

(RESEARCH ARTICLE)



Qualitative assessment of residual organochlorine pesticide in staple foods consumed in Wukari, Taraba State

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International Journal of Frontiers in Science and Technology Research, 2021, 01(02), 001–006

Publication history: Received on 03 July 2021; revised on 18 August 2021; accepted on 20 August 2021

Article DOI: <https://doi.org/10.53294/ijfstr.2021.1.2.0058>

Abstract

This study was aimed to determine the residual organochlorine presence in some staple foods; Yam (*Dioscorea spp*) and Bambara nut (*Vigna subterranean*) sold in Wukari markets. Samples were randomly collected from three major markets across the study areas. Representative samples were cleansed, dried, pulverized and sieved. Extractions were determined using standard analytical techniques while residual organochlorine pesticides were determined using GCMS. The detected organochlorine pesticide residues in yam were Dichlorodiphenyltrichloroethane (DDT), heptachlor, dieldrin, toxaphene and Dichlorodiphenyldichloroethane (DDE) while those detected in Bambara nut were 1, 4dichlorobenzene, methoxychlor, pentachlorophenol, DDT, and toxaphene. This preliminary assessment showed that Yam and Bambara nut consumed in Wukari contained certain level of organochlorine pesticide residues which may be detrimental to human health in the nearest future.

Keywords: Organochlorine; Pesticides; Yam; Bambara nut; Food; Residues

1. Introduction

Organochlorines are a group of chlorinated compounds widely used as pesticides to control pests and insects and also constitute certain percentage in herbicides for weeds control [1]. When a food crops are treated with pesticide, a very small amount of the pesticide can remain in the crop even after harvested. This is known as the 'residue' [2]. Residual agrochemical can be traced in agricultural products due to pesticides application in treatment of seedlings before planting and storage process [3].

OCPs can be potentially leached into groundwater and might alter the quality of water intended for human consumption. In addition, pesticides can be accumulated in fruits and vegetables as another route of exposure to humans [4]

Ravindran *et al.*, [5] stated that when pesticides are applied, only a small percentage (0.3%) of pesticides goes into the aim pest while 99.7% go somewhere else into the environment. This means that the crops which the pesticides are applied to have high proficiency of absorbing part of the pesticide. There has been numerous cases of food poisoning after consumption of meals prepared from yam and beans that were assumed to contain substantial amount of organochlorine insecticide remains have been reported [6, 7]. Their poisoning may cause many symptoms comprising headache, nausea, dizziness, vomiting, tremor, lack of co-ordination and mental confusion [8]. The most commonly used pesticides include insecticides, herbicides, fungicides and rodenticides [9].

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Staple foods are the general and basic foods consumed within a certain geographical settlement. Yam (*Dioscorea spp*) and bambara nut (*Vigna subterranean*) are important major staple food crops grown in many parts of Nigeria by many farmers. Today farmers use modern farming technologies including pesticides/herbicides due to several factors which includes the commercialization of farming, declining labor force in the yam production zones and increasing weed pressure due to climate variability and over cultivation of the soil [10]. These two crops constitute very important staple foods for the Nigerian. Insect pests and weeds are major constraints to the production of these crops both on the field and in storage and subsequently lead to their low productivity [11]. Yam is well distributed in the humid tropics of the Southern part of West Africa, which includes Nigeria, where it is valued as an important source of carbohydrate and is sold either as fresh tuber or as dried chips Dewan *et al.*, [12]. Bambara nut is an annual creeping legume with glabrous trifoliolate leaves and a deep taproot surrounded by lateral profuse roots bearing N-fixing nodules. It ripens its pods underground. It can be eaten fresh or boiled; they can be ground either fresh or dry to make pudding popularly known as Okpa in Nigeria [13].

2. Material and methods

2.1. Description of Study Area

The study was area Wukari Local Government Area in Taraba State, Nigeria. Its headquarters is in the town of Wukari on the A-4 high way. The Donga River flows through the area and the Benue River forms a boundary with Nassarawa state to the Northwest. Wukari Local Government is located on latitude 7°50' 30" N to 7°52'00"N and longitude 9°45'00"E to 9° 47'00"N. It covers an area of about 30km².

