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# Dichloro-diphenyl-trichloro-ethane (DDT) and hexachlorohexane (HCH) pesticide residues in foodstuffs from markets in Ile-Ife, Nigeria

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## ABSTRACT

Levels of dichlorodiphenyltrichloroethanes (DDTs) and Hexachlorocyclohexanes (HCHs) pesticide were evaluated in samples of cowpea grains and dried yam chips obtained from Ile-Ife markets, southwestern Nigeria. The objectives of the study were to establish the presence of the organochlorine pesticide residues in the foodstuffs and also to ascertain whether the residue levels are above their respective permissible levels. Randomly selected samples from highly patronized markets were subjected to standard extraction protocols. The DDT and HCH levels were determined using Gas Chromatography coupled with Electron Capture Detector (GC-ECD). The mean concentration of γ-HCH (Lindane) in cowpea grains was 0.085 mg/kg and 0.042 mg/kg in dried yam chips. The *p,p'*-DDD concentrations were 0.086 mg/kg and 0.159 mg/kg in cowpea and dried yam chips, respectively. γ-HCH detected in all the cowpea samples and 90% in dried yam chips samples were above the recommended EU maximum residue level (MRL) of 0.01 mg/kg. The results of this study indicated that substances that could pose serious health risks were associated, at outrageous levels, with important foodstuffs in Nigerian markets even to the point of sales and consumption.


**Keywords**: Dichlorodiphenyltrichloroethane, hexachlorocyclohexane, pesticide, residue, cowpea grain, yam chip.

## INTRODUCTION

Cowpea is one of the most economically and nutritionally important indigenous African grain legumes produced throughout the tropical and subtropical areas of the world. It plays a key role in agriculture and food supply in Nigeria. Insect pests are major constraints to cowpea production in West Africa. Insect pests that feed on the reproductive plant parts and harvested grains are reported to cause the most economic damage and often necessitate control (Jackai and Adalla, 1997; Karungi et al., 2000). In storage, cowpeas are particularly susceptible to damage mainly by cowpea bruchids (*Callosobruchus maculatus* Fab.) and insecticides are used to protect the grains (Karungi et al., 2000).

Yam is well distributed in the humid tropics of the Southern part of West Africa, which includes Nigeria, where it is valued as important source of carbohydrate. In Nigeria and other West African countries, yam is sold either as fresh tuber or as dried chips. In both forms, yam can be stored with varying successes and benefits with the farmer's


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primary objectives of reducing post-harvest losses and the conversion of the fresh tuber into more convenient form that can store longer than fresh tubers (Eze, 1998). However, during storage, the chips are often infested by insect pests most especially the boring insects which cause considerable damage (Adisa, 1985; Eze et al., 2006) and this necessitates the use of insecticides. The use of insecticides to control insect pests, which cause damage to crops and result in severe loss in food production in tropical countries like Nigeria, has become recognized and accepted as an essential component of modern agricultural production.

Organochlorine pesticides (OCPs) were the first synthetic organic pesticides that were used in agriculture. Dichlorodiphenyl-trichloroethanes (DDTs) and Hexachlorocyclohexanes (HCHs) are probably the best known of these types of pesticides (Kalyoncu et al., 2009). Most of these OCPs are agricultural insecticides or industrial compounds that also double as environmental pollutants and their acute health risks, their long persistence and tendency to accumulate in body tissues have raised a great concern about possible human health impacts due to low but chronic exposure (Salem et al., 2009; Kumar et al., 2013). Also, their lipophilicity, hydrophobicity, stability to photo-oxidation, and low vapour pressure, low chemical and biological degradation rates have led to their accumulation in biological tissues; hence the subsequent magnification of concentrations in organisms, progressing along the food chain (Helberg et al., 2005). Dichlorodiphenyl-trichloroethane (DDT) and hexachlorocyclohexane (HCH) are persistent bioaccumulative contaminants that are found ubiquitously in environmental and biological matrices, including tissues of fish, birds and mammals (ASTDR, 2005, 2008). They are persistent chlorinated pesticides with endocrine activity that may adversely affect the early stages of human reproduction (Mahalingaiah et al., 2012).

