Comparative GC-MS Analysis of the Chemical Profile of Beans (*Phaseolus vulgaris*): Impact of Sniper (Dichlorvos) Contamination and Cooking Methods

Abstract

Aim: The aim of this research is to compare the chemical profiles of black eyed beans (*Phaseolus vulgaris*) subjected to different treatments (dichlorvos contamination, black water extraction, and cooking methods) to identify and evaluate natural components, harmful contaminants, and assess their safety, quality, and potential health implications using GC-MS analysis.
Study Design: An experimental design involving hexane extraction, GC-MS analysis, and comparative profiling of black eyed beans subjected to different treatments to evaluate natural components and harmful contaminants.
Place and duration of study: The study was conducted at University of Africa, Toru-Orua, Nigeria, from February to August, 2024.
Method: Three (3) hexane extracts were prepared from cooked black eyed beans that were subjected to different treatments: Sample A (**As** received from the farmer and cooked to dryness), Sample B (Dichlorvos contaminated, black water extracted, and cooked to dryness), and Sample C (Dichlorvos contaminated, and cooked to dryness). The extracts were analyzed using Gas Chromatography-Mass Spectrometry (GC-MS) to identify and quantify chemical components. Identified compounds were categorized as natural components or contaminants based on their chemical properties and potential health implications.
Results: A total of 43, 51, and 31 compounds were identified in Samples A, B, and C, respectively. Natural components included Prenol (90.0%), a terpenoid alcohol vital for plant metabolism, Benzaldehyde, 2-methyl (70.5%), associated with flavor and defense mechanisms, Benzeneacetaldehyde (88.9%), and o-Cymene (61.8%), contributing to beans' aroma. These compounds highlight the presence of essential metabolic and aromatic components in beans.
However, harmful contaminants were also detected. Benzene (81.9%) and its derivatives, including Benzene, 1-ethyl-3-methyl (68.6%) and Benzene, 1-methyl-3-propyl (70.4%), were identified. Toluene (80.5%), a benzene derivative, was also found and is known for its neurological and respiratory health risks. Other contaminants included 2-Propenoic acid, 2-propenyl ester (92.6%), a skin and respiratory irritant, and 1,3-Butadiene, 2-fluoro (97.0%), a carcinogenic compound. Additional toxic compounds, such as Cyclohexanone, 2-ethyl (90.1%) and Decane, 5-methyl (85.2%), were present, some of which are linked to post-harvest contamination.
These findings underscore the dual presence of beneficial natural components and harmful contaminants, emphasizing the need for improved post-harvest practices to ensure food safety and quality.

Keywords: *GC-MS, Beans, dichlorvos, natural components, contaminants, health implication*

1. **INTRODUCTION**

Legumes, members of the *Leguminosae* family, are classified into three subfamilies: *Papilionoideae*, *Caesalpinioideae*, and *Mimosoideae*. Among these, the subfamily *Papilionoideae* predominantly encompasses edible legume crops such as soybean, chickpea, bean, and pea [1, 2]. Historically, legumes have served as vital sources of nutritional security, particularly during periods of food scarcity, owing to their remarkable durability when properly dried and stored [3, 4]. Black-eyed beans (*Phaseolus vulgaris*), illustrated in Figure 1, are widely recognized for their ease of cultivation and resilience. Furthermore, they are esteemed as an excellent dietary source of protein, contributing significantly to food systems and nutritional health [5-7].

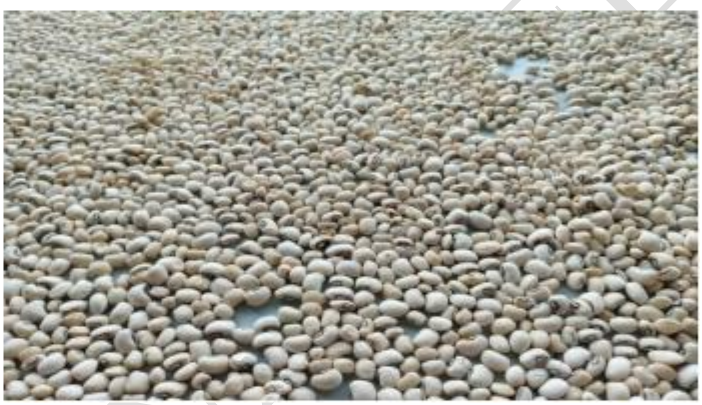

Figure 1: Freshly harvested black eyed beans

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Common beans, often referred to as the "poor man's meat" in Eastern Africa, serve as a critical source of protein for the majority of households. They play a significant role in human nutrition, food security, and income generation for small-scale farmers [8-9]. In many regions, beans are grown seasonally, and after harvesting, they are stored under safe conditions to maintain their quality throughout the season. Proper storage ensures a consistent food supply, availability of seeds for subsequent planting seasons, and surplus produce for income generation [10-11].

The quality of stored beans is influenced by several factors, including initial grain condition, storage conditions, moisture content, and susceptibility to insect pests, bacterial, and fungal infestations. Among these, insect pests pose the most significant threat to stored beans, impacting both their quality and quantity [12-13]. Among the various bruchid species, the common bean weevil (Acanthoscelides obtectus Say) and Zabrotes subfasciatus Boh. are particularly notorious for causing substantial post-harvest damage. Their presence in stored beans results in a considerable reduction in both the quality and quantity of the produce [14-15].

Chemical control methods, including the use of pesticides, are a key component of Integrated Pest Management (IPM) programs. These methods aim to reduce pest populations (insects, pathogens, rodents, etc.) to levels that do not adversely affect crop yield and quality [16]. The modern era of pesticide usage began with the discovery of highly effective compounds such as dichlorodiphenyltrichloroethylene (DDT) and organophosphate (OP) insecticides [17].

Dichlorvos (2,2-dichlorovinyldimethylphosphate), an organophosphate pesticide was first introduced in 1961 [18]. It has the molecular formula, $C_4H_7Cl_2O_4P$ and molecular weight, 220.98 g/mol. Dichlorvos has a boiling point of 140 °C and a vapor pressure of 1.6 Pa at 20°C [19].

