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Levels of organochlorine pesticides residues in dairy products in Kumasi, Ghana

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Abstract

Determination of six organochlorine pesticides, lindane, aldrin, dieldrin, endosulfan, dichlorodiphenyltrichloroethane (DDT), and dichlorodiphenyldichloroethylene (DDE), residues were carried out on three dairy products sampled from six communities in the Kumasi metropolis in Ghana. Cheese samples were collected from three communities, (Tafo, Asawasi, and Aboabo), yoghurt samples from K-Poly and Ayeduasi while yoghurt and milk samples were collected from KNUST. Concentrations of DDT and DDE were, respectively, 42.17 ± 6.00 μg kg^{-1} and 31.50 ± 3.44 μg kg^{-1} in cheese sampled from Asawasi. Cheese samples from Tafo had an average DDT concentration of 298.57 ± 28.02 μg kg^{-1} while DDE concentration was 140.15 ± 56.77 μg kg^{-1}. The highest average concentration of DDT in all the samples was 149.07 μg kg^{-1} detected in cheese samples from Aboabo. Levels of DDT and its metabolite, DDE, in cheese from all the three sampling sites (Aboabo, Asawasi and Tafo) were well below the levels recommended by World Health Organisation (WHO). Mean concentration of DDT in fresh milk samples from KNUST was 12.53 ± 1.61 μg kg^{-1}. As bioaccumulation of these residues is likely to pose problems in higher organisms, like human beings, there is the need for effective monitoring of these residues in the environment. This work, thus, seeks to provide information on levels of pesticide residues in dairy products that will assist in a scientific assessment of the impact of pesticides on public health, agriculture and the environment in Ghana.

Keywords: Dairy products; Organochlorine pesticides; Gas chromatography; Electron capture detector

1. Introduction

Until the early 1980s, many chlorinated insecticides, mainly; aldrin, dieldrin, DDT, and lindane have been used in controlling pests of crops, vectors of some diseases and other aspects of public health in Ghana (UNEP, 2002). Some of these pesticides are still widely used by farmers because of their effectiveness and their broad-spectrum activity (Amoah et al., 2006). Lindane is used on cocoa plantations, vegetable farms, and for the control of stem borers in maize. Endosulfan, marketed as thiodan, is widely used in cotton growing areas, on vegetable farms, and on coffee plantations (Ntow et al., 2006). Organochlorine pesticides such as dichlorodiphenyltrichloroethane (DDT), lindane and endosulfan are also employed to control ectoparasites of farm animals and pets in Ghana (Awumbila and Bokuma, 1994).

Most organochlorine insecticides, except lindane, are very stable solids with limited vapour pressure and very low water solubility. They are highly lipophilic and resistant to microbial degradation (UNEP, 2001; Kaushik and Kaushik, 2007). They can, therefore, accumulate in fatty adipose tissues and in the environment. As these chemicals are inherently toxic to living organisms, the presence of their residues in food items is of a major concern to environmental and consumer groups (Willes et al., 1993). Acute toxic effects of pesticides on animals and humans are fairly easily recognized, but the effects that result from

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Table 1
Mean recovery (%), relative standard deviation (RSD) (%), limits of detection (LD) ($n = 4$)

	Milk			Yoghurt			Cheese		
	Recovery	RSD (%)	LD (μg kg^{-1})	Recovery	RSD (%)	LD (μg kg^{-1})	Recovery	RSD (%)	LD (μg kg^{-1})
Lindane	66	6	0.08	68	4	0.50	85	4	0.10
Aldrin	61	5	0.10	72	2	0.12	73	7	0.20
Endosulfan	72	4	0.15	74	6	0.23	62	8	0.35
p,p′-DDE	82	6	0.10	91	3	0.30	94	6	0.02
Dieldrin	83	5	0.10	72	2	0.05	71	6	0.40
p,p′-DDT	75	13	0.12	95	3	0.04	95	5	0.95

long-term exposure to low doses are often difficult to distinguish. Data on the consumption of individual pesticides in Ghana are very difficult to obtain, because manufacturers are reluctant to disclose such information and there is little governmental control of the use of such chemicals.

