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Original Research Article

Dietary exposure to chlorinated pesticide residues in fruits and vegetables from Ghanaian markets

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ABSTRACT

Analysis of 400 fruit and vegetable samples obtained from open and closed markets in Accra, Ghana was carried out employing a multi-residue method based on solid-phase extraction followed by gas chromatography–mass spectrometry. Generally, the data showed that most of the fruit and vegetable samples analysed contain residues of the monitored pesticides below the accepted maximum residue limit (*MRL*) as adopted by the Food and Agricultural Organization/World Health Organization (FAO/WHO) Codex Alimentarius Commission (CAC), although some pesticide residues were not detected in some of the fruit and vegetable samples. The results obtained further revealed that 20% of the fruit and vegetable samples were above *MRL*, 73% were below *MRL* and 7% contained no detectable level of the monitored pesticides. Estimation of dietary intake of pesticides from fruit and vegetables revealed that, pesticides detected in fruits and vegetables did not cause dietary intake risks. The results recommend the need for regular monitoring for pesticide residues of a greater number of samples for long periods, especially in fruit and vegetables, to protect consumers' health.

1. Introduction

To satisfy the growing demand for fruits and vegetables, farmers around the world including Ghana use pesticides to boost production as well as an insurance policy against the possibility of a devastating crop loss from pests and diseases which pose great problems in fruits and vegetables production (Bempah et al., 2012). Accordingly in Ghana, for several decades now, pesticides have been employed in agriculture not only to control and eradicate crop pests but also in the public health sector for disease vector control (Hodgson, 1996). Nevertheless, there has been a rapid increase in the quantity and use of pesticides in agriculture over the past 10 years. Moreover, this growth trend is expected to heighten in the next decades to meet the growing demand for food (Bempah et al., 2011).

Pesticide residues in fruits and vegetables have now become a major public health concern to consumers probably due to short interval between harvests to market resulting in the likelihood of no testing for pesticide residues. This therefore leads to frighteningly high residual levels in both raw (which are normally eat uncooked) and processed fruits and vegetables in urban markets of Ghana. Pesticides are among the major contaminants of food supply and may be the most important problem to our environment (Zaidi et al., 2005). A number of persistent organochlorines that have been banned or severely restricted are still marketed and used in many developing countries and Ghana is no exception. The misuse of pesticides by concerned individuals, in addition to lack of or weak national controlling plans is behind the outbreak of adverse effects in developing countries (Mansour, 2004). For example, the use of DDT and many other organochlorine pesticides in Ghanaian agriculture has been banned. However, these long persistent compounds are still detectable in many different types of environmental samples.

Furthermore, the usage of these chemicals, especially organochlorine pesticides has occasionally been accompanied by risks to human health and the environment because of their toxic potential, high persistence, bioconcentration, and, especially, their non-specific toxicity (Bempah and Donkor, 2011). Despite the fact

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that the use of certain organochlorine pesticides in agriculture is prohibited in many countries, these compounds have been detected in the environment due to their persistence worldwide.

Such problem is getting more serious all over the world especially in developing countries. It is therefore not surprising that residues of chlorinated pesticides in food have given rise to major concerns especially when these commodities are freshly consumed. 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 being attributed to the ingestion of or exposure to pesticides and therefore it is desirable to reduce these residues (Bempah et al., 2012).

Exposure to pesticide residues through the diet is assumed to be five orders of magnitude higher than other exposure routes, such as air and drinking water (Juraske et al., 2009). According to the World Health Organization (WHO), food consumption consists of 30% (based on mass) fruit and vegetables, which is the most frequently consumed food group (WHO, 2003). Because fruit and vegetables are mainly consumed raw or semi-processed, it is expected that they contain higher pesticide residue levels compared to other food groups of plant origin. There is a necessity to test and analyse these food items to ensure that the levels of these contaminants meet agreed international requirements. Again, there is also the pressing need for their control and monitoring in the environment (Bempah and Donkor, 2011).

Although pesticide residues contamination in foodstuffs have been monitored for decades in most developed countries (Claeys et al., 2011; Stanciu et al., 2005; Pennington et al., 1995a,b; Milacic and Kralj, 2003), fruit and vegetables in Ghana are not much investigated for pesticide contamination. The monitoring and assessment of pesticide levels in fruits and vegetables may provide the basis for risk assessment as a result of human exposure to these chemicals.