Dichlorvos is categorized as a highly hazardous (Class Ib) chemical [20]. It is a volatile compound, and exposure to it can result in acute or chronic toxicity. Inhalation is the most common route of acute toxicity, with symptoms primarily linked to cholinesterase inhibition [21]. Prolonged exposure to dichlorvos may lead to fatal outcomes. Organophosphates, including dichlorvos, act by inhibiting acetylcholinesterase – an enzyme essential for breaking down acetylcholine. In mammals, dichlorvos is primarily metabolized by esterases into dimethyl phosphate and dichloroacetaldehyde [19].

Although no human deaths have been directly attributed to inhalation of dichlorvos, Okoroiwu and Iwara [21] documented the case of a woman who died a day after ingesting dichlorvos. Another reported case involved a 19-month-old girl who succumbed after consuming a cake-like bait containing dichlorvos. In addition, two pesticide workers in Costa Rica reportedly died after spilling a dichlorvos-containing insecticide on their skin and failing to wash it off adequately [21].

In a study involving rats exposed to air containing high concentrations of dichlorvos (up to 34 ppm), all the animals died within three days [22]. Zhang and colleagues [23] reported that acute dichlorvos poisoning induces hemorheological abnormalities in rabbits through oxidative stress mechanisms. Aquatic studies have shown LC50 values ranging from 0.2 – 12 mg/L for freshwater and estuarine fish, indicating significant toxicity to aquatic life [24].

Respiratory irritation following dichlorvos exposure was reported in a study involving children [25]. This study highlighted a strong correlation between acute respiratory symptoms and dichlorvos exposure; however, the authors could not entirely rule out the potential irritant effects of the solvents used to disperse dichlorvos. An animal study investigating the acute toxic effects of inhaled dichlorvos vapor on respiratory mechanisms in guinea pigs revealed a significant decrease in respiratory frequency and

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a significant increase in tidal volume in animals treated with 35 mg/mL and 75 mg/mL concentrations [26]. A histological study on the lungs of rats exposed to dichlorvos demonstrated an extension of basal-associated lymphoid tissue (BALT) in rats exposed for one, four, and five weeks [27]. A study examining the effects of dichlorvos treatment on butyrylcholinesterase (BuChE) activity and lipid metabolism in rats reported a significant decrease in BuChE activity in both sexes of the rats. Furthermore, the study observed a significant increase in triglyceride levels (60–600 %) and total cholesterol (35–75%) [28].

Certainly, there is a plethora of reports on the toxic effects of dichlorvos on living organisms, but there is a limited knowledge on the chemical profile of dichlorvos-preserved crops. Therefore, this research aims to compare the chemical profiles of black eyed beans (*Phaseolus vulgaris*) subjected to different treatments (dichlorvos contamination, black water extraction, and cooking methods) to identify and evaluate natural components, harmful contaminants, and assess their safety, quality, and potential health implications.

2. MATERIALS AND METHODS

2.1 Chemicals and Reagents

Analytical grade chemicals, sourced from BDH and Labtech Chemicals, were utilized in this study without further purification.

2.2 Plant Collection and Identification

Freshly harvested raw black-eyed beans (*Phaseolus vulgaris*) were procured from Kogi, located in the Middle Belt of Nigeria. The plant samples were properly identified and

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authenticated at the Biological Sciences Department of the University of Africa, Toru-Orua, Nigeria.

2.3 Samples Treatments

1000 g of raw black-eyed bean seeds was weighed and split into three fractions labeled A, B, and C. The beans were air-dried for 14 days. The preparation of each sample is detailed as follows:

Sample A (Unadulterated Control)**:** The first fraction of the air-dried beans, labeled A was washed twice with 100 ml of distilled water and cooked to dryness for 60 minutes at 100 °C. The samples were air-dried for another 14 days, pulverized using an electric blender, and stored for subsequent analysis.

Sample B (Dichlorvos-Treated with Black Water Extraction)**:** 5 ml of sniper insecticide (dichlorvos) was evenly sprinkled onto the second portion, manually agitated for 5 minutes, and air-dried for 14 days. The treated beans were washed twice with 100 ml of distilled water and parboiled for 10 minutes at 100°C. The black water was extracted, after which 300 ml of distilled water was added, and the beans were boiled to dryness for 50 minutes at 100°C. The beans were air-dried for 14 days, pulverized using an electric blender, and stored for analysis.

Sample C (Dichlorvos contaminated, and cooked to dryness**)**: 5 ml of sniper insecticide (dichlorvos) was evenly sprinkled onto the third fraction, manually agitated for 5 minutes, and air-dried for 14 days. The treated beans were washed twice with 100 ml of distilled water and boiled to dryness for 60 minutes at 100 °C. The beans were then air-dried for 14 days, pulverized, and stored for analysis

2.4 Gas Chromatography-Mass Spectroscopy (GC-MS) Analysis

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GC-MS analysis of hexane extracts from black eyed beans subjected to different treatments: Sample A (**as** received from the farmer and cooked to dryness), Sample B (Dichlorvos contaminated, black water extracted, and cooked to dryness), and Sample C (Dichlorvos contaminated, and cooked to dryness) was performed using an Agilent 6890 gas chromatograph (GC) coupled with an Agilent 5973N mass spectrometer (MS). The system was equipped with an Agilent 7683 Series Automatic Liquid Sampler for automated sample introduction. Chromatographic separation was achieved using a META X5 fused silica capillary column (30 m × 0.25 mm internal diameter, 0.25 µm film thickness) with a maximum temperature of 325 °C.

