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Contamination levels of selected organochlorine and organophosphorous pesticides in Ghanaian fruits and vegetables

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Abstract

A study was conducted to obtain systematic monitoring data on the contamination levels of selected organochlorine and organophosphorous pesticide residues in fruits and vegetables sold on Ghanaian markets. A total of 309 samples of fruits and vegetables were purchased from the main urban markets and supermarkets in Greater Accra through the months of July, 2009 to May, 2010. The analysis was carried out on GC-ECD employing multi residue analytical technique. The obtained results showed the predominance of methoxychlor in most of the analyzed samples. The detected concentrations of it in pineapple, lettuce, cabbage, cucumber and onion exceeded the European Commission Maximum Residue limits (EC MRLs), as did the concentrations of lindane in papaya, pineapple, cabbage and onion as well as dieldrin in papaya, banana, pineapple and cabbage. Residues of endrin in lettuce and carrot were higher than the EC MRL, as was chlorpyrifos in pineapple. Based on the observations made in these studies, it is proposed that more extensive investigations covering all foodstuffs in Ghana be carried out so as to generate data for policy making, development of consumer information laws and curtailment of the use of some of these pesticides.

Key words: Fruits, Maximum residue limits, Organochlorine, Organophosphorous, Vegetables

Introduction

Pesticides have become widespread pollutants in the environment and now represent a global contamination problem. Hazards associated with these pollutants are their persistence in the environment, their bioaccumulation potential in the tissues of animals and humans through the food chain, and their toxic properties for humans and wildlife (Fu et al., 2003).

These pesticides are widely used on fruits and vegetables because of their susceptibility to insect and diseases. They have been widely used throughout the world since the middle of the last century for their various benefits. Pesticides have been applied in agriculture and animal production to eliminate pests. In this way, to increase both animals and crops outputs, improve quality of products, and decrease the incidence of illnesses propagated by insects (Bempah and Donkor, 2011).

It is therefore not surprising that residues of chlorinated pesticide (OCP) in food have given rise to major concerns. This has reflected in the large number of reports in the literature on this subject (Saeed et al., 2001; Baird and Cann, 2005; Bempah et al., 2011). Moreover, the chronic effects of such exposure levels from food intake are mostly unknown but there is growing evidence of carcinogenicity and genotoxicity as well as endocrine disruption capacity (Miller and Sharpe, 1998) being attributed to the ingestion of or exposure to pesticides. Despite the fact that the use of certain organochlorine pesticides in agriculture is

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prohibited in many countries, these compounds have been detected in the environment worldwide due to its persistent nature (Rejendran and Subramanian, 1999).

In an effort to substitute these persistent organochlorine pesticides, agricultural sectors have shifted towards organophosphate pesticides. However, organophosphate pesticides are generally much more toxic to vertebrates compared to other classes of insecticides even though they rapidly degrade in the environment (Chambers et al., 2001). The usage of these pesticides has brought about great concern in the scientific community on the possible toxic effects of these pesticide contaminations to both aquatic flora and fauna as well as to humans (Jorgenson, 2001).

In Ghana, fruits and vegetables production are on the increase to meet the balanced diet requirement for humans, and for better health. Accordingly, everybody is encouraged to consume more fruits and vegetables as they are essential source of vitamins, fiber etc. Therefore, contamination of fruits and vegetables poses a serious health risk to the public. The monitoring of foodstuffs quality is under the responsibility of the Food and Drugs Board (FDB), Ghana. However, pesticide contaminations in food are not documented in the yearly environmental reports and information on pesticide contaminations is generally lacking (Bempah and Donkor, 2011).

The impacts of pesticide contaminations in food have been well studied in North America, Japan and many parts of Europe (Yamaguchi et al., 2003; Gonzalo et al., 2006; Rosa et al., 2008). In contrast, there is very little data on the levels of pesticide residues in developing countries (Albert, 1996). Therefore, monitoring data from developing countries is an important source of information portraying the state of environment in these countries as well as reflecting the effectiveness of environmental policies. To protect consumer's health, many countries have established legal directives to control levels of pesticides in food, through maximum residue levels (FAO/WHO, 2004).