Work already done in some farming communities in the Ashanti region of Ghana has indicated the presence of organochlorine pesticide residues in fish (Osafo Acquaah, 1997) vegetables, water, sediments, mother's milk and blood samples (Ntow, 2001). Significantly, as high as 30.7 g kg^{-1} hexachlorobenzene and 380.7 g kg^{-1} *p,p′*-DDE were reported to be present in blood samples of some farmer in this study. In another study carried out on the Volta lake, the largest lake in Ghana, lindane and endosulfan were identified in concentrations $\leqslant$0.008 and 0.036 ppb, respectively, in water, and $\leqslant$2.3 and 0.36 ppb, respectively, in sediments. DDT and dichlorodiphenyldichloroethylene (DDE) were also found in sediment samples in concentrations $\leqslant$9.0 and 52.3 ppb, respectively, (Ntow, 2001). No data is however available on the levels of these residues in dairy products which constitute an important part of meal of many communities in Ghana.

Because of their highly lipophilic nature, organochlorine pesticides and their residues may easily concentrate in fatty foods (such as milk products) leading to bioconcentration and biomagnification through the food chain. There is, therefore, the need for constant monitoring of levels of these residues in foodstuffs and the environment in order to avert any environmental and health disaster. This work, thus, seeks to provide information on levels of pesticide residues in dairy products that will assist in a scientific assessment of the impact of pesticides on public health, agriculture and the environment in Ghana.

2. Methodology

All chemicals were purchased from BDH and were of pesticide residue grade. Organochlorine pesticides (lindane, aldrin, dieldrin, *p,p′*-DDE, *p,p′*-DDT, and endosulfan) standards were purchased from Ehrenstorfer, GmbH, Germany, in sealed vials. SPE bond elut C–18, 3 cc/500 mg were purchased from Varian Inc., USA. A Shimadzu GC – 9A gas chromatograph equipped with a ^{63}Ni electron capture detector and SPB – 608 (15 m × 0.5 m film) capillary column was used in the analysis.

Cheese samples were collected from three communities, (Tafo, Asawasi, and Aboabo), yoghurt samples from K-Poly and Ayeduasi while yoghurt and milk samples were collected from KNUST, all in the Kumasi metropolis. Sampling was done in two batches of ten samples each between the period of May–July 2004, for the first batch, and December 2005–March 2006, for the second batch. Sampling was carried out weekly.

About 10 ml of fresh yoghurt and of milk were taken from every drum of processed stuff brought for sale on the day of sampling. For cheese, two balls were randomly selected from every 100 balls being offered for sale. Samples are collected into plain polythene bags, kept frozen in an ice chest and sent immediately to the laboratory. In the laboratory, each of the products was bulked together, ground and mixed thoroughly. A total of twenty samples were taken from each sampling site.

Ten grams of sample (milk or yoghurt) was ground with anhydrous sodium sulphate to yield a dry free-flowing powder which was then transferred into a glass extraction column of length 30 cm and internal diameter 2 cm. The dry column was then eluted with 80 ml of dichloromethane with the first 40 ml allowed to stay in contact with the powder for 30 min. Dichloromethane in the eluate was removed using a rotary evaporator at 35 °C under reduced pressure (US-EPA, 1980).

For cheese, 1 g sample was added to 20 ml methanol, 2 ml of 10% sulphuric acid, and 1 g sodium oxalate to mix. To this was added 20 ml of ethylether/petroleum ether (1:1) and then shaken vigorously for 1 min. The mixture was centrifuged at 1500 rpm for 5 min and the solvent layer transferred into 1 l separatory funnel. To this, was added 5 ml saturated sodium chloride solution and 2 ml of 10% sulphuric acid to wash. Aqueous residue in the centrifuge bottle was re-extracted twice with 10 ml portions of ethylether/pet ether (1:1). The organic portions were combined and the aqueous portion discarded. The solvent layer (extract) was re-washed twice with 20 ml distilled water, 2 ml of 10% sulphuric acid and 5 ml saturated sodium chloride solution. The extract was allowed to stand for 30 min and water drained off. The solvent was evaporated on a rotary evaporator at 40 °C. The extract was allowed to cool and the fat extracted with 10 ml methylene chloride solution (US-FDA, 2002).

Each of the raw extracts was dissolved in 10 ml hexane and passed through pre-conditioned octadecyl C_{18} columns