The main source of human exposure to these OCPs is through dietary ingestion. Generally, HCB and DDT are found in meat, fish, and milk products (Brilhante and Franco, 2006; Mawussi et al., 2009; Yu et al., 2009) and they have a wide range of acute and chronic health effects like cancer, reproductive disorders, immune suppression, congenital defects, and endocrine dysfunction (Dewan et al., 2013).

In Nigeria, pesticides are widely used and misused to control storage insects. There have been reports of poison cases and sudden deaths, blindness, and skin irritation attributed to use and inappropriate storage of pesticides (Adedoyin et al., 2008; Adeleke, 2009). Generally, vital pieces of information with respect to volume and types of pesticides importation, method of applications and handling of objects associated with pesticides are either not available or poorly circulated. Besides, pesticides in food materials are poorly monitored in Nigeria with no information available on the permissible levels of pesticides in food commodities. Also, there is still a paucity of data on the dietary intake of pesticides by the Nigeria population through cowpea grains and yam flour.

The objectives of the study were to establish the presence and levels of the organochlorine pesticide residues in cowpea grains and dried yam chips and ascertain whether the levels are above the permissible levels. This paper therefore presents the results of levels of DDTs and HCHs in the two foodstuffs as part of a surveillance effort on pesticides residues monitoring in food products in Nigeria

## MATERIALS AND METHODS

### Sample collection and preparation

A total of 20 food products consisting of five samples each of cowpea grains and dried yam chips were taken from randomly selected wholesale traders at Odo Ogbe (Ife Central Local Government Area) and Better Life (Ife East Local Government Area) markets in Ile-Ife, Osun State, Nigeria. Foreign matters such as grains, pebbles and pod remnants were manually removed from the cowpeas and both cowpea and yam chip samples were further sun dried to a constant weight. Each of the samples was thoroughly ground to a powdered form using an agate pestle and mortar.

**Extraction procedure**

Accurately weighed 20 g portion of each powdered sample, selected by coning and quartering method, was weighed into a pre-extracted Whatman extraction thimble. The sample extraction was carried out as described elsewhere (Oyekunle et al., 2011) using a soxhlet extractor and dichloromethane (DCM) as the extracting solvent. The extract was concentrated by distilling-off the solvent (DCM) to about 3 mL. The concentrated extract was cooled down to room temperature and then concentrated further to about 2 mL under a stream of high purity (99.99%) nitrogen. The reduced extract was then preserved for chromatographic clean up prior to Gas Chromatography analysis.

**Clean-up experiment**

For the clean-up experiment, a column of about 15 cm x 1 cm i.d. was packed with about 7.5 g activated silica gel prepared in a slurry form in n-hexane. About 2 g anhydrous sodium sulfate was placed at the top of the column to absorb any water in the sample or the solvent. The column was pre-eluted with 15 mL of n-hexane without the exposure of the sodium sulfate layer to air in order to prevent drying up and breaking of the adsorbent. The reduced extract was turned into the column and allowed to sink below the sodium sulfate layer. Elution was done with 2 x 10 mL portions of the extracting solvent (DCM). The eluate was then collected, dried with anhydrous sodium sulfate and evaporated to dryness under a stream of analytical grade nitrogen (99.99%).