2.2. Sampling

A total of nine (9) sample locations were mapped out across the study areas. Each locations (markets) were grouped into three (3); A, B and C for Bambara nut and X, Y, Z for Yam sample collections. A 100 g of the Bambara nut samples were randomly obtained from the various locations (yam market, new market and old market) to form a representative samples while two (2) pieces of yam tubers were randomly collected from the same locations to also form a representative samples. The samples were stored in a code-named container to protect them from moisture and contamination.

2.3. Sample preparation and extraction

The samples were cleaned by picking out stones and other extraneous materials. The Bambara nuts samples were crushed to powdered form using mortar and pestle, also Yam samples were peeled and dried separately. After drying, it was crushed in a mortar using a pestle to form a powder. All samples were sieved separately using a suitable mesh size of 2 mm.

A 100 g of each powdered sample was weighed and mixed with 20 g of anhydrous sodium sulphate to removed residual water (moisture). The sample mixture was poured into a filter paper prior to extraction. The sample extraction was carried out using a soxhlet extractor where the filter paper containing the sample was placed into the extraction thimble of the extractor as described by [14]. Prior to the extraction, the extractor was washed using *n*-hexane and *n*-hexane was used as the extracting solvent. During the extraction process, temperature was maintained at 40°C. The extracts were concentrated by allowing the solvent to evaporate. Heating to concentrate the extract was avoided to make sure any available organochlorine(s) were not tempered with. The concentrated extract was preserved for further analyses.

2.4. GC-MS analysis

The analysis of organochlorine pesticide residues was performed using a Mass hunter Gas Chromatograph equipped with Mass Spectroscopy. The column temperature was programmed from an initial temperature of 50°C and held for 1 min. and later raised to 300°C with a hold time of 5 min. to enable good resolution with different boiling points. The temperature of the injector and detector were 250°C and 300°C respectively. The syringe size used for injecting 1µL into the injection port of the device was 10 µL. The total pressure was 6.78 psi with the total flow rate of 33mL/min.

3. Results and discussion

The results in table 1 below showed the qualitative analysis of Bambara nut. The detected residual organochlorines in sample A are 1, 4-dichlorobenzene and methoxychlor. In sample B, the presence of 1, 4-dichlorobenzene, chlordan and

pentachlorophenol were detected while 1, 4-dichlorobenzene, toxaphene and DDT were qualitatively detected in sample C. In all the three samples, 1, 4-dichlorobenzene was detected at the retention time of 1.6 min, 1.7 min and 1.0 min respectively. It has the shortest retention time. This is evident that organochlorine pesticides containing 1, 4dichlorobenzene are used by farmers as pest control in Bambara nut in the study area. 1,4-dichlorobenzene is an organic

compound with the formula $C_6H_4Cl_2$ and molecular weight of 147 g/mol. The molecule consists of a benzene ring with two atoms of chlorine on opposite sides of the ring. It is used mainly as a fumigant for the control of moths, molds, and mildews and in the control of boring insects [15].

Table 1 Detected Organochlorines Residues in Bambara nut samples A, B and C

Sample A				
S/N	Organochlorines	Retention Time	Molecular Formular	Molecular Wt
1	1,4-dichlorobenzene	1.6 min.	$C_6H_4Cl_2$	147 g/mol
2	Methoxychlor	5.24 min.	$C_{16}H_{15}Cl_3O_2$	346 g/mol
Sample B				
1	1,4-dichlorobenzene	1.7 min.	$C_6H_4Cl_2$	147 g/mol
2	Chlordane	3.44 min	$C_{10}H_6Cl_8$	410 g/mol
3	Pentachlorophenol	4.56 min	C_6HCl_5O	266 g/mol
Sample C				
1	DDT	4.29 min.	$C_{14}H_9Cl_5$	355 g/mol
2	1,4-dichlorobenzene	1 min.	$C_6H_4Cl_2$	147 g/mol
3	Toxaphene	3.49	$C_{10}H_8Cl_8$	414.5 g/mol

US. Environmental Protection Agency reported that exposure to 1, 4-dichlorobenzene results in irritation of the skin, throat and eye [15].