The GC oven temperature program started at 70 °C, held for 2 minutes, and increased to 300 °C at a rate of 20 °C/min. Ultra-high-purity helium (99.99 %) was used as the carrier gas at a flow rate of 1.0 mL/min. A 1 µL sample volume was injected in split mode with a split ratio of 20:1. The injection port, transfer line, and ion source were maintained at 280 °C, while the source and quadrupole temperatures were set at 230 °C and 150 °C, respectively. Mass spectra were acquired over a scan range of 50 to 550 amu with electron ionization energy of 70 eV, and the electron multiplier voltage was autotuned.

2.5 Chemical Compounds Identification

Chemical compounds in the extracts were identified based on their retention times and by comparing the corresponding mass spectra against the NIST library (version 2014), which includes over 590,000 spectral patterns. Advanced computer algorithms facilitated the identification of molecular weights, molecular formulas, chemical

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structures, and fragmentation patterns. This method ensured precise characterization of the chemical constituents in the palm oil samples.

2.5 Statistical Analysis

Data obtained from Gas Chromatography-Mass Spectrometry (GC-MS) analyses were subjected to one-way analysis of variance (ANOVA) using SPSS version 21.0. All analyses were conducted in triplicate, and results are presented as mean values ± standard deviation.

3. RESULTS

The results of the study are presented in Tables 1–3, which detail the findings from the GC-MS analyses. Visual representations of the results are provided in Figures 2–7. These analyses offer comprehensive insights into the chemical composition of bioactive compounds in the three Phaseolus vulgaris samples (A, B, and C). The subsequent sections discuss the results obtained for each sample in detail.

Table 1: GC-MS analysis of bioactives in unadulterated cooked *Phaseolus vulgaris* powder (sample A)

S/N	Retention Time (min)	Bioactive compound	Probability percentage (%)	Molecular formula (MF)	Molecular weight (MW)
1.	1.270	2-Propenoic acid, 2-propenyl ester	92.6	$C_6H_8O_2$	112
2.	1.333	1,3-Butadiene, 2-fluoro	97.0	C_4H_5F	72
3.	1.409	Oxirane, propyl	96.8	$C_5H_{10}O$	86
4.	1.429	3-Penten-2-ol	92.2	$C_5H_{10}O$	86
5.	1.468	Prenol	90.0	$C_5H_{10}O$	86
6.	1.577	2-Pentyn-1-ol	87.5	C_5H_8O	84

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7.	1.774	Benzene	81.9	C_6H_6	78
8.	1.947	1,5-Hexadiyne	89.2	C_6H_6	78
9.	2.126	4-Pentynoic acid	97.7	$C_5H_6O_2$	98
10.	2.334	1-Pentene, 3,3-dimethyl	49.5	C_7H_{14}	98
11.	2.395	Cycloheptane	76.8	C_7H_{14}	98
12.	3.466	Cyclooctane	63.7	C_8H_{16}	112
13.	3.611	1,3-Cyclopentadiene, 5-(1-methylethylidene)-	82.8	C_8H_{10}	106
14.	3.702	Bicyclo[2.1.1]hex-2-ene, 2-ethenyl	83.1	C_8H_{10}	106
15.	3.748	Toluene	80.5	C_7H_8	92
16.	3.779	Cyclopropane, 1-methyl-2-pentyl	52.0	C_9H_{18}	126
17.	3.874	o-Xylene	65.8	C_8H_{10}	106
18.	3.897	Bicyclo[2.1.1]hex-2-ene, 2-ethenyl	83.1	C_8H_{10}	106
19.	3.990	Cyclohexane, 1,2,3-trimethyl	77.8	C_9H_{18}	126
20.	4.067	Pentalene, octahydro-1-methyl	77.1	C_9H_{16}	124
21.	4.121	Cyclohexanone, 2-ethyl	90.1	$C_8H_{14}O$	126
22.	4.183	4-Methyl-1,3-heptadiene	56.8	C_8H_{14}	110
23.	4.248	(Z)-4-Decen-1-ol, trifluoroacetate	67.4	$C_{12}H_{19}F_3O_2$	252
24.	4.275	Benzeneacetaldehyde	88.9	C_8H_8O	120
25.	4.334	Benzene, 1-ethyl-2-methyl	63.3	C_9H_{12}	120
26.	4.400	2-Nitro-1-phenyl-ethano	91.3	$C_8H_9NO_3$	167
27.	4.451	2,3-Heptadien-5-yne,	76.0	C_9H_{12}	120

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		2,4-dimethy			
28.	4.471	3-Hexene, 3-ethyl-2,5-dimethyl	91.2	$C_{10}H_{20}$	140
29.	4.554	Benzaldehyde, 2-methyl	70.5	C_8H_8O	120
30.	4.639	2-Piperidinone, N-[4-bromo-N-butyl]	82.0	$C_9H_{16}BrNO$	233
31.	4.666	Decane, 4-methyl	62.3	$C_{11}H_{24}$	156
32.	4.697	o-Cymene	61.8	$C_{10}H_{14}$	134
33.	4.724	Benzene, 1,2,4-trimethyl	65.7	C_9H_{12}	120
34.	4.763	Cyclohexane, butyl	82.7	$C_{10}H_{20}$	140
35.	4.853	Decane, 5-methyl	85.2	$C_{11}H_{24}$	156
36.	4.874	Benzene, 1-methyl-3-propy	70.4	$C_{10}H_{14}$	134
37.	4.904	Benzene, 1-ethyl-3,5-dimethyl	50.1	$C_{10}H_{14}$	134
38.	4.943	Naphthalene, decahydro	66.8	$C_{10}H_{18}$	138
39.	5.068	Benzene, 1-ethyl-2,3-dimethyl	53.7	$C_{10}H_{14}$	134
40.	5.097	Undecane	55.0	$C_{11}H_{24}$	156
41.	5.219	9-Iodotricyclo[4.2.1.1(2,5)]decane	81.5	$C_{10}H_{15}I$	262
42.	5.325	trans-Decalin, 2-methyl	82.0	$C_{11}H_{20}$	152
43.	5.581	Dodecane	62.2	$C_{12}H_{26}$	170

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Figure 2: GC-MS chromatogram of unadulterated boiled beans powder (sample A)