In contrast such legal legislation does not exist in most developing countries, like Ghana so as to minimize the exposure of the consumer to harmful or unnecessary intake of pesticides, to ensure the proper use of pesticides in terms of granted authorization and registration (application rate and pre-harvested intervals) and to permit the free circulation of pesticide treated products, as long as they comply with the fixed MRLs. This may be due to lack of financial support for scientific research, environmental policy and regulations for control and monitoring in the environment. In countries where they exist, the agencies responsible lack the required capacity to ensure compliance and enforcement of regulations (Tchounwou et al., 2002; Bozongo et al., 2004; Bhanti and Taneja, 2007, Osman et al., 2010).

The objective of this study was to obtain systematic monitoring data on the contamination levels of selected organochlorine and organophosphate pesticide residues in fruits and vegetables sold on Ghanaian markets. The selection of these pesticides was based on previous usage except for the organophosphate insecticides. This paper reports the contamination levels of these pollutants in fruits and vegetables sold on the Ghanaian markets.

Materials and methods

Study area

The study area is selected markets in the Greater Accra region of Ghana. These locations are well known for the sale of vegetables and fruits and are the recipients for the fruits and vegetables produce from the urban and rural areas of Ghana.

Sample collection

A total of 309 samples of fruits and vegetables were purchased from the main urban markets and supermarkets in Greater Accra through the months of July, 2009 to May, 2010. The fruit samples used in this study included papaya, water melon, banana, mango, pear and pineapple, while the vegetable samples included tomato, lettuce, cabbage, carrot, onion and cucumber (Table 1). The sample size was at least 1kg for small and medium sized of fresh product. The minimum weight for large sample sizes was 2kg (for example pineapple, cabbage, and water melon), where the unit was generally more than 250g (Codex Alimentarius Commission, 2000).

The samples were sealed and labeled with a unique sample identity and put in an iced chest contained. All samples were transported to pesticide residues laboratory, Ghana Atomic Energy Commission, and were refrigerated (at 5°C). These samples were then extracted and analyzed (within 24 hours from the time of their collection) for the presence of pesticide residues.

Table 1. Number of fruit and vegetables samples analyzed and number of samples with pesticide residue detected.

English name	Scientific name	No. of samples	No. of samples with residues
Fruits			
Papaya	*Carica papaya*	20	13
watermelon	*Citrullus lanatus*	15	8
banana	*Musa sapientum*	34	8
Mango	*Mangifera indica*	25	11
pear	*Pyrus communis*	20	7
pineapple	*Ananas sativus*	25	15
Total		139	62
Vegetables			
Tomato	*Lycopersicon esculentus*	30	15
Lettuce	*Lactuca sativa*	30	14
Cabbage	*Brassica oleracea*	25	17
Carrot	*Daucus carota*	25	13
Onion	*Allium cepa*	30	13
Cucumber	*Cucumis sativus*	30	13
Total		170	85

Sample preparation

Fresh fruit and vegetable samples were thoroughly shredded and homogenized. Approximately 20.0 g of the sample was macerated with 40 ml of ethyl acetate. Sodium hydrogen carbonate 5.0 g and anhydrous sodium sulphate 20.0 g were added to remove moisture and further macerated for 3 minutes using the ultra-turax macerator. The samples were then centrifuged for 5 minutes at 3,000 rpm to obtain the two phases. The supernatant was transferred to a clean graduated cylinder (25 ml) to measure its volume.

Solid-Phase extraction

A solid phase extraction was carried out using SPE column according to Netherlands analytical methods of pesticide residues and foodstuffs with modification (2007). The florisil column (500 mg/8 ml) cartridge was conditioned with 5 ml of a mixture solution of acetone:n-hexane (3:7, v/v) through the column. The sorbent was never allowed to dry during the conditioning and sample loading steps. The extract column was fitted with 20-port vacuum manifold with a receiving flask placed under the column to collect the eluate. Sample loading was performed under vacuum at flow rates of 5 ml min^{-1}. After the passage of the extract, the column was dried by vacuum aspiration under increased vacuum for 30 min. The pesticides were eluted with 10 ml (3, 3, 4 ml) of ethyl acetate, concentrated to 1 ml using a rotary evaporator and then dried by a gentle nitrogen stream. This was dissolved in 1 ml of ethyl acetate; pesticides were then quantified by gas chromatograph equipped with electron capture detector (GC-ECD).