**Gas chromatographic analysis**

The detection and determination of the pesticide residues were performed by dissolving the sample eluate in 1 mL n-hexane before injecting 1 µL of the 1.0 $cm^3$ purified extract into the injection port of a Gas Chromatograph with a $^{63}Ni$ Electron Capture Detector (GC-ECD, Hewlett Packard 5890 Series II) equipped with the ChemStation software. The column consisted of a DB-5 fused silica capillary column (30 m length × 0.32 mm i.d. × 0.25 µm film thickness). The column temperature was programmed from 60 $^oC$ at a rate of 20 $^oC$/min to 140 $^oC$, held for 1 min, and then continued at a rate of 11 $^oC$/min to 280 $^oC$, held for 4 mins so as to enhance good resolution at different boiling points. The temperatures of the injector and detector were 250 $^oC$ and 280 $^oC$, respectively. The injection was carried out on a splitless injector at 200 $^oC$ and the purge activation time was 30 s. The carrier gas was Nitrogen at 29.2 $cm^3$/sec., measured at 150 $^oC$. The run time was 23 minutes. Identification of pesticide residues was accomplished using reference standards and relative retention time techniques, while the concentration of the residues was determined by comparing the peak heights of the samples with the corresponding peak heights of the reference standards of known concentrations.

**Quality control measures**

Quality control measures adopted to ensure that the analytical procedures used complied strictly with appropriate standards and specifications and to ensure that the results obtained are reliable, valid and of high quality included the determinations of percentage recovery and detection limit.

**Percent recovery (%R) determination**

Two samples of pulverized cowpea grains and dried yam chips, each weighing 20 g were chosen. For each foodstuff, one sample was spiked with 10 mg $kg^{-1}$ standard mixture consisting of some of the available organochlorine pesticides of interest. The mixture was thoroughly mixed together to ensure maximum homogenization. The other sample was left unspiked. The two samples were extracted and cleaned up following the procedures of Oyekunle et al. (2011). Using an injection needle, 1.0 µL of the mixture was injected into the GC column for GC-ECD analysis. The recoveries of OCs were determined by comparing the peak areas of the OCPs after spiking with those of the unspiked and the percentage recovery (%R) was evaluated based on the expression:

$$\%R = \frac{\text{Peak area of A} - \text{Peak area of A}'}{\text{Peak area of OCP standard}} \text{ x } 100$$

where A = OCP in spiked sample and $A'$ = OCP in unspiked sample.

**Determination of limit of detection (LOD)**

The limits of detection (LOD) were evaluated by the determination of concentrations that give signals equal to the blank signal plus three standard deviations of the blank based on the empirical and more specific definition described by Miller and Miller (2000) using the relationship:

$y_C = y_B + 3S_B$

where $y_C$= analyte signal equivalent to detection limit; $y_B$= blank signal; and $S_B$= standard deviation of the blank. From the value of $y_C$, the analyte concentration corresponding to the detection limit was evaluated for GC-ECD determination of OCPs.

**Statistical analysis**

Descriptive statistics (mean, range and standard error) and Correlation analysis were used to analyze the results obtained using SAS version 9.2 software (SAS Institute, 2003). The correlation coefficient at 5% level of significance was used to determine the relationship between each pair of the OCPs.

**RESULTS**

The levels of DDT and HCH pesticides residues determined in dried yam chips are presented in Table 1. All isomers of HCH were detected in the yam chips analysed. The α-HCH is the main component of technical HCH while γ-HCH is the major component of lindane formulation. The observed levels of δ-HCH, γ-HCH and α-HCH ranged between 0.034-0.972 mg/kg, 0.0-0.101, and 0.004-0.267 mg/kg and their mean concentrations were 0.147, 0.042 and 0.037 mg/kg, respectively. Among this group of OCPs, methoxychlor was also detected in yam chips with a mean concentration of 0.048 mg/kg and a range of 0.024 to 0.067 mg/kg. The average concentrations of DDT isomers were 0.042, 0.054 and 0.086 for *p,p'*-DDT, *p,p'*-DDE and *p,p'*-DDD, respectively. Of all the OCPs analysed, δ-HCH recorded the highest concentration of 0.147 mg/kg.

The mean concentration and ranges of HCHs and DDT residues in cowpea grains are given in Table 2. The highest mean concentration of 0.085 mg/kg (0.020-0.238 mg/kg) for γ-HCH was recorded among the HCH isomers and *p, p'*-DDD (0.159 mg/kg) was the highest DDT isomers with the range between 0.070 and 0.312 mg/kg. The values of δ-HCH and β-HCH ranged from 0.019 - 0.125 mg/kg and 0.011 - 0.144 mg/kg with mean concentrations of 0.062 and 0.047 mg/kg, respectively. The average concentrations of *p, p'*-DDT and *p, p'*-DDE in the samples were 0.053 mg/kg and 0.073 mg/kg respectively.