Table 2: GC-MS analysis of bioactives in dichlorvos adulterated black water extracted *Phaseolus vulgaris* powder (sample B)

S/N	Retention Time (min)	Bioactive compound	Probability percentage (%)	Molecular formula (MF)	Molecular weight (MW)
1.	1.241	Isobutane	92.9	C_4H_{10}	58
2.	1.270	2-Propenoic acid, 2-propenyl ester	92.6	$C_6H_8O_2$	112
3.	1.329	1,3-Butadiene, 2-fluoro	97.0	C_4H_5F	72
4.	1.403	Oxirane, propyl	96.8	$C_5H_{10}O$	86
5.	1.443	Prenol	90.0	$C_5H_{10}O$	86
6.	1.570	2-Pentyn-1-ol	87.5	C_5H_8O	84
7.	1.884	Benzene	81.9	C_6H_6	78
8.	1.938	4-Pentynoic acid	97.7	$C_5H_6O_2$	98
9.	2.094	Hexane, 3-methy	83.5	C_7H_{16}	100
10.	2.396	Cycloheptane	76.8	C_7H_{14}	98

11.	2.434	1-Pentene, 3,3-dimethy	49.5	C_7H_{14}	98
12.	2.556	1-Nonanol	61.4	$C_9H_{20}O$	144
13.	2.582	2-Heptyn-1-ol	87.5	$C_7H_{12}O$	112
14.	2.622	1,5-Hexadien-3-yne, 2-methyl	91.5	C_7H_8	92
15.	3.278	Acetic acid, trichloro-, nonyl ester	76.1	$C_{11}H_{19}Cl_3O_2$	288
16.	3.453	Cyclooctane	63.7	C_8H_{16}	112
17.	3.586	Benzenepropanamine	92.0	$C_9H_{13}N$	135
18.	3.615	1,3-Cyclopentadiene, 5-(1-methylethylidene)	82.8	C_8H_{10}	
19.	3.733	Toluene	80.5	C_7H_8	92
20.	3.764	3,5-Octadiyne	86.2	C_8H_{10}	106
21.	3.800	1-Dodecanol	55.4	$C_{12}H_{26}O$	186
22.	3.857	Bicyclo[2.1.1]hex-2-ene, 2-ethenyl	83.1	C_8H_{10}	106
23.	3.884	3,5-Octadiyne	86.2	C_8H_{10}	106
24.	3.976	Cyclohexanone, 4-ethyl	89.0	$C_8H_{14}O$	126
25.	4.052	Pentalene, octahydro-2-methyl	68.0	C_9H_{16}	124
26.	4.108	Cyclohexanone, 2-ethyl	90.1	$C_8H_{14}O$	126
27.	4.169	Cyclohexane, (1,2-dimethylbutyl	92.4	$C_{12}H_{24}$	168
28.	4.236	(Z)-4-Decen-1-ol, trifluoroacetate	67.4	$C_{12}H_{19}F_3O_2$	252

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29.	4.262	Benzene, propyl	89.4	C_9H_{12}	120
30.	4.321	2,3-Heptadien-5-yne, 2,4-dimethyl	76.0	C_9H_{12}	120
31.	4.362	Benzene, 1-ethyl-3-methy	61.7	C_9H_{12}	120
32.	4.543	Benzaldehyde, 2-methyl	70.5	C_8H_8O	120
33.	4.459	3-Hexene, 3-ethyl-2,5-dimethyl	91.2	$C_{10}H_{20}$	140
34.	4.585	Benzene, 1,2,3-trimethy	61.4	C_9H_{12}	120
35.	4.627	Benzeneacetaldehyde, α-methyl	78.7	$C_9H_{10}O$	134
36.	4.654	Decane, 4-methy	62.3	$C_{11}H_{24}$	156
37.	4.685	p-Cymene	70.4	$C_{10}H_{14}$	134
38.	4.711	Benzene, 1,2,4-trimethyl	65.7	C_9H_{12}	120
39.	4.752	Cyclohexane, (2-methylpropyl	93.6	$C_{10}H_{20}$	140
40.	4.843	Decane, 5-methyl	85.2	$C_{11}H_{24}$	156
41.	4.864	Benzene, 1-methyl-3-propyl	70.4	$C_{10}H_{14}$	134
42.	4.894	Benzene, 1,4-diethyl	71.4	$C_{10}H_{14}$	134
43.	4.932	Naphthalene, decahydro	66.8	$C_{10}H_{18}$	138
44.	5.023	o-Cymene	61.8	$C_{10}H_{14}$	134
45.	5.057	Benzene, 4-ethyl-1,2-dimethyl	51.0	$C_{10}H_{14}$	134
46.	5.087	Undecane	55.0	$C_{11}H_{24}$	156
47.	5.209	Adamantane-2-thiol	88.7	$C_{10}H_{16}S$	168

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48.	5.233	trans-Decalin, 2-methyl	82.0	$C_{11}H_{20}$	152
49.	5.316	Naphthalene, decahydro-2-methyl	74.9	$C_{11}H_{20}$	152
50.	5.572	Dodecane	62.2	$C_{12}H_{26}$	170
51.	6.016	Tridecane	61.2	$C_{13}H_{28}$	184