Gas chromatography- electron capture detector (GC-ECD) analysis

Gas chromatograph GC-2010 equipped with ^{63}Ni electron capture detector (ECD) with split/splitless injector that allowed the detection of contaminants even at trace level concentrations (in the lower µg/g range) from the matrix to which other detectors do not respond was employed. The injector and detector temperature were set at 280 ^{o}C and 300°C respectively. A fussed silica ZB-5 (30 m x 0.25 mm, 0.25 µm film thickness) was used in combination with the following oven temperature program: initial temperature 60°C, held for 1 min, ramp at 30°C min^{-1} to 180°C, held for 3 min, ramp at 3°C min^{-1} to 220°C, held for 3 min, ramp at 10°C min^{-1} to 300°C. Nitrogen was used as carrier gas at a flow rate of 1.0 ml min^{-1} and make up gas of 29 ml min^{-1}. The injection volume of the GC was 1.0 µl. The residues detected by the GC analysis were confirmed by the analysis of the extract on two other columns of different polarities. The first column was coated with ZB-1 (methyl polysiloxane) connected to ECD and the second column was coated with ZB-17 (50% phenyl, methyl polysiloxane) and ECD was also used as detector. The conditions used for these columns were the same.

Quality control and quality assurance

Quality control and quality assurance were included in the analytical scheme. The recovery, precision and linearity of studied pesticides were evaluated by adding a working mixture to 20 g of chopped untreated samples; the spiked samples were made to stand for at least 1 hour before the

extraction. Ten replicate samples were extracted and analyzed according to the proposed procedure as described previously. Precision was calculated based on daily repeatability of 10 samples, whereas reproducibility was carried out on 5 different days. Recoveries were calculated for three replicate samples. Percent recoveries in spiked samples ranged 87% - 120%. Accordingly, the sample analysis data were corrected for these recoveries. Detection limit(s) of the method were also assessed based on the lowest concentrations of the residues in each of the matrices that could be reproducibly measured at the operating conditions of the GC; which were 0.001mg/kg. Blank analyses were also carried in order to check any interfering species in the reagents.

Results

Organophosphorus pesticides are widely used in agriculture and animal production for the control of various insects. These compounds have higher acute toxicity than chlorinated pesticides and they have the advantage of being more rapidly degraded in the environment. Organochlorine pesticides, which over a decade ago were being used in Ghana, are highly persistent. Most of them have been banned, yet their residues still appear as pollutants in food as well as in the environment. Residue levels of these compounds in fruits and vegetables are listed in Tables 2 and 3.

Levels of pesticide residues found in fruits collected from the various market centers

The identities of all the two groups of pesticide (organochlorine and organophosphorus) residues found in fruits are given in Table 2. Among the various organochlorine pesticides in the present study, lindane is the predominant compound in the fruit samples. The detected levels of it varied greatly. For instance, the minimum value for it was detected in watermelon (0.004mg/kg) and the maximum of 0.133mg/kg was found in pineapple.

Table 2. The detected levels (mg/kg) of pesticide residues in Ghanaian fruits samples.