Table 3 shows the correlation between pairs of pesticide compounds in dried yam chips samples analysed. A pair wise linear correlations among levels of organochlorine pesticides in yam chips samples indicated strongly positive and significant ($P<0.001$) relations between β-HCH and δ-HCH ($r = 0.913$) and between α-HCH and δ-HCH ($r = 0.998$) ($P < 0.01$). A positive correlation also existed between *p,p'*-DDD and *p,p'*-DDE ($r = 0.693$) ($P<0.05$) and between DDE and DDT ($r = 0.747$) ($P<0.01$). However a negative non-significant correlation were found between α-HCH and β-HCH ($r = -0.335$), α-HCH and γ-HCH ($r = -0.482$), β-HCH and δ-HCH ($r = -0.333$), and γ-HCH and Methoxychlor ($r = -0.231$).

**Table 1:** Levels of pesticide residues (mg/kg) in dried yam chips from markets in Ile-Ife, Nigeria.

| **Pesticide** | **α BHC** | **β-BHC** | **γ-BHC** | **δ-BHC** | **Methoxychlor** | ***p,p'*-DDE** | ***p,p'*-DDD** | ***p,p'*-DDT** |
|---|---|---|---|---|---|---|---|---|
| Mean | 0.037 | 0.033 | 0.042 | 0.147 | 0.048 | 0.054 | 0.086 | 0.042 |
| SE | 0.026 | 0.009 | 0.009 | 0.092 | 0.004 | 0.012 | 0.026 | 0.014 |
| Min | 0.004 | 0.0 | 0.0 | 0.034 | 0.024 | 0.008 | 0.0 | 0.0 |
| Max | 0.267 | 0.107 | 0.101 | 0.972 | 0.067 | 0.103 | 0.214 | 0.137 |

**Table 2:** Levels of pesticide residues (mg/kg) in cowpea grains from markets in Ile-Ife, Nigeria.

| **Pesticide** | **α BHC** | **β-BHC** | **γ-BHC** | **δ-BHC** | **Methoxychlor** | ***p,p'*-DDE** | ***p,p'*-DDD** | ***p,p'*-DDT** |
|---|---|---|---|---|---|---|---|---|
| Mean | 0.019 | 0.047 | 0.085 | 0.062 | 0.042 | 0.073 | 0.159 | 0.053 |
| SE | 0.003 | 0.014 | 0.024 | 0.014 | 0.006 | 0.014 | 0.024 | 0.012 |
| Min | 0.007 | 0.011 | 0.020 | 0.019 | 0.018 | 0.015 | 0.070 | 0.0 |
| Max | 0.044 | 0.144 | 0.238 | 0.125 | 0.077 | 0.140 | 0.312 | 0.120 |

**Table 3:** Correlation matrix for DDT and HCH pesticides concentrations in dried yam chips.

| | **α-BHC** | **β-BHC** | **γ-BHC** | **δ-BHC** | **Methoxychlor** | ***p,p'*-DDE** | ***p,p'*-DDD** | ***p,p'*-DDT** |
|---|---|---|---|---|---|---|---|---|
| α-BHC | 1.00 | | | | | | | |
| β-BHC | -0.335 | 1.00 | | | | | | |
| γ-BHC | -0.482 | 0.913** | 1.00 | | | | | |
| δ-BHC | 0.998** | -0.333 | -0.481 | 1.00 | | | | |
| Methoxychlor | 0.486 | -0.107 | -0.231 | 0.495 | 1.00 | | | |
| *p,p'*-DDE | 0.258 | 0.484 | 0.417 | 0.266 | 0.567 | 1.00 | | |
| *p,p'*-DDD | 0.268 | 0.509 | 0.513 | 0.272 | 0.428 | 0.693* | 1.00 | |
| *p,p'*-DDT | 0.069 | 0.463 | 0.448 | 0.069 | 0.247 | 0.747** | 0.207 | 1.00 |