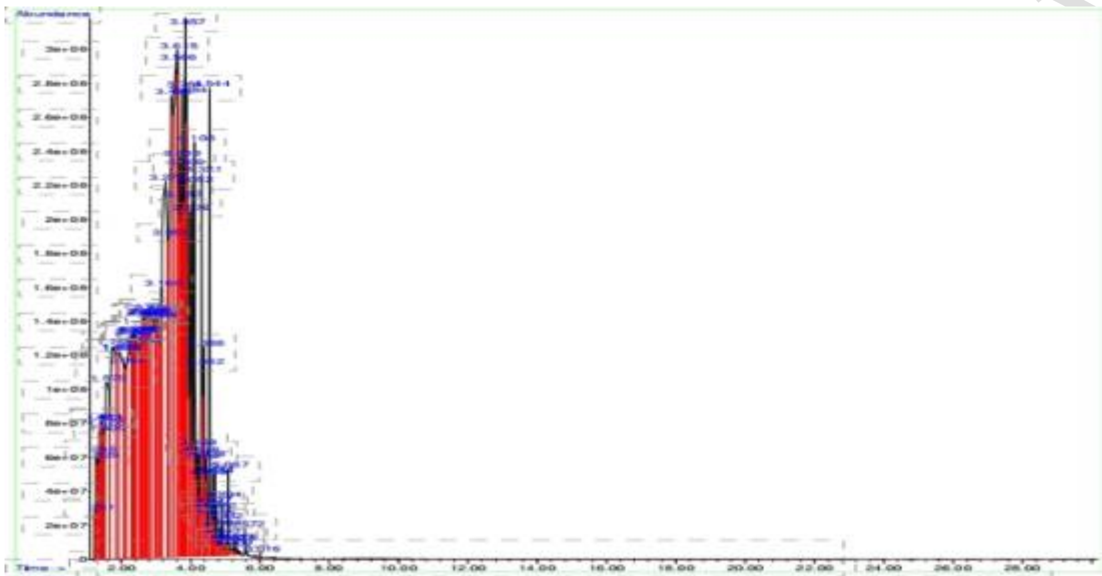

Figure 3: GC-MS chromatogram of sniper-adulterated, black water extracted boiled beans powder (sample B)

Table 3: GC-MS analysis of bioactives in dichlorvos adulterated cooked *Phaseolus vulgaris* powder (sample C)

S/N	Retention Time (min)	Bioactive compound	Probability percentage (%)	Molecular formula (MF)	Molecular weight (MW)
1.	1.273	2-Propenoic acid, 2-propenyl ester	92.6	$C_6H_8O_2$	112
2.	1.332	1,3-Butadiene, 2-fluoro	97.0	C_4H_5F	72
3.	1.411	Aziridine, 2,2-dimethyl	95.5	C_4H_9N	71
4.	1.453	1,2,3-Trimethyldiaziridine	94.7	$C_4H_{10}N_2$	86

5.	1.501	Prenol	90.0	$C_5H_{10}O$	86
6.	1.573	Oxirane, (1-methylbutyl)	93.8	$C_7H_{14}O$	114
7.	1.924	Benzene	81.9	C_6H_6	78
8.	2.090	2-Hexyn-1-ol	86.3	$C_6H_{10}O$	98
9.	2.363	1-Pentene, 3,3-dimethyl	49.5	C_7H_{14}	98
10.	2.422	Cycloheptane	76.8	C_7H_{14}	98
11.	2.666	Toluene	80.5	C_7H_8	92
12.	3.466	Cyclooctane	63.7	C_8H_{16}	112
13.	3.618	1,3-Cyclopentadiene, 5-(1-methylethylidene)	82.8	C_8H_{10}	106
14.	3.779	2-Methylenecyclohexanol	85.3	$C_7H_{12}O$	112
15.	3.872	Bicyclo[2.1.1]hex-2-ene, 2-etheny	83.1	C_8H_{10}	106
16.	3.990	Dichloroacetic acid, nonyl ester	79.3	$C_{11}H_{20}Cl_2O_2$	254
17.	4.067	Cyclohexane, 1-propenyl	68.3	C_9H_{16}	124
18.	4.122	Cyclohexanone, 2-ethyl	90.1	$C_8H_{14}O$	126
19.	4.249	(Z)-4-Decen-1-ol, trifluoroacetate	67.4	$C_{12}H_{19}F_3O_2$	252
20.	4.276	Benzene, propyl	89.4	C_9H_{12}	120
21.	4.637	Benzene, 1,2,4-trimethyl	65.7	C_9H_{12}	120
22.	4.664	Decane, 4-methyl	62.3	$C_{11}H_{24}$	156
23.	4.761	Cyclohexane, butyl	82.7	$C_{10}H_{20}$	140
24.	4.872	Benzene, 1-methyl-3-propyl	70.4	$C_{10}H_{14}$	134
25.	4.902	1,3,8-p-Menthatriene	67.6	$C_{10}H_{14}$	134
26.	4.940	Naphthalene, decahydro-, trans	66.9	$C_{10}H_{18}$	138
27.	5.029	o-Cymene	61.8	$C_{10}H_{14}$	134
28.	5.094	Undecane	55.0	$C_{11}H_{24}$	156

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29.	5.240	trans-Decalin, 2-methyl	82.0	$C_{11}H_{20}$	152
30.	5.322	Naphthalene, decahydro-2-methyl	74.9	$C_{11}H_{20}$	152
31.	5.579	Dodecane	62.2	$C_{12}H_{26}$	170

Figure 4: GC-MS chromatogram of sniper-adulterated boiled beans powder (sample C)

4. DISCUSSION

Table 1 contains forty three (43) GC-MS identified compounds from the hexane extract of sample A. The maximum peak, 97.7%, was recorded for 4-Pentynoic acid while the minimum peak, 50.1%, was observed for Benzene, 1-ethyl-3,5-dimethyl. Peak area percentages below 5% were considered irrelevant (Figure 2). Potential natural components of beans include: Prenol also known as 3-methyl-2-buten-1-ol (90.0%). Prenol acts as a simple terpenoid alcohol that participates in biosynthetic pathways and serves as a precursor for isoprenoids essential for plant growth and metabolism [29]. Benzaldehyde, 2-methyl also known as o-tolualdehyde (70.5%) is a secondary metabolite and can be associated with flavor, defense mechanisms, or metabolic

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processes in plants [30]. Benzeneacetaldehyde (88.9%) forms a part of the complex mixture of aromatic compounds that contribute to the characteristic flavor and fragrance of beans [31]. o-Cymene also known as (1,4-dimethylbenzene (61.8%) is a monoterpene known for its pleasant, citrusy, and slightly sweet aroma [32].