Pesticide types	Papaya	Watermelon	Banana	Mango	Pear	Pineapple
Organochlorines						
Lindane	0.100*±0.004 (0.092-0.105)[a]	0.004±0.002 (0.004-0.006)	<LOD[b] -	0.010±0.010 (0.006-0.022)	0.009±0.003 (0.006-0.012)	0.133*±0.014 (0.121-0.153)
Methoxychlor	0.006±0.002 (0.004-0.012)	<LOD -	0.008±0.004 (0.004-0.012)	0.004±0.001 (0.004-0.006)	<LOD -	0.031*±0.023 (0.007-0.052)
Aldrin	0.004±0.002 (0.001-0.008)	<LOD -	<LOD -	<LOD -	0.007±0.003 (0.003-0.009)	0.006±0.002 (0.004-0.008)
Dieldrin	0.017*±0.020 (0.002-0.040)	<LOD -	0.090*±0.103 (0.013-0.203)	<LOD -	<LOD -	0.012*±0.008 (0.007-0.018)
Endrin	<LOD -	<LOD -	0.006±0.002 (0.004-0.012)	<LOD -	<LOD -	0.004±0.002 (0.004-0.008)
p,p'-DDE	<LOD -	0.004±0.001 (0.004-0.008)	<LOD -	0.010±0.004 (0.005-0.011)	<LOD -	<LOD -
p,p'-DDT	0.012±0.006 (0.008-0.014)	0.008±0.004 (0.006-0.010)	0.038±0.032 (0.005-0.062)	0.020±0.002 (0.018-0.021)	<LOD -	<LOD -
Organophosphorus						
Diazinon	<LOD -	<LOD -	<LOD -	<LOD -	<LOD -	0.007±0.003 (0.001-0.009)
Dimethoate	0.008±0.002 (0.002-0.012)	0.004±0.001 (0.004-0.006)	<LOD -	0.010±0.014 (0.004-0.018)	<LOD -	0.006±0.002 (0.002-0.008)
Pirimiphos-methyl	<LOD -	<LOD -	<LOD -	0.004±0.001 (0.002-0.006)	<LOD -	0.014±0.012 (0.008-0.018)
Chlorpyrifos	0.008±0.002 (0.004-0.010)	0.003±0.002 0.002-0.005	0.006±0.002 (0.004-0.012)	0.005±0.003 (0.003-0.007)	0.017±0.007 (0.012-0.025)	0.055*±0.011 (0.041-0.062)
Profenofos	0.003±0.002 (0.001-0.005)	<LOD -	<LOD -	<LOD -	<LOD -	<LOD -
Malathion	<LOD -	<LOD -	<LOD -	<LOD -	<LOD -	0.006±0.002 (0.002-0.008)

Each value is the mean of five samples with four determinations

a Range in bracket

b LOD= 0.001 mg/kg sample ; Values designated by asterisks are higher than the EC-MRLs for the respective pesticide (see MRLs in Table 4-5)

Minimum values for methoxychlor were detected in mango (0.004mg/kg) and the maximum of 0.031mg/kg was found in pineapple. 0.004mg/kg of aldrin was detected in papaya and the maximum of 0.007mg/kg was found in pear. Minimum value of 0.012mg/kg of dieldrin was found in pineapple and maximum value of 0.090mg/kg was detected in banana whiles 0.004mg/kg of endrin was found in pineapple and maximum of 0.006mg/kg was found in banana.

Moreover, p,p'-DDE was having a minimum value of 0.004mg/kg in watermelon and maximum value of 0.010mg/kg in mango while p,p'-DDT recorded a minimum value (0.008mg/kg) in watermelon and maximum value of 0.038mg/kg was found in banana.

With respect to the organophosphorus pesticides, Table 2 shows that diazinon and malathion were the least predominant pesticide with residues of 0.007mg/kg and 0.006mg/kg in pineapple samples. However, chlorpyrifos was the most dominant pesticide residues. The minimum value of 0.003mg/kg of it was found in watermelon and the maximum value of 0.055mg/kg in pineapple. Following chlorpyrifos is dimethoate, where the minimum value (0.004mg/kg) of it was found in watermelon and maximum value of 0.010mg/kg in mango. Minimum value of pirimifos-methyl (0.004mg/kg) was detected in mango and maximum value of 0.014mg/kg was found in pineapple.