Highly sensitive and selective analytical procedures to determine residues in a variety of food matrices have been developed. Gas chromatography with mass spectrometric detection (GC–MS) has been used successfully for the analysis of many volatile pesticides and offers simultaneous quantitation and confirmation of a large number of pesticides, excellent separation efficiency and high speed of analysis.

To protect consumer's health, many countries have established legal directives to control levels of pesticides in food, through maximum residue levels, *MRLs* (FAO/WHO, 2004; Council Directive, 2003). The levels of pesticide residues in foodstuffs are generally legislated so as to minimize the exposure of the consumer to harmful intakes of pesticides, to ensure the proper use of pesticides in terms of granted authorization and registration (application rates and pre-harvested intervals) and to permit the free circulation of pesticide-treated products, as long as they comply with the fixed *MRLs* (Osman et al., 2010).

In cognizance of these directives, the purpose of the study was to monitor and evaluate the residual concentrations of organochlorine pesticide residues in fruit and vegetables collected from selected markets in the Accra metropolis and to estimate the potential health risks associated with each of the organochlorine pesticides in Ghanaian fruit and vegetables. Additionally, the results are compared with the maximum residue levels (*MRLs*) of pesticides, recommended by the Food and Agricultural Organisation/World Health Organisation (FAO/WHO) Codex Alimentarius Commission (2007) for fruit and vegetables.

2. Materials and methods

2.1. Sampling

The study areas are selected markets in the Accra Metropolis. A total of 400 samples of fruits and vegetables was purchased from open markets, supermarkets, roadside grocery shops and peddlers. From each market, a sample size of at least 1 kg for small and medium sized fresh product was purchased. The minimum weight for large sample sizes was 2 kg, where the unit was generally more than 250 g (Codex Alimentarius Commission, 2000), which was quite representative since the markets from where these food stuffs examined were scattered throughout the cities. For the analysis, only the edible portions were included, whereas bruised or rotten parts were removed. The various collected samples (item, scientific name, number) are presented in Table 1.

2.2. Sample preparation and treatment

Samples of fresh fruits and vegetables (2.0 kg) were thoroughly shredded and homogenized. Approximately 120 g of the sample were used for pesticide analysis. Determination of pesticide residues in fruits and vegetables were performed according to the Netherlands Analytical Methods for Pesticide Residues in Foodstuffs (2006) with modifications.

2.3. Chemicals and materials

Pesticide standards were obtained from Dr. Ehrenstofer GmbH (Germany) with certified purities ranging from 97 to 99%. Concentrations of standard solutions were corrected for the certified purity of the standards. Sodium hydrogen carbonate and anhydrous sodium sulfate were purchased from E. Merck (Darmstadt, Germany). Pesticide-grade ethyl acetate, hexane and analytical grade acetone were also purchased from Merck. Milli-Q water of 15 MΩ cm resistivity was obtained from a water purification system (PURELAB Option-R, ELGA, UK). Solid-phase extraction cartridges column size (500 mg/8 mL) were obtained from Honeywell Burdick & Jackson (Muskegon, MI).

2.4. Extraction and clean-up

Triplicate sub-samples (40.0 g each) of fruit and vegetables were homogenized and macerated with 40 mL of ethyl acetate. Sodium hydrogen carbonate (5.0 g) and anhydrous sodium sulfate (20.0 g) were added to remove moisture and further macerated for 3 min using an Ultra-Turrax macerator (T25; IKA, Labortechnik, Staufen, Germany). The samples were then centrifuged for 5 min at 3000 rpm to obtain two phases. The extraction process was

Table 1
Names of samples and incidence of pesticide residues in fruit and vegetables from Accra markets.

Commodity	Scientific name	No. of samples	% with one or more residues
Fruit			
Mango	*Magnifera indica*	40	86
Pineapple	*Ananas sativus*	40	100
Apple	*Malus domestica*	50	57
Vegetable			
Green pepper	*Piper nigrum*	60	86
Tomato	*Lycopersicon esculentus*	50	100
Carrot	*Daucas carota*	60	79
Lettuce	*Lactuca sativa*	50	100
Cabbage	*Brassica oleracea*	50	100