Natural toxins, Lectins, capable of causing severe stomachache, vomiting and diarrhea were also analysed from Sample A. These include: 2-Propenoic Acid, 2-Propenyl Ester (Acrylic Acid) (92.62%), 1,3-Butadiene, 2-fluoro (97.0%), Decane, 5-methyl (85.2%), Benzene, 1-ethyl-2,3-dimethyl (53.7%), Cyclohexanone, 2-ethyl (90.1%), Oxirane, propyl (96.8%), Benzene, 1-ethyl-2-methyl (63.3%), 1-Pentene, 3,3-dimethyl (49.5%) [33].

Table 2 contains fifty one (51) GC-MS identified compounds from the hexane extract of sample B. The maximum peak (97.7%), was recorded for 4-Pentynoic acid while the minimum peak, 49.5 %, was observed for 1-Pentene, 3,3-dimethyl (Figure 3). Potential natural components of beans include: Prenol (90.0 %) and o-Cymene (61.8). Non-natural components of beans or lectins analysed from sample B include: Pentyn-1-ol (87.5 %), Cyclohexanone, 4-ethyl (89.0 %), Cyclohexanone, 2-ethyl (90.1 %), Benzene, propyl, 89.4 %, Cycloheptane (76.8%), Acetic Acid, Trichloro-, Nonyl Ester (76.1%) [33].

Table 3 contains thirty one (31) identified compounds from the hexane extract of sample C. Potential natural compounds include: Prenol (90%); 1,3,8-p-Menthatriene (66.9%) is associated with sweet aroma of beans [34]; o-Cymene, a secondary metabolite (61.8%) [35].

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Non-natural components include: Aziridine, 2,2-dimethyl, an irritant (95.5%), Benzene, propyl (89.4%), Benzene, 1-methyl-3-propyl, toxic to aquatic life with long lasting effects (70.4%); 2-Methylenecyclohexanol (85.3%); Naphthalene, decahydro-, trans (66.9%) is a clear colorless solvent with an aromatic odor; 1-Pentene, 3,3-dimethyl (49.5%) is a highly flammable liquid and vapor that can cause serious eye damage; (Z)-4-Decen-1-ol, trifluoroacetate (67.4%); Decane, 4-methyl (62.3%); Benzene, 1-methyl-3-propyl (70.4%) is a preservative or disinfectant [36-39]. The maximum peak (90.0%), was recorded for 1,3-Butadiene, 2-fluoro while the minimum peak (49.5%), was observed for 1-Pentene, 3,3-dimethyl (Figure 4). The contaminants detected in the three Samples (A, B and C) are attributed to the degradation products of dichlorvos or to other contaminants introduced during the harvest and post-harvest processes.

4.1 Health Implications of Contaminants in Beans

2-Propenoic acid, 2-propenyl ester, (Figures 5a, 6b), also known as allyl acrylate is an irritant to the skin and eyes, and may cause respiratory issues with prolonged exposure [40]. 1,3-Butadiene, 2-fluoro, (Figure 5b), can be harmful; 1,3-butadiene is a known carcinogen and can cause respiratory problems [41]. Benzene, (Figure 5c), is highly toxic; a carcinogen linked to leukemia and other blood disorders [42]. Toluene, (Figure 5d – 7b), is toxic; can cause neurological damage, respiratory issues, and is harmful if ingested [43].

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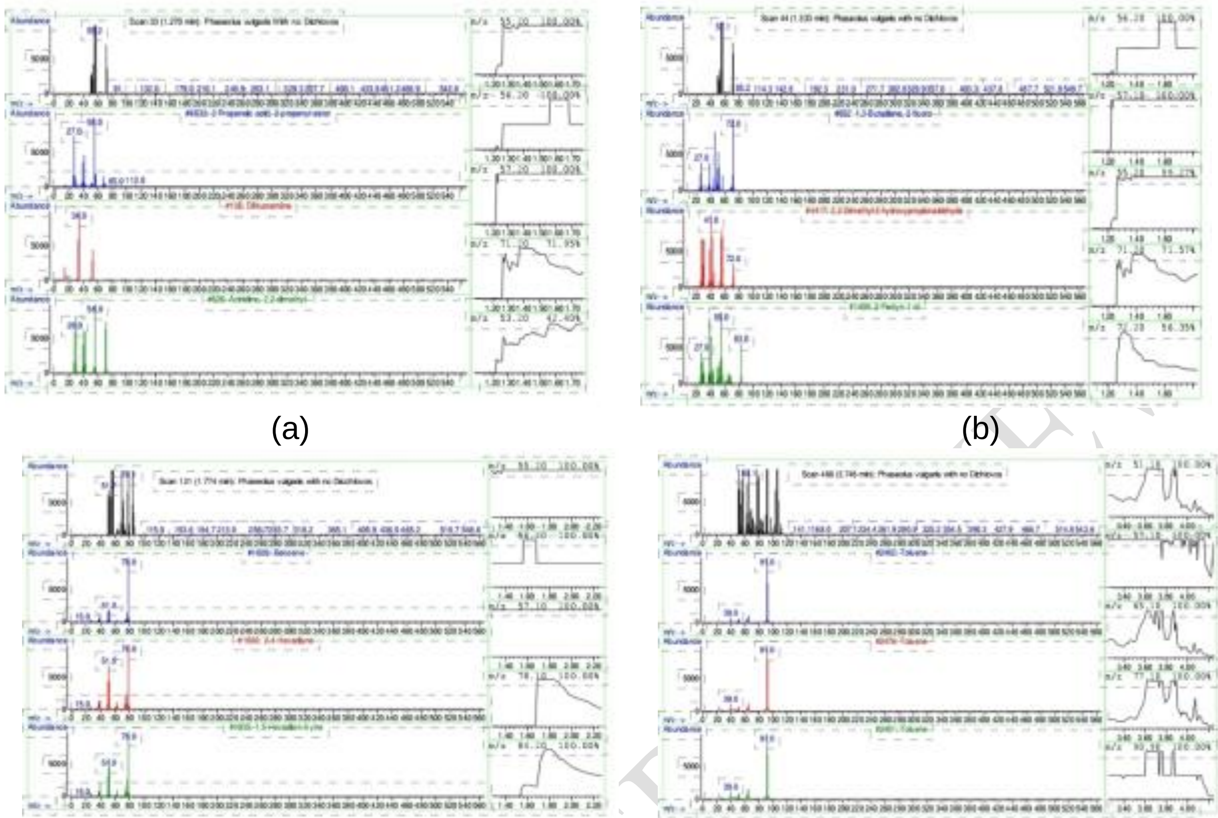