Levels of pesticide residues found in vegetables collected from the various market centers

In regard to the organochlorine pesticides found in vegetable samples, Table 3 indicates that methoxychlor and p,p'-DDT were the most predominant pesticides with maximum residual concentrations of 0.041mg/kg and 0.035mg/kg present in onion samples while minimum residual concentrations of 0.004mg/kg each were also present in tomato and carrot samples, respectively.

Table 3. The detected levels (mg/kg) of pesticide residues in Ghanaian vegetables samples.

Pesticide types	Tomato	Lettuce	Cabbage	Carrot	Cucumber	Onion
Organochlorines						
Lindane	0.008±0.002	0.006±0.002	0.100*±0.004	<LOD[b]	<LOD	0.019*±0.002
	(0.004-0.010)[a]	(0.004-0.006)	(0.095-0.102)	-	-	(0.016-0.020)
Methoxychlor	0.004±0.002	0.023*±0.008	0.023*±0.008	0.008±0.004	0.020*±0.002	0.041*±0.022
	(0.002-0.008)	(0.031-0.022)	(0.031-0.022)	(0.006-0.012)	(0.018-0.021)	(0.025-0.066)
Aldrin	<LOD	0.008±0.004	<LOD	0.010±0.021	<LOD	0.006±0.002
	-	(0.006-0.012)	-	(0.008-0.040)	-	(0.004-0.008)
Dieldrin	0.004±0.008	<LOD	0.035*±0.013	<LOD	0.010±0.004	<LOD
	(0.002-0.040)	-	(0.030-0.052)	-	(0.005-0.013)	-
Endrin	<LOD	0.040*±0.035	0.007±0.003	0.016*±0.008	<LOD	<LOD
	-	(0.080-0.015)	(0.005-0.009)	(0.006-0.032)	-	-
p,p'-DDE	0.013±0.009	0.041±0.022	0.008±0.004	<LOD	<LOD	0.023±0.008
	(0.007-0.015)	(0.025-0.066)	(0.006-0.010)	-	-	(0.016-0.031)
p,p'-DDT	0.012±0.006	0.020±0.002	0.032±0.010	0.004±0.002	0.009±0.003	0.035±0.005
	(0.008-0.014)	(0.018-0.021)	(0.030-0.040)	(0.004-0.008)	(0.005-0.013)	(0.030-0.040)
Organophosphorus						
Diazinon	0.009±0.003	0.004±0.001	0.016±0.005	0.005±0.002	0.009±0.006	0.008±0.004
	(0.003-0.013)	(0.002-0.006)	(0.010-0.019)	(0.003-0.011)	(0.003-0.011)	(0.004-0.010)
Dimethoate	0.013±0.009	0.021±0.013	<LOD	0.020±0.014	<LOD	0.006±0.002
	(0.007-0.019)	(0.018-0.024)	-	(0.018-0.024)	-	(0.002-0.008)
Pirimiphos-methyl	0.017±0.007	<LOD	0.003±0.001	<LOD	0.010±0.007	<LOD
	(0.012-0.025)	-	(0.001-0.006)	-	(0.006-0.021)	-
Chlorpyrifos	0.026±0008	0.011±0.010	0.007±0.003	0.040±0.026	<LOD	0.055±0.011
	(0.018-0.025)	(0.001-0.021)	(0.003-0.009)	(0.038-0.044)	-	(0.041-0.062)
Profenofos	0.010±0.004	<LOD	0.008±0.004	0.012±0.009	0.003±0.001	0.040±0.002
	(0.005-0.011)	-	(0.002-0.010)	(0.010-0.016)	(0.001-0.009)	(0.008-0.044)
Malathion	0.038±0.032	0.003±0.003	0.004±0.001	0.007±0.003	0.010±0.008	<LOD
	(0.005-0.062)	(0.001-0.006)	(0.004-0.008)	(0.005-0.011)	(0.008-0.012)	-

Each value is the mean of five samples with four determinations

a Range in bracket

b = 0.001 mg/kg sample

Values designated by asterisks are higher than the EC-MRLs for the respective pesticide (see MRLs in Table 4-5)

In contrast with the trend exhibited in methoxychlor and p,p'-DDT, lindane recorded a minimum value of 0.006mg/kg in lettuce and maximum value of it (0.010mg/kg) was recorded in cabbage. Unlike lindane, p,p-DDE recorded a maximum value in lettuce (0.041mg/kg) and a minimum value in cabbage (0.008mg/kg). Maximum residual concentrations of aldrin, dieldrin and endrin were detected in carrot, cabbage and lettuce to be 0.010, 0.035 and 0.040mg/kg, respectively while minimum concentration values were detected in onion (0.006mg/kg), tomato (0.004mg/kg) and cabbage (0.007mg/kg), respectively.

