–24779.

Saxena, K.B., Kumar, R.V. and Sultana, R. (2023) 'Role of legumes in sustainable agriculture and environmental protection', *Legume Research: An International Journal*, 46(1), pp. 1–8.

Yadav, S.S., Redden, R., Chen, W. and Sharma, B. (2020) 'Chickpea breeding and management: Improving productivity under changing climatic conditions', *Agriculture*, 10(5), p. 187.

Zhou, Y., Xu, J. and Zhang, L. (2020) 'Advances in soybean research: From breeding to biotechnology', *Frontiers in Plant Science*, 11, p. 1156.

## TABLE OF RESULTS

### PROXIMATE COMPOSITION

<b>Proximate Analyzed</b>	<b>T0 (Control) 0%</b>	<b>T1 (Treated with 10% sniper)</b>	<b>T2 ( Treated with 20% sniper)</b>	<b>T3 (Treated with 50% sniper)</b>
% Moisture content	9.4	11.9	14.17	14.68
% Ash content	3.86	3.54	3.50	3.97
% Protein content	16.93	18,73	19.50	18.80
% Ethyl extract	0.48	0.65	1.11	1.00
% Crude fibres	14.23	18.47	18.63	19.50
% NFE	54.87	46.37	42.97	42.84

### HEAVY METAL ANALYSIS

<b>Samples analyzed</b>	<b>Lead</b>	<b>Copper</b>
T0 (Control)	0.00	0.09
T1 (Treated with 10% sniper)	0.01	0.14
T2 (Treated with 20% sniper)	0.02	0.17

T3 (Treated with 505 sniper)	0.03	0.27
------------------------------	------	------

### METAL ANALYSIS

SAMPLE ANALYSED Label	RESULTS in Mg/L							
	Zn	Ca	Mg	Fe	Na	Ni	Cr	Cd
<b>T0</b>	0.58	0.20	18.10	4.10	18.10	0.06	0.01	0.00
<b>T1</b>	0.93	0.40	17.00	4.20	17.00	0.07	0.02	0.00
<b>T2</b>	1.27	0.20	28.80	5.00	28.80	0.07	0.04	0.00
<b>T3</b>	1.32	0.30	23.30	4.20	23.30	0.09	0.04	0.00
<b>T4</b>	2.29	0.50	24.00	6.60	24.00	0.12	0.05	0.00

KEYS;

T0: Control

T1: Treated with 10% Sniper.

T2: Treated with 20% Sniper.

T3: Treated with 50% Sniper.