Figure 5: Chromatograms of major chemical compounds analysed from Sample A: 2-Propenoic acid, 2-propenyl ester (a), 1,3-Butadiene, 2-fluoro(b), Benzene (c), Toluene (d)

Isobutane (Figure 6a) is a flammable solvent with a low toxicity, but can be an asphyxiant in high concentrations [44]. Cycloheptane, (Figure 6c), is low to moderate toxic but can cause central nervous system effects [45]. Benzaldehyde, 2-methyl, (Figure 6d), is a benzaldehyde derivative with low toxicity but can cause irritation [46].

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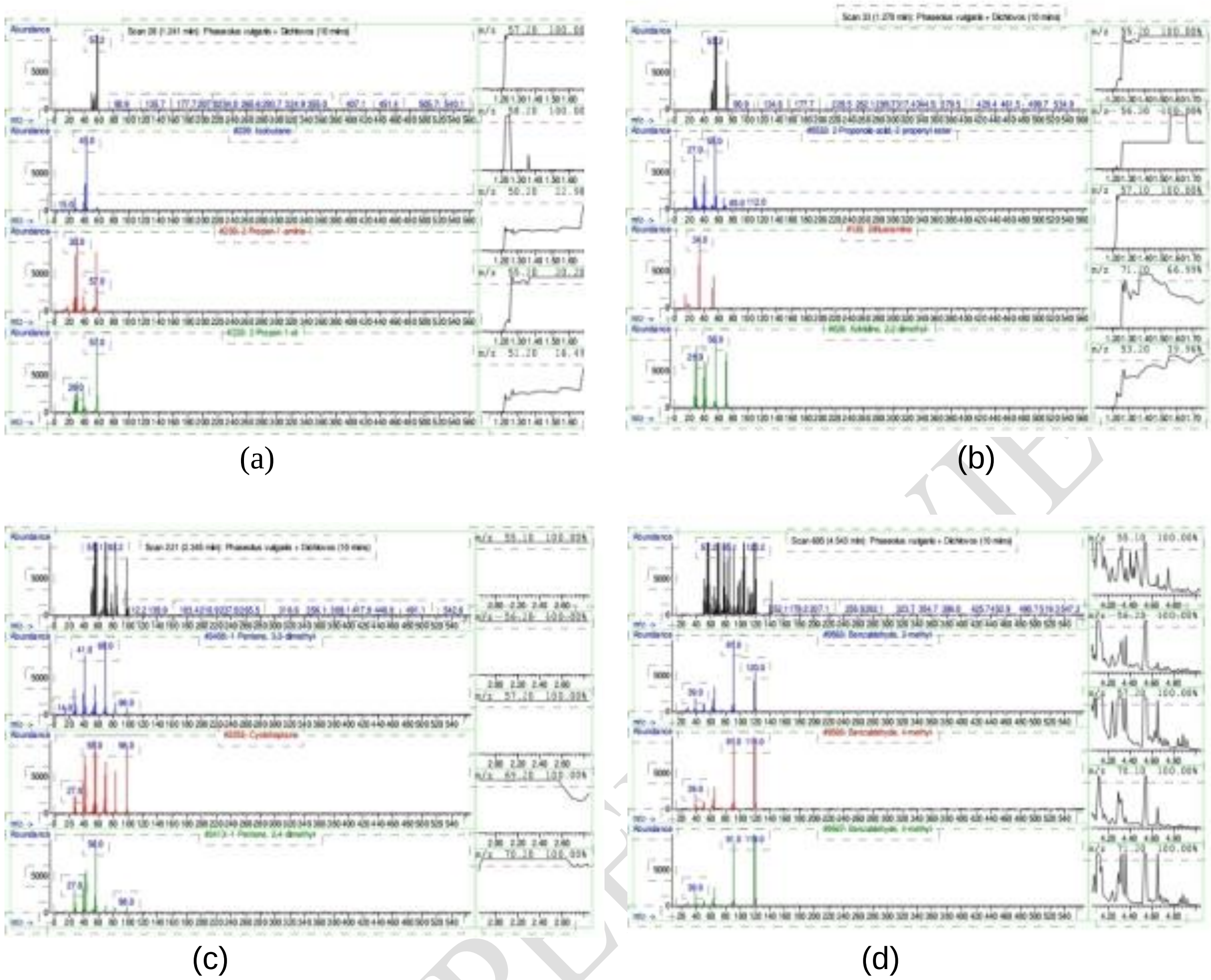

Figure 6: Chromatograms of major chemical compounds analysed from sample B: Isobutane (a), 2-Propenoic acid, 2-propenyl ester (b), Cycloheptane (c), Benzaldehyde, 2-methyl (d)

Propylene oxide (Oxirane, propyl, Figure 7a) is a toxic compound that can cause irritation, respiratory issues, and is classified as a potential human carcinogen [47], while dodecane (Figure 7c) serves as a solvent and a distillation chaser [48].