In the case of organophosphorus pesticides found in vegetable samples, diazinon is the most predominant pesticide residues found in the analyzed vegetable samples with maximum concentration levels of it (0.016mg/kg) found in cabbage and a minimum value of 0.004mg/kg found in lettuce. Next to diazinon are chlorpyrifos, profenofos and malathion. Chlorpyrifos achieved a maximum value of 0.055mg/kg in onion and a minimum value of 0.007mg/kg in tomato samples analyzed. Corresponding values for profenofos were 0.012mg/kg in carrot and 0.003mg/kg in cucumber samples, respectively. Furthermore, the maximum detected residue of malathion was detected in tomato (0.038mg/kg), and the minimum value was found in lettuce (0.003mg/kg). Maximum concentration values of dimethoate and pirimifos-methyl were detected in lettuce and tomato to be 0.021mg/kg and 0.017mg/kg respectively whiles minimum concentration values were also detected in onion (0.006mg/kg) and cabbage (0.003mg/kg) samples, respectively.

The data further showed occurrence of some pesticide residues in fruits and vegetables at levels exceeding maximum residue limits (MRLs). Compared with the MRLs established by EC (2006), methoxychlor is most often exceeded MRL values (41.6%), followed by lindane and dieldrin (33.3%), endrin (16.6%) and chlorpyrifos (8.3%) (Tables 4 and 5).

Overall residues were found in 41.4% of fruit samples and 58.9% of vegetable. The reason for this might be that, vegetables are highly sensitive to pest and need for successive applications of pesticides treatments, leaving in consequence higher level of residues that tolerated and protected from pest infestation.

From this work, it can be seen that, lindane is detected in papaya, pineapple, cabbage and onion at levels higher than the MRLs set by EC (2006). Also, methoxychlor was higher in pineapple, lettuce, cabbage, cucumber and onion than the MRL. It can also be seen that dieldrin detected in papaya, banana, pineapple and cabbage were higher than the MRL. Also, endrin in lettuce and carrot as well as chlorpyrifos in pineapple were detected at levels higher than the MRL recorded by EC (Table 4). The results indicated that pesticides should be applied correctly using only the required amounts and following label directions.

Table 4. Maximum residue levels for organochlorine pesticides in the selected fruits and vegetables.

Commodity	Maximum residue levels, MRLs (mg/kg)						
	Gamma-HCH	methoxychlor	aldrin	dieldrin	endrin	p,p'-DDE	p,p'-DDT
Fruits							
Papaya	0.01	0.01	0.01	0.01	0.01	0.05	0.05
Water melon	0.01	0.01	0.03	0.03	0.01	0.05	0.05
Banana	0.01	0.01	0.01	0.01	0.01	0.05	0.05
Mango	0.01	0.01	0.01	0.01	0.01	0.05	0.05
Pear	0.01	0.01	0.01	0.01	0.01	0.05	0.05
Pineapple	0.01	0.01	0.01	0.01	0.01	0.05	0.05
Vegetables							
Tomato	0.01	0.01	0.01	0.01	0.01	0.05	0.05
Lettuce	0.01	0.01	0.01	0.01	0.01	0.05	0.05
Cabbage	0.01	0.01	0.01	0.01	0.01	0.05	0.05
Carrot	0.01	0.01	0.01	0.01	0.01	0.05	0.05
Onion	0.01	0.01	0.01	0.01	0.01	0.05	0.05
Cucumber	0.01	0.01	0.02	0.02	0.01	0.05	0.05

Table 5. Maximum residue limits for organophosphorus pesticides in the selected fruits and vegetables.