*significant t-test at 0.05 level of probability
**significant t-test at 0.01 level of probability

**Table 4:** Correlation matrix for DDT and HCH pesticides concentrations in cowpea grains.

| | **α-BHC** | **β-BHC** | **γ-BHC** | **δ-BHC** | **Methoxychlor** | ***p,p'*-DDE** | ***p,p'*-DDD** | ***p,p'*-DDT** |
|---|---|---|---|---|---|---|---|---|
| α-BHC | 1.00 | | | | | | | |
| β-BHC | 0.960** | 1.00 | | | | | | |
| γ-BHC | 0.716** | 0.761** | 1.00 | | | | | |
| δ-BHC | 0.775** | 0.792** | 0.871** | 1.00 | | | | |
| Methoxychlor | 0.762** | 0.808** | 0.790** | 0.835** | 1.00 | | | |
| *p,p'*-DDE | 0.530 | 0.502 | 0.627* | 0.594 | 0.593 | 1.00 | | |
| *p,p'*-DDD | 0.890** | 0.873** | 0.802** | 0.834** | 0.763** | 0.829** | 1.00 | |
| *p,p'*-DDT | 0.753** | 0.795** | 0.755** | 0.686* | 0.632* | 0.807** | 0.894** | 1.00 |

*significant t-test at 0.05 level of probability
**significant t-test at 0.01 level of probability

**Table 5:** EU-MRLs and Percent concentration of DDT and HCH pesticides compounds in dried yam chips and cowpea grains from markets in Ile-Ife, Nigeria.

| | **Dried yam chips** | | | | **Cowpea grains** | | | |
|---|---|---|---|---|---|---|---|---|
| | **Mean Conc. (mg/kg)** | **% above MRLs** | **% Conc. By group** | **EU-MRL (mg/kg)** | **Mean Conc. (mg/kg)** | **% above MRLs** | **% Conc. By group** | **EU-MRL (mg/kg)** |
| α HCH | 0.037 | 30 | | 0.01 | 0.019 | 60 | | 0.01 |
| β-HCH | 0.033 | 70 | | 0.01 | 0.047 | 90 | | 0.01 |
| γ-HCH | 0.042 | 90 | | 0.01 | 0.085 | 100 | | 0.01 |
| δ-HCH | 0.147 | 100 | | 0.01 | 0.062 | 100 | | 0.01 |
| **∑HCB** | **0.259** | | 53.0 | | **0.213** | | 39.4 | |
| *p,p'*-DDE | 0.054 | 50 | | 0.05 | 0.073 | 40 | | 0.05 |
| *p,p'*-DDD | 0.086 | 40 | | 0.05 | 0.159 | 100 | | 0.05 |
| *p,p'*DDT | 0.042 | 30 | 37.2 | 0.05 | 0.053 | 40 | 52.8 | 0.05 |
| Methoxychlor | 0.048 | 100 | 9.8 | 0.01 | 0.042 | 100 | 7.8 | 0.01 |
| **∑ DDTs** | **0.230** | | 47.0 | | **0.327** | | 60.6 | |
| Total OCPs | **0.489** | | **100.0** | | **0.54** | | **100** | |

The correlation between the DDT and HCH pesticides in cowpea grains analyzed is presented in Table 4. There was a strongly positive and statistically significant relationship between the pesticide compounds. A high correlation existed between α-HCH and β-HCH (r = 0.960) ($P<0.01$), γ-HCH and δ-HCH (0.871) ($P<0.01$), β-HCH and δ-HCH (0.792) ($P<0.01$). A high significant correlation also existed between *p,p'*-DDD and all the isomers of HCH while a high relation was also recorded between *p,p'*-DDD and *p,p'*-DDE (0.829) ($P<0.01$), *p,p'*-DDD and *p,p'*-DDT (0.894) ($P<0.01$).