Methoxychlor had the highest retention time (5.24 min) among the samples with molecular weight of 346 g/mol. Bordirski *et al.*, [16] reported that they are effective against a wide range of pests on field crops, vegetables, fruits and stored grains.

Studies had shown that exposure to methoxychlor and chlordane had caused developmental and reproductive effects, such as abortions, reduced fertility, reduced litter size, and skeletal effects [17].

Similar research conducted by [2] revealed that detected chlordane was found in Bambara nut and cowpea samples. Chlordane and Pentachlorophenol have been classified as group B2, probable human carcinogen [18]. DDT had a retention time of 4.26 min with molecular formula $C_{14}H_9Cl_5$ and molecular weight of 355 g/mol. Ravindran *et al.*, [5] reported that people are most likely to be exposed to DDT from foods, including meat, fish, and dairy products. A review of liver cancer studies concluded that organochlorine pesticides, including DDT, may increase hepatocellular carcinoma risk [19].

Table 2 Detected Organochlorines Residues in Yam samples X, Y and Z

Sample X				
S/N	Organochlorines	Retention Time	Molecular Formular	Molecular Wt
1	DDT	4.49 min.	C ₁₄ H ₉ Cl ₅	355g/mol
2	Heptachlor	3.19 min.	C ₁₀ H ₅ Cl ₇	374g/mol
Sample Y				
1	Dieldrin	11.9 min	C ₁₂ H ₈ Cl ₆ O	381g/mol
2	Toxaphene	9.46 min.	C ₁₀ H ₈ Cl ₈	414.5g/mol
Sample Z				
1	DDT	17.9 min.	C ₁₄ H ₉ Cl ₅	355g/mol
2	DDE	16.12 min.	C ₁₄ H ₈ Cl ₄	290.8g/mol

The results presented in table 2 above shows the presence of DDT, DDE, Dieldrin, Heptachlor and Toxaphene in Yam sample. The result indicates that DDT were detected in sample X and Z with retention time of 4.49 min and 17.9 min respectively. Dichlorodiphenyldichloroethylene (DDE) is an organochlorine compound formed by the loss of Hydrogen chloride (dehydrohalogenation) from DDT [20]. DDE is classified as a Group B2, probable human carcinogen according to [21].

Heptachlor had a retention time of 3.19 min with the molecular formular C₁₀H₅Cl₇ and molecular weight of 374 g/mol. Bethesda [22] reported that exposure to heptachlor may result in nervous system effects, with oral studies showing gastrointestinal effects. Olufade *et al.*, [23] also carried out similar analysis to determine the level of organochlorine pesticide residues in dry yam chips and their findings revealed that heptachlor was detected in their samples and consequently stressed that the high level of residues in yam chips was as a result of past usage arising from the cultivation of the crop on contaminated soils where application of the insecticides were intense.

Dieldrin has the molecular formula C₁₂H₈Cl₆O and molecular weight of 381 g/mol with retention time of 11.9 min. It was found in sample Y only. Similar result was obtained by [24] in their findings in which they reported that dieldrin in agriculture has left sediments and soil with heavy concentration. It has been linked to health problems such as Parkinson's, breast cancer, and immune, reproductive and nervous system damage [25].

4. Conclusion

The investigation of organochlorine pesticides residues in the studied staple foods shows that 1,4-dichlorobenzene was present in Bambara nut sold within the study area while DDT was also present in Yam sold in two sample locations. The presence of these chlorinated compound may result to short- or long-term health effect. This study limits to only qualitative analysis therefore, cannot give the actual level or concentrations of these residual organochlorine compound.

Compliance with ethical standards

Acknowledgments

The authors thank Mr. Godfrey G. S for his laboratory assistance.

Disclosure of conflict of interest

None of the authors have any conflicts of interest to declare.

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