Commodity	Maximum residue levels, MRLs (mg/kg)					
	Diazinon	Dimethoate	Pirimiphos-methyl	Chlorpyrifos	Profenfos	Malathion
Fruits						
Papaya	0.02	0.02	0.05	0.50	0.05	-[a]
Water melon	0.02	0.02	0.05	0.05	0.05	-
Banana	0.02	0.02	0.05	3.00	0.05	0.50
Mango	0.02	0.02	0.05	0.05	0.05	-
Pear	0.30	0.02	0.10	0.50	0.05	0.50
Pineapple	0.02	0.02	0.05	0.05	0.05	-
Vegetables						
Tomato	0.50	0.02	0.20	0.50	0.05	3.00
Lettuce	0.02	0.50	0.50	0.05	0.05	3.00
Cabbage	0.02	0.02	0.50	0.50	0.05	-
Carrot	0.20	0.02	0.05	0.10	0.05	0.50
Onion	0.50	0.02	0.10	0.20	0.05	3.00
Cucumber	0.02	0.02	0.10	0.05	0.05	3.00

[a]-No EC MRL

Discussion

The occurrence of selected organochlorine and organophosphate pesticides was studied in the selected urban markets and supermarkets in Greater Accra region of Ghana. The pesticides detected were lindane, methoxychlor, aldrin, dieldrin, endrin, p,p'-DDE, p,p'-DDT, diazinon, dimethoate, pirimiphos-methyl, chlorpyrifos, profenofos and malathion. This study has shown the presence of organochlorine pesticides despite the fact that they have been banned for a considerable amount of time in Ghana. This study therefore suggest the possibility of sporadic use of these pesticides for agriculture or mainly due to the past extensive use of these pesticides for agriculture in Ghana as it has been banned for over a decade ago.

These findings corroborate the findings of Nakata et al. (2002) who found elevated levels of organochlorine pesticides residues in fruits and vegetables collected from Shanghai and Yixing, China. Similarly, in an investigation carried out by Hura (1999), by monitoring organochlorine residues in fruits and vegetables at Eastern Romania, it was concluded that organochlorine pesticides were found in all analyzed samples. A similar research conducted by Mukherjee et al. (2011) in West Bengal, India, to access the level of organochlorine pesticides residues in vegetables revealed that, the concentration of ∑OCPs was ranged between, <0.01– 65.07µg/kg with average of 9.67±2.34µg/kg (wet wt.). The concentration of ∑DDT, ∑HCH, aldrin, dieldrin and heptachlor was 3.49±0.93µg/kg, 2.07±0.53µg/kg, 1.32±0.65µg/kg, 1.36±1.18µg/kg and 1.80±0.4µg/kg (wet wt) respectively

The data therefore show the decreased concentrations of the residues of organophosphorus pesticides, which were detected in some of the analyzed samples of fruits and vegetables under investigation except chlorpyrifos which exceeded MRL in pineapple samples. This might be due to its ability to degrade rapidly in the environment than organochlorine pesticides. Similar results were obtained by Abou-Arab and Abou Donia (2001) who found that samples collected from Egypt contained organophosphorus pesticides particularly, malathion, dimethoate and profenofos at levels ranging from 0.061 to 1.756mg/kg. In 2006, Bai et al. (2006) concluded that the OP pesticide residues were present in fruits and vegetables in Shaanxi area of China.

Conclusion

Contamination of the fruits and vegetables with these pesticide residues poses a significant health risk to the public from consuming contaminated fruits and vegetables. The other foodstuffs are also threatened by the presence of pesticides residues. The presence of pesticide residues is attributed to more quantity and cosmetic quality of these commodities which create over reliance on pesticides. While greater portion of pesticides being consumed in the country are used on fruits and vegetables. This monitoring study is being continued to provide more information on the pesticide contaminations in foodstuffs in Ghana, which will further contribute to the information available on pesticide residues found in the food commodities in Ghana.

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