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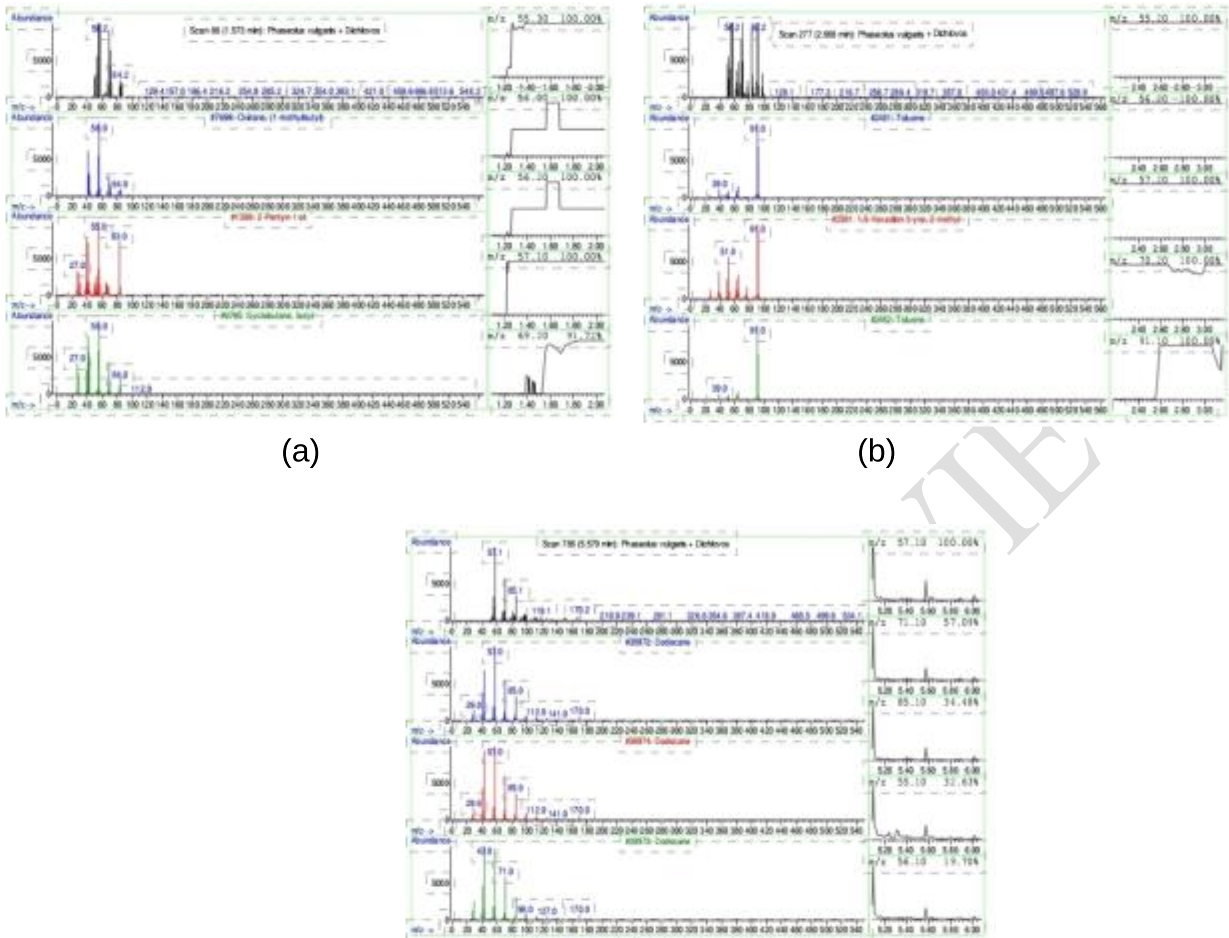

(a) (b)

(d)

Figure 7: Chromatograms of some chemical compounds analysed from sample C: Oxirane, (1-methylbutyl) (a), Toluene (b), Dodecane (c)

5. CONCLUSION

The GC-MS analysis of black eyed beans subjected to different treatments (sample A, B, and C) revealed the presence of beneficial phytochemicals and substantial levels of volatile toxic compounds in all the samples. While the identified phytochemicals may offer some health benefits, the detection of toxic substances raises significant health concerns. Many of the compounds found are associated with adverse effects on human health.

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Dichlorvos is highly toxic to the nervous system, and its degradation or reaction with other substances can form harmful byproducts such as dichloroacetic acid, nonyl ester. These compounds are linked to acute symptoms like respiratory and skin irritation, headaches, and dizziness. In more severe cases, they may cause organ damage to the liver, kidneys, and thyroid, or lead to long-term effects such as carcinogenicity and mutagenicity.

Benzene and its derivatives, such as toluene, were also detected. These substances are often byproducts of pesticide degradation or contamination during storage and handling. Benzene is a known carcinogen, and toluene can cause neurological symptoms and other toxicological effects upon exposure. Additionally, cycloalkanes like cyclohexane and cyclooctane were present, potentially originating from solvents or byproducts in pesticide formulations. These volatile compounds may contribute to respiratory irritation and other health risks. Toxic hydrocarbons such as naphthalene and decane, likely resulting from the breakdown of complex organic molecules in pesticides, pose further risks. Naphthalene, for instance, is associated with hemolytic anemia and is classified as a possible human carcinogen.

Dichlorvos is moderately water-soluble, but washing or discarding the first water after parboiling does not guarantee complete removal. Heat from cooking may not effectively degrade dichlorvos into safe byproducts, and some degradation products remain harmful. Thus, any residual pesticide, even in small amounts, poses a significant hazard. The persistence of these toxic compounds makes it clear that conventional processing methods are insufficient to mitigate the risks associated with contamination.

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The findings underscore the urgent need for improved handling, storage, and monitoring of pesticide use in agricultural produce to minimize contamination. The presence of volatile toxic compounds, particularly organophosphates, benzene derivatives, and hydrocarbons, represents a major public health concern. Research into effective strategies for decontaminating affected beans is essential to ensure food safety and protect consumers from the harmful effects of these substances.

RECOMMENDATION

Beans should not be preserved with Sniper (diclovos) and beans contaminated with sniper should not be consumed under any circumstances, even after cooking. The health risks posed by organophosphates are too significant to ignore.

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