Table 5 reports the percent concentration of DDT and HCH residues and the MRLs for dried yam chips and cowpea grains analyzed. MRL has not been established for dried yam chips but we used that of yams as stated in pesticides EU-MRLs database regulation (EC) No. 396/2005. Ninety percent and 100% of γ-HCH detected in yam chips and cowpea sampled respectively were above the maximum level of 0.01 mg/kg recommended by EU. However, only 30% and 40% of DDT detected in yam chips and cowpea grains respectively were above MRLs. The concentration of *p,p'*-DDD detected in all the cowpea samples were above the MRL while only 40% of the yam chips samples were above the EU recommendation of 0.05 mg/kg residue limit. The total HCH were 53% and 39% in yam chips and cowpea grains, respectively. However, the cowpea grain samples recorded higher concentrations of total DDT of 61% compared to 47% detected in yam chips.

## DISCUSSION

The most notable result in this study was the frequency of detection of DDT and its metabolites and HCH and its isomers in cowpea and dried yam samples. The predominance of γ-HCH (lindane) amongst the hexachlorohexanes detected in the cowpea grains samples in this study implies that the insecticide must have been used for treating cowpea grains against insect pest attack either on the field and/or for storage. Lindane (the active ingredient of Gammalin 20EC®) has been a household name in agricultural communities of Nigeria. The insecticide was for a long time the only insecticide used in cacao agroecosytem for the control of cacao mirids. It has been used on a wide range of soil-inhabiting and plant-eating (phytophagous) insects and commonly used on a wide variety of crops and in warehouses. In Nigeria, it is marketed under the trade names of Gammalin 20EC®, Gammalin super 20EC®, and Capsitox 20EC®. Apart for use on field crops, the widespread use of the insecticide for other purposes is common among the farmers and traders for protection of storage insect pests of crops. Orkwor et al. (1997) reported the use of lindane against *Dinoderus* spp. and *S. zeamais* in the store. Although lindane has been officially banned in Nigeria, it is still very much available in the local markets. Unfortunately, it is either there is a paucity of data on OCP importation and consumption or the data is not even available at all. However, it has been established that some of the banned or restricted chemicals are smuggled into the country through the neighbouring countries. Nsikak and Aruwajoye (2011) reported the detection of appreciable amount of γ-BHC (lindane) in *S. lycopersicum* and *C. annum* samples commercially sold in Ota, Ogun State, Nigeria while Sosan et al. (2008) detected appreciable amount of lindane in blood serum of cacao farmers in southwestern Nigeria.

The high concentration of *p,p'*-DDD amongst the DDTs and its predominance in two foodstuffs indicated that the DDT in insecticides applied for control of insect pests of cowpea had substantially metabolized into *p,p'*-DDD. According to (ATSDR, 2002), DDD enters the environment during the breakdown of DDT which can undergo slow biodegradation through reductive dechlorination to form the product. It enters the body mainly when a person eats contaminated food. Residues of DDT have been reported to be the most frequently encountered OCP in beans (*P. vulgaris*) sampled from Lagos markets in Nigeria (Ogah et al., 2012).

Dichlorodiphenyltrichloroethanes (DDT) and its metabolites can be adsorbed onto surface soil or get mobilized into the aquatic systems and become sediments eventually. It has been estimated that as much as 50% DDT can remain in soil after 10-15 years of its application (ATSDR, 2002; WHO, 2003). For instance, the over-reliance on the use of pesticides (OCPs in particular) by farmers of Oke Osun settlement in Osun State, Nigeria confirmed the reason for DDT residues in soil samples from the area (Oyekunle et al., 2011). Thus, the presence of DDT and its metabolites in the food samples under study could be as a result of the presence and persistence of these OCPs in the environment and the soil over which they were cultivated.

Of the isomers of HCH, γ-BHC has been known to be the only insecticidally effective isomer. The isomer δ-HCH has no insecticidal property and would not have been exclusively used in controlling insect pests of yam and dried yam chips. However, the high concentration of δ-HCH amongst the chlorinated benzenes detected in yam chips suggested the sale of technical BHC (which is a commercial mixture of γ-HCH and other isomers of which δ-BHC probably had the highest percent concentration), or it might be that other isomers disappeared more readily than δ-BHC under storage conditions.

The concentrations of the DDT and HCH isomers detected in the two foodstuffs showed higher percentages of the residues in cowpea grains that were above the MRLs when compared with dry yam chips indicating that a higher quantity of the pesticide was applied on cowpea either on the field or in storage or both. Similar observations were made by Mawussi et al. (2009) in Togo where levels of OCPs detected in cowpea grains exceeded MRLs. Adeyeye and Osibanjo (1999) reported residue levels of organochlorines in raw fruits, vegetables and tubers from markets in Nigeria. Aldrin + dieldrin, total HCH, and total DDT were detected at 98, 79 and 49% levels, respectively, of all tuber samples while Ogah et al. (2012) also reported that DDT had the highest violating concentration which was 57% above its MRLs when compared with OCPs in bean samples studied in Lagos State, Nigeria. In Turkey, Kalyoncu et al. (2009) reported that DDT and its metabolites and HCH were the predominant contaminants in fish muscles while Musa et al. (2010) also found DDT to be the predominant contaminant in fish samples from Northeastern Nigeria.

Epidemiological evidences have established that exposure to OCPs even at trace levels is associated with a wide array of adverse effects on human health while the chronic exposure to low levels of these pesticides can also cause a wide range of serious harmful effects in animals and humans. The pesticide residues detected in cowpea grains and yam chips are known to be harmful to humans especially at levels above MRLs. Multiple case control studies have shown a correlation between blood DDT/DDE levels and development of breast cancer (Demers et al., 2000; Charlier et al., 2003; Cohn et al., 2007; Ferro et al., 2012) while the HCB, DDT, and dichlorodiphenyl-dichloroethylene (DDE - the primary metabolite of DDT), continue to be detected in human blood (ATSDR, 2002), amniotic fluid (Foster et al., 2000) and breast milk (Tsang et al., 2011).

The use of DDT and HCH have been banned or severely restricted in several countries, but these are still being produced and exported to the developing countries where users in these countries find the chemicals to be affordable and versatile in pests control (van den Berg, 2009). In Nigeria, the Federal Environmental Protection Agency (FEPA) Regulations of 1990 banned the importation of OCPs in response to international concerns about their effects. In spite of the ban, OCPs are still available today for sale in the informal market “under cover’’. Also, the agrochemical industries are not giving due regard to promotion of ecologically sound practices that will enhance sustainability in agricultural production while reducing the adverse health effects of pesticide use. This could be attributed to the fact that the agrochemical business in Nigeria is not properly coordinated. It is fragmented and unorganized, with a lot of malpractices going on in the process of its marketing and distribution (Sosan and Akingbohungbe, 2009; Asogwa and Dongo, 2009; Sosan et al., 2013).

**Conclusion**

Contrary to the UN's campaign and against the backdrop of minimizing and eventually phasing out Persistent Organic Pollutants (POPs) which globally gave rise to the Stockholm Convention of 2001, Nigeria as a member nation, a decade after the convention, still uses these OCPs against insect pests to the extent that they were detected in cowpea grains and dried yam chips in concentrations above the EU-MRLs. Although the samples of the foodstuffs analyzed in this study were taken from bagged stock of wholesale traders which covered only two major markets in a town in southwestern Nigeria, there is a need to increase the scope and coverage of the study to further establish facts about the unguided use of the OCPs in crop protection activities. Nonetheless, our study is reporting for the first time pesticide residues in the cowpea and yam chips in Nigeria and thus providing baseline information on levels of DDT and HCH residues in these food products. The information will assist in a scientific assessment of the impact of pesticides on public health in Nigeria. A strict enforcement of regulations and regular monitoring of pesticides residues in food products in Nigeria is advocated to minimize health risks.

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